Progress in Engineering Application and Technology Vol. 1 No. 1 (2020) 1–12


**PEAT**

Homepage: https://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 0000-0000

# A Prototype Design of Water Filtration System and Recycling System for Flushing Toilet

**Nur Aslini Roslan[1], Nurdalila Saji[1]***

[1]Nur Aslini Binti Roslan,
UTHM Kampus Pagoh, Hab Pendidikan Tinggi Pagoh,
KM1, Jalan Panchor, 84600 Panchor, Johor, MALAYSIA.

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2020.01.01.001
Received 10 September 2020; Accepted 09 November 2020; Available online 02 December 2020

**Abstract**: Water is an invaluable source of nature; each resident needs water for their daily needs. Water is an essential source in generating various economic income in agricultural, industrial, fisheries, and electricity generation. However, people nowadays are being irresponsible with the use of water. The World Health Organization (WHO) has reported that every individual worldwide uses water resources between 50 and 165 liters per day. In Malaysia, the population of wasting water exceeding international standards. Therefore, to minimize the water wastage, an initiative is taken to overcome the problem with the prototype design of a water filtration system and a recycling system for a flushing toilet to filter wastewater or greywater from the kitchen sink, toilet sink, and floor trap in bathrooms. This study aims to design a prototype, produce, and test the effectiveness of the prototype design so that the water filtration system is veritable. This prototype uses natural ingredients and economical products to clean wastewater, and it uses the gravity system. This prototype uses natural ingredients and economical products to clean wastewater, and it uses the gravity system. Tests involved in examining the prototype of the water filtration system are leak detection test and refined water cleanliness quality test. The water hygiene quality test is to obtain the value of pH, TSS, TDS, and BOD. Besides, the water hygiene test ensures that the filtered water is not greasy, eliminating soap foam and solid waste such as hair. The prototype is set up and placed on a house sink to reduce water pollution. This project focuses on the filtered water from the kitchen sink, toilet, and floor trap for the flushing toilet system. The flushing toilet system usually uses direct water. Thus, using this prototype, it can minimize water wastage and reduce the water tariff rate.

**Keywords**: Water filtration system, recycling system, economical product, gravity system

## 1. Introduction

**Corresponding author: nurdalila@uthm.edu.com*

Water is one of the primary sources of water used by every citizen of the world. The surface of the earth holds almost 70.0 % of the water and 30.0 % of the land. Therefore, water is an easy source to find and easy to use. Water sources include lakes, rivers, dams, or reservoirs such as wells, springs, and rainwater. Hence, water conservation is one of the most critical issues facing today. Estimates of overall water availability, drinking water, agricultural usage, and sanitation are 2.5 percent of the world's water supply. Water demand is very high, and analysts predict water demand will double over the next three decades [1].

Additionally, the sink drainage system should normally be drained into the drain, but some of the particles present in the sink water, such as oil, soap, etc. Today, sinks are blocked by fats, oils, and soaps. It is a global problem as it caused water pollution to be increased. According to the environmental agency of the United States 10,350 to 36,000 sewerage on flow (SSO) occurring every year [2]. In Malaysia, the estimated total quantity of wastewater from the urban and industrial sectors entering the sewerage system is 2.97 billion cubic meters a year [3]. Also, Malaysia's population growth rate of 1.5 % increase in the Malaysian population could increase wastewater quantity [4].

### 1.1 Problem Statement

Water is a priceless treasure that has the right to be appreciated. Every resident is in dire need of water for daily living. It is essential in various economic areas such as agriculture, industrial, fisheries, electricity generation, in-house use, and so on. Besides that, on the ground almost 3/4 of the earth's surface is watery [5]. The World Health Organization (WHO) has designated individuals worldwide to use 50 to 165 liters of water per day. Therefore, the Malaysian Water Company stated that the average water per person using the water source was 221 liters per day, which exceeded international standards. According to the National Water Service Commission (SPAN), the average annual wastewater in Malaysia is 50,000 liters of water a year [6]. The wastewater cause might come from the irresponsible behavior and selfish attitude of the resident that neglecting the effects of wastage of water sources.

Besides, each building has a drainage system in both the kitchen and the toilet. Usually, this system will cause clogging problems in the sink, that might be caused due to the blockage of fat, oil, and soap. This causes the wastewater to become contaminated, and the water cannot be used for other uses. It is generally known that overeating fat and oil can cause clogged drainage. Besides, soaps can also cause clogged channels when soaps become lumps [7]. Therefore, each time the sink is used it will cause the waterway to become narrower or smaller and cause the sink to clog up.

Furthermore, the problem often encountered in wastewater filtration is using electricity to isolate oil and wastewater in the sink. Oil trap systems use high voltage water pumps to separate oil and wastewater so that the sink does not clog [8]. A grease trap made of stainless steel or fiberglass is an oil trap or oil and fat filtering product derived from a dishwasher [9]. If oil traps or grease use the steel, it will cause erosion on grease traps due to hydro sulfuric acid, hydro sulfuric formed from a mixture of water with grease, detergent, and solid waste [10].

### 1.2 Project Objective

The specific objectives of this project include:

- Design prototype water filtration system for use in toilet flushing system.
- Produces a prototype of a water filtration system and recycles it for use in toilet washers.
- Test the effectiveness of prototype design of the water filtration system to be produced.

### 1.3 Project Scope

i. The study area is concentrated in the kitchen sink or the water room and the bathroom's trap floor in the private home house.

ii. This study's main function is that recycled water can be used in the sink, and in the kitchen or bathroom sink a water filtration system is installed for reuse.

iii. This study is focused on users who use the kitchen sink or bathroom.

iv. This prototype test is to produce a prototype design of the water filtration system, and to test the residual water, whether it is reusable or not.

## 2. Methodology

The methodology covers the main aspects of the research process, namely designing, collecting data. The methodology contains reports and explanations to produce evidence that can support a conclusion. Figure 1 shows a methodology chart for this study. A prototype design of a water filtration system and recycling system for flushing toilets has 4 phases of flow. The first phase begins with identifying the problems, the study's objectives, and continuing the literature review. Subsequently, the second phase begins with the design process, material preparation, manufacturing, and testing. Besides, at the end of this phase, the result will be identified. Next, the third phase is about the analysis and discussion of this project. Finally, the fourth phase is the conclusion and proposal for developing the prototype design of a water filtration system and recycling system for flushing toilets.

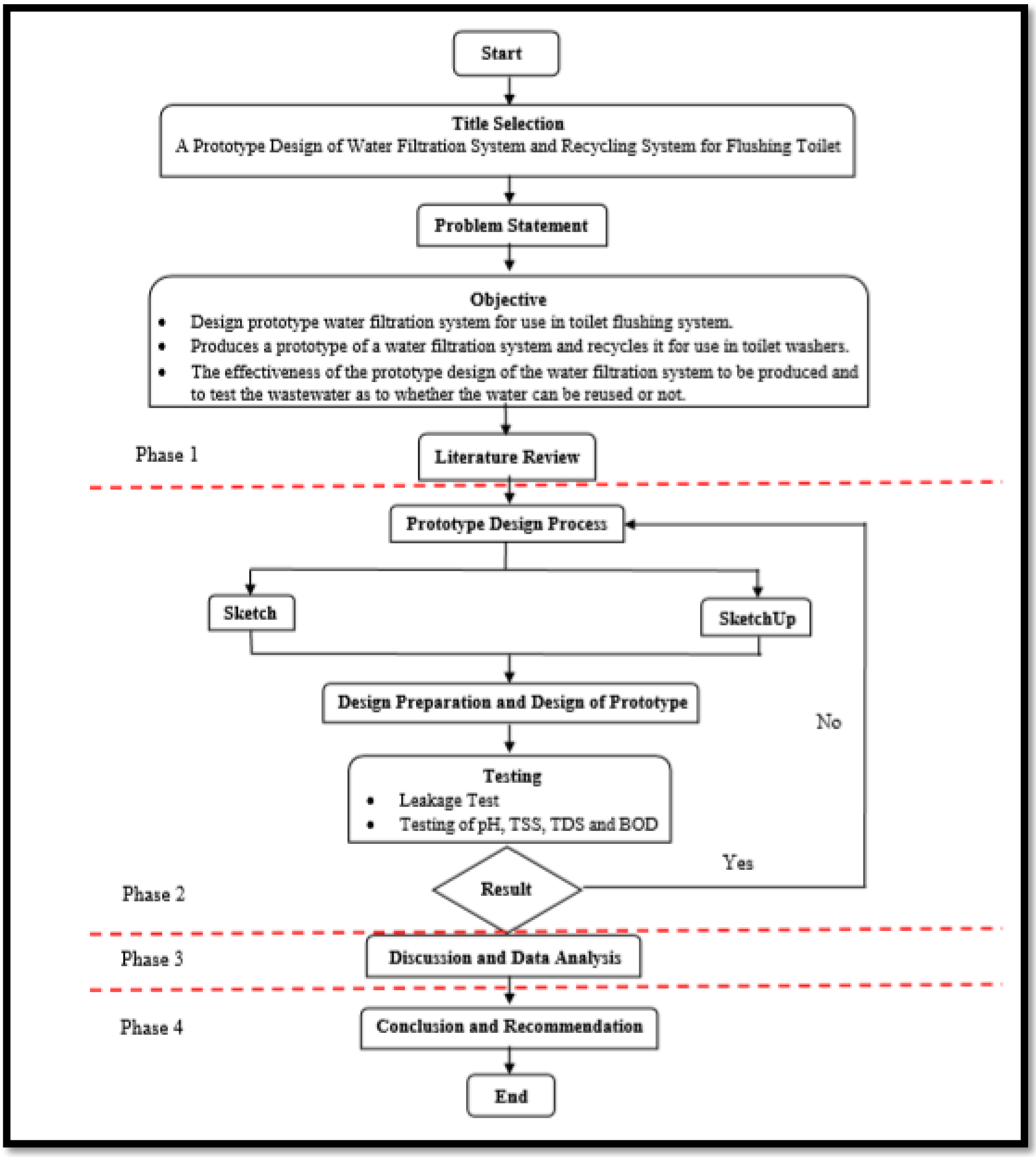


**Figure 1: Methodology Chart**

The latter's design is the whole idea of developing the final design, aimed at assessing its effectiveness. The process of designing the prototype starts with the sketch and then the sketch is simplified using a 3-dimensional device. In this phase, there is also a selection of materials to produce a prototype design of the water filtration system and recycling system for flushing toilets. The main materials used are readily available such as coconut coals, charcoal, gravel, sand, and sponge to produce the prototype design. Figure 2 shows that the prototype design of the water filtration system and recycling system for the flushing toilet that has been generated.

**Figure 2: Prototype design of a water filtration system and recycling system for flushing toilet**

The last second phase, the test must be done after producing the prototype. Leakage tests are done to ensure the effectiveness of the prototype has been produced. Also, tests on wastewater should be conducted to ensure that filtered wastewater can be recycled for use in flushing toilet. Among the tests performed on wastewater are pH value tests, total suspended solid, total dissolved solid and biochemical oxygen demand. Figure 3 below shows the testing of wastewater in laboratory.

**Figure 3: Testing of wastewater**

## 3. Result and Discussion

The data analysis process is very important in a study. This process also discusses the tests and results obtained from the studies that have been conducted. Therefore, data obtained through five tests have been carried out namely leakage test, wastewater test such as pH value test, total suspended solid, total dissolved solid and biochemical oxygen demand. As a result of the analysis that has been performed some research data have been found. As a result of the analysis of filtered wastewater, the water can be reused for use at flushing toilet.

### 3.1.Testing of Wastewater before and after being filtered

#### 3.1.1 Testing of pH value

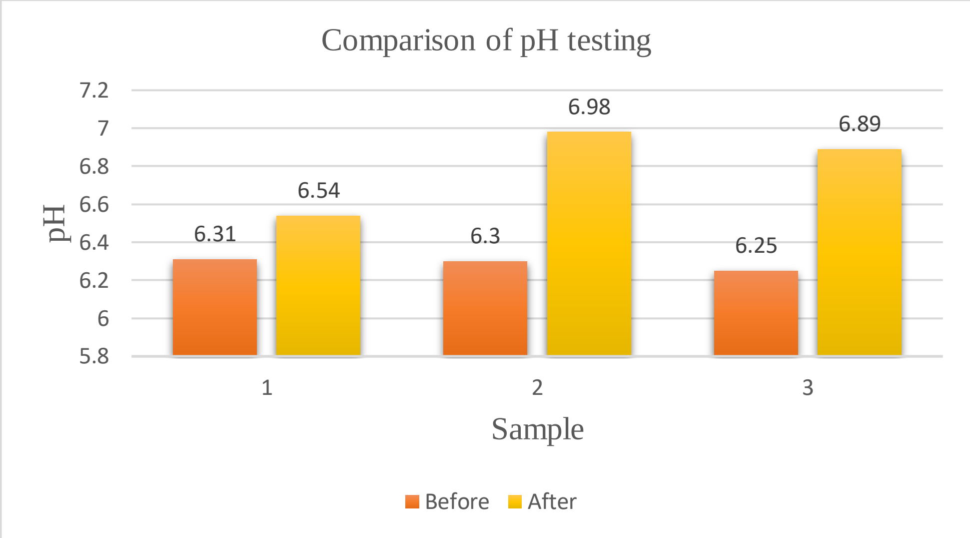


**Figure 4: Comparison of pH testing graph**

Based on Figure 4, the comparison of test results of wastewater pH before and after filtering. The pH test has three wastewater samples that must be made before and after filtering using the water filtration system's prototype design. The testing of pH for distilled water was performed to make comparisons before making pH Test against wastewater. Two samples have been taken from the distilled water pH test, these are the first results for 7.72 in the first sample and the second sample is 7.89. Therefore, the graph shows that the wastewater test results can be recycled and used for flushing toilets but the water cannot drink. However the wastewater that has been tested has acid, a combination of detergents and oils forms it. The graph shows the highest pH value of the filtered wastewater in the second sample, which is the water pH value of 6.98. The pH value of the water is close to scale 7 which indicates that the water is neutral. The figure below shows the chart of the predetermined water pH value.

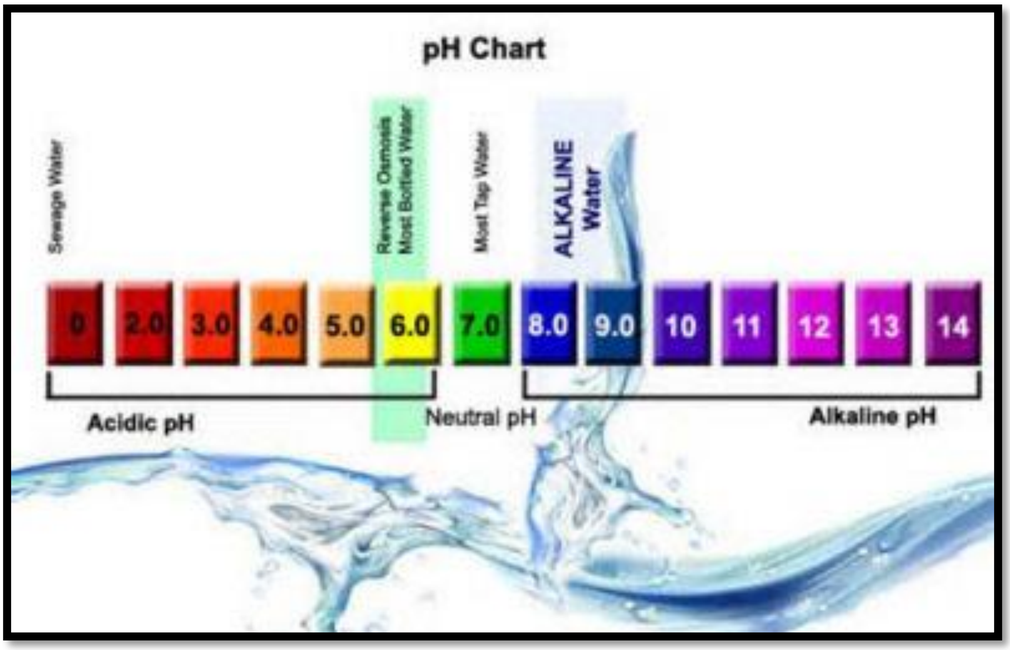


**Figure 5: pH scale chart [11]**

3.1.2 Testing of Total Suspended Solid

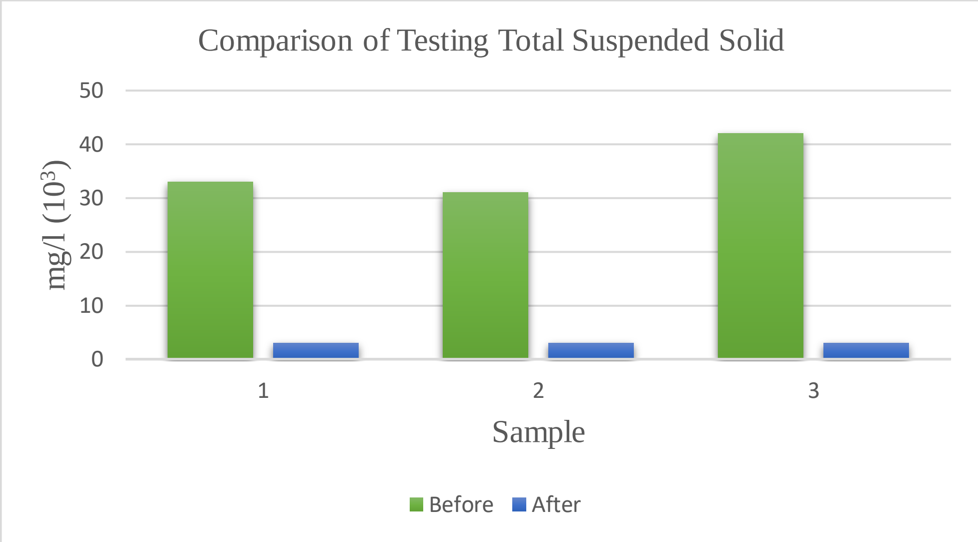


**Figure 6: Graph of comparison of testing total suspended solids**

Figure 6 shows a comparison graph for the total suspended solid test against before and after filtered of wastewater. This test aims to know the suspended solids in the wastewater and identify whether the water is clean or not. The graph shows that the filtered wastewater has a high amount of solids, the highest value being 42 mg / l and that the water is not clean and is not suitable for flushing toilets. Besides, the results for the filtered water showed a suspended solid in very low wastewater of 3 mg/l and categorized the water as clean water and can be reused.

3.1.3 Testing of Total Dissolve Solid

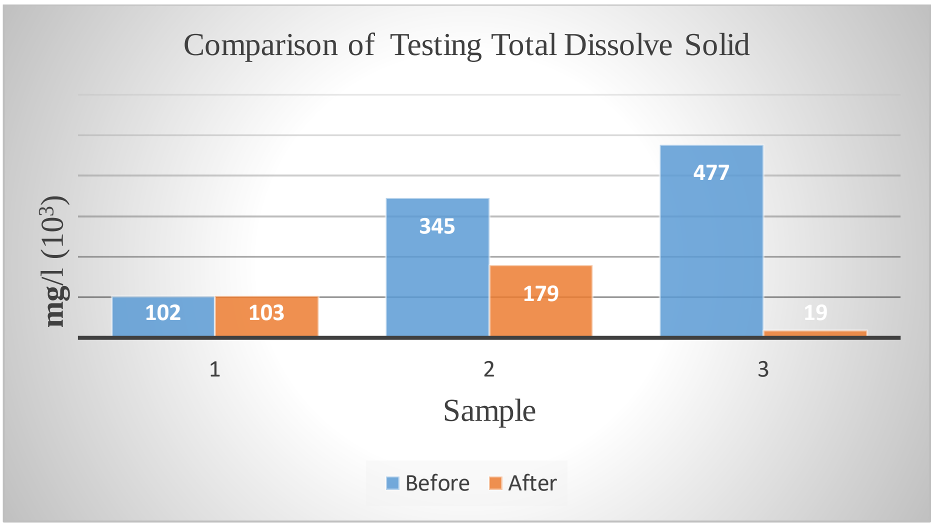


**Figure 7: Graph of comparison of testing total dissolve solid**

Based on figure 7 shows a comparison graph for the total dissolve solid test against wastewater before and after filtering. The purpose of this total dissolve solid test to identify the particles that cannot be seen in the water and ensure that the wastewater that has been tested can be reused or not. Before doing the TDS test you need to do a TSS test first to take the water that has made the TSS test. After that, the water is then placed in an evaporator dish and placed in the oven to dry. The graph of comparison for TDS results against wastewater indicates the lowest value is 19 mg/L. Therefore, water can be recycled for use for flushing toilet. Particle values from 0-50 indicate that they do not have as many particles and high-grade deionized water. If values above 200 mg / l are high in zinc and there is salt in the water. Figure 8 shows the water quality scale showing total dissolved solids (TDS).

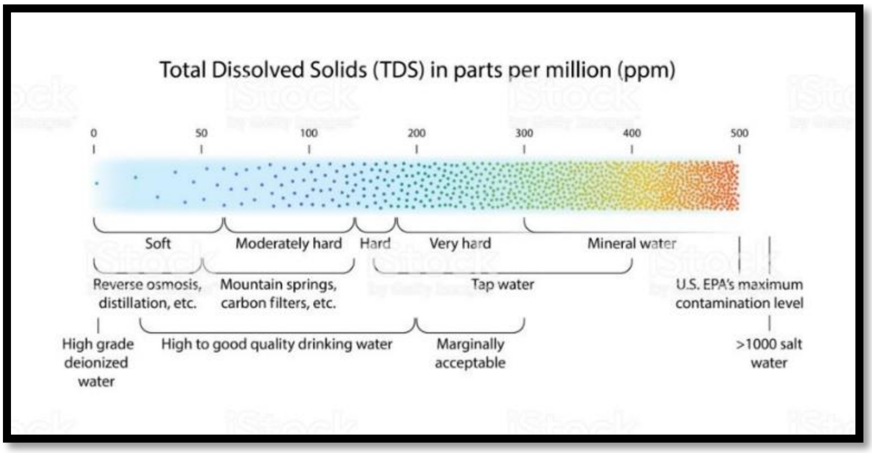


**Figure 8: water quality scale showing total dissolved solids (TDS) [12]**

3.1.4 Analysis of Wastewater Using Biochemical Oxygen Demand (BOD) Testing.

3.1.4.1 BOD testing on graywater using peat filters

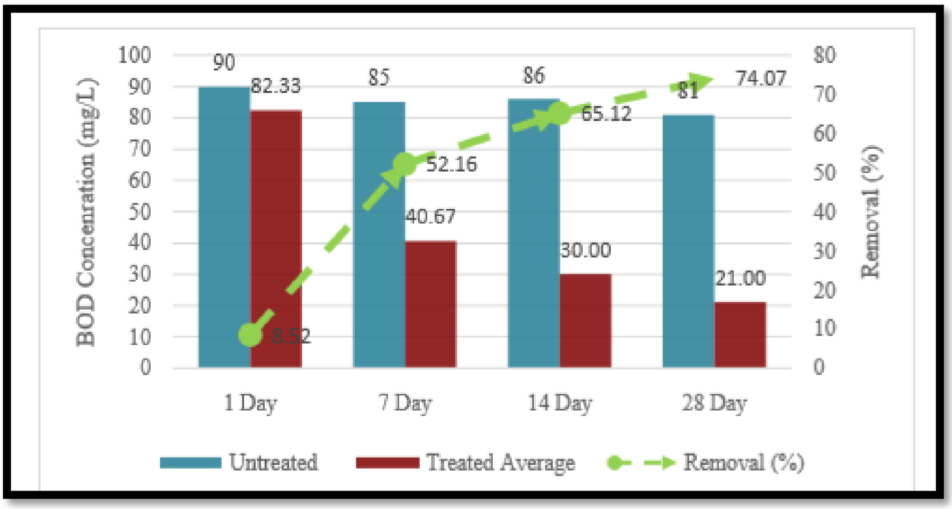


**Figure 9: Graph comparison of testing biochemical oxygen demand**

Based on Figure 9, BOD testing of bathroom gray water. This test was conducted by [13] entitled the feasibility of the direct filtration over peat filter media for bathroom grey water treatment. Hence, the diagram above shows a comparison of BOD tests taking 1 day, 7 days, 14 days, and 28 days.The graph shows that the test of the wastewater that has been filtered using peat filters, as a result of the results of this experiment showing a long time to be taken down the concentration value of the BOD. Therefore, grey water can be used for the use of toilet flushes, because the organic matter in the water is less than that of untreated greywater. Usually for BOD testing takes five days, however, for the analysed journal it can take up to 28 days to see the BOD concentration decrease. The lowest BOD test was 21 mg / l in 28 days and the pollutants in the gray water decreased. In addition, the highest BOD test is 82.83 mg / l and has a high pollutant in the greywater.

3.1.4.2 BOD testing of greywater filtered using charcoal and sand

**Table 1: BOD testing of grey water using charcoal and sand filters**

| Filter Medium | Pollutant | New Filter 500 mg $BOD_5$ $L^{-1}$ |
|---|---|---|
| Charcoal | TSS | 83±8 |
| | $BOD_5$ | 97±3 |
| | COD | 94± |
| Sand | TSS | 56±29 |
| | $BOD_5$ | 75±6 |
| | COD | 72±2 |

Table 1 shows the results for BOD testing of gray water using charcoal and sand filters. Therefore, for this study [14] and charcoal filter for greywater treatment to remove contaminants in water and the water can be recycled. As a result of the $BOD_5$ testing, using charcoal filtration is 97 mg / l and sand filtration are 75 mg / l. The use of charcoal as a filter shows a higher pollutant concentration than sand. Furthermore, according to the Malaysian Standard for the study of BOD5 in the fifth grade (V), the BOD5 water is greater than 12 mg / l (> 12). Figure 10 shows the water quality according to the Malaysian Standard and the class for water.

| PARAMETER | UNIT | CLASS | | | | | |
|---|---|---|---|---|---|---|---|
| | | I | IIA | IIB | III | IV | V |
| Ammoniacal Nitrogen | mg/l | 0.1 | 0.3 | 0.3 | 0.9 | 2.7 | > 2.7 |
| Biochemical Oxygen Demand | mg/l | 1 | 3 | 3 | 6 | 12 | > 12 |
| Chemical Oxygen Demand | mg/l | 10 | 25 | 25 | 50 | 100 | > 100 |
| Dissolved Oxygen | mg/l | 7 | 5 - 7 | 5 - 7 | 3 - 5 | < 3 | < 1 |
| pH | - | 6.5 - 8.5 | 6 - 9 | 6 - 9 | 5 - 9 | 5 - 9 | - |
| Colour | TCU | 15 | 150 | 150 | - | - | - |
| Electrical Conductivity* | μS/cm | 1000 | 1000 | - | - | 6000 | - |
| Floatables | - | N | N | N | - | - | - |
| Odour | - | N | N | N | - | - | - |
| Salinity | ppt | 0.5 | 1 | - | - | 2 | - |
| Taste | - | N | N | N | - | - | - |
| Total Dissolved Solid | mg/l | 500 | 1000 | - | - | 4000 | - |
| Total Suspended Solid | mg/l | 25 | 50 | 50 | 150 | 300 | 300 |
| Temperature | °C | - | Normal + 2 °C | - | Normal + 2 °C | - | - |
| Turbidity | NTU | 5 | 50 | 50 | - | - | - |
| Faecal Coliform** | count/100 ml | 10 | 100 | 400 | 5000 (20000)ᵃ | 5000 (20000)ᵃ | - |
| Total Coliform | count/100 ml | 100 | 5000 | 5000 | 50000 | 50000 | > 50000 |

**WATER CLASSES AND USES**

| CLASS | USES |
|---|---|
| Class I | Conservation of natural environment.<br>Water Supply I – Practically no treatment necessary.<br>Fishery I – Very sensitive aquatic species. |
| Class IIA | Water Supply II – Conventional treatment required.<br>Fishery II – Sensitive aquatic species. |
| Class IIB | Recreational use with body contact. |
| Class III | Water Supply III – Extensive treatment required.<br>Fishery III – Common, of economic value and tolerant species; livestock drinking. |
| Class IV | Irrigation |
| Class V | None of the above. |

**Figure 10: Water quality according to Malaysia Standard and water classes [15]**

3.1.4.3 BOD testing of grey water, using gravel filtering water

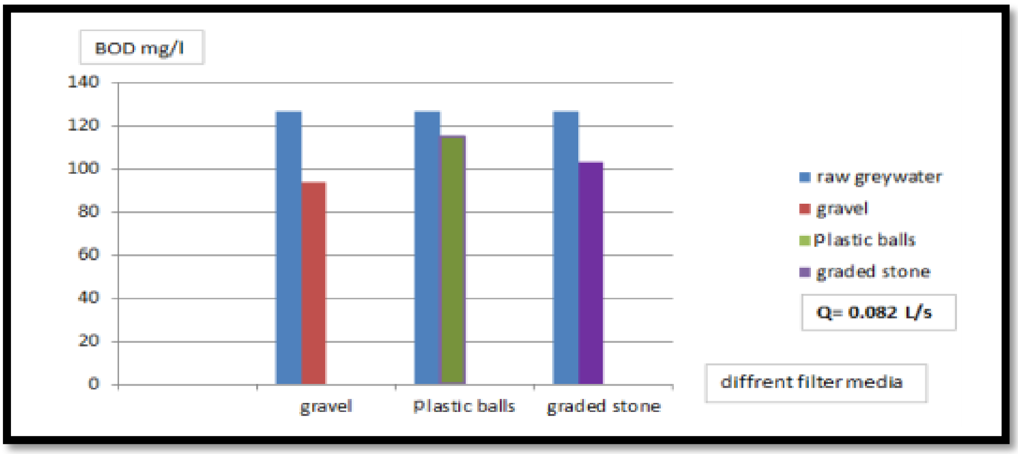


**Figure 11: Comparison of BOD testing using gravel, plastic, and graded stone materials**

Figure 11 shows a comparison of BOD testing using gravel, plastic and graded stone, but for the prototype design study the water filtration system and recycled for use in the flushing toilet only focused on gravel filtration. Thus, the journal that made this study was [16]. Fouad entitled Reuse of Gray Water. Therefore, as a result of this BOD test, gravel is an excellent material for removing pollutants in the water compared to plastic and graded stones. The results for BOD testing using gravel were 94 mg / l compared to 123 mg / l and the percentage showed was 26.0 % & 31.0 %.

## 4. Conclusions

According to the study of the development prototype design of water filtration system and recycling system for flushing toilets, the objectives have been achieved. Therefore, the first objective is to design prototype water filtration system for use in the flushing toilet system. A prototype of this water filtration system was built to filter greywater located in the sink or drain trap floor drainage. The second objective is to produce a prototype design of water filtration system and recycling system for flushing toilets. The prototype of the water filtration system has been successfully created and there are also additions to make the prototype more perfect.

The third objective is to test the effectiveness of the prototype design of the water filtration system to be produced and to test the wastewater as to whether the water can be reused or not. As a result of tests conducted on refined greywater using a prototype water filtration system, the water can be reused for use in a flushing toilets. Among the tests performed were leak tests, pH value tests, TDS, TSS and BOD tests. Therefore, the results for testing the pH of wastewater after filtration show that for the testing of the first sample is 6.54, the second sample is 6.98 and the third sample is 6.89. The results for testing the pH value of water and the water can be reused because the pH value of the water has been close to the pH value of 7 (neutral). Next, the results of total suspended solid of wastewater testing showed that the three water samples were 3 mg/l the same. Besides that, the results for total dissolve solid testing showed that the sample in the first sample was $103x10^3$ mg/l, the second sample was 179 $x10^3$ mg/l and the last sample was $19x10^3$ mg/l. This indicates that the third sample can be reused because the wastewater contains low particles. For the next test is BOD test, there are 3 different tests of the material used. Among the results of the BOD test is the test using a peat filter which shows the lowest value at 28 days is 21 mg/l. The next BOD test result is testing using charcoal and sand. The test result for the charcoal filter is 97 mg / l and the sand filter is 75 mg/l. For the last BOD test result is the use of gravel showing that the BOD value is 94 mg/l. Hence, BOD testing the use of gravel as a filter is great because it can remove pollutants. After testing the wastewater after filtration using the prototype design of the water filtration system, the water can be reused for the flushing toilet. Therefore, this greywater test was conducted at the Environmental Engineering Laboratory, UTHM Pagoh.

4.1.1 The Problems and Challenges when Producing a Prototype Design of Water Filtration System and Recycling System for Flushing Toilet.

- The prototype design of water filtration system and PVC pipe installation has problems.
- The problems and challenges faced were how to make containers or places for materials for water filtration systems such as coconut, stone, sand and coal.
- During the first test, there was food waste and light oils passed through into the second container.

4.1.2 Recommendation

After conducting this study, there are several suggestions for future experiments that could be made to further the development of the Bachelor Project. Follow-up suggestions to suggest are:

- Perform Biochemical Oxygen Demand Test on wastewater filtered through sink or floor trap.
- Change or improve natural materials to filter wastewater or greywater such as shells, peat, and cotton and so on.
- Improve a better second container for placing materials between rocks, sand and charcoal, some fine materials or particles do not pass to the next level to keep the water clean and safe.

**Acknowledgement**

The authors would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support.

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