# Prototype Innovation for Small-Scale Household Liquid Waste Processing Using Biofilter Technology

I Gusti Agung Bagus Wirajati[1], I Dewa Made Cipta Santosa[2], and Ida Ayu Gede Bintang Madrini[3]

[1,2] Mechanical Engineering Department, Politeknik Negeri Bali, Bali, Indonesia
[3] Agricultural and Bio-System Engineering Department, Udayana University, Bali, Indonesia
igabwirajati@pnb.ac.id

**Abstract.** Processing household liquid waste is a significant environmental challenge, especially in urban areas with high population density. This research aims to develop and test a prototype of an innovative small-scale biofilter system for processing household liquid waste. We designed this prototype to be an efficient, environmentally friendly, and user-friendly solution for the general public. The bio-filter prototype consists of several main components, including a biological filter with decomposing bacterial media, an aeration system, and a physical filtration layer. This study involved the creation of a prototype to handle household liquid waste. We will use this prototype design in the future to ascertain the safety level of household liquid waste for environmental disposal.

**Keywords:** Bio-filter, Household, Liquid Waste Processing, Prototype, Small Scale

## 1 Introduction

Household liquid waste is waste water that comes from domestic activities such as bathing, washing, and cooking which usually contains various organic and inorganic pollutants which can reduce water and environmental quality if not treated properly, potentially causing health problems for the community (Dewi, 2018; Saputra et al., 2024; Dewi, 2021). Household waste production, which usually contains environmentally polluting compounds such as potassium, calcium, and soluble organic compounds, has a greater amount compared to waste production from sectors produced outside the household, such as industry (Himawan et al., 2022; Nasir & Saputro, 2015). If the compounds contained in waste exceed the specified levels, the water cannot be used for its proper purposes. The sources of waste that contribute as environmental pollutants besides animal waste are waste that comes from households. If this is left unchecked, it will result in pollution for both society and the surrounding environment. The environmental impact of this waste production has encouraged several parties, including educational institutions, to look for sustainable alternatives (Kadam et al., 2024; Nasir & Saputro, 2015; Sołtysik et al., 2024). Generally, household liquid waste is disposed of into the environment. Direct waste disposal without processing will cause


A. A. N. G. Sapteka et al. (eds.), *Proceedings of the International Conference on Sustainable Green Tourism Applied Science - Engineering Applied Science 2024 (ICoSTAS-EAS 2024)*, Advances in Engineering Research 249,
https://doi.org/10.2991/978-94-6463-587-4_60

high levels of environmental pollution in the future. One effort to solve this pollution problem requires efforts to minimize the pollution it causes. One of these efforts is to create a liquid waste prototype. This prototype can later be used to determine to what extent the liquid waste produced by the household can be processed first before finally being confirmed safe to be disposed of into the environment (Setiyono et al., 2016; Himawan et al., 2022; Masruroh et al., 2023). Laboratory-scale liquid waste management prototypes are still rarely found, so to provide education on how to properly manage household liquid waste, this prototype can be simulated. The study focuses on developing a biofilter system specifically tailored for small-scale household liquid waste. The integration of biofilter technology with decomposing bacterial media makes the system both environmentally friendly and effective in treating wastewater. The aim of this research is to design a prototype of household liquid waste that can be used to determine whether the waste will be safe to dispose of into the environment.

## 2 Methodology

This research focuses on developing a prototype of bio-filter system that is effective in processing liquid waste, to reduce negative impacts on the environment. The research methods used include needs analysis, system design, and performance testing of the system that has been designed. With this approach, it is hoped that it can make a real contribution in providing practical and efficient solutions for small-scale liquid waste management, especially at the household level.

## 3 Result and Discussion

### 3.1 Result

**Prototype Design.** A description of the design or modeling of a prototype for processing small-scale liquid waste in households with a bio-filter system shown Figure 1.

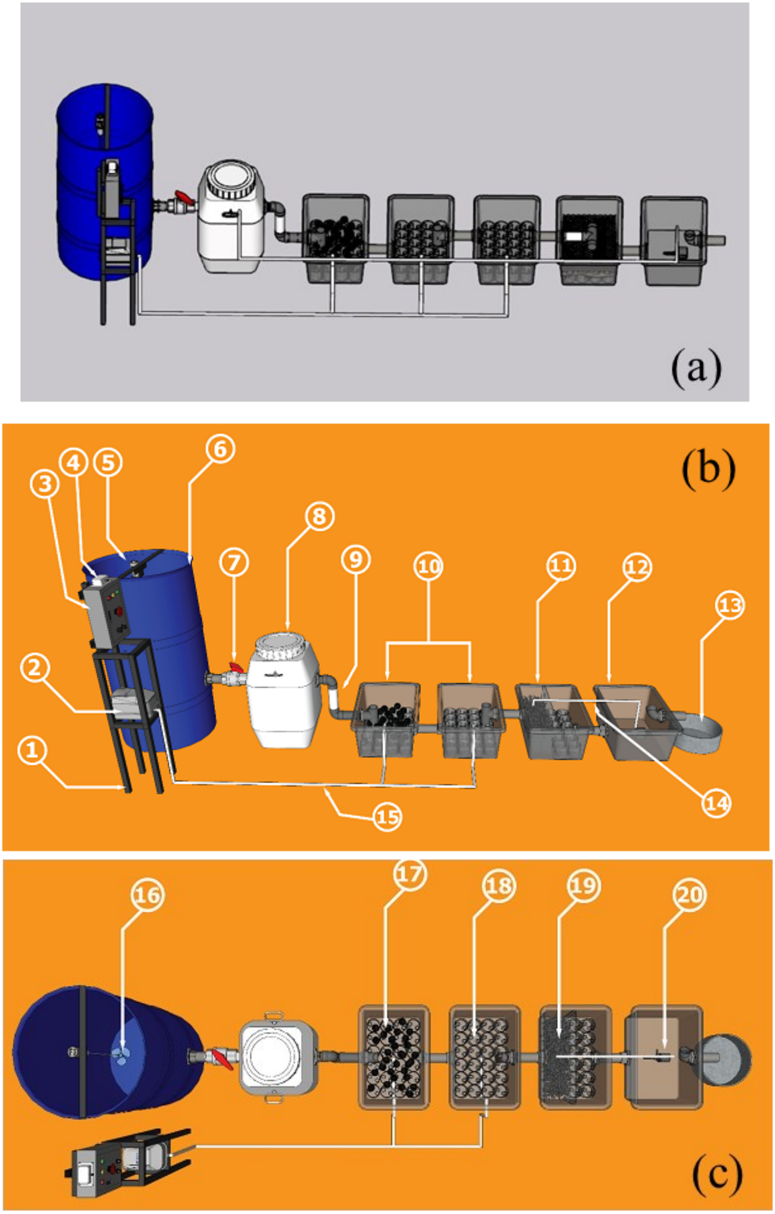


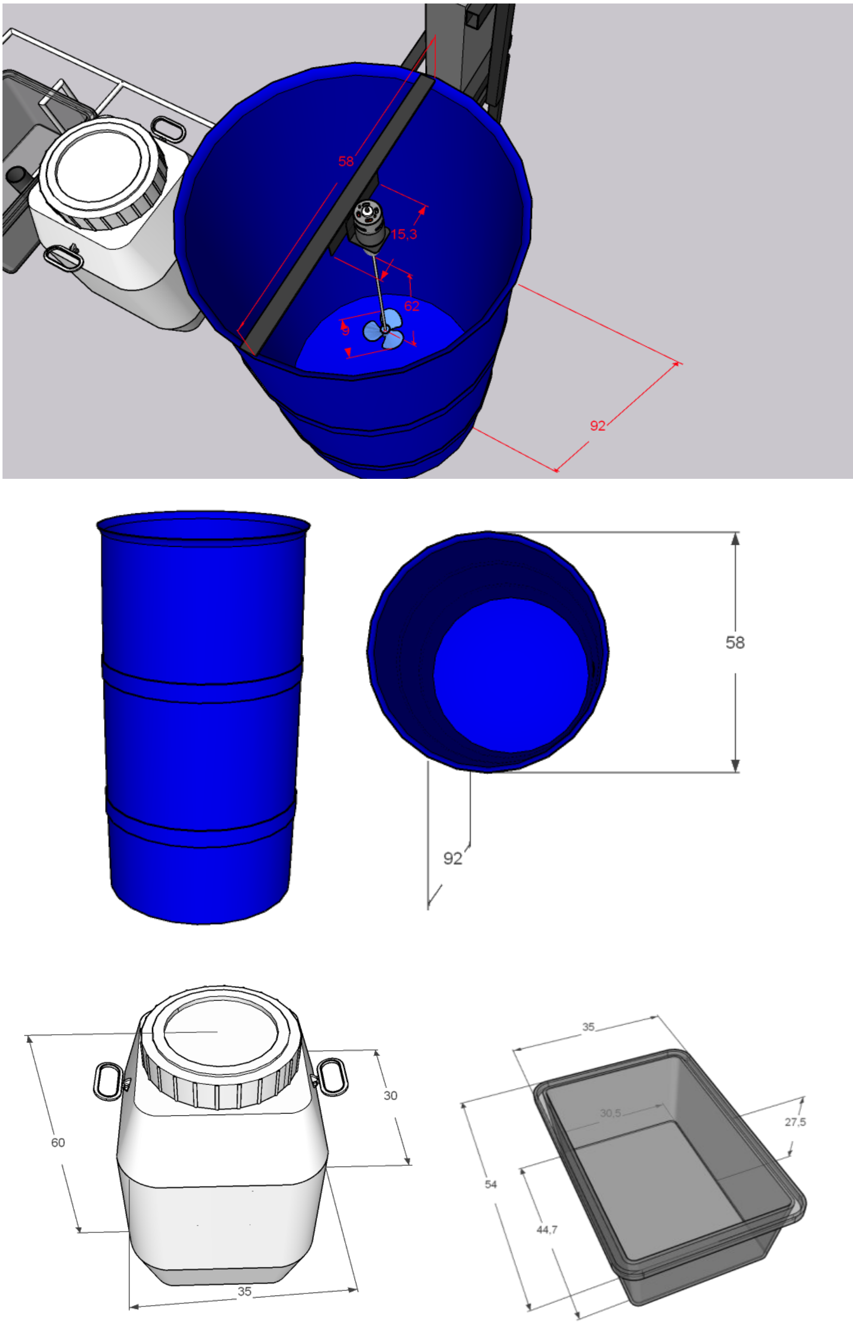

**Figure 1.** Prototype design: (a) scheme (b) side view and (c) top view

The information in Figure 1, which is indicated by numbers, provides information about the details of the tool components installed on the prototype, namely:

1. Hollow iron frame measuring 2.5 × 2.5 cm for the aerator and panel box
2. Resun Pump LP 20 aerator

3. Panel Box
4. DC Motor Speed Control Dimmer
5. DC motor 775
6. Plastic Drum (Main Waste Storage) Capacity 200 Liters
7. Stop Valve
8. 50 Liter Capacity Plastic Drum
9. 3⁄4 inch pipe
10. Aerobic Tub
11. Anaerobic Tub
12. Final Deposition Tank
13. Processed Water Storage
14. 5/8 inch circulation pump flow pipe
15. Air blow pipe from the aerator
16. Mixer fan blade
17. Bioball
18. Biofilter media from plastic bottles
19. Gravel
20. Circulation Pump

The liquid waste processing prototype design model is a system with a bio-filter method as the processing center. The initial settling tank is also equipped with a filtering tank which will filter out food waste, then this initial settling tank will collect the initial wastewater that comes out of production, this tank will regulate the wastewater discharge before it enters the processing process. Anaerobic bio-filter tanks are used for biological processing which requires bacteria (microorganisms) during the filtration processing process. The aerator will increase the oxygen supply by blowing air using an aerator unit into the aerobic bio-filter tank. Next, the processed water that comes from the anaerobic bio-filter tank will enter the aerobic bio-filter tank for the filtration process through filter media that contains bacteria. These bacteria can oxidize organic substances because of the air supply from the aerator. The circulation pump will play a very important role in maintaining good bio-filter performance. The final settling tank will separate or precipitate solid waste in the wastewater so that the processed water becomes clear.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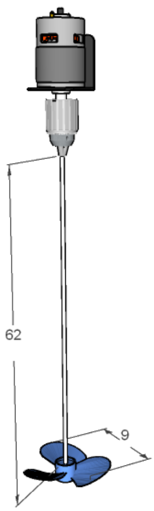


**Figure 2.** Prototype parts dimensions in details

In the first process, wastewater enters the initial storage tank, Figure 1(a), which is the center for storing wastewater to be processed. In this initial storage tank, there is a stirrer fan blade, Figure 2, which functions as a waste stirrer. During this stirring process, the valve is always closed. The stirring process carried out by the stirrer fan blades is operated electrically.

In the second process, the waste that has been stirred in the initial storage tank is then transferred to the initial settling tank by opening the flow valve first. Here the waste is left for a while so that the remaining solid waste carried over from the first process can settle, Figure 3.

After the initial sedimentation process, the waste liquid enters a holding box containing a plastic bottle filter and bio-ball. Here the waste liquid undergoes another sedimentation process. From here the waste liquid will then enter a box containing only a plastic bottle filter. These two boxes are called the aerobic bio-filter process. In the aerobic bio-filter process, oxygen is needed so that the bacteria in the waste liquid can reproduce, Figure 1(b) number 10.

The next process is a process called anaerobic bio-filter which occurs in box 3, figure 1 (b) number 11. This process takes place without the help of bacteria. This process is the final process before the waste liquid finally goes to the final sedimentation box which will separate the dirt so that the water that will be discharged into the environment becomes clear.

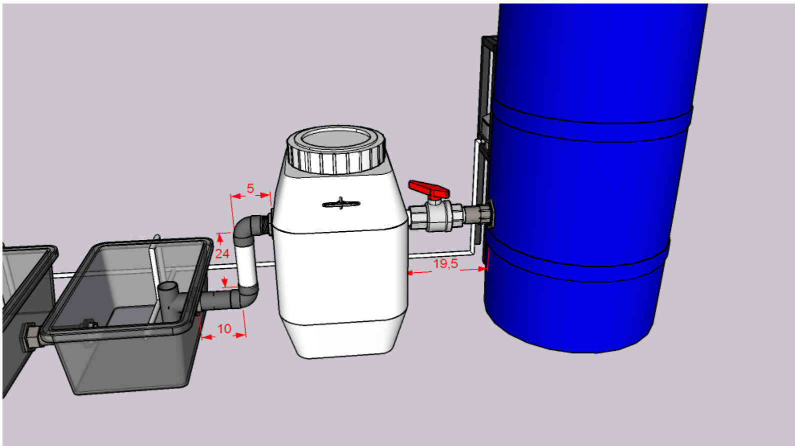


**Figure 3.** Dimensions of the initial settling tank

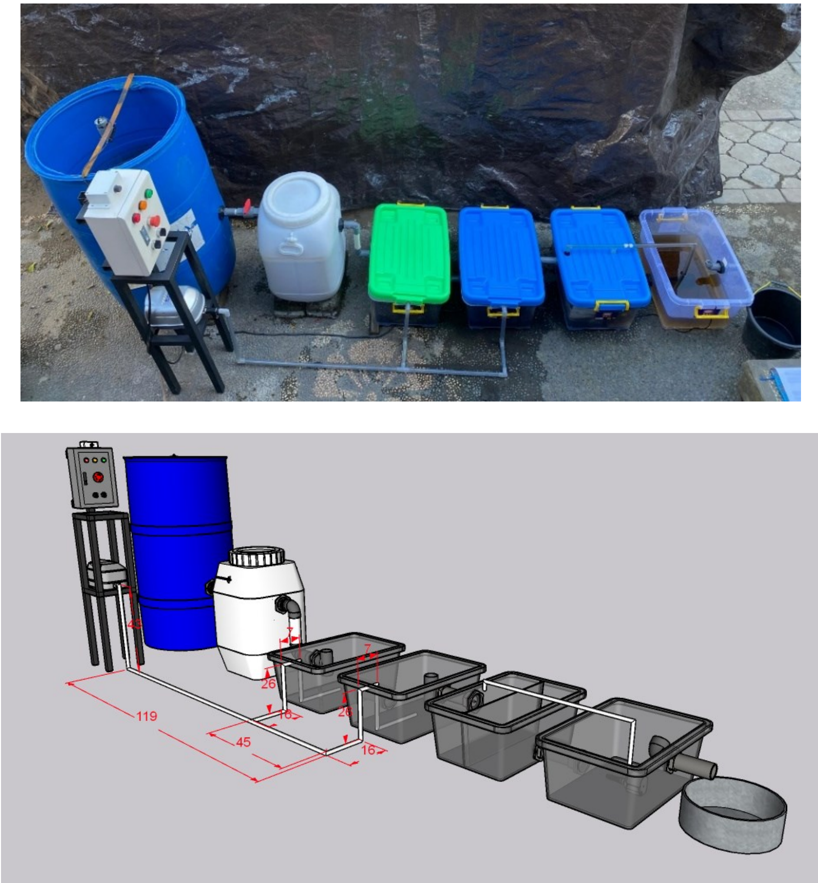


**Figure 4.** The protoype scheme

**Operasional Procedure of The Protoype.** The following are the steps in operating the tool so that users can understand it easily so that the tool can operate properly:

a. Put wastewater into a 200 Liter plastic drum (Main Waste Tank).
b. Turn on the DC 775 Motor by turning the dimmer to the right.
c. Open the Stop Valve so that wastewater enters the 50 Liter drum (Sedimentation Tank).
d. Wait for the wastewater to fill the aerobic, aerobic and final sedimentation tanks.
e. Turn on the Aerator (Resun Pump LP-20) on the panel box by turning the first selector switch to the right to supply air to the aerobic tank.
f. Turn on the circulation pump on the panel box by turning the second selector switch to circulate water from the final sedimentation tank to the anaerobic tank.

### 3.2 Discussion

Once the design is complete, an initial test needs to be carried out as a way to find out whether the prototype can be operated or not. Table 1 shows the results of the operational test that has been carried out. The types of waste water that are input into the prototype tool are kitchen waste, toilet waste (excluding human waste), laundry waste, and mixed sand and cement waste. To measure the temperature and acidity of the water in the tank, a thermometer and pH meter will be inserted into the tank that has been filled with water before processing and after processing. The first is in the equalizing tank and the second is in the final sedimentation tank.

**Table 1.** Data collection of color and pH of wastewater

| No. | Time | Liquid waste before processing | | Liquid waste after processing | |
|---|---|---|---|---|---|
| | | Color (Litmus Paper) | pH | Color (Litmus Paper) | pH |
| 1 | 12:25 | 7 | 6.25 | 7 | 25.1 |
| 2 | 12:30 | 7 | 6.28 | 7 | 26.4 |
| 3 | 12:35 | 7 | 6.25 | 7 | 25.8 |
| 4 | 12:40 | 7 | 6.41 | 7 | 30.0 |
| 5 | 12:45 | 7 | 6.32 | 7 | 30.1 |
| 6 | 12:50 | 7 | 6.42 | 7 | 30.2 |
| 7 | 12:55 | 7 | 6.35 | 7 | 30.0 |
| 8 | 13:00 | 7 | 6.41 | 7 | 30.1 |
| 9 | 13:05 | 7 | 6.64 | 7 | 30.3 |

Table 1 shows the results of the prototype commissioning test conducted for half an hour. The data provided in the table includes observations of liquid waste before and after processing, focusing on two main parameters, namely those measured using litmus paper and pH Meter. From observations before processing, the color of the liquid waste remained constant at a value of 7, while the pH varied slightly between 6.25 and 6.28. After processing, the color remained unchanged, at a value of 7, but the pH increased significantly to a range of 25.1 to 26.4. This indicates that a processing process has occurred in the prototype. The processing process carried out successfully increased the pH of the liquid waste. However, the processing did not affect the color change of the liquid waste. Thus, although there was a significant increase in pH after processing, no changes were detected in the color of the liquid waste. Further analysis is needed to evaluate the overall impact and effectiveness of this treatment. This indicator provides an overview that the prototype can operate in liquid waste processing.

## 4 Conclusion

Testing of the biofilter prototype showed that this system is effective in treating small-scale household wastewater. From the design results and also the commissioning test on the prototype, it can be concluded that the design results can function well. The indicator of success in question is the change in pH value.

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