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SALIA (Liquid Waste Filter) to Reduce Microplastic Pollution from Loundry Waste

Denti Suastikasari, Naura Azahratul Masfufa✉, Viantika Putri Bakhrudin, & Yurika Yasmin Azahra
SMA Negeri 1 Patianrowo

Keywords

Filter; Natural fiber; Microplastic; Waste water

Abstract

Microplastic pollution from laundry waste poses a threat to soil and water. A device called SALIA (Liquid Waste Filter) was created to filter microplastics before the wastewater is discharged into the sewer. Therefore, this study aims to determine the effectiveness of the SALIA device in filtering microplastic particles from laundry wastewater using an experimental method. The device was designed with natural fibers including straw, water hyacinth stems, coconut fiber, luffa, and gravel. Experimental testing was conducted on two device designs: the first with a thickness of 1-2 cm and the second with a thickness of 3-4 cm. The first device, tested with a 1-liter sample, showed an average reduction of 82.35%. Meanwhile, the second device, tested with 30-liter sample, successfully reduced particles by up to 99%. The results showed that both devices reduced the number of microplastic particles from laundry wastewater. The large thickness of the material makes the filter path long, making microplastics easily trapped. These findings provide hope for efforts to reduce microplastics with simple tools and local materials.

INTRODUCTION

Microplastic pollution has become an increasingly concerning environmental issue, both in aquatic environments and in soil. Microplastics are plastic particles measuring less than 5 mm (Andrady, 2011). One of the sources of microplastics comes from laundry wastewater (Napper & Thompson, 2016). Wastewater from washing clothes that contains microplastics can enter soil and aquatic environments through drainage systems . Microplastics found in soil can significantly alter how soil functions, particularly in terms of water regulation and supporting microbial life (Machado et al., 2018). Several studies have reported that microplastic particles can reduce water quality, affect the health of aquatic ecosystems, and even impact human health (Jambeck et al., 2015). These particles can be ingested by humans directly through the consumption of clean water and through the food chain (Rochman et al., 2015).

Fiber-type microplastics are most commonly found in laundry wastewater or from washing machines (Rizkia & Hendrasarie, 2023). Napper & Thompson (2016) It also highlights that commonly found fibers include polyester, nylon, and acrylic. Microplastic fibers make up a large proportion of micro-plastics found in the environment, especially in urban areas, and their amount continues to increase (Hernandez et al., 2017). According to data from BPS (2024), Indonesia's population has reached 284.7 million people. Given this high population, microplastic waste generated from laundry activities has significant potential to pollute aquatic environments. Microplastic pollution is produced daily through routine clothes washing (Browne et al., 2011). The release of these fibers has become a major issue due to the large volume and the daily frequency of washing activities.

The high volume of laundry waste-

✉ @n4uraam@gmail.com, Surabaya, East Java
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water containing these fibers is further exacerbated by domestic wastewater management systems in Indonesia. Many studies and literature reviews report that around 51–53% of greywater in Indonesia is discharged directly into water bodies without treatment (Firdayati et al., 2015; Harahap et al., 2018). Other studies also indicate that blackwater (from toilets) is typically collected in septic tanks, while greywater (including laundry wastewater) is often combined with rainwater and discharged into drainage systems or open channels. The literature also notes that greywater accounts for approximately 50–80% of total household wastewater (Firdayati et al., 2015). Meanwhile, the coverage of centralized or communal wastewater treatment systems (WWTPs) remains very limited compared to the total number of households in Indonesia, which is around 70 million (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2024).

Therefore, efforts to control sources of microplastic pollution need to be implemented immediately to reduce long-term environmental impacts. Hence, alternative solutions that are simple, affordable, and utilize natural/local fiber materials are highly needed. In several developed countries, efforts have been made to address microplastic pollution from laundry, such as installing specialized filters in washing machines. However, these technologies are still relatively expensive and not easily accessible to the general public, especially in developing countries (Henry et al., 2019). To address this issue, a microplastic filtration device called SALIA (Liquid Waste Filter) has been developed using natural/local fiber materials. Various local materials have the potential to enhance filtration effectiveness (Syafrudin et al., 2021). SALIA is made from natural fibers such as straw, water hyacinth stems, coconut fiber, sponge gourd (luffa), and gravel. Therefore, this study aims to determine the effectiveness of the SALIA (Liquid Waste Filter) device, which utilizes local materials such as straw, water hyacinth stems, coconut fiber, sponge gourd, and gravel, in reducing the amount of various microplastic particles present in laundry wastewater. The results of this study are expected to provide an alternative point-of-source solution that is simple, low-cost, and sustainable for controlling microplastic pollution at the household level.

RESEARCH METHODS

This study was conducted on September 6–7, 2025. It employed an experimental method to determine the effectiveness of natural material layer thickness in filtering microplastics, as well as to test the durability and performance of the SALIA filter using wastewater volumes of 1 L and 30 L.

The experimental method is used to examine cause-and-effect relationships by manipulating independent variables and controlling external variables (Santos et al., 2018). The experiment utilized two different SALIA designs to observe the effect of filter layer thickness on microplastic filtration effectiveness. Repeated trials were conducted to ensure consistency of the results. The experiment was carried out under different conditions, namely: (1) initial laundry wastewater vs. rinse water, and (2) SALIA design 1 vs. SALIA design 2. SALIA design 1 used natural fiber layers with a thickness of 1–2 cm, while SALIA design 2 used thicker layers of 3–4 cm as the independent variable. The controlled variables included: (1) the number of microplastic particles filtered from the laundry wastewater as the dependent variable, and (2) the type of filtering materials (sponge gourd/luffa, straw, coconut fiber, water hyacinth stems, and gravel).

The design phase of the SALIA device began with preparing all required tools and materials. A used 1.5 L plastic bottle was cut at the bottom to form an open tube. The bottle cap was removed, and the bottle was inverted so that the mouth faced downward. The natural filtering materials were then arranged inside the bottle in layers. For SALIA

Source: Processed Primary Data, (2025)

Figure 1

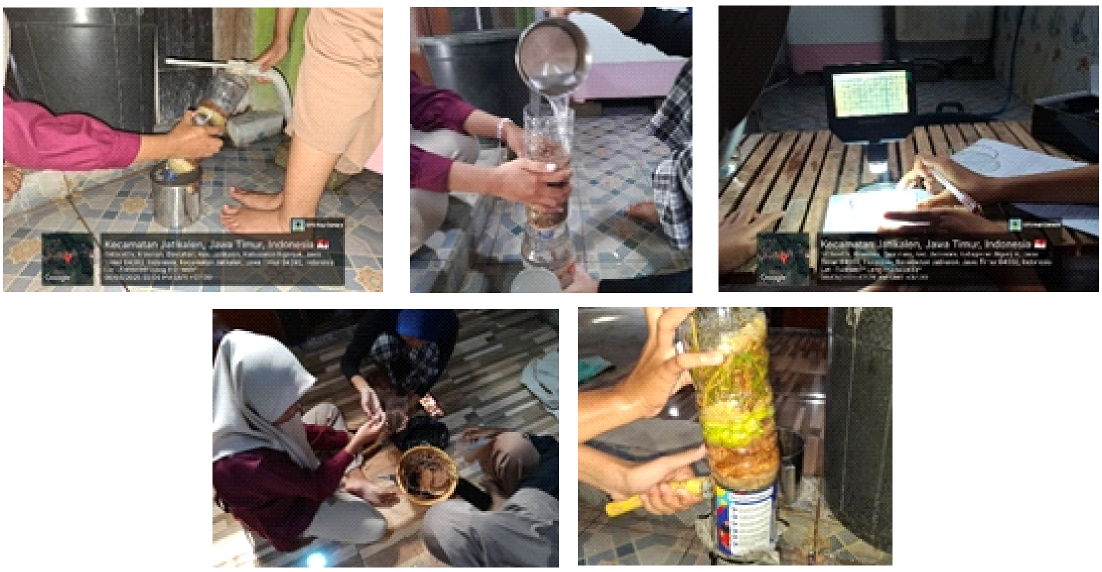
Comparison of Two SALIA Designs: A. First SALIA ; B. Second SALIA

design 1, the arrangement started with sponge gourd (luffa) and ended with coconut fiber, with each layer having a thickness of 1–2 cm. For SALIA design 2, the layers started with sponge gourd at the base, followed by straw, coconut fiber, water hyacinth stems, sponge gourd, straw, sponge gourd, and finally gravel at the top, with each layer having a thickness of 3–4 cm. This arrangement was designed so that laundry wastewater could pass through and be filtered by the natural fiber materials, allowing microplastic particles to be trapped and reduced.

The microplastic testing stage in laundry wastewater and the SALIA device trials were conducted under varying conditions. The first test was carried out on September 6. Before testing the device, the researchers first collected samples to examine the presence of microplastics in the wastewater. The formula for calculating microplastic reduction is presented below:

%Reduction= (Initial Amount-Final Amont)/Initial Amount x 100 (1)

The first day of testing involved three trials using 1 liter of laundry wastewater with the first SALIA design. In the first trial, the researcher collected 1 liter of wastewater from the first rinse cycle. The sample was placed in a container before being filtered using the SALIA device. In the second trial, another 1 liter sample was taken, but this time it was filtered directly through the SALIA device without being collected in a container. The wastewater flowed directly from the



Source: Processed Primary Data, (2025)

Figure 2

SALIA Fabrication and Testing Process

Table 1
Microplastic Abundance in Laundry Wastewater Before Filtration

Sample Condition (1 Liter Volume)	Number of Fibers	Number of Filaments	Total Initial Microplastics
First Rinse (Without Detergent)	7	2	9
Washing with Powder Detergent	17	2	19

Source: Processed Primary Data, 2025

washing machine outlet into the filter. The third trial was conducted slightly differently. A 1 liter sample was collected intermittently, meaning the wastewater discharge from the washing machine continued to flow while the sample was gradually collected in small amounts. Testing continued on September 7 using a larger volume. A total of 30 liters of rinse water from the washing machine was collected, including both the first rinse (using powdered detergent) and the second rinse (after detergent use in the first cycle). On the second day, testing was conducted using the second SALIA design.

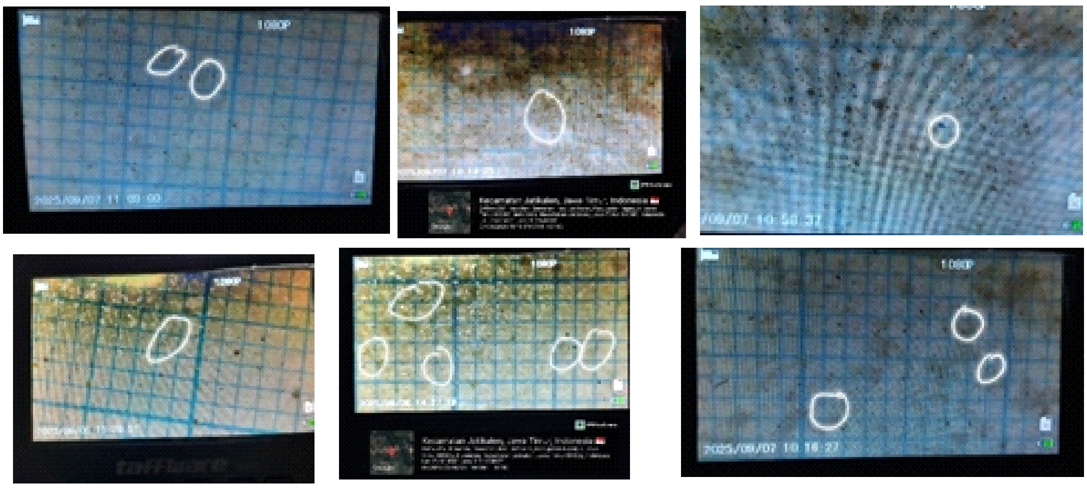
RESULTS AND DISCUSSION

This study was conducted to determine the effectiveness of the SALIA device in filtering microplastics from laundry wastewater. The experiment was carried out using two different designs, namely a filter layer thickness of 1–2 cm (first design) and 3–4 cm (second design).

Initial Characteristics of Laundry Wastewater (Pre-Filtration Conditions)

Based on Table 1, it is evident that laundry wastewater contains microplastics. These results indicate that clothing washing activities are a significant source of microplastics in households, with washing using powdered detergent producing more than twice the number of fibers compared to rinsing without detergent.

Without proper filtration, microplastics in laundry wastewater will be released into the environment, such as rivers, where they can settle into sediments (Cahyaningtyas & Chandra, 2024; Fitriyah et al., 2022). These extremely small particles are difficult to degrade naturally and can be transported by water flow to larger water bodies, including lakes and oceans. Their presence in sediments allows microplastics to accumulate over time and interact with aquatic organisms (Yusuf & Effendi, 2024). In addition, microplastics can act as vectors for harmful chemicals and micro-



Source: Processed Primary Data, (2025)

Figure 3
Microplastics Found in Laundry Wastewater

Table 2
Comparison of SALIA Design 1 and Design 2 Performance

Performance Comparison	Design 1 (1–2 cm)	Design 2 (3–4 cm)
Reduction Efficiency	**82,35%**	**99%**
Sample Volume Tested	**1 Liter**	**30 Liters**

Source: Processed Primary Data, 2025

organisms, thereby increasing the risk of contamination in aquatic ecosystems and the food chain (Asrul et al., 2022).

Analysis of the Effect of Washing Variables on Microplastic Release

The initial data show that washing with powdered detergent releases more microplastics (19 particles) compared to the first rinse/without detergent (9 particles). This indicates that chemical substances and mechanical friction during washing significantly influence the release of fibers from clothing. The friction enhanced by powdered detergent, along with the chemical effects of the detergent, causes synthetic fibers to detach more easily from fabrics. As a result, the microplastic pollution load in wastewater increases (Khairunnisa et al., 2024).

The difference in sample volume (1 liter vs. 30 liters) also reflects the principle of concentration: although the 30-liter wastewater sample contains a much higher total number of microplastics, the concentration per liter is lower than that of the 1-liter sample. This is an important consideration in sampling methodology and analysis.

Effect of Filter Layer Thickness (Experimental Design)

The comparison between the two SALIA designs demonstrates that the thickness of the material layers directly affects filtration performance.

Based on Table 2, it is evident that Design 2 (with a thickness of 3–4 cm) achieved a reduction efficiency of up to 99%, making it significantly more effective and capable of filtering larger water volumes (30 liters) compared to Design 1 (82.35%), which used a 1-liter sample. The high effectiveness of Design 2 is consistent with filtration theory Xiao et al. (2018). The thicker the filter media, the longer the water flow path (*filter bed depth*) that particles must pass through. This longer pathway provides greater opportunities for microplastic particles to be retained within the pores of the filter layers through mechanisms such as interception and adhesion. The optimal results were achieved because the SALIA device remained compact and had not yet reached saturation during testing.

Microplastic Filtration Mechanism by Natural Materials

The effectiveness of the SALIA device largely depends on the natural properties and unique structures of its constituent materials, which operate through a layered filtration principle. Gravel functions as the initial layer to retain larger debris while maintaining proper water circulation and drainage, thereby preventing clogging in the finer filter layers (Wulandari et al., 2020), Meanwhile, straw, sponge gourd (luffa), and coconut fiber serve as the main filtering components. Their dense and fine fiber structures especially coconut fiber are capable of physically trapping small microplastic particles. In addition, water hyacinth stems, which have hollow and porous structures, contribute to particle removal through adsorption and physical retention within their pores (Bapat & Jaspal, 2020; Cundari et al., 2022), Thus, the combination of these materials creates a natural filtration system that not only performs mechanical filtration but also utilizes the fibers' ability to capture and retain pollutants, including microplastics.

CONCLUSION

This study demonstrates that the SALIA is effective in reducing microplastic particles from laundry wastewater. Based on testing of two device designs with material thicknesses of 1–2 cm and 3–4 cm, it is evident that the thicker the filter layer, the higher its ability to retain microplastic particles. The effectiveness reached 82.35% for a 1-liter sample and up to 99% for a 30-liter water volume. These results indicate that the use of natural/local fiber materials such as straw, water hyacinth stems, coconut fiber, sponge gourd (luffa), and gravel can serve as a simple, low-cost, and environmentally friendly filtration alternative. This system can function as a preliminary filter before household wastewater is discharged into final drainage systems. Thus, this study provides a practical contribution to efforts in controlling microplastic pollution through appropriate, accessible technology that can be easily applied at both household and community levels.

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