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RESEARCH ARTICLE

# Evaluation of MiniPlast Filters for Microplastic Removal from Laundry Wastewater

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**ABSTRACT**

Microplastic pollution is considered a serious threat because it is associated with potential environmental and human health damage due to its bioaccumulation properties and ecological risks. An initiative emerged to make filters that have technical specifications for quality products. MiniPlast Filter is the newest type of filter innovation, implementing a sustainable system in its use in society. This research aims to determine the working system of the MiniPlast Filter in removing microplastics and the efficiency of eliminating microplastics using the MiniPlast Filter tool. The study examines the effect of using the MiniPlast Filter (independent variable) on reducing microplastics in laundry wastewater (dependent variable). This MiniPlast Filter can reduce the possibility of successfully and effectively spreading microplastics. Based on microscope observations with a dry weight of 7.0 kg, clothes washed by filtering water containing microplastics with the colours of microplastics, namely yellow, purple, red, black, blue and green, were found in observations using a light binocular microscope with a 10x magnification lens at the Botany Laboratory, Halu Oleo University. It was found that the average number of microplastics without using the MiniPlast Filter was 4,710 MPs, and the average number using the MiniPlast Filter was 390 MPs.

## Introduction

Microplastics are a growing concern in both the scientific community and the media today [1]. These tiny particles, typically less than 0.2 inches (5 mm) in diameter, pose a significant threat to living organisms [2]. Microplastics are commonly found in rivers, oceans, and soil and are often consumed by animals. Due to their small size, microplastics are ubiquitous, present in environments ranging from tropical waters to the Arctic, and from urban beaches to deep-sea ecosystems that are largely untouched by humans [3]. In Indonesia, microplastics are found in ocean areas, estuaries, river sediments, fish stomachs, and coral reef sediments [4]. Research indicates that the number of fish containing microplastics in Indonesia can be up to five times higher than in the United States [5]. Fragments and fibre are the most frequently encountered forms of microplastics, often originating from fishing gear, synthetic fibre clothing, and fishing nets. Microplastics from textile fibres are released into wastewater during washing and are carried into the sea with each load of laundry. Microfibres released from textiles during washing have been widely reported as a significant source of microplastic pollution [6].

The laundry industry contributes to environmental pollution, particularly in water bodies, due to the waste generated during the washing process [7]. Microplastic pollution is expected to increase with the growing number of laundry industries. As consumers continue to wash clothes, microplastics will remain in wastewater, further exacerbating the issue [8]. Microplastic fibres, often made from synthetic materials like nylon and polyester, are widely used in clothing. Polyester, in particular, is known for its durability and ability to retain body heat, making it a popular choice for sportswear and outdoor clothing [9]. Nylon, originally developed for military applications, is now commonly used for items like bags. A study by Napper & Thompson [10] found that a 6 kg load of laundry, consisting of cotton-polyester mixtures, could release an estimated 137,951 fibres. The numbers rise to 496,030 and 728,789 fibres per load for pure polyester and

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acrylic fabrics. This means that each wash can release over 700,000 fibres into the environment. Unfortunately, most washing machines lack effective filters, and standard filters cannot capture microplastic particles small enough to be seen by the human eye [11].

In response to this growing issue, there has been an initiative to develop filters with specific technical specifications designed to prevent the spread of microplastics into the environment. However, such microplastic filters remain scarce worldwide [12]. While these filters are produced in Europe and the United States, consumers in Asian countries, including Indonesia, face higher costs due to the price of the product and shipping fees, along with long wait times for delivery. The MiniPlast Filter represents a significant advancement in filtration technology. This innovative device is designed to address the problem of microplastic contamination by providing a sustainable solution for communities. The MiniPlast Filter prevents microfibres from being released into the environment during the laundry process. Its main components include a stainless-steel filter, stainless fibres, and filter cloth. The MiniPlast Filter offers several advantages: affordability, ease of use, high removal efficiency, and being the first microplastic filter developed in Asia.

However, this study aims to address a significant research gap. While existing studies focus on the general need for microplastic filters, there is limited research exploring the specific aspects of these filters, such as cost-effectiveness, efficiency, and the feasibility of local production. This study seeks to fill that gap by evaluating these critical factors and assessing the potential for local production of the MiniPlast Filter in Indonesia. Despite the growing recognition of the issue, previous research has not thoroughly explored the cost-effectiveness, operational efficiency, or the feasibility of manufacturing microplastic filters locally, particularly in regions like Indonesia. This study aims to investigate these overlooked aspects, providing a more comprehensive understanding of the practicality and potential impact of the MiniPlast Filter in tackling microplastic pollution in Southeast Asia.

## Materials and Methods

### Study Area

#### *Study Area and Sampling*

Sampling was conducted at Nazila Laundry, located on H.E.A Mokodompit Street, Anduonouhu, Kendari, Southeast Sulawesi. Two types of water samples were collected: the first sample was from the wastewater after the clothes-washing cycle, and the second sample was from the wastewater after the drying cycle. Sampling took place at 10:00 Central Indonesia Time (CIT), with four sample bottles used for collection.

#### *Laboratory Analysis*

The identification of microplastics in the clothes-washing wastewater was carried out in the laboratory at Halu Oleo University, specifically in the Pharmacy and Botany Labs. The samples were first filtered using a Miniplast filter tool in the Pharmacy Lab. Then, the microplastics in the filtered water were identified using a binocular light microscope with a 10x magnification lens in the Botany Lab, Faculty of Mathematics and Natural Sciences, Halu Oleo University.

#### *Filtration Process*

In the Pharmacy Lab, a vacuum filtration system, including Buchner funnels and GF/glass circle filter paper, was used to separate microplastic particles from the wastewater. This filtration process took approximately 3 hours per sample. The clothes-washing wastewater was divided into four sample bottles: two for the washing cycle wastewater and two for the drying cycle wastewater. Each of these samples underwent filtration, and the entire process took approximately 12 hours over two days. The first day of filtering was from 10:00 to 19:00 CIT, and the second day's filtering session lasted from 13:00 to 15:00 CIT.

### Data Collection

The data collection procedure in this study was conducted using two different approaches: one without the MiniPlast Filter and one with the MiniPlast Filter. For the procedure without the MiniPlast Filter, data was collected over two consecutive days from 08:00 to 17:00 CIT. Two 1-liter glass bottles were prepared to collect wastewater samples from a local laundry industry. One bottle contained wastewater from the washing process, while the other was filled with wastewater from the drying process of the washing machine. Following sample collection, the equipment for filtration was prepared, including a vacuum filtration setup, a 100 mm Buchner funnel, petri dishes, and 90 mm GF/glass circle filter papers. The Buchner funnel was mounted onto the vacuum filtration apparatus, and a piece of filter paper was placed inside. The vacuum pump was then activated to initiate filtration of the two samples. Upon completion, the filter paper was carefully removed using tweezers and transferred to a petri dish for further processing. To eliminate residual moisture, the filter paper was oven-dried at 105 °C for 20 minutes. After drying, microplastic particles retained on the filter surface were identified and counted using a binocular light microscope with a 10x magnification lens. The results were recorded using the multi counter application to facilitate accurate data entry and ensure consistency in microplastic quantification.

For the procedure utilizing the MiniPlast Filter, the vacuum filtration process was conducted over a single day from 08:00 to 16:00 CIT, while the subsequent microplastic observation using a binocular microscope was completed over two days, from 12:00 to 15:00 CIT each day. As in the previous method, two 1-liter glass bottles were used to collect wastewater from the washing and drying processes. The MiniPlast Filter system was assembled using a stainless-steel filter, stainless steel fibres, and filter cloth, alongside the other required equipment: a vacuum filtration unit, a 100 mm porcelain funnel, a petri dish, and 90 mm GF/glass circle filter paper. The filtration process began with the porcelain funnel installed on the vacuum filtration system and the filter paper placed inside. The MiniPlast Filter components were arranged in sequence above the filter paper. Once the vacuum pump was activated, the wastewater samples were passed through the filter. During the first stage of filtration, the stainless-steel filter acted as a surface barrier, capturing larger particles. In the second stage, the stainless-steel fibres trapped microplastics between the strands. The final stage employed filter cloth with smaller pores to retain any particles that escaped the earlier stages.

After filtration, the filter paper was removed with tweezers and placed in a petri dish. It was then oven-dried at 105 °C for 20 minutes. Once dried, the filter paper was examined under a binocular light microscope at 10x magnification to identify and count the microplastic particles. The multi counter application was again used to record the data accurately and efficiently. The effectiveness of the MiniPlast Filter was evaluated using an efficiency formula to calculate the percentage reduction in microplastics (Equation 1). The multi counter application is used to simplify and improve the accuracy of the identification process and count the number of microplastic particles in filtered samples. After filtering using the MiniPlast Filter and drying the sample in the oven, the filter paper containing microplastics is then analyzed using this application. This application allows researchers to quickly and accurately count the microplastic particles on the filter paper.

$$\textit{Efficiency (\%)} = \frac{P_{without} - P_{with}}{P_{without}} \; x \; 100\% \qquad (1)$$

Description:

$P_{without}$: represents the number of microplastic particles without the MiniPlast Filter

$P_{with}$ : represents the number of microplastic particles with the MiniPlast Filter

## Results

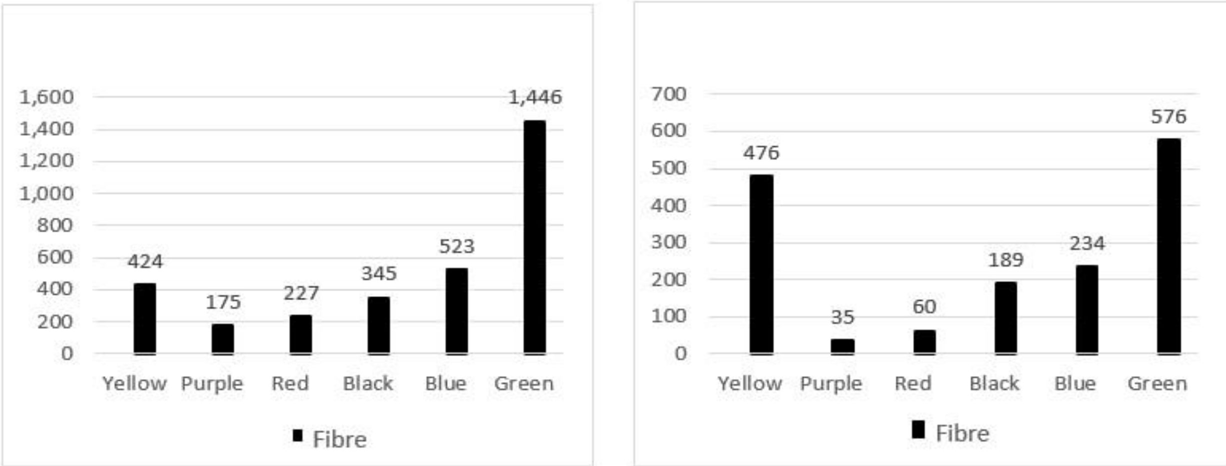
### Miniplast Filter Working System

The MiniPlast Filter working system applies a multi-stage filtration concept where three filters will pass through microplastic particles after leaving the washing machine. In the first stage, the particles will pass through a stainless filter, utilising the surface filtration principle where the microparticles can be retained on the surface. Next, there is stainless fibre; the stage is expected to filter the microplastic particles and pass through the filter gaps; the final stage is a cloth filter with a smaller pore size so that the remaining microplastic particles that were not retained in the previous filtering can be filtered at this stage. The filter cloth is conditioned at the final stage to reduce the filtering load and extend its service life. Filter cloth has round and smooth strands, and the material is very resistant to alkali. This results in a very strong and stable fabric that does not peel and is not affected by washing detergents (this type of filter is of good quality as it prevents damage due to abrasion and mechanical stress). Meanwhile, stainless steel filters are chosen because they have good durability, are not easily damaged and have a long service life [13]. All materials that make up the MiniPlast Filter do not use dyes and do not contain addictive ingredients.

### Identification of the Amount of Microplastics from Clothes Washing Waste without Using a MiniPlast Filter

The first stage of research and observations in the pharmaceutical laboratory was a screening process using materials such as a vacuum pump, Bucher funnel, oven, petri dish, 500 ml measuring cup and filter paper. The Bucher funnel filters wastewater from washing clothes and then places filter paper in it to filter the dregs from flowing clothes waste. The vacuum pump is useful for removing various gas molecules in a closed room.

Next, it will be thrown into an open area to ensure that the air pressure in the room reaches a certain level. The measuring cup functions as a container for wastewater from washing clothes so that it doesn't spill and knows how many ml have been poured. Petri dishes are used as containers for filter paper for drying in the oven so that observations can be made using a microscope in the Botany Laboratory. The results of the washing machine wastewater, categorized by fiber color, can be seen in Figure 1, which displays the graphs for both the milling and drying processes without the MiniPlast Filter.




(a) (b)

**Figure 1.** (a) Graph of washing machine milling wastewater (without MiniPlast filter); (b) washing machine drying wastewater graph (without MiniPlast filter).

**Identification of the Amount of Microplastics from Clothes Washing Waste Using MiniPlast Filter**

It identifies the number of microplastics using a binocular light microscope with a 10x magnifying lens. The special potential exists in using MiniPlast Filter as a filter media to reduce microplastics in clothing fibres used in the laundry industry or households. The aim of making the MiniPlast Filter tool is to minimize the spread of microplastics into the environment, especially water bodies so that it can also prevent negative impacts that will be received by living creatures. This tool has a big opportunity to be commercialized because, so far, no company or country has produced this tool in the Asian region. By using this tool, all communities have taken part in protecting and preserving the environment. In research, the difference between using a MiniPlast Filter is the multi-stage filtration process or what is usually called multi-stage filtration, which passes through 3 components, namely a stainless-steel filter, stainless fibre and a cloth filter, which has a very good function in filtering clothes washing wastewater and can remove microplastics. The following is an analysis of data on the number of microplastics using the Miniplast Filter (Figure 2).

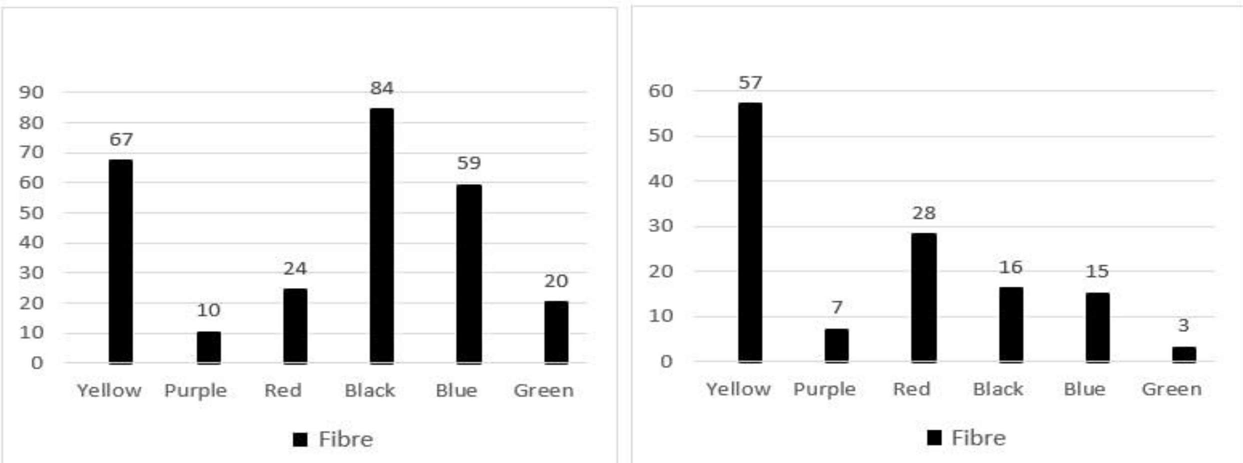



**Figure 2.** (a) Washing machine milling wastewater graph (using MiniPlast filter); (b) graph of washing machine drying wastewater (using MiniPlast filter).

**Comparison of the Amount of Microplastics in Clothes Washing Waste Using MiniPlast Filters and Without Using MiniPlast Filters**

Based on research, it was found that the MiniPlast Filter was able to remove a total of 91.71% of microplastics, compared to previous research, which had the highest removal, namely Planetcare; this tool was able to remove 90% of microplastics. The amount of microplastics in clothing washing waste with and without the MiniPlast Filter reveals notable differences. When analyzing the washing waste, it becomes clear that the presence of the filter impacts the amount of microplastics released. The MiniPlast Filter effectively reduces the number of microplastics that enter the wastewater during laundry. Without the filter, a higher concentration of microplastics is found in the washing waste [14]. This comparison emphasizes the importance of using the MiniPlast Filter to mitigate microplastic pollution. It can be seen in Table 1.

**Table 1.** Recapitulation of microplastic identification results.

| No. | Treatment | Amount of microplastics |
|---|---|---|
| 1 | Without MiniPlast Filter | 4,710 particles/L |
| 2 | Using MiniPlast Filter | 390 particles/L |
| Percent (%) allowance | | 91.71% |

**Characteristics of the MiniPlast Filter (Filter Cloth) Tool**

Filter cloth is a type of cloth made from cotton, nylon, polyester and polypropylene. The material is determined by the kind of fluid and the level of filtration cleanliness [15]. In this research, the main component of the MiniPlast Filter itself was used because of its small pore size so that the remaining particles that were not retained in the previous component could be filtered at the final stage using a filter cloth [16]. From previous research, the research analyzed the ability of the MiniPlast filter to remove microplastics from clothing washing waste, carried out further testing on one of the components of the MiniPlast filter, namely the filter cloth, by testing the tensile strength, elongation of the cloth, and cross-sectional photos of the filter cloth to determine the pores of the cloth to support the removal of microplastics [17]. By using the MiniPlast filter tool. From the test results of the MiniPlast Filter tool component, namely filter cloth. Testing has been carried out in the Lab. Textile manufacturing and testing results at Indonesian Islamic University were obtained: Testing nylon tensile strength and elongation, testing thickness of nylon fabric, and testing the air permeability of nylon fabric (Table 2). Filter cloth is often also known as a press cloth filter, usually made from polyamide (nylon), which has good resistance to acids, alkalis, and oxidation [18]. A longitudinal cross-section of nylon or filter cloth is shown in Figure 3.

**Table 2.** Recapitulation of microplastic identification results.

| Sample code | Test | Tensile strength (N) | Effect value (%) | Nylon fabric thickness (mm) | Air penetrability (cmH2O) | $cm^3$/sec | Cfm | Direction |
|---|---|---|---|---|---|---|---|---|
| Cloth 1 (400 x 1.6 Mesh) | Tensile strength | 154.998 | 21.933 | 0.091 | 71.7 | | | |
| Cloth 2 (400 x 1.6 Mesh) | Tensile strength | 142.245 | 24.666 | 0.091 | 70.7 | 71.325 | 140 | Fabric width |
| Cloth 3 (400 x 1.6 Mesh) | Tensile strength | 146.169 | 25.533 | 0.091 | 71.2 | | | |
| Average value (400 x 1.6 Mesh) | - | 147.804 | 24.044 | 0.091 | 71.2 | | | |
| Cloth 1 (400 Mesh) | Tensile strength | 173.637 | 32.133 | 0.091 | | | | Fabric length |
| Cloth 2 (400 Mesh) | Tensile strength | 174.618 | 27.533 | 0.091 | | | | Fabric length |
| Cloth 3 (400 Mesh) | Tensile strength | 169.713 | 27.066 | 0.091 | | | | Fabric length |
| Average value (400 Mesh) | - | 172.656 | 28.911 | 0.091 | | | | |
| Cloth 1 (600 x 1 Mesh) | Tensile strength | 165.789 | 20.466 | 0.079 | 22.1 | | | Fabric width |
| Cloth 2 (600 x 1 Mesh) | Tensile strength | 168.732 | 18.666 | 0.079 | 26.1 | 23.328 | 45.9 | Fabric width |
| Cloth 3 (600 x 1 Mesh) | Tensile strength | 161.865 | 19.266 | 0.079 | 21.5 | | | Fabric width |
| Average value (600 x 1 Mesh) | - | 165.462 | 19.466 | 0.079 | 23.23 | | | |
| Cloth 1 (600 Mesh) | Tensile strength | 143.226 | 18 | 0.079 | | | | Fabric length |
| Cloth 2 (600 Mesh) | Tensile strength | 145.188 | 18 | 0.079 | | | | Fabric length |
| Cloth 3 (600 Mesh) | Tensile strength | 143.226 | 17.733 | 0.079 | | | | Fabric length |
| Average value (600 Mesh) | - | 143.88 | 17.911 | 0.079 | | | | |

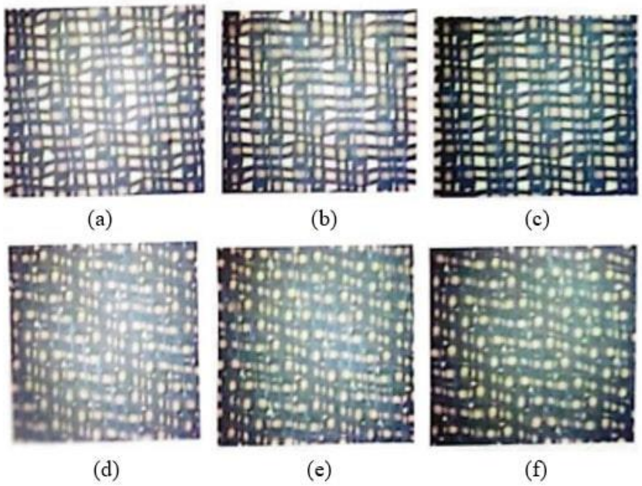


**Figure 3.** Photo tests of longitudinal cross sections of nylon fabric, (a) photo 400 Mesh-1st; (b) photo 400 Mesh-2nd; (c) photo 400 Mesh-3th; (d) photo 600 Mesh-1st; (e) photo 600 Mesh-2nd; (f) photo 600 Mesh-3th.

**Comparison of Similar Products in Removing Microplastics**

Table 3 presents a comparison of the specifications for similar microplastic removal products currently available on the market. The table includes details on the product names, prices, filter types, removal efficiency, and the country of origin for each product. The MiniPlast Filter is compared with three other prominent filters: Planetcare, Fitrol, and the Lint Luv-R. Notably, the MiniPlast Filter stands out with its impressive removal efficiency of 91.71%, which is higher than the removal efficiency of the other products. Additionally, the MiniPlast Filter offers a more affordable price point compared to the competitors, making it an attractive option for consumers. This comparison highlights the potential advantages of the MiniPlast Filter in terms of both efficiency and cost, particularly for addressing microplastic contamination in laundry wastewater.

**Table 3.** Specifications for similar products.

| Product name | Planetcare | Fitrol | The Lint Luv-R | MiniPlast Filter (Design) |
|---|---|---|---|---|
| Price | €144.50<br>(± IDR 2,300,000.00) | $159.99<br>(± IDR 2,300,000.00) | $150<br>(± IDR 2,200,000.00) | ± IDR 1,200,000.00 |
| Filter type | Catridge filter | Fabric filter | Stainless stell filter | Multi-stage filter |
| Removal efficiency | 90% | 89% | 87% | 91.71% |
| Country of origin | Europe | USA | USA | Indonesia |

## Discussion

From the results of the identification of dried samples and observations using a microscope (Figure 1), it was found that the microplastics resulting from clothing washing waste have the shape of elongated fibres like ropes and are fibrous, thin, and resemble lines [19]. The number of microplastics without using the MiniPlast Filter combined with milling water and drying water was 4,720 with the microplastic colours yellow, purple, red, black, blue and green. From the analysis results without using a filter, it was found that the distribution of microplastic fibres in washing machine drying wastewater showed a variety of colours: yellow, purple, red, black, blue, and green [20]. The data is divided into two categories, represented by graphs (a) and (b), indicating the concentration of microplastics in two separate samples or scenarios. In the first graph (a), a total of 3,140 microplastic fibres were identified, with green fibres being the dominant group, comprising 1,446 particles. Other colours, such as yellow (424), blue (523), black (345), red (227), and purple (175), were also present but in much smaller quantities. In graph (b), the total number of microplastic fibres detected was 1,570.

Green remained the dominant colour, but with 576 microplastic fibres detected, a notable decrease from the first sample. Yellow microplastics appeared in a slightly reduced amount (476), while purple, red, black, and blue showed even lower numbers, with purple having only 35 fibres and red 60 fibres, the lowest recorded among the colours represented. The high concentration of green fibres in both graphs is noteworthy. This could be attributed to the fact that green is a common colour in textiles, such as clothing and household materials, which are major sources of microplastics in washing wastewater [21]. Additionally, the decrease in microplastic particles in graph (b) could be related to the presence or absence of a filtration system. This factor may have influenced the reduction of microplastics in the second sample [22]. The analysis suggests that the type and colour of microplastic fibres in washing wastewater can vary significantly. The prevalence of green fibres and the lower amounts of others, such as purple and red, highlight the diversity of sources contributing to microplastic contamination in wastewater [23]. Understanding these patterns can help refine wastewater treatment methods, particularly in reducing the release of microplastics into the environment [24].

The results in Table 1 of this study clearly demonstrate the effectiveness of the MiniPlast Filter in reducing microplastic contamination in laundry wastewater. Without the use of the MiniPlast Filter, the wastewater was found to contain 4,710 microplastic particles/L. However, after filtering the wastewater with the MiniPlast Filter, the number of microplastic particles was significantly reduced to only 390 particles/L. This reduction represents an impressive 91.71% decrease in microplastic concentration, calculated by comparing the microplastic count before and after filtration. The high efficiency of the MiniPlast Filter in removing microplastics highlights its potential as a viable solution to combat microplastic pollution, especially in wastewater from laundry processes. These results underscore the MiniPlast Filter's capacity to significantly mitigate the environmental impact of microplastics by removing a substantial proportion of the particles, making it an effective tool for ensuring cleaner water and a healthier environment.

The effectiveness of the filter is evident from the dramatic decrease in microplastic concentration, emphasizing its crucial role in reducing microplastic pollution in laundry wastewater. Additionally, based on the examination and analysis data, the microplastic particles in the sample were predominantly fibre-shaped, with sizes ranging from < 500 µm to 4.5 mm. The identification process was carried out over two days, from 10:00 to 16:00 CIT, at the Botany Laboratory of the Faculty of Mathematics and Natural Sciences, Halu Oleo University, using a microscope. The samples, which had been filtered and dried at the Pharmacy Laboratory of Halu Oleo University, provided critical data for this study. These findings further emphasize the MiniPlast Filter's role in addressing microplastic contamination in laundry wastewater effectively, ensuring cleaner water and a positive environmental impact.

The data in Table 2 presents the analysis of the tensile strength and elongation test values for nylon fabric used in the MiniPlast Filter. Based on the data, the highest tensile strength for the 400 × 1.6 Mesh nylon fabric was 154.998 N in the first test, measured in the weft direction (the width of the fabric). In the second test, the tensile strength increased to 174.618 N in the warp direction (the length of the fabric), indicating that higher tensile strength values correspond to greater strength. For the 600 × 1 Mesh nylon fabric, the tensile strength in the second experiment was 168.732 N in the weft direction, while the warp direction had a tensile strength of 145.188 N. While the tensile strength in the second test was slightly lower than in the first, the variation between the first, second, and third tests was minimal. Therefore, the tensile strength of the fabric used in the MiniPlast Filter is considered adequate for its intended use. Regarding the elongation values, the 400 × 1.6 Mesh nylon fabric demonstrated a noticeable trend where the elongation value decreased in the warp direction from the first to the third trial, while the elongation value in the weft direction increased over the same period. This suggests that the fabric is able to stretch more in the weft direction without losing its structural integrity. For the 600 × 1 Mesh nylon fabric, the elongation values in both the warp and weft directions were consistent, with a slight decrease from the first to the third experiment, indicating good elasticity and durability of the fabric [24].

Based on these results, it can be concluded that the filter cloth used in the MiniPlast Filter is of high quality. The tensile strength and elongation data suggest that the fabric is both strong and flexible, making it well-suited for the filtration process [25]. The performance of the nylon fabric in terms of tensile strength and elongation is essential for the MiniPlast Filter's ability to effectively remove microplastics while maintaining its integrity over time. Previous studies have shown that microplastic particle size affects the performance of fabric filters, and the efficiency of these devices is crucial in reducing the release of microfibres during laundry processes. In addition to the tensile strength and elongation tests, a photo test of the longitudinal cross-section of the nylon fabric used in the MiniPlast Filter was also conducted. This test aimed to determine the structural properties of the filter cloth, further ensuring its suitability for microplastic removal. The results of the cross-sectional analysis provide valuable insight into the fabric's structure and its ability to trap microplastics effectively, confirming the MiniPlast Filter as a reliable tool for reducing microplastic contamination in laundry wastewater [26].

Based on the image in Figure 3, the cross-sectional photo of the 400 Mesh filter cloth from the third trial reveals that it has tighter pore spaces compared to the first trial, both in the weft and warp directions. This indicates an improvement in the filter cloth's density, making it more efficient at capturing microplastics. [27]. The cross-sectional photo of the 600 Mesh filter cloth also shows similar characteristics, with pores that are relatively close together. As a result, the filter cloths have very small pores, which enhances their ability to trap microplastic fibres effectively. The tensile strength and elongation values, combined with the cross-sectional analysis, confirm that both the 400 Mesh and 600 Mesh filter cloths are highly effective components for microplastic removal [28]. The 400 Mesh filter cloth, with pore sizes equivalent to 37 µm, 0.037 mm, or 0.0015 inches, is well-suited for trapping larger microplastics [29]. The 600 Mesh filter cloth, with smaller pores measuring 20 µm, 0.02 mm, or 0.00079 inches, is even more efficient at filtering out finer microplastics. These filter cloths' small pore sizes, combined with their strength and flexibility, make them ideal for effectively removing microplastic fibres from clothes-washing wastewater. The results from the cross-sectional photos, tensile strength, elongation values, and analysis under a binocular microscope all demonstrate that the filter cloths have a very small density, further proving their suitability for microplastic filtration [30]. These findings emphasize the high performance and effectiveness of the MiniPlast Filter in reducing microplastic contamination, making it a reliable solution for cleaner wastewater and a healthier environment.

Table 3 compares the specifications of the MiniPlast Filter with similar microplastic removal products currently available on the market, including planetcare, fitrol, and the Lint Luv-R. These products were designed with similar objectives: to reduce microplastic contamination from laundry wastewater. The table outlines key details such as product price, filter type, removal efficiency, and country of origin. Based on the information in Table 3, it is clear that the MiniPlast Filter stands out as the first product in Asia specifically designed to remove microplastics from clothes-washing wastewater. It offers an impressive removal efficiency of 91.71%, which surpasses the efficiency of other competing filters like planetcare (90%), fitrol (89%), and the Lint Luv-R (87%) [31]. The MiniPlast Filter utilizes a multi-stage filter system, composed of multiple layers of filter media, to ensure thorough and efficient filtration of microplastics from washing wastewater. In addition to its high efficiency, the MiniPlast Filter is priced at IDR 1,200,000, making it significantly more affordable compared to the other filters, which range in price from approximately IDR 2,200,000 to IDR 2,300,000. This combination of superior filtration performance and cost-effectiveness makes the MiniPlast Filter an attractive option for consumers seeking an affordable solution to microplastic pollution in laundry wastewater. This comparative analysis emphasizes the value and potential of the MiniPlast Filter in addressing environmental concerns related to microplastic contamination [32].

## Conclusions

Based on the results and description of the discussion in this research regarding the ability of the MiniPlast Filter to remove microplastics, the author can draw the following conclusions: Based on microscope observations with a dry weight of 7.0 kg of clothes before washing by filtering water containing microplastics with the colour of microplastics namely yellow, purple, red, black, blue and green, found in observations using a light binocular microscope with a speed of 10x magnification of the average number The average microplastic found without using the Miniplast Filter was 4,710 microplastic particles/L. Meanwhile, from the washing wastewater, the colours of microplastics were yellow, purple, red, black, blue, and green. The results of observations using light binocular microplastics with a 10x magnification lens showed that the average number of microplastics using the Miniplast Filter was 390 microplastic particles/L. Based on the study and data analysis, it can be concluded that the emissions of microplastic particles in washing wastewater after using a filter have an efficiency of 91.71%. This MiniPlast Filter can reduce the possibility of microplastics spreading in the environment, especially in water bodies, so it can successfully and effectively remove microplastic particles.

## Author Contributions

**RMR**: Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Visualization, Writing - Original Draft, Writing - Review & Editing; **GPC**: Conceptualization, Supervision, Validation; **WOSWM**: Conceptualization, Supervision, Validation.

## Conflicts of Interest

There are no conflicts to declare.

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