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Filtration Examination of Biofilter Made of Banana Trunk Waste Due to Mitigate Microplastics Emission from Laundry Waste Water

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Abstract**—** *Most of particles contained in waste water laundry are microplastics since more than 80% of our cloths now days are made of synthetic fibers. Many reports about the danger of microplastics are provided in various journal. This research aims to find out effectivity of biofilter resulted from banana trunk and performance of filtration tool. The method used in this research include: 1. Characterization and filtration of microplastic PE (polyethylene) and waste water laundry, 2. filtration test PE, biofilter and waste water laundry, 3. construction and examination of filtration tool. Result of this research showed that microplastic PE is identified by CH_2 group with wave length 1463 cm^{-1} and the shave unorderly spherical and the size is 13 mm. Biofilter able to filtrate microplastics reference and microplastics from waste water laundry since there is no CH_2 group at wave length 1400s cm^{-1}. However, capability of biofilter to filtrate microplastics is on size ≥ 13 mm which is showed by the SEM. At the meanwhile, EDS result states that Whatmann filter paper is better in filtration than biofilter itself. Filtration tool is able to reduce microplastics content which is showed by reducing of intensity of CH_2 from 1449 cm^{-1} to 1402 cm^{-1}.*

Keywords**—** *Microplastic, laundry waste water, biofilter, filtration*.

I. INTRODUCTION

Whether we realize or not, now days, we are depend on daily goods made of plastic materials and this condition become our comfort zone. Increasing in production and purchasing of plastic materials cause increasing volume of plastics waste exponentially following increasing of world population. As a figure, consumption of plastics for Indonesia reaches 10 kg per capita per year, so we might predict how much plastics waste are produced. As a consequent, these plastics change into microplastics in environment and threat our life wholly.

In the last decade, furious increasing of fast fashion become a dominan factor in growing of both production and quantity of microplastics pollutant (Cobbing and Vicaire, 2016). Microplastics emission origin from synthetic textile washing activities is found as a main source of microplastics and it is estimated these activities contribute about 35% of primary microplastic emission for marine environment. Even, microplastics have already found in sediment and this can accelerate degradation of building block of plastic polymer into CO_2. Of this, microplastics can be one of global warming accelerators.

Concentration of microplastic fiber in a sea water sample has strong correlation with quantity of synthetic fiber production (Thompson et al. 2004). Verschoor *et al*. (2014) made a prioritize sources of microplastics and give high score (7/10) for textile and garmen which is produced from synthetic fiber material that release fiber during washing and wearing. It can be concluded that this concentration would increase linearity onward, especially if it relates to growing of world population trend, mainly in developing countries and trend of development of material technology on plastic polymers.

Regarding to trends above, it must be done evaluation in order to quantification of how much microplastic fiber has released during washing synthetic clothing in order to mitigate microplastic that released to environment Releasing also consider to type of washing machine (*top load versus frontload brand*), kind and age of garmen (Hartline et al., 2016).

Due to solve microplastic pollution problem comes from waste water laundry, it is needed a breakthrough by purchasing of simple technology where easy to find material (for example, from surrounding where we live or by purchasing of waste in surrounding), cheap, applicable, and recyclable. With benefit of physical and chemical properties of pollutant and adsorbent cellulose based, it is used banana trunk as bio-mass biofilter to attach microplastics from waste water laundry.

Therefore, researchers are interested to investigate filtration capacity of biofilter made of cellulose extracted from banana trunk due to mitigate microplastics from laundry. This research aims to find out the effectivity of filtration of biofilter and to find out the effectivity of performance of filtration tool.

II. MATERIALS AND METHOD

A. Research Location

This work was conducted in Chemistry Laboratory, Mataram University, Lombok Island, NTB Province, Indonesia.

B. Materials

Cellulose biofilter, fine powder banana trunk biofilter, Whatman paper, tissue, banana trunk powder, gravel, cassa cotton, sand, aluminium foil, microplastic PE (polyethylene), aquadest, stainless steel plat, and waste water laundry.

2.3 Method

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Characterisation of microplastic PE

Characterisation of microplastic PE for its morphology, topology and functional group was conducted by using FTIR (Fourier Transform Infra-red) analysis and also by using SEM (Scanning Electron Microscope). Results of these characterisations would be used as reference for sample from waste water laundry.

Filtration Test for Biofilters Uses Microplastic PE

5 gr PE is dissolved in aquadest 100 mL and then filter with biofilter made of banana trunk. Result of filtration then be analysed with FTIR and SEM. With the same way, filtration and analysis are applied for biofilter made of cellulose rendemen

Characterisation of Wasre Water Laundry

100 mL of waste water laundry was analysed with FTIR, SEM and EDS. This characterisation aims to find out the character of microplastic from waste water laundry.

Filtration test for biofilter uses waste water laundry

100 mL of waste water laundry was filtrated in a series of filtration: 1. use biofilter made of banana trunk, 2. use biofilter made of cellulose rendement, and 3. use Whatmann filter paper. Those three filtrats are then be analysed with FTIR

Construction of Filtration Tool

This tool is designed by application of *AutoCAD* and the material is stainless steel. Performance Test Tool

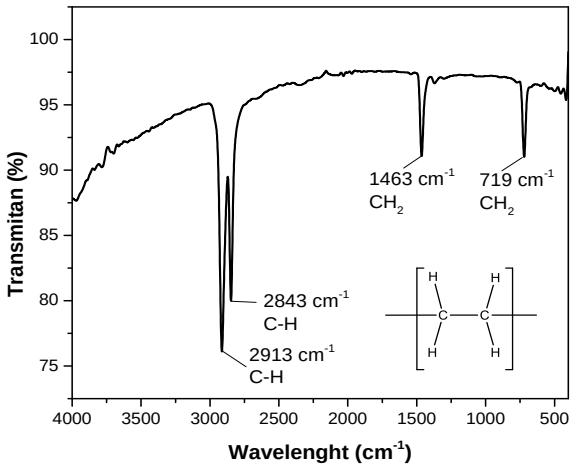
For this purpose, we used fine powder banana trunk as biofilter then is added with sand placed inside the tool. This filtration tool is designed with application canva.com. This tool is completed with tap so it could flow the liquid.

III. Results and Discussion

3.1 Microplastic PE

This research used microplastic PE because most of synthetic textile produced and available in the market based on PE. Identification of this microplastic used FTIR analysis in order to find out the functional group and to detect its characteristic vibration in sample so it can be gained information such as molecular structure, covalently compounds, purity of material, and functional group of molecules (Aspi et al., 2013).

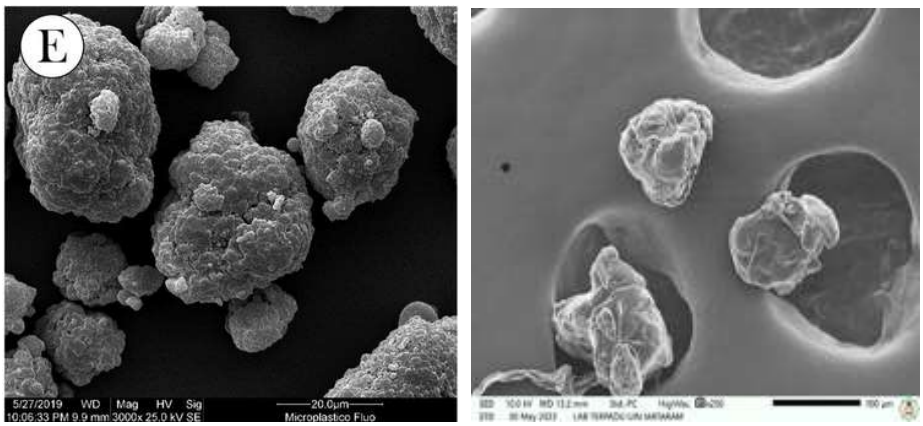
Result of FTIR analysis showed there are group of C-H *strench vibration* at wave length 2913 cm^{-1} and 2843 cm^{-1}, group CH_2 *bend* at wave length1463 cm^{-1} and group CH_2 *rock* at wave length 719 cm^{-1} (Dia, Wa Ode Asma La, Kantun Wayan, Kabangga, 2021). Wave length 1463 cm^{-1} shows type of microplastic that is HDPE (high density polyethylene) (Peltzer & Simoneau, 2013). This result of FTIR analysis indicated that microplastic PE has molecular structure $(C_2H_4)_n$. This type of polyethylene has thermoplastic property which derived from petroleum.



Result FTIR analysis for Microplastic PE

According to Thomson et al., 2009, microplastik has dimension of particle about 0.1 µm to 5 mm. At the mean while, Rizkia, 2022 said that microplastics in fiber type have size 3 – 15 mm. Of SEM result from this PE has spherical shape irregularity and its size as 13 mm.

A B



SEM results (A) microplastic in amphibian (Araujoa et al., 2019) and (B) microplastic PE

Filtration PE Uses Biofilter Made of Banana Trunk and Cellulose Rendemen

Biofilter made of cellulose rendemen and of fine powder banana trunk are used to filtrate microplastic PE. This

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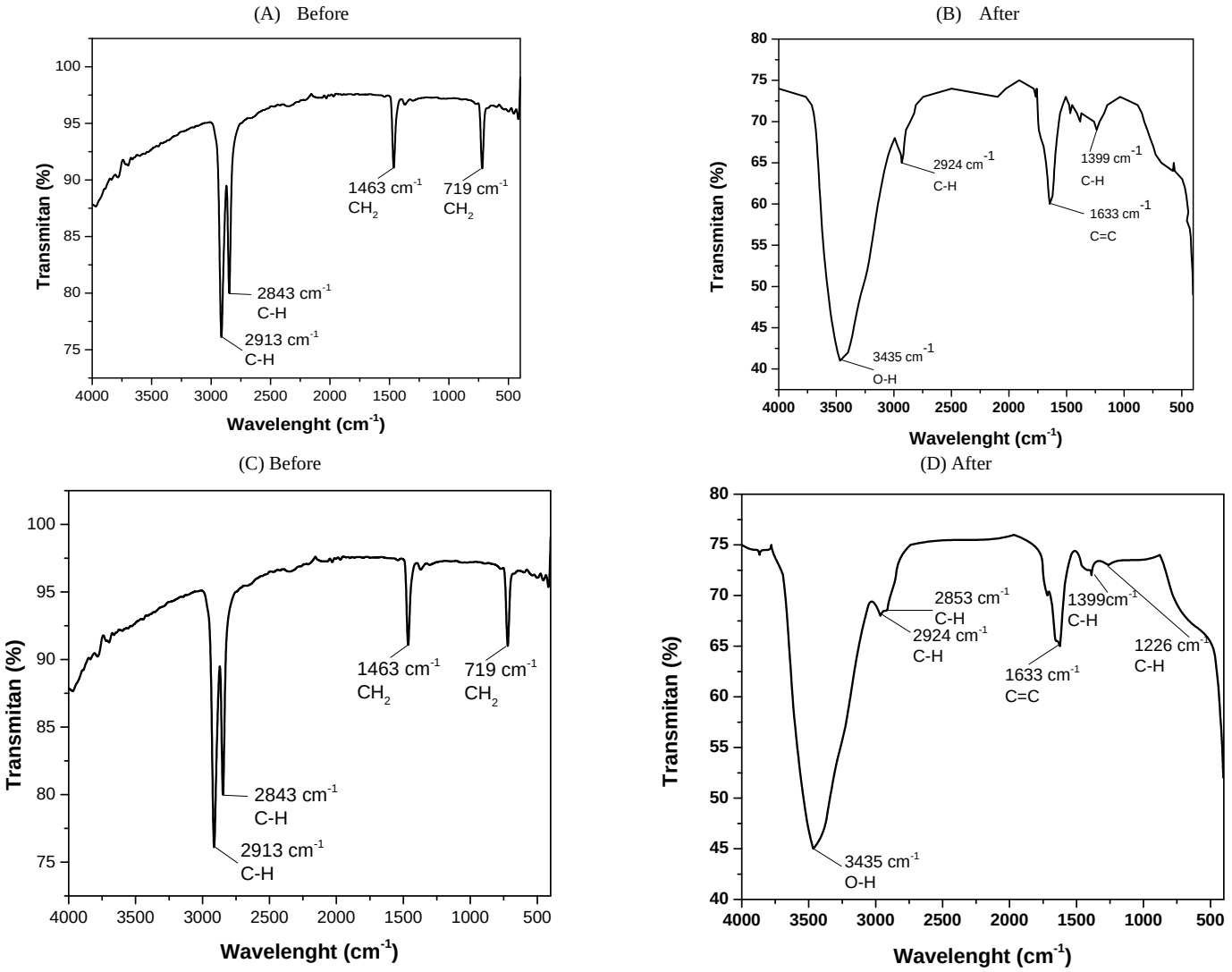
filtration aims to find out the level of filtration of that biofilter. This is showed by data before and after filtration for sample microplastic PE. After filtration process with those two biofilters, it can be seen that there is only function group of cellulose in filtrate and there is no wave length 1463 cm^{-1}. This indicates there is no microplastic in filtrate. Therefore, It can be concluded that biofilter cellulose and banana trunk able to filter microplastic PE.



Result of FTIR analysis (A) before and (B) after filtration PE used fine powder banana trunk; (C) before and (D) after filtration used cellulose referense

Result of FTIR analysis reveals that filtration of microplastic PE used biofilter made of banana trunk and cellulose reference and this shows that there is no PE in filtrate. This is confirmed that there is no wave length 1463 cm^{-1} which indicates the existing of CH_2 group in filtrate. However, this research has a weakness that is cellulose fiber is very easy to bound water molecule (H_2O) and as a consequence filtrate could be contain cellulose group. This compounds can be seen with existence of the strongest intensity peak at wave length 3435 cm^{-1}. This means there is availability of OH group with *stretching vibration*. That OH group roles as hydrogen bonding intramolecular which represents long chain β-glucose contained in long chain cellulose (Lismeri, 2017).

3.2 Filtration of waste water laundry used biofilters banana trunk and cellulose reference

Waste water laundry can be said as pollutant that contents much surfactant, carboxyl methyl cellulose (CMC), calcium (Ca), phosphate (P), SiO_{32}, bleaching agent (Kusuma et al., 2019). Also, waste water laundry contents much microplastics of fiber type which has hydrophobic proper (Rizkia & Hendrasarie, 2022). Hydrophobic property of waste water laundry causes hydrophobic group inside cellulose can be bonded with microplastics. This could be proven from the result of absorbed waste water laundry by cellulose biofilter and banana trunk biofilter used FTIR analysis.

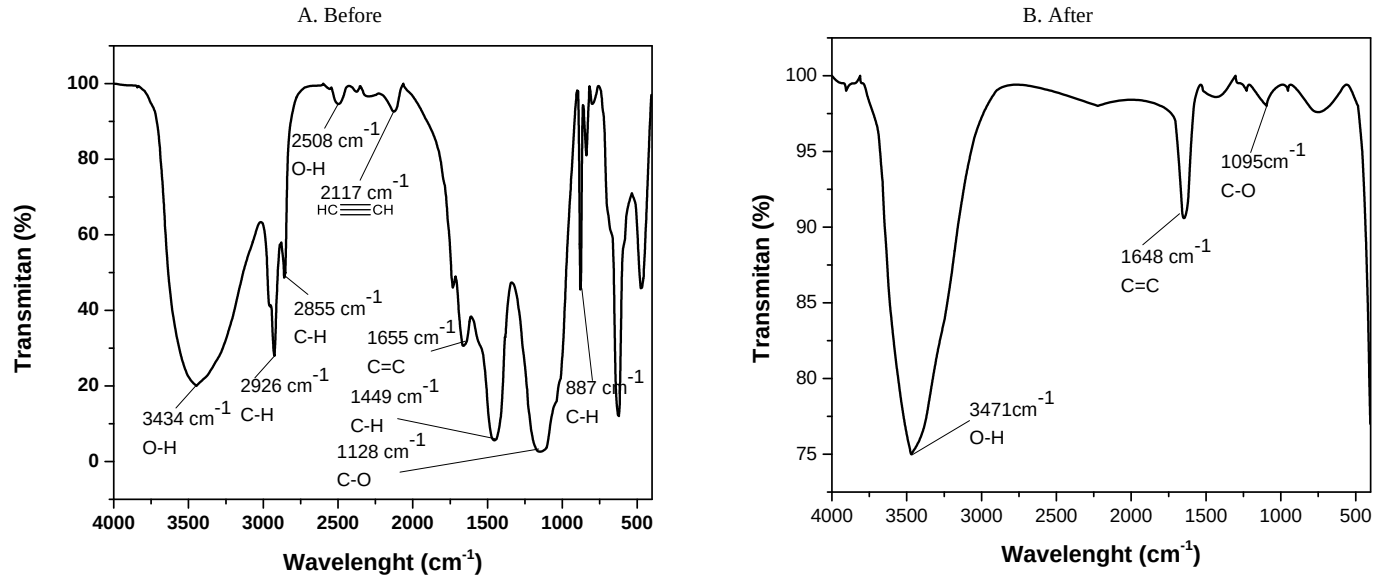
In this research, waste water laundry contents microplastic PE. This is showed by values wave length 2926 cm^{-1} and 2855

Jeckson Siahaan, I Wayan Budiarsa Suyasa, and I Gusti Bagus Sila Dharma, "Filtration Examination of Biofilter Made of Banana Trunk Waste Due to Mitigate Microplastics Emission from Laundry Waste Water," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 11, pp. 115-121, 2024.

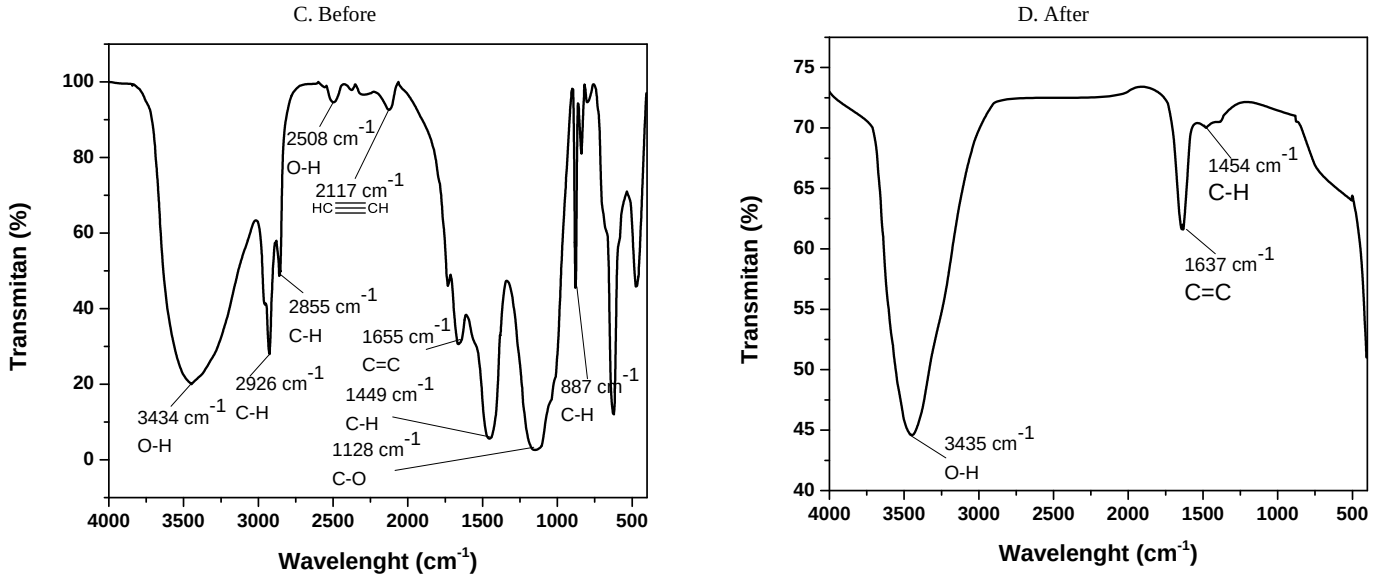
cm^{-1}; this means there is bonding C-H *strench vibration*. CH_2 bend is showed by wave length 1449 cm^{-1}.

It is found also O-H group that bonded with microplastic PE which is showed by wave length 3434 cm^{-1}. After filtration used those two biofilters, the fact is there is no group which indicate availability of microplastic PE anymore. This indicates that efficiency of filtration using biofilters banana trunk, cellulose rendemen and Whatman filter paper are good enough. However, grade of absorptivity toward pollutant on Whatman filter paper is better than biofilter banana trunk and cellulose rendement because function group O-H contained in Whatman filter paper has sharper peak. This may be caused the pores in Whatman filter paper is smaller than biofilter cellulose rendemen and biofilter banana trunk. Even though these biofilters have bigger pores than Whatman paper, innovation of this banana biofilter is suitable as a more friendly and economically suits for societies or laundry business than Whatman filter paper.

Morphology of microplastic contained in waste water laundry was analysed with SEM and the result is in orderly shape. Picture (a) shows that the size of microplastic is 13.8 mm (1500 X), picture (b) shows microplastic with size 13.7 mm (1500 X) and picture (c) shows microplastic with size 13 mm. Of these sizes, it could be concluded that Whatman filter paper, biofilter cellulose reference and biofilter banana trunk able ti filter microplastic with size more than 13 mm.

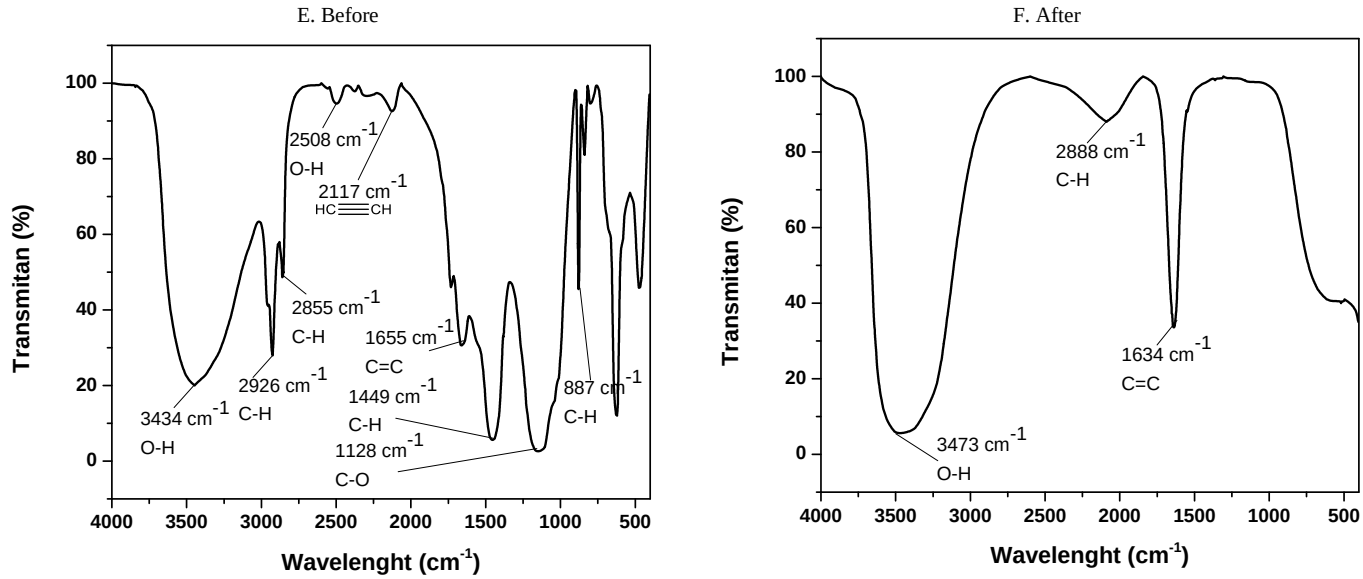


Result of FTIR analysis (A) before (B) after Filtration used Whatman filter paper

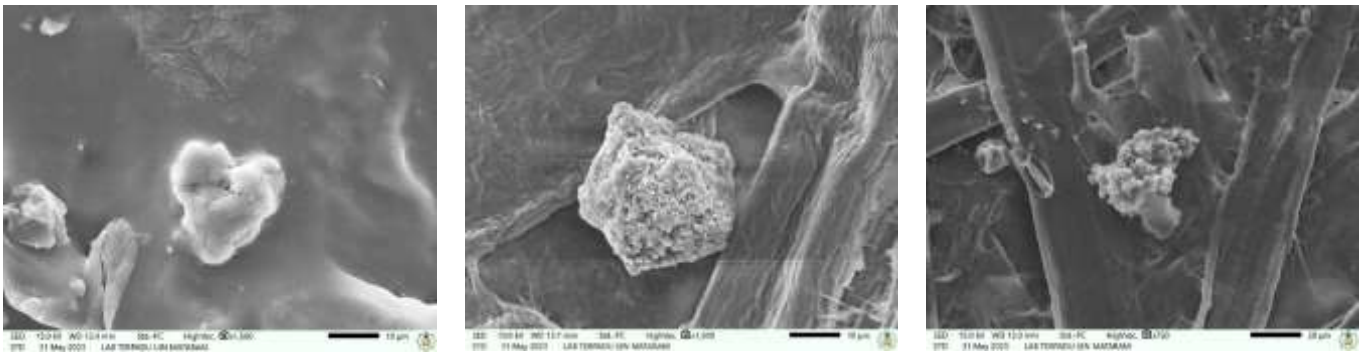


Result of FTIR analysis (C) before (D) after Filtration used biofilter cellulose reference 2x

Jeckson Siahaan, I Wayan Budiarsa Suyasa, and I Gusti Bagus Sila Dharma, "Filtration Examination of Biofilter Made of Banana Trunk Waste Due to Mitigate Microplastics Emission from Laundry Waste Water," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 11, pp. 115-121, 2024.



Result of FTIR analysis (E) before (F) after Filtration used Biofilter banana trunk



(a) (b) (c)

Results of SEM waste water laundry

Based on size, this microplastic of waste water laundry can be grouped as microplastic fiber. This accords to microplastic fiber size that is 3 – 15 mm (Rizkia & Hendrasarie, 2022). This microplastic fiber is a very danger pollutant to living creatures, especially marine and fresh water biotas. However, there is weakness of these biofilters such they only able to filter microplastics with size ≥ 13 mm, so microplastic with size <13 mm would be released. This could be happen because biofilters were made conventionally. Undoubtedly, from the results of this research, there is a hope that in future this biofilter is promising to be developed so it can be used to filter microplastics with size < 13 mm. Strengthen of this biofilter is it is able to filter microplastics fiber with size from ≥13 mm, so this could be developed in future.

EDS analysis on picture above shows the result of filtration of waste water laundry. This analysis aims to find out atoms are contained in filtrate of biofilter whis is made of banana trunk. Minerals are contained in filtrate are not danger. They are magnesium, calcium, sodium, and selenium. Titanium is found in filtrate only 0.05% and titanium oxide ia a very good to absorber for pollutan. Iron which is contained in filtrate is very low, that is 0.16% and the upper limit for this element is 0.3 mg so this biofilter is still good to be used as biofilter for waste water laundry. Note, the optimum result of filtration is using Whatman filter paper because atoms which are contained in filtrate looks clear. This is the graph of EDS results.

3.3 Filtration Tool for Waste water laundry

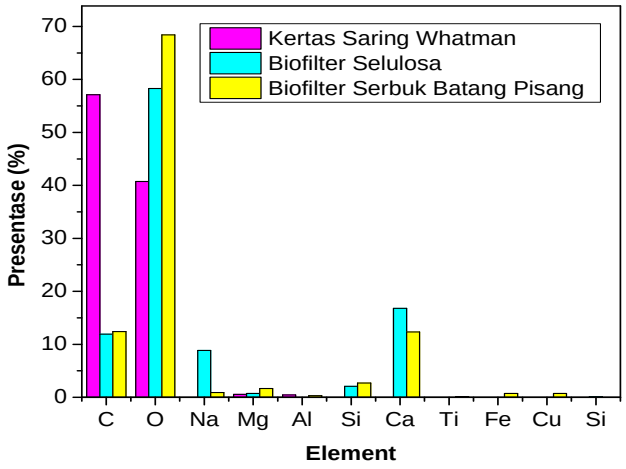
Construction of prototype of tool for filtration tool which will be used for waste water laundry is designed by applying *Autocad* aplication. Its specification such as: it is made of stainless steel material; height 60 cm, wide 30 cm and diameter 14 cm. This tool is completed with cover and body, discharge hole, and a space for flowing water. Waste water laundry is added into the tool through upper part and then passing several layers of cellulose, casa cotton, small stone so it results a clean and clear filtrate and this is in turn to be tested.

3.4. Laundry Waste Filtration Equipment

A prototype of a laundry waste filtration device designed using the Autocad application was designed using stainless steel material with a height of 60 cm, a width of 30 cm and a diameter of 14 cm. This tool is equipped with a tool cover and tool body, a drain hole, and a place for clean water to flow. Laundry wastewater will be entered through the top and will

Jeckson Siahaan, I Wayan Budiarsa Suyasa, and I Gusti Bagus Sila Dharma, "Filtration Examination of Biofilter Made of Banana Trunk Waste Due to Mitigate Microplastics Emission from Laundry Waste Water," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 11, pp. 115-121, 2024.

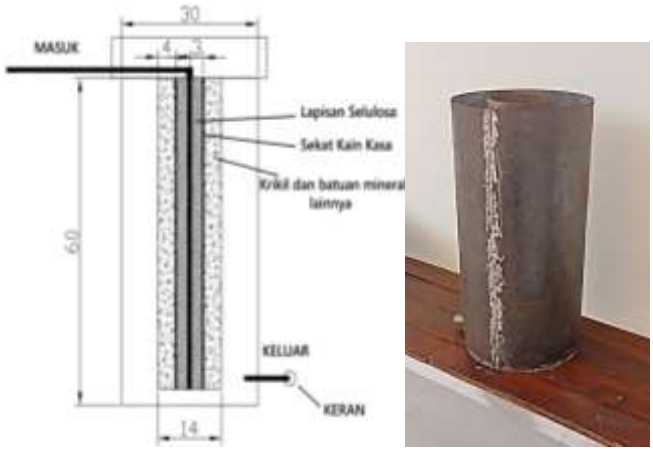
then pass through several layers of cellulose, gauze, gravel and other mineral rocks to produce clean filtered water. The water filtered through this tool will be tested next.



Result of SEM

3.5 Filtration Waste Water Laundry Uses Tool

Result of filtration by using designed tool shows that waste water laundry contains microplastic PE. This is proven by wave length 2926 cm^{-1} and 2855 cm^{-1} that stated the existence of C-H bonding *strench vibration* and CH_2 bend is showed by wave length 1449 cm^{-1}. After waste water laundry passed through the tool, the intensity of microplastic PE decreased and this is showed at wave length 2930 cm^{-1}. C-H group (2930 cm^{-1}) in waste water laundry showed a sharp peak, but after passing the filtration process, the intensity decreases.

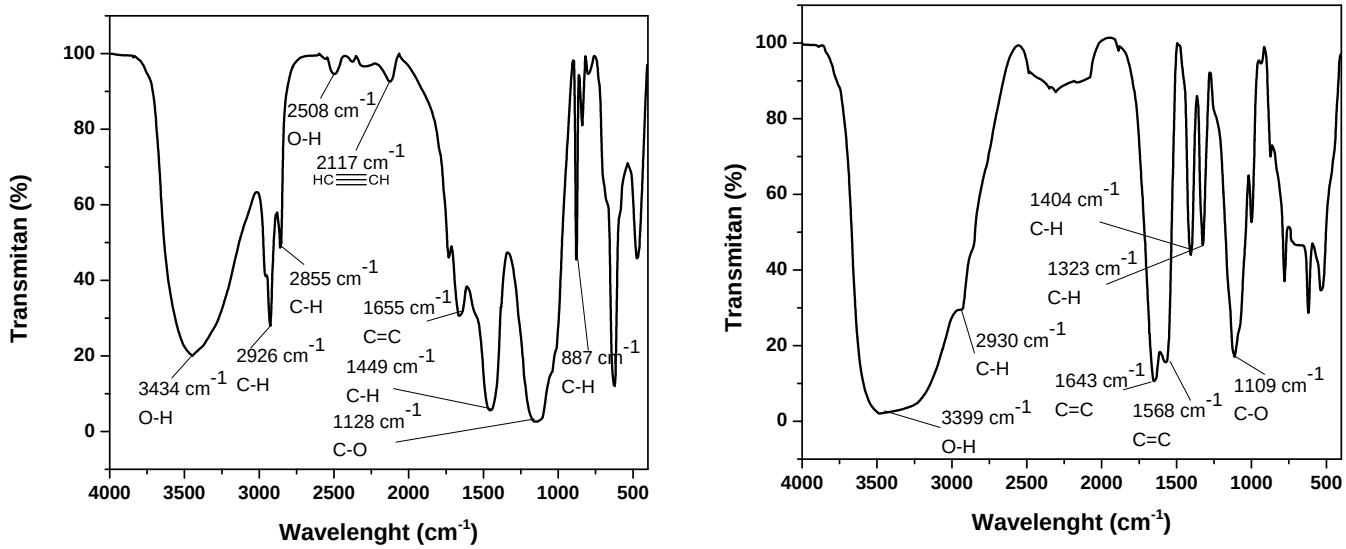


Filtration tool

The wave length 1449 cm^{-1} which is read, it means there is CH_2 bonding of microplastic PE contained in waste water laundry. Filtration used the tool may reduce the intensity of microplastic that contained in waste water laundry which is showed by wave length 1402 cm^{-1}. (from 1449 cm^{-1} to 1402 cm^{-1}).

A. Before

B. After



Result of FTIR analysis before and after filtration used tool

IV. CONCLUSION

Microplastic PE is recognized by CH_2 group at wave length 1463 cm^{-1} and its shape is inorderly spherical with size 13 mm. Filtration with biofilter is able to filter microplastic and this is proven that there is no CH_2 group at wave frfiltrate microplastic with size ≥13 mm which is showed by the result of SEM in filtration of waste water laundry. Result of EDS confirms that Whatmann filter paper is better than this biofilter in filtration. Filtration tool which is designed is able to reduce microplastic content and this is showed by decreasing of intensity of CH_2 from 1449 cm^{-1} to 1402 cm^{-1}.

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