Scenario 2 Microplastic Filter: Cleaning With Coconuts

Thurs-18: Siddm47, Kalsij8, Dhillk27, Rossh14, Joh8

By: Shayan, Jasmine, Karanveer, Hannah, and Andrew

McMaster University

[1][2]

Table of Contents

01 Our Scenario

The goal of this project is to design a filter fiber and a filtration device which focuses on filtering out microplastics and microbeads

- **Microbead and microplastic filtration**
  - Must capture microplastic particles between 10-20 μm radius

- **Large-scale water treatment plant**
  - Located in Hamilton, Ontario
  - Population of about 25000 citizens

02

Regulations

Regulations Impacting Our Design

- **CEPA Microbeads Regulations In Canada**
  - Microbeads are plastic particles **≤ 5mm**
  - Canada **bans** manufacture, import, and sale of toiletries that contain microbeads[3]
  - This matters for us because Canada is treating small plastic particles as an **environmental pollution issue**, which supports our need to remove microplastics before effluent is released[4]

Regulations Impacting Our Design

- **Single use Plastic Prohibition Regulation**
  - Prohibits several high litter single-use plastic categories
    - Ex. Bags, cutlery, certain food containers etc.
  - Part of the national goal is to reduce plastic pollution and move towards **zero plastic waste by 2030**
  - This reinforces a “prevention first” and supports investing in filtration to reduce plastic released into the environment[5]

What These Regulation Mean for Our Design

Prevent Adding New Microplastics

- Filter media and parts should **not shed plastic dust or beads**
- The design should **reduce microplastics overall**, not create more during use[6]

Waste Handling and Disposal

- Captured Microplastics become concentrated solid waste
- Cleaning/backwash must include **capture and containment**
- Waste should be sent for controlled disposal (not released back into effluent)[7]

Proof of Performance

- Compliance is not one test, it's **constant performance**
- Track microplastics removal with a simple metric
  - Ex. Particles/L before vs After
- Re-check after cleaning cycles to confirm performance does not drop

03

Sustainability Concerns

Sustainability Challenges in Microplastic Filtration

➢ **Environment Impact**
- Microplastic can accumulate in river, lakes, and oceans and harm aquatic ecosystems [8]
- Small plastic particles can enter the food chain and affect wildlife and human health
- Wastewater treatment plants are a major pathway for microplastic entering natural water systems

Sustainability Challenges in Microplastic Filtration

- **Waste Management**
  - Captured microplastics must be handled through controlled disposal or recycling systems [9]
  - Proper waste management prevents plastics from re-entering waterways

Sustainability Challenges in Microplastic Filtration

- **Preventing Secondary Pollution**
  - Filtration systems should avoid shedding plastic particles or fibers
  - Filter material must remain stable in wastewater environments
  - Designs should remove contaminants without introducing new pollutants

Sustainability Challenges in Microplastic Filtration

- **Long Filter Lifespan**
  - Durable filters reduce the need for frequent replacements
  - Cleaning processes such as backwashing allow filters to be reused [10] [11]
  - Longer lifespan reduces material waste and manufacturing demand

04

Why We Chose Our Material

Why We Chose Coir Fiber

Why Coir Fiber?

- Strong durability in wet environments
- Low production cost
- Environmentally sustainable and biodegradable

Decision Matrix:

Ramie Fiber	Coir Fiber	UHMWPE Fiber
24	**32**	23

Coir Fiber [12]	Average Value
Young's modulus (GPa):	5
Yield strength (MPa):	125
Tensile strength (MPa):	165
Density (kg/m^3):	1185
Embodiment energy (MJ/kg)	10.8
Specific carbon footprint (kg/kg)	0.869
Number of Pores	1174.6
Pore Size (m)	1.8*10^-5

Porosity Conditions

- Considerations for porosity were made accounting for the removal of microplastics by choosing the following metrics:
  - Length of Micropore (1.7 mm)
  - Number of Micropores (1174.6 pores)
- The porosity calculated was **0.2275** which can indicate a very porous and fine filter for taking out microplastics
- Through calculating the Young Modulus using porosity, the value produced can demonstrate that Coir Fiber is still a relevant choice as it falls in the range of typical stiffness for the material chosen

Coir Fiber Material [13]

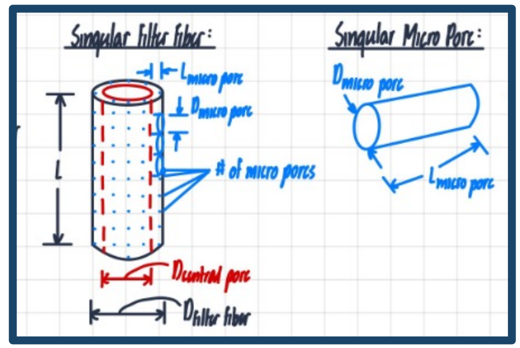
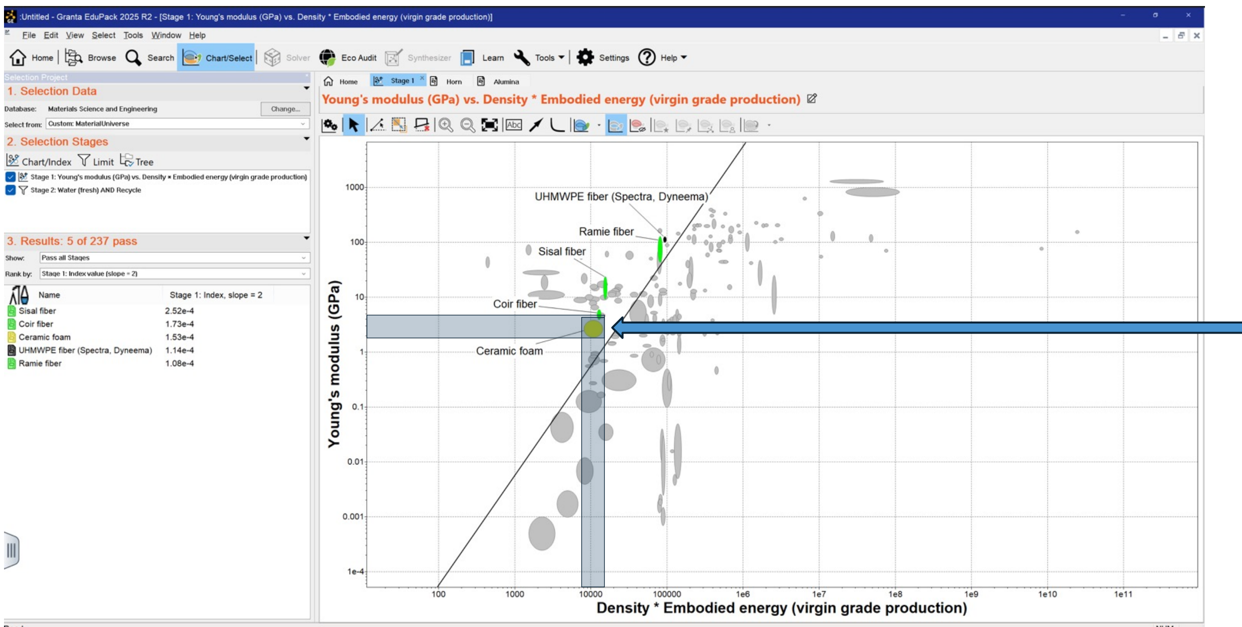


Diagram of Parts of Filter [14]

Ashby Chart for Porosity

- The following Ashby Chart shows that using the calculated Young Modulus, Coir Fiber remains to be a strong choice as it is between 1-10 and above the MPI threshold line



X Coordinate: **Density** (without porosity)

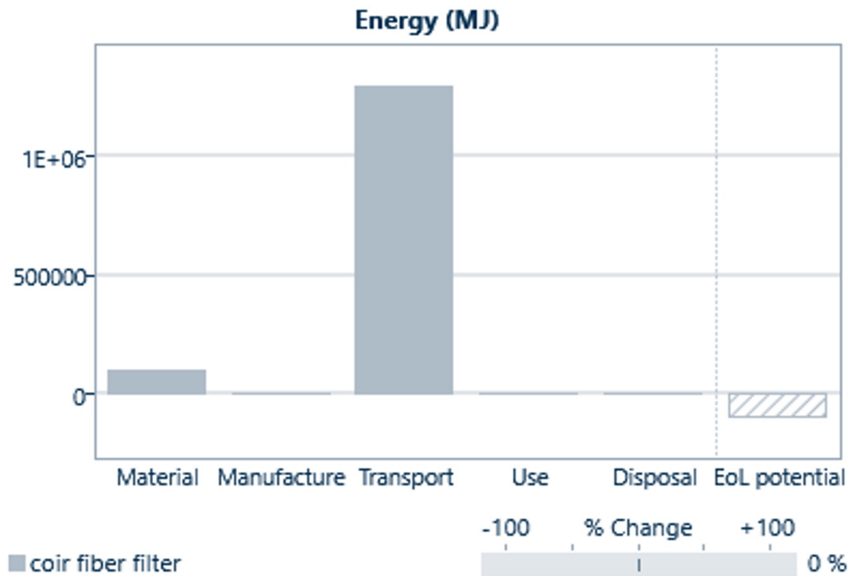
Y Coordinate: **Young Modulus**

Ashby Chart for Young Modulus vs Density for Top Fibers for Water Filter [12]

05

Eco Audit

ECO Audit Results



Energy details   Climate change (CO2-eq) details

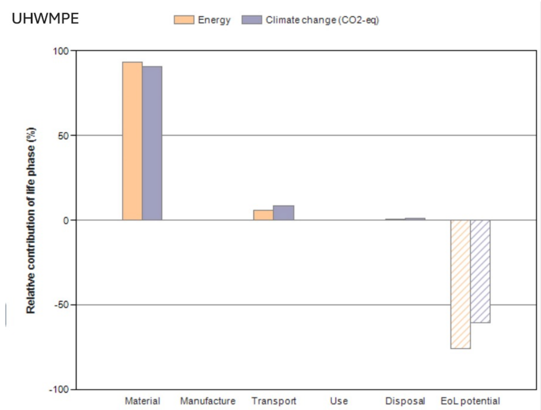
Phase	Energy (MJ)	Energy (%)	Climate change (CO2-eq) (kg)	Climate change (CO2-eq) (%)
Material	9.87e+04	7.1	7.94e+03	8.0
Manufacture	0	0.0	0	0.0
Transport	1.3e+06	92.8	9.17e+04	91.9
Use	0	0.0	0	0.0
Disposal	1.83e+03	0.1	128	0.1
Total (for first life)	**1.4e+06**	**100**	**9.98e+04**	**100**
End of life potential	-9.87e+04		-7.94e+03	

[12]

- **The majority of the energy is used during transportation**

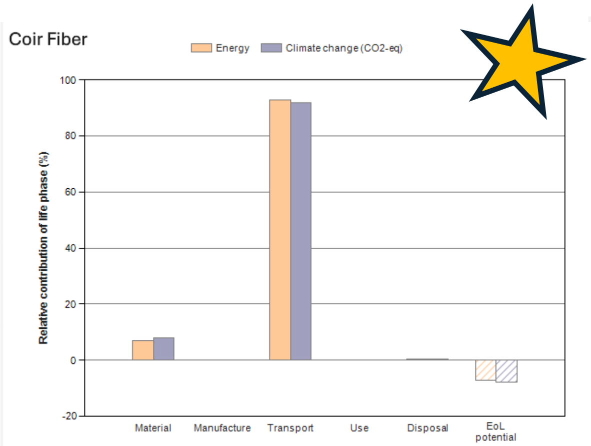
- **Very little energy usage during material extraction.**
- **Positive EoL Potential**

How Do They Compare?



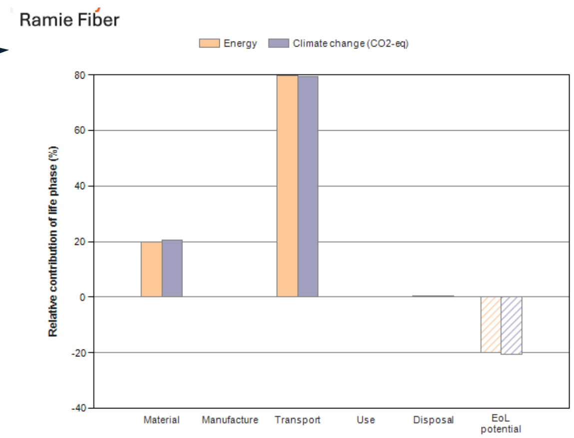
[12]

- Relatively high material extraction energy
- Low transportation energy
- High EoL potential



[12]

- Lowest material extraction energy
- High transportation energy
- Some EoL Potential



[12]

- Highest transportation energy

The end

References

[1] "Project Two: Wastewater Filtration Mechanical Design of Filters in a Wastewater Treatment Plant" project module, Department of Engineering, University of McMaster, Winter, 2026
[2] "Brand Resources." Accessed: Mar. 18, 2026. [Online]. Available: https://mcmasteru365.sharepoint.com/sites/BrandResources
[3] Environment and Climate Change Canada, "Microbeads in Toiletries Regulations: Frequently Asked Questions," Government of Canada. [Online]. Available: https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/microbeads-toiletries-regulations-frequently-asked-questions.html. [Accessed: Jan. 29, 2026].
[4] Government of Canada, "Microbeads in Toiletries Regulations (SOR/2017-111)," Justice Laws Website. [Online]. Available: https://laws-lois.justice.gc.ca/eng/regulations/SOR-2017-111/page-1.html. [Accessed: Jan. 29, 2026].
[5] "Single-use Plastic Prohibition Regulations" Government of Canada [online]. Available: https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/reduce-plastic-waste/single-use-plastic-overview.html [Accessed Jan. 29, 2026]
[6] Government of Canada, "Guidelines for Canadian Drinking Water Quality - Summary Tables," Government of Canada [Online]. Available: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html#t4 [Accessed: Jan. 29, 2026].
[7] Government of Canada, "Guidance on Monitoring the Biological Stability of Drinking Water in Distribution Systems," Government of Canada [Online]. Available: https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidance-monitoring-biological-stability-drinking-water-distribution-systems.html#b3 [Accessed: Jan. 29, 2026].
[8] J. P. Silva, P. S. Sampaio, and H. de Pablo, "Filtration solutions for microplastic mitigation: Cutting-edge filtration technologies and membrane innovations for environmental protection," MDPI, https://www.mdpi.com/2076-3417/16/1/439 (accessed Mar. 18, 2026).
[9] Https://www.sciencedirect.com/science/article/pii/S2211379718320771?via=ihub | Request PDF, https://www.researchgate.net/publication/328544309_httpswwwsciencedirectcomsciencearticlepiiS2211379718320771via3Dihub (accessed Mar. 18, 2026).
[10] EPA, https://www.epa.gov/sdwa/overview-drinking-water-treatment-technologies (accessed Mar. 18, 2026).
[11] W. F. Admin, "Eco-friendly filtration innovations: A how-to guide," Water Filter Stuff, https://waterfilterstuff.com/eco-friendly-filtration-innovations-a-how-to-guide/ (accessed Mar. 18, 2026).
[12] Ansys (2025). Ansys® Granta EduPack (Version 2025 R1). [Software]. Cambridge: Ansys, Inc.]
[13] Environmental Construction Solutions, "Understanding Eco-Friendly Coir Fibers and Their Benefits for Erosion Control," Environmental Construction Solutions [Website]. https://ecsproductsva.com/blog/understanding-eco-friendly-coir-fibers-and-their-benefits-for-erosion-control. [Accessed: Mar. 18, 2026]
[14] "Week 6 Lecture 4 Water Treatment Slides," 1P13 – Lab A, Engineering, McMaster, University, Term 2, 2026