

Novel Methods for Microplastic Remediation from Cosmetic Wastewater as a Response to Poor Consumer Awareness of Microplastic Contamination

Himani Kumar

Investigating the intersection between environmental engineering and public policy, this study evaluates remediation of the harmful presence in wastewater of microplastics, tiny plastic particles under 5mm in size, which have become a significant environmental threat, posing hazards such as ingestion by marine life, bioaccumulation in the food chain, and proven health risks to humans including endocrine disruption and exposure to toxic chemicals. To test novel removal methods, we experiment with dialysis tubing as well as UV irradiation and identify dialysis tubing as the most effective form of wastewater filtration, reducing microplastics in wastewater by approximately 50%. Compared to current commercial forms of wastewater remediation like sand filters, which primarily remove larger particles, membrane bioreactors, which combine biological treatment and membrane filtration, and advanced oxidation processes, which use chemical reactions to degrade contaminants, dialysis tubing shows a promising higher efficiency in reducing microplastics due to its ability to filter out smaller particles more effectively. Alongside remediation, this study investigates awareness of microplastic risk among users of cosmetics, in the interest of simultaneously cultivating prevention (discretionary use; knowing the risks), in the form of regulatory labeling, as is more common in Europe, as a policy tool. In survey results for this study, participants who were aware of microplastics scored marginally better in a knowledge quiz than those who were not (62.5% vs 57.59%, respectively), indicating evidence of a gap in consumer understanding. Alongside novel methods to remediate wastewater, stricter regulations and mandatory labeling of microplastic-containing products show clear potential to mitigate environmental impact.

Presenting Author: Himani Kumar

Microplastic Remediation of Wastewater Due to Poor Consumer Awareness of Contamination

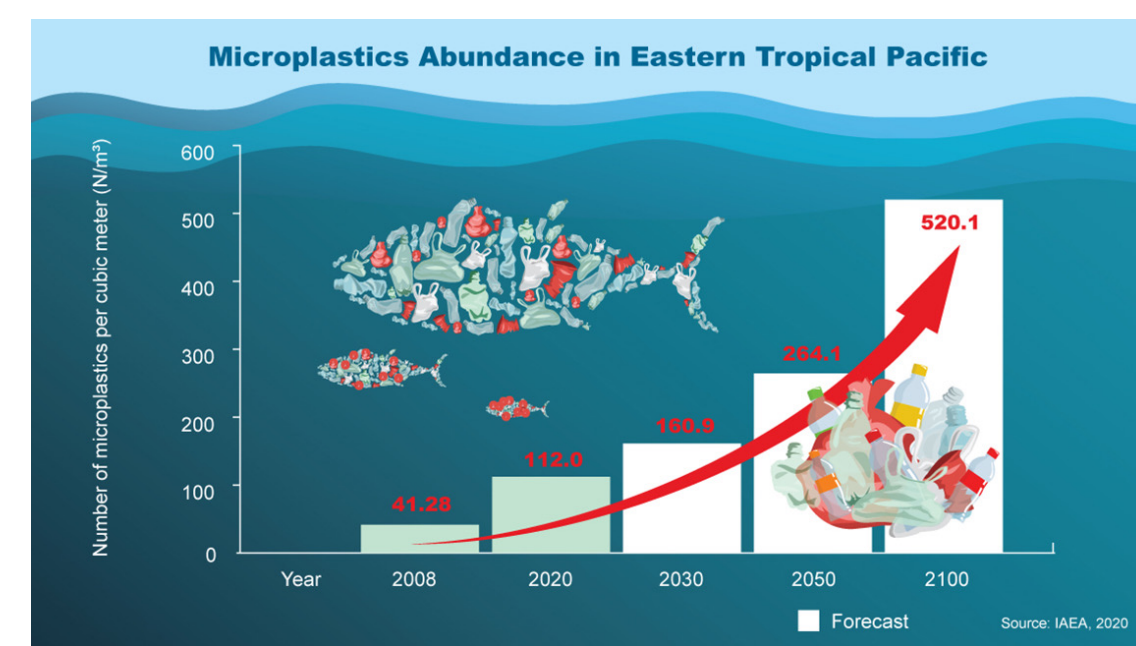
Himani Kumar, Farmington High School

Research Mentors: Dr. Laura Butterfield, Farmington High School

Introduction

- Microplastics are tiny particles (<5mm) originating from the breakdown of larger plastics from industrial processes and cosmetic products.
- These particles persist in the environment and harm aquatic ecosystems and human health, by disrupting endocrine functions.
- Despite regulations like the Microbead-Free Waters Act of 2015, gaps and loopholes allow continued microplastic use.

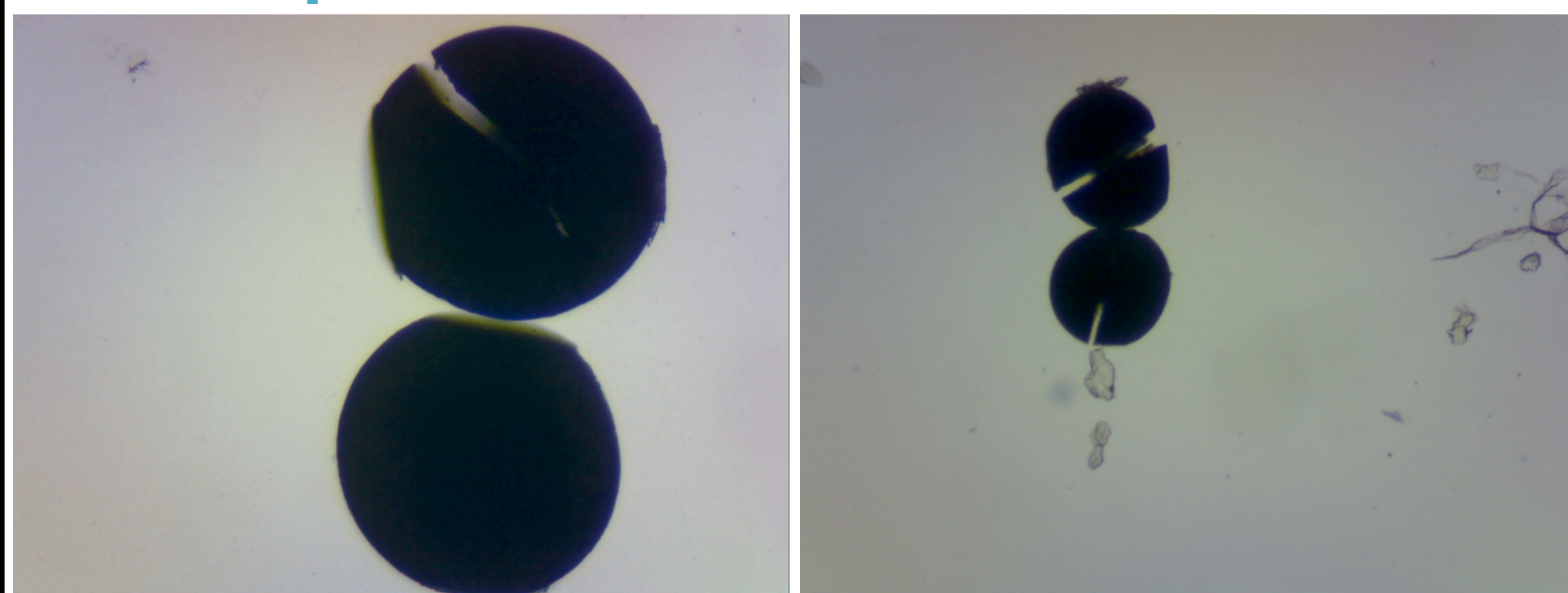
- This study analyzes microplastic presence in cosmetics, reviews regulations, and tests removal methods to propose strategies for reducing environmental impacts.



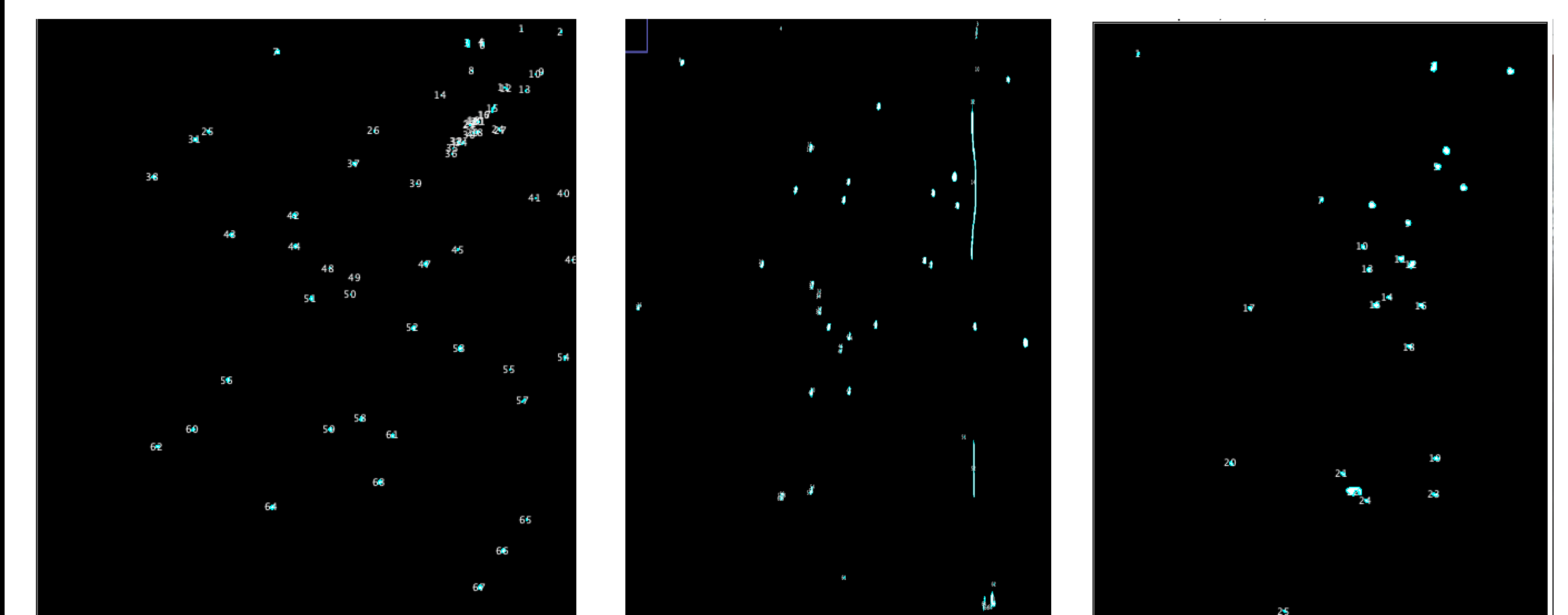
Methods

- Polyethylene (PE) microplastics (500-600 μm) were mixed into a 0.1% solution using distilled water and a surfactant. The mixture was stirred for 5 minutes to ensure even distribution.
- 300 mL of the microplastic solution was exposed to UV-C radiation at 254 nm for various durations (0 to 166 hours). Changes in particle size and shape were analyzed using microscopy and ImageJ software.
- Three filter types (cellulose filter paper, activated carbon filter, and dialysis tubing) were tested. Each was weighed before and after filtering 300 mL of microplastic solution to determine the removal efficiency.
- A survey created on Qualtrics measured consumer awareness of microplastics in cosmetics, sampling mainly high school students. Data was analyzed using Excel and statistical methods.

Experimentation Results



UV Testing: Microplastics under a digital microscope (400x magnification) after UV-C exposure. Photos were taken at intervals of 0, 18, 90, 138, and 166 hours. Left: 90 hours. Right: 138 hours.



Filtration Testing: Two filtration trials were conducted. Trial 1 used 5.6 mL of filtered water, while Trial 2 used 0.7 mL. Left: Carbon trial 2, 60 particles, 94.27% reduction. Middle: Dialysis tubing trial 2, 60 particles, 94.27% reduction. Right: Grade 4 paper trial 2, 25 particles, 97.61% reduction.

Experimentation Results Summary

Removal/Degradation Process	Before Filter/UV Light Sample	After Filter/UV Light Sample	Percent Efficiency (percentage of particles removed)
UV-C Radiation	897,000 perfectly sphere particles in 300mL of solution	897,000 sphere particles in 300mL of solution	0.00% efficient*
Carbon Filter	149,500 particles in 100mL of solution	14,643 particles in 100mL of solution	90.21% efficient
Dialysis Tubing	149,500 particles in 100mL of solution	6,929 particles in 100mL of solution	95.37% efficient
Grade 4 Filter Paper	149,500 particles in 100mL of solution	12,607 particles in 100mL of solution	91.57% efficient

Figure 3: Summary of data shown above depicting dialysis tubing as the most efficient.

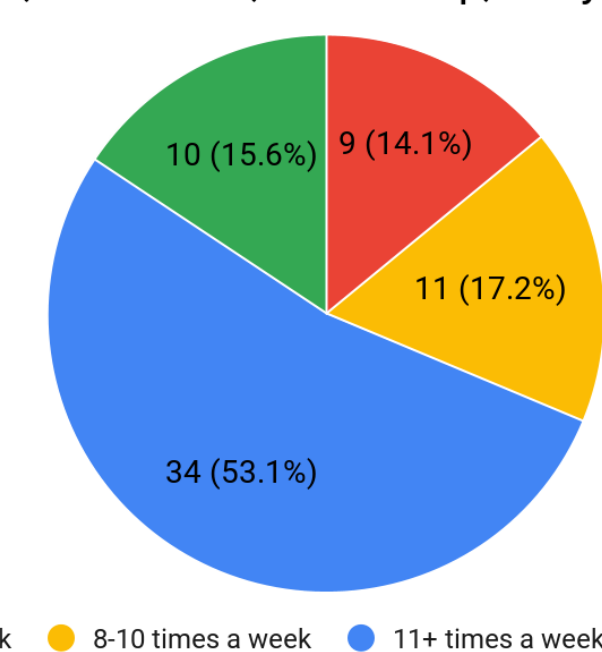
*The UV-C radiation was a method of microplastic degradation instead of physical removal of the microplastics.

The particle counts show the particles remaining after being filtered by the filter being tested. The negative control of this experiment is that there is no change in the particle count from before filtration and after. The results compare the percent of particles filtered so it can be compared between trials.

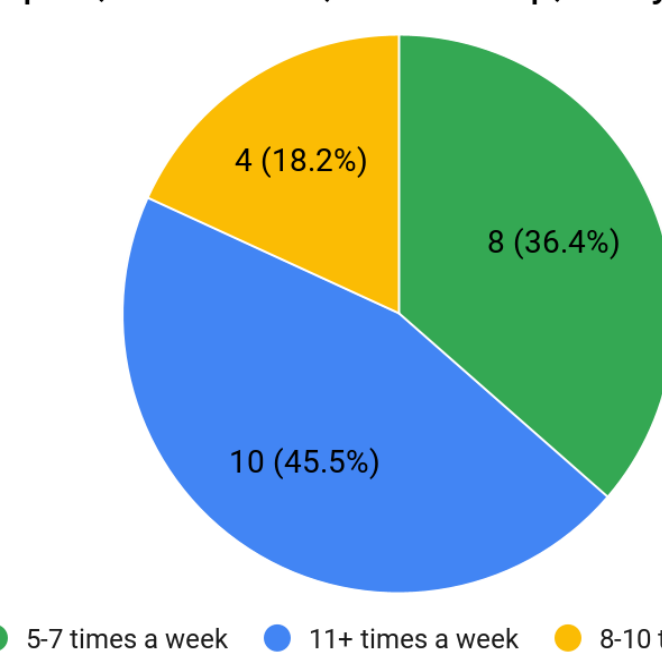
Survey Results

The survey garnered responses from 92 participants spanning four genders (male, female, non-binary, genderqueer) and a wide age range from 6 to 55 years old. Analysis of the survey data revealed varying levels of awareness regarding microplastics in cosmetics among participants. Notably, a concerning lack of knowledge was observed among certain demographic groups, highlighting the need for targeted educational initiatives to enhance understanding of this environmental issue. Additionally, the survey provided insights into consumer preferences and behaviors regarding the use of cosmetic products containing microplastics, indicating potential avenues for regulatory intervention and consumer advocacy.

How often do you use washable cosmetics products (ex: shampoo, face wash, hand soap, body wash, etc)

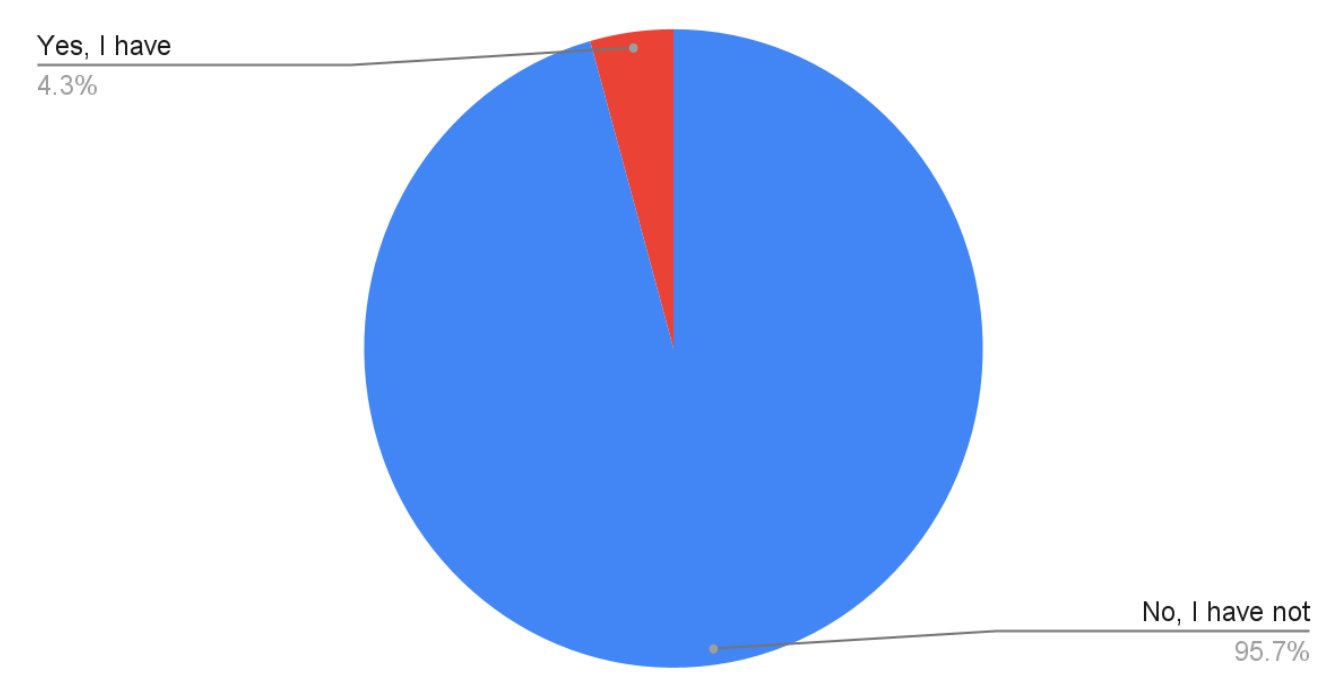


How often do you use washable cosmetics products (ex: shampoo, face wash, hand soap, body wash, etc)

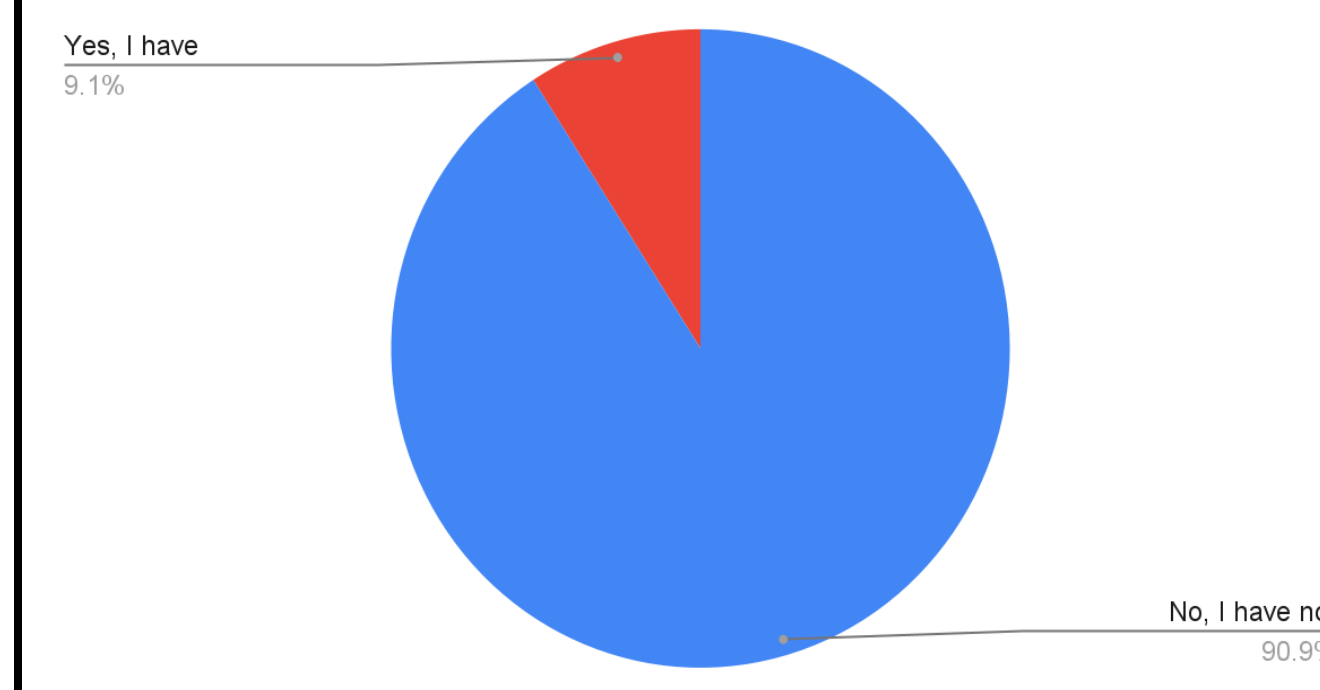


Left: Female data cut depicting that the majority of females use washable cosmetic products 11+ times a week.
Right: Male data cut depicting that the most number of males use washable cosmetic products 11+ times a week.

Have you ever actively looked for information about microplastics in the cosmetics you use?



Have you ever actively looked for information about microplastics in the cosmetics you use?



Left: People who use cosmetics 11+ times a week.
Right: People who use cosmetics less than 11 times a week.

Average Knowledge Quiz Scores (Percentage Correct)

Have looked into microplastics in their cosmetic products	62.50%
Have not looked into microplastics in their cosmetic products	57.59%

Figure 8: Table depicting the average knowledge quiz scores being slightly higher for participants who have previously looked into microplastics in their cosmetic products.

Conclusions

Key Findings

- Dialysis tubing proved to be the most effective filtration method for removing microplastics, outperforming carbon filtration and Grade 4 paper (Figure 3).
- UV radiation did not effectively degrade microplastics, aligning with existing research, and suggesting the need for alternative or combined degradation techniques.

Recommendations for Future Implementation

- Further research should explore integrating dialysis tubing into existing wastewater treatment systems to improve microplastic filtration.
- Combining dialysis tubing with other advanced methods, such as membrane bioreactors and oxidation processes, could create more comprehensive solutions.

Consumer Awareness & Regulatory Insights

- Our survey indicated low consumer awareness of microplastics in cosmetics, highlighting a need for mandatory product labeling and educational initiatives.
- The U.S. can learn from the EU's strict regulations and labeling practices, which have significantly increased awareness and reduced microplastic use.

Future Research Directions

- Investigate the long-term effects of UV exposure on microplastics and potential chemical changes.
- Test and optimize hybrid filtration and degradation systems to assess real-world efficiency and feasibility.

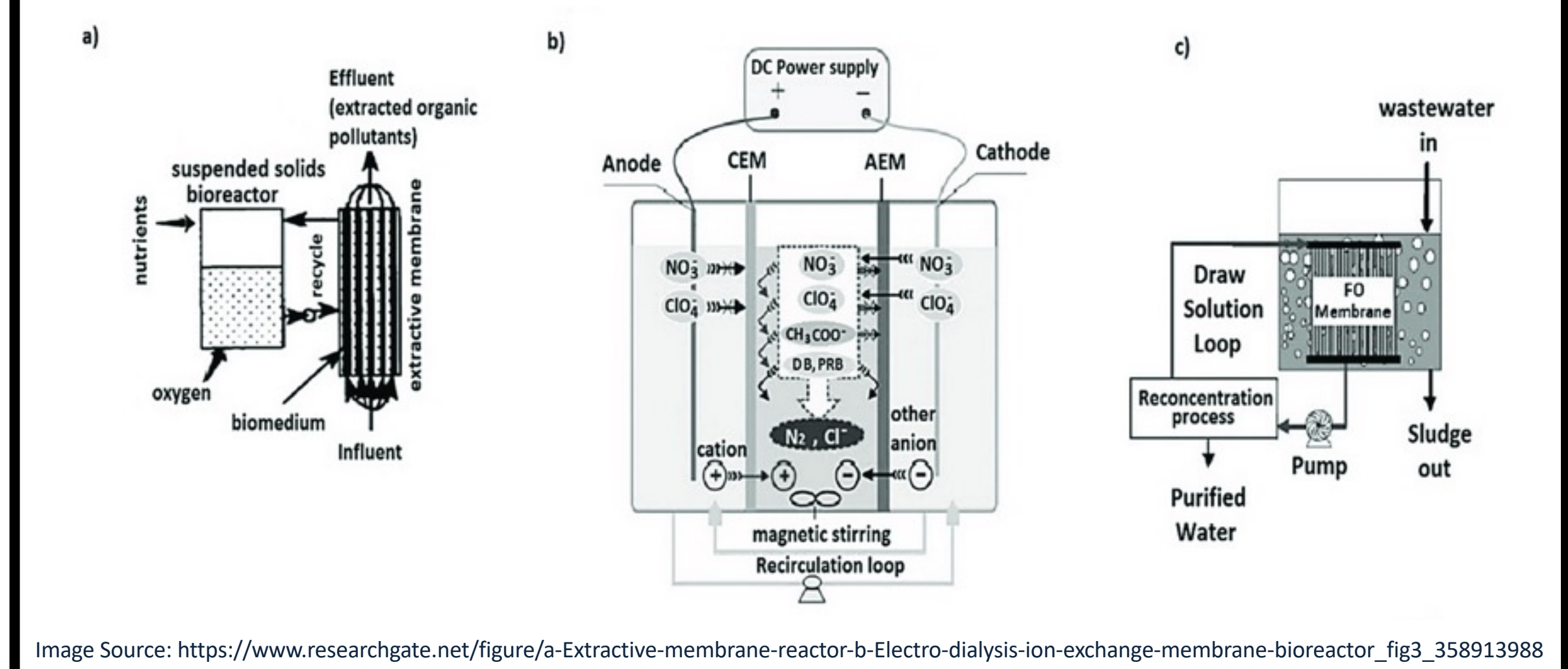


Image Source: https://www.researchgate.net/figure/a-Extractive-membrane-reactor-b-Electro-dialysis-ion-exchange-membrane-bioreactor_fig3_358913988

References



Published Research Paper



Appendix + Bibliography

Acknowledgments

I would like to express my sincere gratitude to my research advisors and mentors for their guidance and support throughout this project. I also appreciate the contributions of my colleagues who helped with the consumer awareness survey and provided valuable feedback. Finally, I thank the institutions that made this research possible, as well as the conference organizers for the opportunity to present these findings.