MICROPLASTIC REMOVAL BY ELECTROCOAGULATION

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Research Question: How does the voltage applied across Aluminium electrodes in the method of electrocoagulation affect the mass of microplastics extracted from water over a time period of 15 minutes?

1. INTRODUCTION

- Microplastics (MPs) are plastic particles less than 5mm in size. They have accumulated in Earth's water bodies at an alarming rate over the past decades
- They have now contaminated several ecosystem and pose health risks for both marine life and humans, such as cancer or respiratory disorders.
- Electrocoagulation is a method to purify these MPs from waste water.
- Metal electrodes are electrolyzed in water, producing metal hydroxide and hydrogen gas.
- Metal hydroxide molecules act as coagulation nuclei for MPs, while hydrogen gas bubbles carry the clumps to the surface

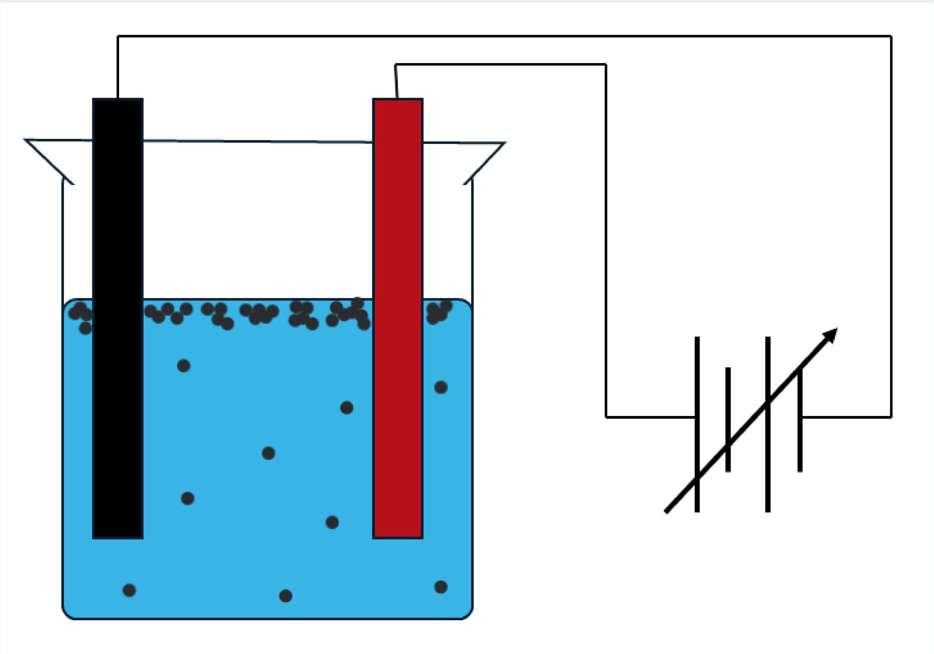

Figure 1: Diagram of experimental setup

Figure 2: MP collection process

2. OBJECTIVE

- We planned to mathematically model the effect of varying electrode voltages on the amount MP coagulation.
- We wished to find a "plateau point" for different voltages. This was defined to be the point in time after which the rate of MP removal was less than 1 mg/min, which we consider to be negligible.
- We also wanted to determine a voltage beyond which any increase in voltage would negligibly decrease the time taken to reach the plateau point

3. METHODOLOGY

- The experimental setup is depicted in Figure 1.
- To measure amount of MPs extracted, our initial idea was to count MPs in a sample under a microscope but this did not work because of difficulties in pipetting out samples.
- We invented a new method, where we used a quadrant of filter paper to collect coagulated MPs from the surface, as shown in Figure 2.
- The dry mass of the filter paper was measured before and after the collection to find how much microplastics had been extracted (Figure 3). This was assumed representative of the total coagulated MP mass.
- Each voltage was maintained for 15 mins with a sample taken every 5 min.
- This data was used to model the amount of microplastics coagulating against time for each voltage. The natural logarithmic curve fit best to our data

$$M(t) = A \ln(Bt+C) + D$$

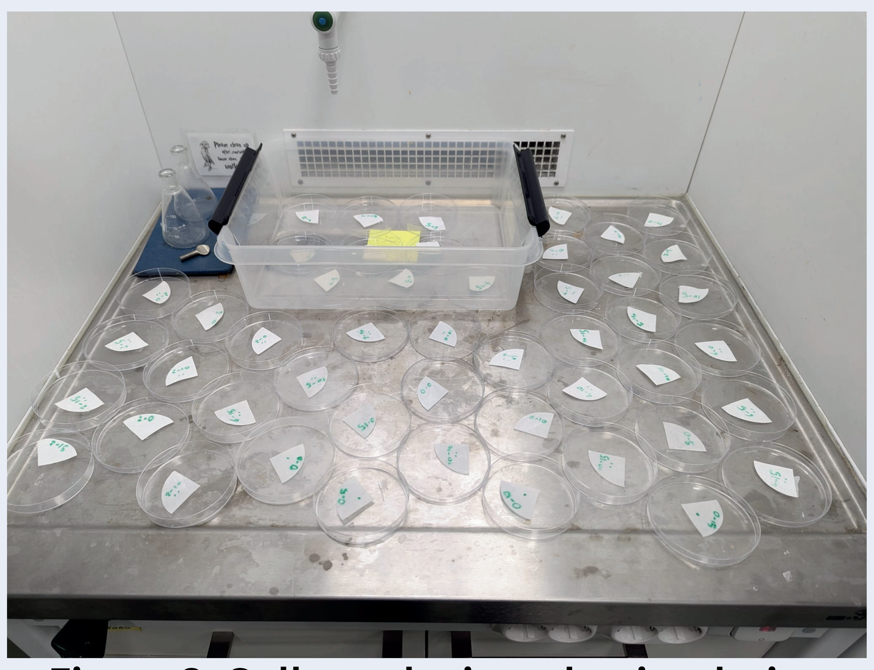

Figure 3: Collected microplastics drying

Figure 4: MPs coagulating at cathode

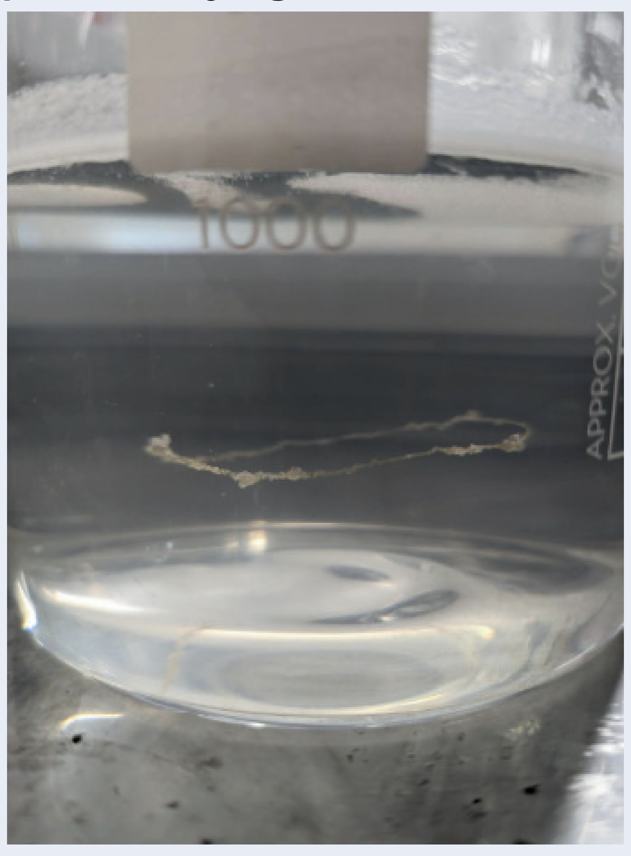

Figure 5: Strange microplastic structures forming overnight

4. RESULTS

- Mass of MPs extracted had increased with time, with usually decreasing rate of MP extraction (Figure 6)
- In the experimental duration, varying voltages did not seem to affect coagulated MP masses
- For electrode voltages V < 8.00V, the amount of MPs extracted with time could be closely modelled by a logarithmic curve in the 15 mins. The model for V=0.00V and 2.00V was rejected, because it did not follow real world conditions
- V=10.0V showed the least "plateau point" = 21 min
- The plateau point for the voltages was identified (Table 1)
- 8V stood out among the voltages, as it led to the greatest decrease in plateau point time from 6.00V, and increasing the voltage further to 10.0V led to a negligible improvement in the plateau point

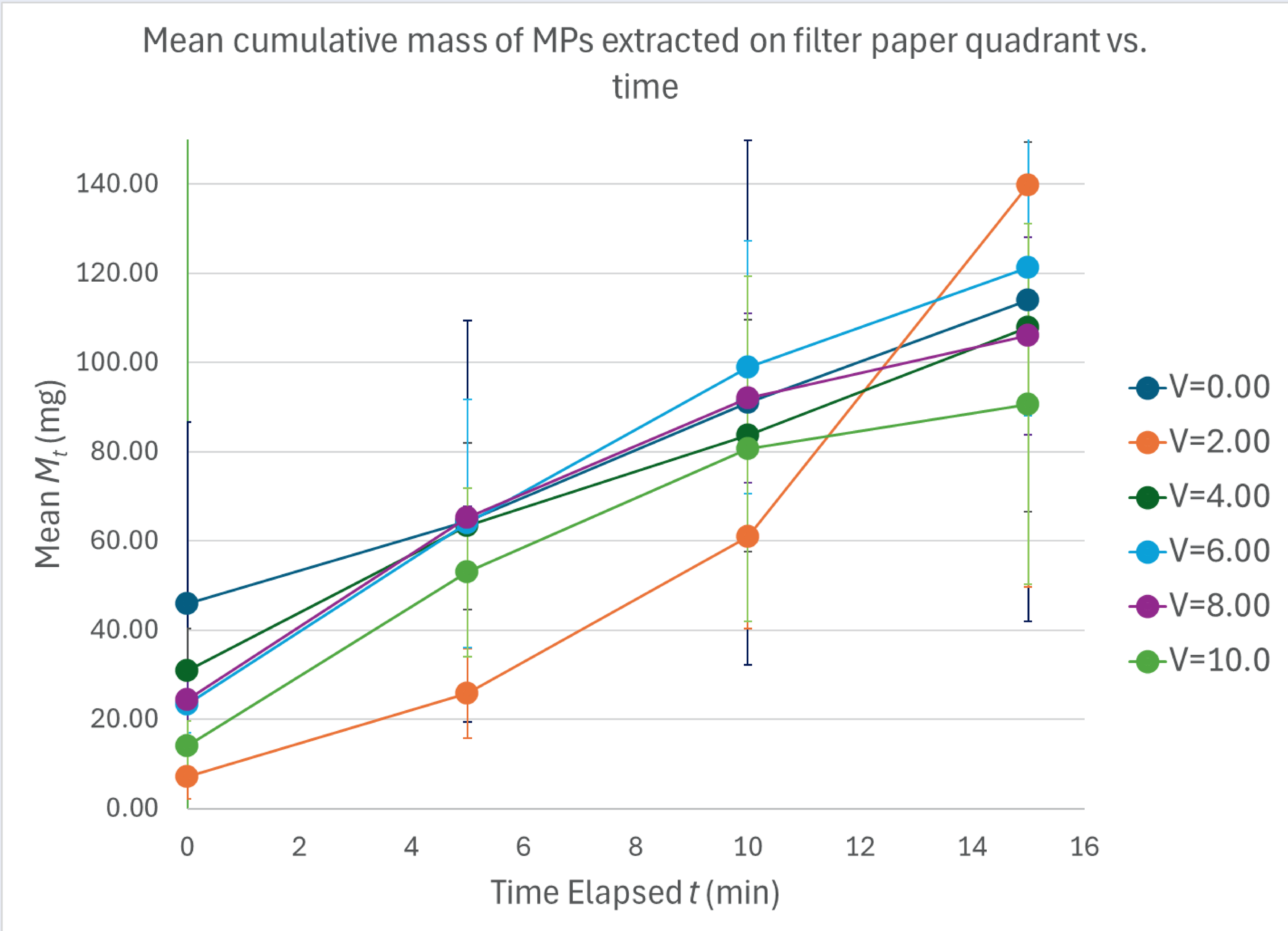

Figure 6: Mass of microplastics extracted

Table 1: Plateau Point Data

V (in V)	0.00	2.00	4.00	6.00	8.00	10.0
t (in min)	Model rejected after 15 min		119	113	23	21

5. LIMITATIONS

Various sources of error:

- Though the filter paper quadrants were the same area, MPs were collected from slightly different areas of the liquid surface
- The electrodes were not kept at a perfectly constant distance away from each each other
- Collecting more data will make our models more accurate, especially for V=0.00V and 2.00V, since their models did not show real world conditions
- The initial t=0s reading for all the microplastics is not the same for all voltages which shows that the distribution of MPs was not initially homogeneous, perhaps due to uneven stirring

6. CONCLUSIONS

- We identified the plateau point for different voltages
- Corporations can use this data to run the electrocoagulation process for the optimal amount of time that maximizes MP extraction for minimum time
- We also identified the best voltage, 8.00V, in the experimental domain, providing a good option for corporations which purify wastewater to optimize the electrocoagulation process
- These findings save time, energy, and money, making electrocoagulation more appealing and contributing to the effort to clear the oceans, one particle at a time