Microplastic Extraction Through Airflow at Terminal Velocity

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Abstract

This research has explored varying methods of extracting microplastics from dry beach sand samples. Extraction methods have included separation by density, separation by electric charge, separation by size, and separation by the difference in terminal velocity. Extensive testing using a scale wind tunnel and anemometer was performed to confirm the ability of airflow to separate microplastic from beach sand according to their terminal velocities. Testing proved the terminal velocity separation method to be successful. This method will be implemented on an autonomous robot once the research team may reconvene.

Methods

The team initially drafted several methods for microplastic extraction. Through team discussion and decision matrices made by the Design Sub-team, the following extraction methods were deemed viable:

- Density separation
- Size separation
- Separation by electric charge
- Separation by difference in terminal velocity.

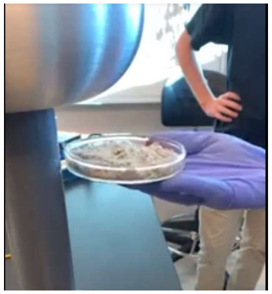
Due to their less efficient nature, density separation and size separation were ruled as tertiary choices. To choose between these two methods, the following decision matrix was used.

Criteria	Weight	Density		Size	
		Score	Total	Score	Total
Cool Factor	1	3	3	2	2
Energy Drain	4	2	8	4	16
Volume	2	4	8	3	6
Complexity (Designing)	5	3	15	4	20
Feasibility	3	3	9	4	12
Failure Potential	4	3	12	4	16
Time-Consumption	2	4	8	2	4
Effectiveness	3	2	6	3.5	10.5
Software and Electrical Complexity	2	3	6	3	6
Maintenance	4	2	8	3	12
	0	0	0	0	0
	0	0	0	0	0
Total (out of):	150		83		104.5

Separation through electric charge or terminal velocity were then deemed test worthy. Calculations were then performed to obtain the electric field strength required to pick up plastic and for the terminal velocities of microplastic and sand.

Results

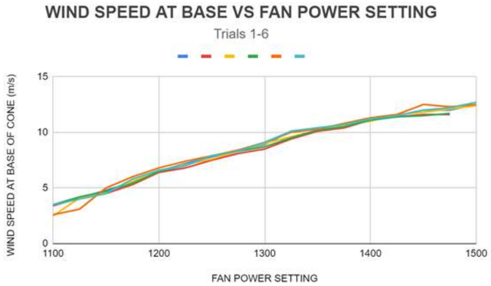
The team identified that the electric charge of sand should differ from that of microplastic. Testing to confirm was performed using a Van de Graff generator as shown below:



The test failed for the following reasons:

- Sand was attracted to the Van De Graaf generator
  - Sand was more easily polarized than microplastic
- After the generator was turned off, the sand was difficult to remove from the generator
  - This would make it very difficult for the robot to remove the sand entirely on its own

Using calculus and physics concepts, the team calculated the theoretical terminal velocity of microplastic of average size was 11.03 ft/s and that of sand was 3.21 ft/s. To test these theoretical values, the team constructed a simulated wind tunnel using Bernoulli's Principle. Since airspeed inside a tube increases as the tube's diameter decreases, the team created a tube of 2' in length that was 6" wide at the intake and 1" wide at the outtake. The following graph shows a result of the acquired airspeeds at the outtake:



Simulated tunnel testing proved that the air speed could match that of the theoretical terminal velocity of microplastic. A mixture of microplastic and sand was then injected at the intake and the microplastic naturally separated from the sand. The operating airflow was at the terminal velocity of sand, allowing it to move past the falling microplastic.

Conclusion

Terminal velocity separation was chosen through decision matrices and team discussion. This method was proven by first calculating the terminal velocities of a microplastic of average density and a single grain of sand, respectively.

This method has been proven successful for the following reasons:

- Fast enough air speed can be obtained in a small simulated wind tunnel to be at the terminal velocity of sand
- Sand can be separated from microplastics due to the 109.83% difference respective terminal velocities
- Specifically designed and 3D printed parts will make up the tunnel to contain airflow
- Propeller blades like that of drones can be used to cause the airflow to move

Forthcoming

The team will be implementing the proven sand sorting method on an autonomous robot in Fall 2020. Following the reconvening of Embry-Riddle, the team will be meeting once again to construct the robot and test it along Volusia County's shoreline.

Methods are being explored to reuse and upcycle microplastics including:

- Conversion to 3D printing filament
- Molding microplastics into bricks to construct buildings
- Conversion to generic building materials
- Conversion to manufacturing materials
- Molding microplastics into receptacles for aquaponics
- Research into the further breakdown of microplastics
- Research on the effect of microplastics on human health