DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

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Recovery of Microplastics from Marine Sediment

Introduction

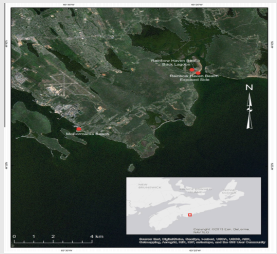
Aquatic microplastic pollution is a growing concern due to potential harm to aquatic life.

To address this, our project is to design a process to recover microplastics from marine sediment. Some specifics:

- 98% recovery by mass
- 90% recovery by number
- Modular system
- Fits within side-by-side 40 ft storage containers
- Operable in both coastal and freshwater environments
- Determine cost of cleaning sediment

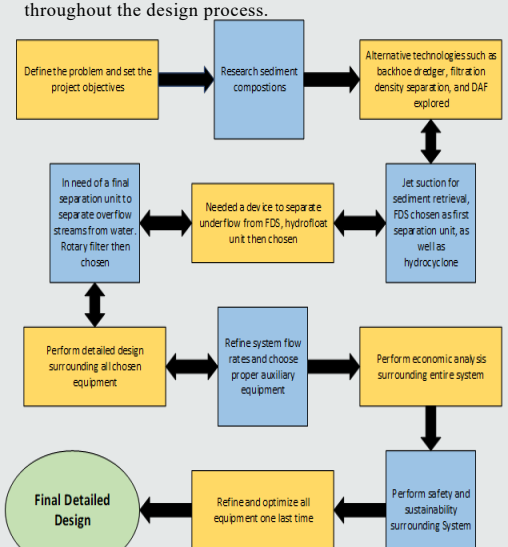
Location of three potential sampling sites within NS

- Rainbow Haven Beach
  - Back Lagoon
  - Exposed Side
- McCormacks Beach

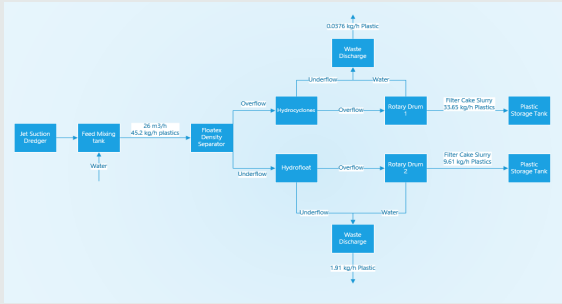


Design Approach

Base of the problem is removing dilute contaminant, without chemical means, due to environmental concerns. Flowchart briefly illustrates design approach taken throughout the design process.

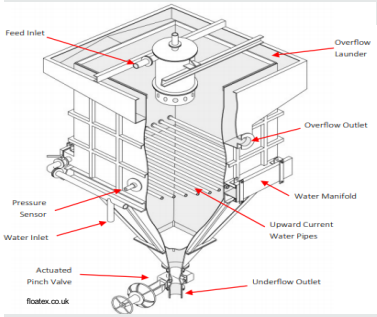


Details of Design



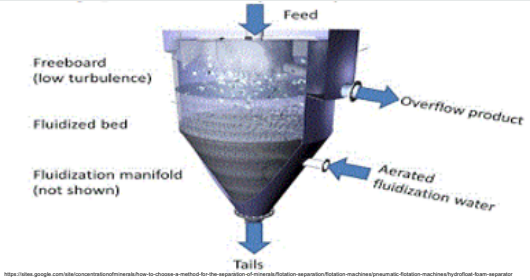
- Jet suction system used to retrieve the sediment sending it to a mixing tank.
- Initial separation by FDS, sending it to a Hydrofloat and Hydrocyclone where further separation takes place
- Streams are sent to a Rotary Filter for the final separation, where they are stored for disposal
- Storage can hold ~9 hours of operation

Floatex Density Separator



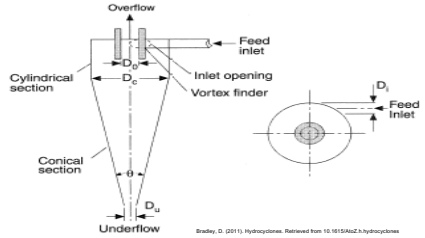
- First cut, separates light from heavy plastics for further processing.
- Teeter water pushes low slip velocity particles to overflow, others settle.
- Height: 5.3 m, Footprint: 1 x 1 m

Hydrofloat Separator



- Separates the large and heavy plastics from the sediment particles
- Utilizes the difference in hydrophobicity between the plastics and sediment to separate the two.
- Dimensions (DxH): 36x82 in

Hydrocyclone



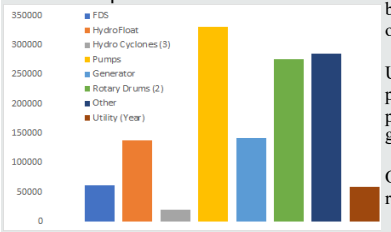
- Separates the small and light microplastics entering from the FDS
- Separation device uses gravitation and centrifugal force to separate light from the course particles.
- Dimensions (DxH): 12x48 in

ALAR Auto-Vac 340 Rotary Filter

- Separates the microplastics from water of the overflow streams from the Hydrofloat and hydrocyclone
- The filter must be able to separate a wide range of plastics (0.1-5000 microns)
- Filter cake that has a moisture content of below 15%
- Dimensions (HxWxL): 8' x 8'-7" x 12'-7"

Economic Analysis

Capital Cost Estimation



*Does not include boat for aquatic operation.

Utility is based on power needs, provided by diesel generator.

Other includes retrieval, storage, etc.

The cost of the separation units and utilities is relatively small. Moving streams, recovering plastic at end is main expense.

Column1	Area Cleaned (m2)	Utility	TAC
Year	62462	$ 59,435	$ 515,140
Day	171	$ 163	$ 1,411
Purchase Cost	$ 1,251,460	Bare Module Cost	$ 2,795,735

Assumed one shift per day due to storage limitation. Operators not included. Cleaning area assumes 5cm depth of sediment. The total annualized cost allow for an estimation of possible sale price or service charge. Market is unknown, but cost does not seem unreasonable.

Conclusion and Recommendations

Current recovery is ~96% by mass, will vary based on specific plastic and sediment composition. Large, heavy plastics are the most difficult to remove. Cost does not seem unreasonable, but market is unknown. System is transportable, operable in different conditions.

Mass of plastic entering the FDS (kg/h)							
Size (microns)	Density (kg/m3)						
	850	950	1050	1150	1250	1350	
0 - 100	0.26	0.31	0.13	0.04	0.04	0.09	Overflow
100 - 250	0.81	0.95	0.41	0.14	0.14	0.27	
250 - 500	2.72	3.18	1.36	0.45	0.45	1.64	Underflow
500 - 1000	4.77	5.57	2.39	1.43	1.43	2.87	
1000 - 5000	3.44	4.02	1.72	1.04	1.04	2.07	
Total	12.00	14.03	6.01	3.10	3.10	6.94	45.19

Mass of plastic recovered from system (kg/h)							
Size (microns)	Density (kg/m3)						
	850	950	1050	1150	1250	1350	
0 - 100	0.27	0.31	0.13	0.04	0.04	0.09	Hydrocyclone
100 - 250	0.81	0.95	0.41	0.14	0.14	0.27	
250 - 500	2.72	3.18	1.36	0.45	0.45	0.99	Hydrofloat
500 - 1000	4.77	5.57	2.39	1.28	1.19	2.22	
1000 - 5000	3.43	4.02	1.71	1.04	1.04	1.86	
Total	12.00	14.03	6.00	2.95	2.86	5.43	43.26

To improve results:

- Sediment/plastic composition/distribution should be known for site
- Investigation into the hydrophobicity of various sediment particles
- Simulation or scale testing to ensure theory calculations are correct
- Using a more advanced calculation technique for the numerical simulations and to perform simulations for the hydrocyclone using software such as the Fluent Software

Design procedure for outside-drum rotary vacuum filter. (1965). *Chemical and Petroleum Engineering*, *1*(5), 376-382. Green, DW and Perry, RH, *Perry's Chemical Engineers' Handbook*, Chapter 6, 8th Edition, McGraw-Hill, 2007 Hidalgo-Ruz, V., Gutow, L., Thompson, R., Thiel, M. (2012). Microplastics in the Marine Environment: A Review of the Methods Used for Identification and Quantification. *Environmental Science & Technology*, *46*(6), 3060-75. 10.1021/es2031505. Matthan, A., & Hill, P. (2014). Microplastic fibers in the intertidal ecosystem surrounding Halifax Harbor, Nova Scotia. *Marine Pollution Bulletin*, *81*(1), 69-79. Patchaiyappan, A., Zaki Ahmed, S., Dowarah, K., Jayakumar, S., Devipriya, S. P. (2020). Occurrence, distribution and composition of microplastics in the sediments of South Andaman beaches. *Marine Pollution Bulletin*, *156*.