Microplastic Analysis in Beach Sand: Isle of Man

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Abstract

Microplastic pollution is a growing problem around the world, especially in marine environments as plastics are the most prevalent type of marine debris found in the world's oceans (Zhang, 2017). There are a variety of sources and types of microplastics but can be grouped by physical description such as fibers, fragments, films, and foams. Plastics can be mistaken as food or carry contaminants to those ingesting water or food containing microplastics, resulting in adverse effects in humans and ecosystems. The Isle of Man sits between Ireland and England in the Irish Sea, and plastics are deposited on the island's beaches by wind, currents, and tides. It is hypothesized the beaches with larger human populations will have higher numbers of microplastics. Three samples were taken at the low and high tide marks from three beaches located on the East, Southeast, and Northwest sides of the island during the YSU Field Investigation course in the spring 2023 (Figure 2). A modified NOAA method was used to determine the amount of microplastics present, and through this process, it was found that the dominant type of microplastic was black or blue fiber of small or medium length (<5mm, 5-10mm). The hypothesis was rejected since Kirk Michael Beach had the highest amount of microplastics of all three of the beaches sampled. This may be attributed to currents, tidal flows, or boat activity which tend to be on the west side of the island.

Figure 1 Types of microplastics

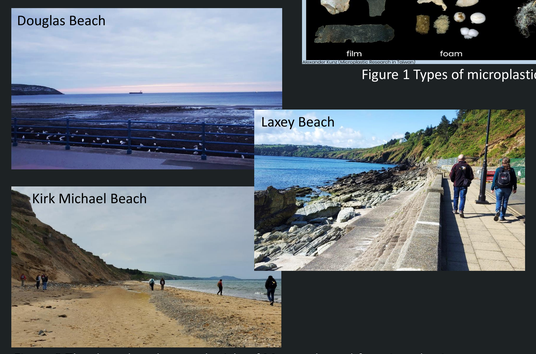


Figure 2 The three beaches on the Isle of Man evaluated for microplastics.

Introduction

Microplastics are plastic pieces less than 5mm in size (NOAA, 2023), and they can come from a variety of sources, including (Figure 1):

- Secondary: Fragments, films, fibers - larger plastics that degrade into smaller pieces
- Primary: Microbeads, nurdles – particles designed for commercial use

These substances can cause problems in ecosystems and organisms, from aquatic organisms mistaking them for food to microplastics carrying diseases and toxic chemicals into the bodies of humans and other organisms.

This project focuses on microplastics found in beach sand from the Isle of Man, and it is part of a continuing project to examine microplastic pollution around the island. This research objectives are to determine whether tidal fluctuation and the proximity and size of populations to the beaches sampled contribute to the amount of microplastics found in the samples. It is hypothesized:

- The high tide zone will see more microplastics due to wave action in the low tide zone breaking up microplastics into pieces that are too small to analyze visually.
- Beaches that have a higher human population nearby will contain more microplastics.

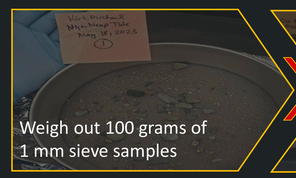
The populations near each of the selected beaches as stated in the Isle of Man's 2021 census show that Douglas Beach has the largest nearby population (Isle of Man Government, 2022):

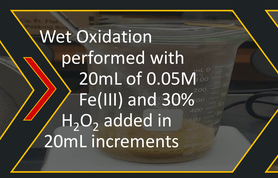
- Douglas = 26,677 (31.7% of total pop.)
- Laxey = 1,656
- Michael = 1,522

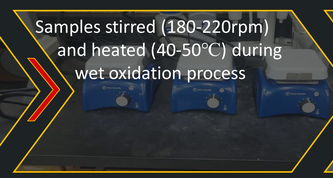
Based on these assumptions, the sample of the Douglas Beach high tide zone should see the highest amount of microplastics in this analysis.

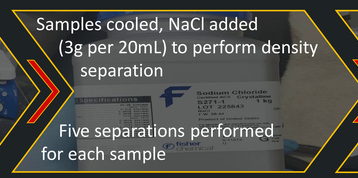
Methodology

Samples were taken from three beaches on the Isle of Man as a continued evaluation of microplastics in beach sand. The method used for this research is a modified NOAA method (NOAA, 2024) with additions of density separations previous developed in prior research. The samples were initially dried on the island before being flown back to Ohio.

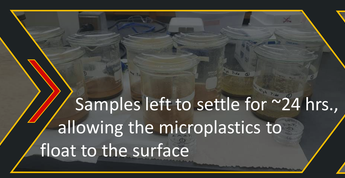

Weigh out 100 grams of 1 mm sieve samples


Wet Oxidation performed with 20mL of 0.05M Fe(III) and 30% H_2O_2 added in 20mL increments


Samples stirred (180-220rpm) and heated (40-50°C) during wet oxidation process

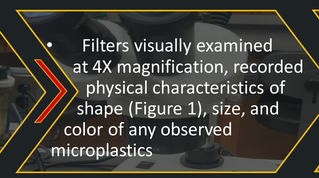

Samples cooled, NaCl added (3g per 20mL) to perform density separation

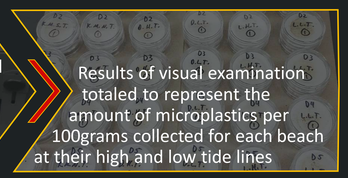
Five separations performed for each sample


Samples left to settle for ~24 hrs., allowing the microplastics to float to the surface


Supernate filtered through 1.2 micron glass filters using vacuum filtration

Collected as little sediment as possible when removing supernate


- Filters visually examined at 4X magnification, recorded physical characteristics of shape (Figure 1), size, and color of any observed microplastics


Results of visual examination totaled to represent the amount of microplastics per 100grams collected for each beach at their high and low tide lines

Results

When examining the glass filters the following parameters were used for characterizing the size of the microplastics:

Fibers:	Fragments and Films
• Small = <5mm	• Small = <0.25mm
• Medium = 5-10mm	• Medium = 0.25-1mm
• Large = >10mm	• Large = >1mm

Filter examination yielded the following (Figure 4):

- Highest MP concentration – Kirk Michael
- MP concentrations higher in high tide zone:
  - Kirk Michael Beach
  - Laxey Beach
- Small blue/black fibers the dominant MP in most samples (Figure 3)

Kirk Michael Beach

Tide	Microfibers /100g	Total MP /100g	St. Dev.
High Tide	50	61.3	±17.2
	Dominant MP: Small blue and black fibers		
Low Tide	49.3	56.7	±9.1
	Dominant MP: Small blue and black fibers		

Laxey Beach

Tide	Microfibers /100g	Total MP /100g	St. Dev.
High Tide	36.7	39.3	±3.2
	Dominant MP: Small blue and black fibers		
Low Tide	30.7	32	±8.1
	Dominant MP: Small blue, grey, and black fibers		

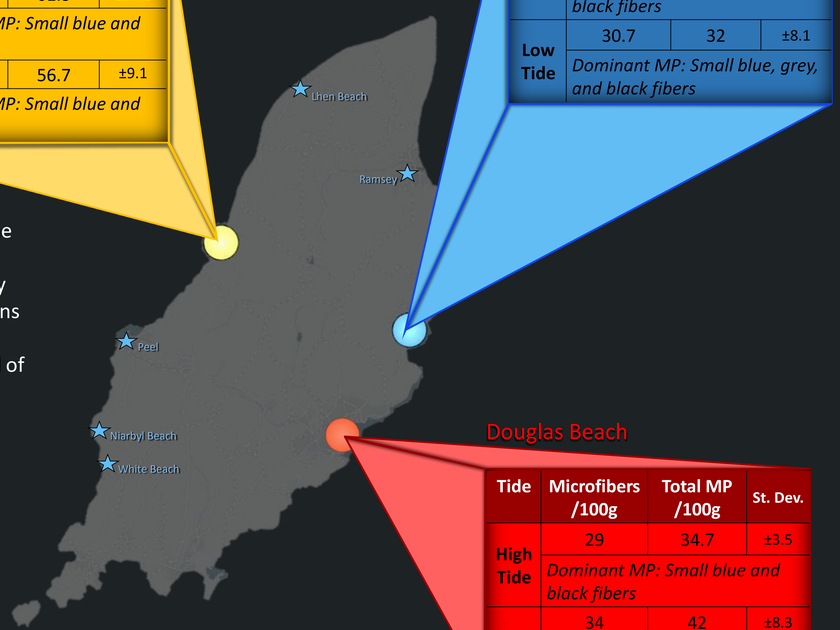


Figure 4 Results of microplastic analysis on Isle of Man sand samples taken in May 2023.

Douglas Beach

Tide	Microfibers /100g	Total MP /100g	St. Dev.
High Tide	29	34.7	±3.5
	Dominant MP: Small blue and black fibers		
Low Tide	34	42	±8.3
	Dominant MP: Small blue, grey, and black fibers		

Table 2 Previous analysis of MP from additional IOM beaches. HT = High Tide, LT = Low Tide, MT = Mid Tide

Sample (2020)	Microfibers (number)	Total MP /100 g	Standard Deviation
Peel HT	20.7	32.4	± 7.9
Peel LT	20.7	26.4	± 8.3
Sample (2017)	**Microfibers /100g**	**Residual /100g**	**Avg. Total MP/ 100 g**
Ramsey HT	15.7	2.4	18.1
Ramsey MT	23.6	3.6	27.2
Lhen HT	9.7	1.2	10.9
Lhen MT	0.0	0.0	0.0
Niarbyl HT	4.4	1.5	5.9
Niarbyl MT	4.0	5.3	9.2
White HT	15.1	5.0	20.2
White LT	13.4	2.4	15.9

Figure 3 Magnified fibers observed on glass filters

Compared to results from previous research (Table 2), the beaches sampled for this project had significantly higher concentrations of microplastics. Peel Beach was the only beach from the previous sampling that had concentrations comparable to those in this project, and this is probably because the other four beaches used a different method of analysis than the one on this project.

One blank was run for each beach, and they were left uncovered throughout the process until vacuum filtration was completed. Microplastics were found in each blank (Table 1). There was direct contamination within the pipetting process as the suction balls shed rubber/plastic fragments (Figure 5) throughout the samples (not included in the results).

Table 1 Blank data from glass filter analysis

Blanks	Total Microplastics
Kirk Michael	8
Douglas	27
Laxey	32

Discussion

It was originally assumed that more microplastics would be measured at the beach that had the largest nearby population, but the results show that the opposite was true in this case. This could be for a few reasons, including:

- Current dynamics around the island
- More cleanup opportunity on more populated beaches (Beach Buddies)
- Fishing around the island (Blue Nets)
- Plastic is coming from sources outside of the island

Figure 5 Magnified fragments observed on glass filters.

The population element of the hypothesis is rejected, but the influence of tidal fluctuation on the observed microplastics is evident in the data. There is an increase concentration of MPs in the high tide zone in 2/3 of the beaches from this sampling and 3/5 of the beaches from the previous sampling (Table 2). With more sampling and the improved method used in this project, this trend may become more evident.

This project was based off the microplastic analysis method designed from previous microplastics research. This research identified additional improvements that can be made to reduce contamination and improve results:

- Complete 4 or more density separations to extract microplastics.
- Run blanks that are open and blanks that closed to the environment.
- Use a different method of pipetting to remove the contamination seen in this analysis.

References

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