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Article

An analysis of the distribution of microplastics along the South Shore of Long Island, NY

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SUMMARY

Plastic pollution has exponentially increased in recent years, becoming an international concern. Microplastics, or plastic particles measuring less than 5 mm in length, have consequently become ubiquitous and harmful in the marine environment, ultimately putting the biosphere at risk. Scientists recognize the importance of understanding the distribution of microplastics in the environment to develop policy and tools to combat this issue and promote sustainability. In this experiment, we sought to identify the concentrations of microplastic pollution in the sand of various locations along the coastline of the South Shore of Long Island, New York. This study involved an initial collection of sand followed by microplastic extraction with sodium chloride, filtration, and quantification via microscopy. We hypothesized that there would be a higher concentration of microplastics in the sand of the beaches that are closer in proximity to New York City whereas the locations farthest from the city would have lower concentrations of the contaminants. Based on the resulting p-value of 0.75, we concluded that there were no statistically significant differences between the numbers of microplastics collected from each sampling location. However, since microplastics were retrieved from each of these four sampling locations, there is evidence that microplastics are present along the South Shore, which is important to further research.

INTRODUCTION

First escalating after World War II to meet the demands of society, plastic production has exponentially increased from 2.3 million tons in 1950 to 448 million tons in 2015, with this number expected to double by 2050 (1). Combined with the lack of recycling efforts and an increasing "throw-away" consumer culture among society, plastics continue to rapidly accumulate on Earth. For instance, a recent report deduced that European countries recycle between 35% and 45% of their plastic waste, while the United States only recycles a mere 10% (2). This statistic not only highlights the severity of this issue in the United States, but it also depicts a pressing problem that is plaguing the planet, as a shocking majority of plastic waste is not recycled and is left to pollute the Earth. As a result of mediocre recycling practices, the remaining abundance of plastic waste accumulates in landfills or the natural environment and typically enters the marine environment (3). Every year, about 8 million tons of plastic waste escapes into the oceans from coastal nations, which is the equivalent of placing five garbage bags of trash on every foot of coastline of the world (1). Now ubiquitous in the marine environment, plastics put the marine ecosystem at risk.

Once circulating in the world's oceans, plastics can take hundreds of years to fully degrade (1). However, this plastic debris breaks down into smaller particles relatively quickly due to the abundance of wind, sunlight, and wave action, causing the realities and prevalence of plastic pollution in marine environments to sometimes go unnoticed (1). These smaller particles, categorized as microplastics, can measure from only a few micrometers to 5 mm in length (4). To put the size of these plastic particles into perspective, they can be compared to the size of a grain of rice or a sesame seed, and in some cases, they can be invisible to the naked eye. While some microplastics can originate from larger plastic pieces that break down through various weathering processes, termed secondary microplastics, microplastics can also be purposefully produced at their size through manufacturing means for consumer products like cosmetics, which are known as primary microplastics (4). These microplastic contaminants, both primary and secondary, are now recognized on an international scale as one of the most powerful and concerning marine pollutants. A 2017 statement made by the European Union Commission established the significance of microplastics in our world, expressing that microplastics are of great concern due to the negative effects on aquatic life, aquatic environments, biodiversity, and possibly to human health (5). For instance, researchers have determined that microplastics are a detriment to the endocrine and lymphatic systems of marine animals upon frequent mistaken ingestion (6). Evidence also suggests that humans consume a plethora of microplastics through drinking tap water, taking in air, or in some cases, eating shellfish, although the exact threat these particles pose to human health currently remains unknown (6). Proposed consequences to human health include the ingestion of toxic substances and respiratory distress, among other potential complications (7). Ultimately, it is vital to evaluate all aspects of microplastics, yet various critical investigations and studies have yet to be completed.

This issue of microplastic pollution is a growing and relatively new topic of interest, posing a need for further

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understanding of the presence and distribution of these microplastics in the environment (8). Increasing our level of comprehension is essential in developing appropriate policy and management tools to address this prominent issue. Further knowledge regarding microplastics will hopefully raise awareness to decrease plastic consumption and advocate for a more sustainable future.

Coinciding with the abundance of microplastics in the marine environment, these particles can turnover in beach environments and appear in the sand. To better understand the presence and distribution of microplastics along shorelines, we analyzed the sand of the beaches along the South Shore of Long Island, New York for microplastics. This location not only provides insight into the environmental conditions of the specific location, but it also serves as a basis for understanding other locations that are both located in close proximity to an urban area and are directly exposed to an ocean. By taking the nearby populous New York City (NYC) into account, we investigated how the distribution of microplastics varied depending on the sampling location in proximity to NYC. These inquires led to the establishment of our research question: how does the distribution of microplastics on the beaches along the South Shore of Long Island, New York vary depending on proximity to NYC, a populated urban area?

Based on the waste disposal problems that coincide with a densely populated area and a recent report that discovered the abundant presence of plastics and microplastics in the waterways surrounding NYC, we hypothesized that there would be a higher concentration of microplastic pollution in the sand from the beaches closer in proximity to NYC whereas the locations farthest from the city would have lower concentrations of the contaminants (9, 10). However, data and statistical analysis revealed a p-value of 0.75, leading us to the conclusion that there were no statistically significant differences between the numbers of microplastics collected from each sampling location.

RESULTS

In order to test our hypothesis and better understand a potential relationship between microplastic distribution and proximity to an urban area, sand was collected both above and below the wrack line from beaches along the South Shore of Long Island. These two locations of sampling were based on the wrack line in an effort to ensure consistency and uniformity among the different samples. The wrack line was also an ideal location for sampling because since it is a line of debris, it would be a probable location for any potential microplastics. After the collection of these sand samples, a floatation solution and microscope were used to gather data.

Type of Microplastic Polymer	Density (g/cm^3)
Expanded Polystyrene (EPS)	0.015-0.03
Polypropylene (PP)	0.89-0.91
Polyethylene (PE)	0.94-0.97
Polystyrene (PS)	1.04-1.08

Table 1. Common Microplastic Polymer Densities. The salt solution chosen (sodium chloride, which has a density of 1.2 g/cm^3) permits that microplastics of lower densities can be extracted via the filtration method (11).

Microplastics can be retrieved from different sediments with the help of various floatation solutions, such as sodium chloride (NaCl) or sodium iodide (NaI) (11). Only sodium chloride was utilized for this project, as it is both inexpensive and environmentally friendly in comparison to other options (11). After testing the sodium chloride negative control, we determined that there were no microplastics present in the solution. This guaranteed that the purified sodium chloride filtration solution was not a potential contaminant to the samples and their results. Sand has a density of approximately 2.65 g/cm^3, sodium chloride has a density of approximately 1.2 g/cm^3, and many microplastics have lower densities than both (**Table 1**) (11). Once the sand and sodium chloride were spun, any potential microplastics would float along the top of the solution with the sand settled at the bottom since substances of lesser densities rise to the top.
We conducted ten trials per location, five above the wrack line, or the line of debris and organic material that remains on the

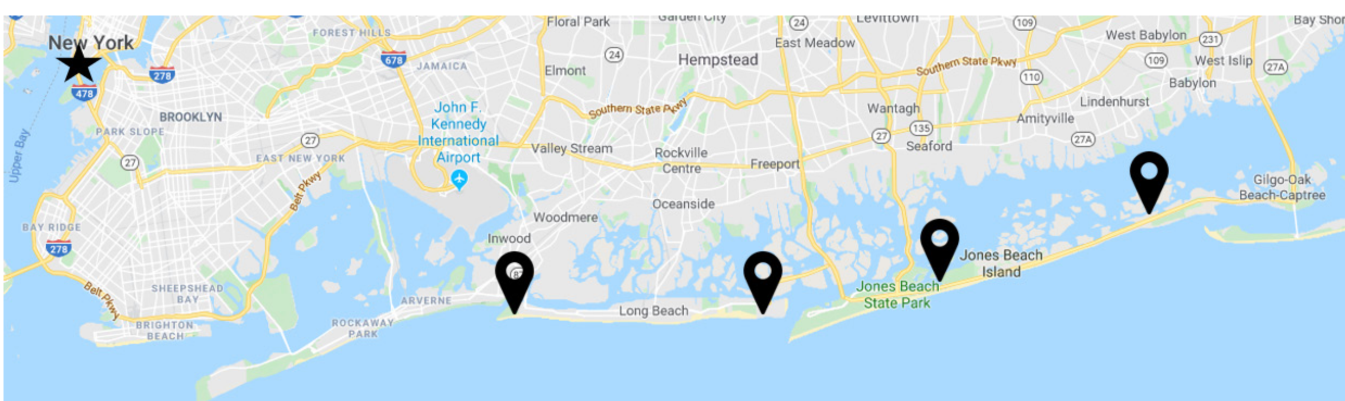

Figure 1. Sampling Locations in Relation to New York City. New York City is starred, and the beach locations are pinned, including Atlantic Beach, Point Lookout Beach, Jones Beach, and Overlook Beach, from west to east respectively.

	Atlantic	Point Lookout	Jones	Overlook
Above Wrack Line	1	3	2	2
Below Wrack Line	2	3	4	3
Total	3	6	6	5

Table 2. Number of Microplastics Retrieved from Each Beach Location. These numbers represent the total number of microplastics found in the given locations (n=10).

shore after high tide recedes, and five below the wrack line. Afterwards, the total number of microplastics retrieved from the four beach locations was organized and recorded (**Table 2**), with Atlantic Beach being the farthest west and closest in proximity to NYC and Overlook Beach being the farthest east and farthest in proximity to NYC (**Figure 1**). In total, both microplastic fibers (**Figure 2**) and microplastic fragments (**Figure 3**) were retrieved and accounted for, while there were no microplastic films found in any of the experimental groups. Overall, 6 of the total retrieved microplastics were fragments, while the remaining 14 collected microplastics were fibers. As evidenced by the data (**Table 2**), there does not seem to be a substantial difference in the total number of microplastics extracted from each location. However, the numbers do suggest that more microplastics were extracted from the sand samples below the wrack line, which is indicative of the idea that these contaminant particles wash up on shore via the ocean.

A Chi-square test was used to analyze the significance of these numerical results, as this test is commonly conducted to test for the difference in the distribution of categorical variables between various groups. In this case, the total number of microplastics from each location were compared using this test. The test resulted in an overriding p-value of 0.75, and since the p-value was greater than the significance level of 0.05, the differences in the number of microplastics across each sampling location were not statistically significant.

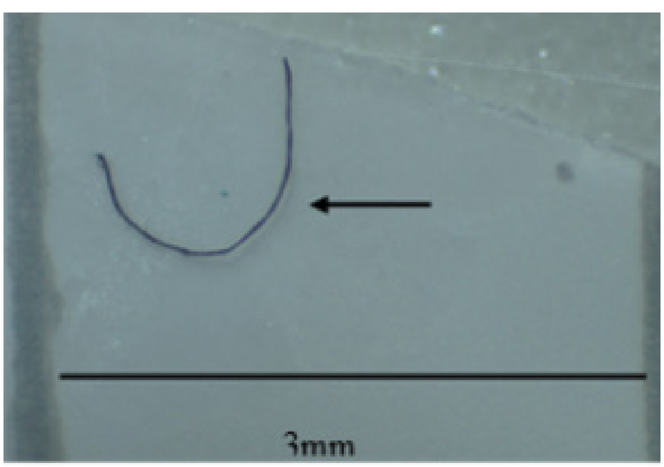

Figure 2. Blue Microplastic Fiber. This microplastic fiber was retrieved from above the wrack line at Atlantic Beach.

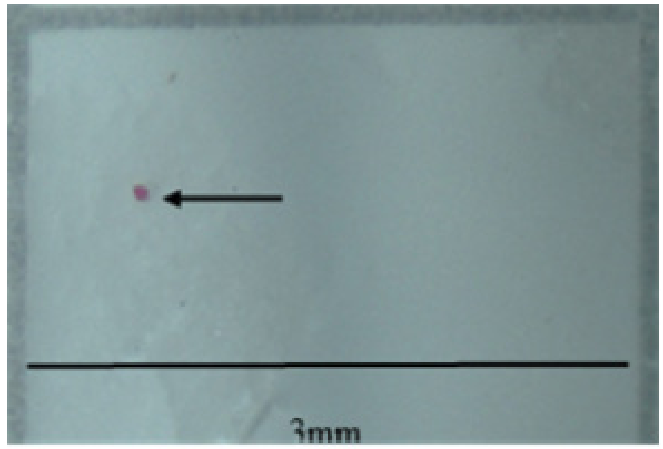

Figure 3. Pink Microplastic Fragment. This microplastic fragment was retrieved from below the wrack line at Jones Beach.

DISCUSSION

Although different numbers of microplastics were found at each location, these differences were not statistically significant. Overall, the calculated p-value could be due to the low number of collected microplastics, as there was not an abundance of data due to laboratory and time constraints. These results led to the conclusion that the beaches sampled do not show a statistically significant relationship between microplastic pollution numbers and proximity to New York City. With this conclusion, the amount of microplastics found on any given beach on the South Shore of Long Island, NY may not be influenced by the beach's location or proximity to New York City. However, a larger sample size could further validate this conclusion.

The statistical results of this study could be deemed surprising compared to existing work, such as the comprehensive study published by Foderaro on the proliferation of plastic in the waterways around New York City (10). Despite the study's findings that the waters surrounding New York City contain an estimated 165 million plastic particles at any given time, the beaches closer to this polluted water did not seem to contain more microplastics compared to the beaches farther east (10).

Additionally, based on a study that investigated various Belgian marine sediments for microplastics, lower numbers of microplastics were retrieved than expected in our research study. Claessens *et al.* extracted 92.8±37.2 microplastics of all forms per 1000 g of dry weight sand collected from beaches along the Belgian coast (12). This can be broken down to an average of approximately 4.64 microplastics per every 50 g of dry weight sand. Compared to our results, which involved 50 g of dry weight sand per trial, we extracted fewer microplastics. While some trials were unsuccessful in finding any microplastics, upwards of three microplastics were found in other trials of 50 g sand increments. Holistically speaking, we did not extract nearly as many microplastics as the aforementioned researchers did. This could be explained by various limitations and sources of error or be evidence that microplastics are found in lesser quantities at the locations studied.

Though a smaller absolute number of microplastics were recovered, our data collection did reveal that microplastics were, in fact, present in some capacity in the sand from each sampling location along the South Shore of Long Island. These findings support other studies which have previously discovered microplastics in sand and other sediment samples (12). However, this emphasizes a larger problem: the widespread pollution of microplastics. Our study established that the South Shore of Long Island, New York is yet another location that has been marked by the presence of microplastic contaminants, which have the potential to harm local biodiversity and surrounding locations. The need for a solution to this environmental problem and emerging concern is of utmost importance. There should be further efforts and measures taken to limit the amount of plastic pollution to counteract this issue. Now knowing that microplastics are present at the South Shore, management tools and different policies can be enacted specifically in the area, which could contribute to stopping the problem on a larger scale.

It is important to account for the limitations of this research and methodology, as they may have impacted the results of the study. Since this methodology relied on a light microscope and the human eye to observe and quantify any microplastics, there could have been errors in counting the number of microplastics observed. While this is a commonly used method, it is possible that microplastics may have been overlooked. It has been found that while many microplastics are colorful, the ones that are transparent or white are not as easily picked up by the researcher when using a microscope (13). Additionally, Song *et al.* reported that microplastics less than 1 mm in size are hard to distinguish from non-plastic particles (13). As a result, the microplastic count could have been underestimated due to technical limitations. This could serve as the reasoning behind the relatively low number of extracted microplastics in this study, especially when making comparisons and considering other published research.

Sample size is another factor that could have limited the results of this research. Increasing the sample size, or the amount of sand and the number of trials conducted per location, would increase the validity of both the results and resulting p-value. We hope to continue conducting trials in attempts to strengthen the results and findings of this research.

Additionally, sand samples were collected on one day during the month of October due to the timeframe of the research study. There is a possibility that the time of year or season influence the amount of microplastics found along the shoreline. In order to mitigate this potential outside factor, we require studies that span one year during which sand samples from each location are collected and examined for microplastics at multiple, seasonal time points. Other microplastic studies similarly conducted research based on the collection of water samples or sediment samples from one given period and did not account for this potential limitation, however, this variable could be considered for future research studies (12).

Further research should be conducted to determine if other urban areas influence the amount of microplastics present in the sand of nearby beaches. As an example, studies could be conducted along the coastline of the Pacific in relation to Los Angeles, California to determine if the amount of microplastics found in the sand samples varies based on proximity to the city. Los Angeles has many similarities to New York City, as it is located along the coast of a major body of water and is densely populated. Conclusions drawn from an experiment of this caliber, in addition to our research that was done in relation to New York City, could potentially lead to more considerable conclusions regarding the effect of urban areas on the distribution of microplastic pollutants and further add to the conversation regarding microplastics and their distribution. Conducting this same research along the whole South Shore of Long Island, NY may also prove to be similarly beneficial and allow for the collection of more substantial data, as this study did not span the whole coastline. Overall, this knowledge would be vital for developing key management tools and effective policy to control and limit the amount of microplastics in the environment.

Due to the limitations regarding the methodology and the possibility of underestimating the number of microplastics in a sample, there is a need for further research to develop a standardized and validated methodology for microplastic quantification. While microplastic extraction techniques exist and are commonly used by researchers, many are flawed and coexist with some extent of error (13). A standardized methodology for the extraction of microplastics in sediments would be ideal, as it would allow researchers to efficiently and reproducibly extract sample material as well as compare results among various studies with minimal error in this regard.

METHODS

Collection of Sand

The samples of sand for this experiment were collected all on the same day in between times of low and high tide. Each sampling location was approximately equidistant from each other, spanning a total area of about 25 miles along the South Shore of Long Island, New York. The four beaches sampled, in order from west to east, included Atlantic Beach, Point Lookout Beach, Jones Beach, and Overlook Beach, which are all popular beaches on Long Island (**Figure 1**). Using a stainless-steel shovel, the top 5 cm of sand was collected from a 50 cm x 50 cm quadrant in two places at each beach: 1.5 meters below the wrack line and 1.5 meters above the wrack line. The collected samples were labeled accordingly and transported in separate containers to the school laboratory where they were left to dry for 24 hours at room temperature before further experimentation occurred.

Extraction Preparation

A 1 L saturated solution of NaCl was made from 358.9 g of NaCl in distilled water (14). Using sterile glassware to reduce the chance of contamination, the NaCl and water were added to a beaker containing a magnetic stir bar, and the mixture was stirred at 600 rpm for approximately 6 hours, allowing the salt to dissolve. The concentrated salt solution was then purified by filtering it through a 0.45-µm membrane filter into a new sterile flask using a vacuum pump. A vacuum pump was used to quickly and efficiently pulled the solution through the filter. This filter had a very small pore size, which allowed only the sodium chloride to pass through, thereby capturing any impurities. Purifying this sodium chloride was significant, as it reduced the risk of contaminating the samples or introducing any outside particles, which would otherwise impact the results gathered.

Extraction

For the microplastic extraction process, 50 g of dried sand from a given sample was mixed with 200 mL of the concentrated NaCl in a sterile 500 mL flask. The mixture was stirred at 600 rpm for approximately 5 minutes. The stir plate allowed the solution and the sand sample to rigorously combine before leaving them to settle.

After the spinning took place, the samples were left in covered flasks at room temperature for 24 hours. To isolate microplastics, the top 50 mL of the spun mixture was aspirated, or drawn, from the flask using a glass pipette. For each sample and trial, this supernatant, or top layer, which contained any potential microplastics, was filtered through sterile gridded 0.45-µm pore size membrane filter paper into a glass flask using a vacuum pump. Any existing microplastics were left on the filter paper while the remaining solution was contained in the flask. This process was repeated five times for each of the eight samples, as well as with 200 mL of the sodium chloride, which served as the negative control to confirm that the NaCl solution contained no microplastics or other particles that would influence our results.

Quantification

Each 0.45-µm pore size membrane filter paper was stored in a labeled sterile petri dish for 24 hours until placed on a slide to be viewed under a light microscope. A 24-hour waiting period before viewing was essential, as the filters had to be completely dry. Wet filters would have reflected the light of the microscope and limited the ability to view any microplastics (15). The light microscope was set to a 40x magnification, as this setting allowed for the quantification of microplastics measuring between 0.3 and 5 mm (14). Since microplastics measure 5 mm or smaller, this microscope setting enabled the viewing of almost all microplastics except for the smallest of particles. The filter paper utilized was gridded with boxes that had measured lengths of 3 mm to ensure that a suspected microplastic met the requirement of being less than 5 mm. These microplastics were identified and quantified based on published reference pictures and other characteristics, such as firmness and color (16). Since plastics are firm, a potential microplastic can be squeezed with fine tip forceps. Compared to other materials that may be confused with plastics, plastic maintains its shape once squeezed by the forceps. Additionally, plastics are often colorful and can be in the shape or form of fibers, films, or fragments. While microplastic fibers look like thin colorful threads, fragments appear as pieces of plastic, and films are thin pieces of plastic, similar to plastic food wrappers. These guidelines and characterizations were used to carefully draw conclusions regarding the presence of microplastics within a sample with as much accuracy as possible. Pictures were taken of each sample and the number of observed microplastics were recorded in a data table.

Statistical Analysis

Once quantified, the total number of microplastics collected from each of the four sampling locations was calculated. Using a Chi-square test with a significance level of 0.05 and an expected value of 5, the numbers of microplastics retrieved from the different samples were compared to determine if the differences in the number of microplastics from the varying locations were statistically significant or if the numbers of microplastics collected from each beach was independent of its location.

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