ORIGINAL ARTICLES

Microplastics in The Bahamas: A Reconnaissance Quantifying the Prevalence on Selected Beaches in New Providence

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Abstract

Plastic substances, unlike organic materials, disintegrate over long periods of time. After degradation, larger plastic materials that are broken down into smaller pieces ranging in sizes of less than 5 mm are known as microplastics. To investigate microplastics on Bahamian beaches, this reconnaissance study was conducted on three beaches in New Providence: Cabbage Beach, Goodman’s Bay, and Montague Beach. Ten samples were collected from each beach along the high tide line and assessed for microplastics. The microplastics were then visualized using a dissecting microscope with a magnification of 25x or greater. In the 30 samples, an average of 13.5 microplastics were identified at Cabbage Beach; an average of 15.8 were identified at Goodman’s Bay, and an average of 16.3 were identified at Montague Beach. Fibres were the most prevalent type of microplastic observed, but film, pellets, and fragments were also identified. As the concern for the environments of Small Island Developing States grows, the need for research on the distribution and accumulation of microplastics is crucial.

Introduction

Plastic pollution has been an important environmental concern, as the world's capacity to contend with it has become diminished by the ever-increasing production of plastic disposable products (Parker, 2019). The global concern of environmental plastics in the marine ecosystem has gained increased attention, leading to demands for further action. Plastics have been described by researchers and the mainstream media as a growing source of stress in the marine environment (Barnes et al., 2018) and constitute the major source of marine pollution, with numbers ranging from 60 to 80% in fragment abundance within the marine environment (Derraik, 2002). The fishing industry alone is responsible for approximately 18% of marine plastic waste found in the ocean's ecosystem (Andrady, 2011) and marine pollution occurs when fishing gear is either lost or disposed of at sea. Starvation, suffocation, lacerations, diminished reproduction rate, and death can all occur as animals become entrapped in marine plastic debris (Xanthos & Walker, 2017). In marine environments, the presence of plastics raises a variety of problems that slow economic development. Stranded plastic on beaches is an aesthetic problem that affects the tourism industry (Jang et al., 2014).

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The increasing demand for products containing plastics poses a great threat to the marine environment worldwide, particularly in Small Island Developing States such as The Bahamas. Various international regulatory strategies to tackle plastic marine waste, specifically of plastic bags and microbeads, have been documented in the past, and this has been recently supplemented by increased public awareness due to the efforts of multinational organizations and agencies (Schnurr et al., 2018) and sustained research attention (Andrady, 2011).

Due to improper waste management, plastics contribute to marine pollution. Properties found ideal for the consumer industry requires the incorporation of various artificial additives. These include phthalates and bisphenol A, as well as antimicrobials such as triclosan to mitigate biodegradation, or antioxidants to reduce the fragile nature of plastics (National Oceanic and Atmospheric Administration Marine Debris Program, 2014). Due to the toxicity of some plastics, the indirect ingestion of microplastics by humans and marine organisms through the food chain is a cause for concern.

Microplastics are small plastic particles that measure less than 5 mm (0.2 in.) in diameter. Microplastics enter the marine environment either as primary microplastics or as secondary microplastics. Plastics that are designed to be microscopic are known as primary microplastics. Usually, these plastics are used in facial washes, as well as in a wide range of beauty products such as exfoliators. They are also used in air-blasting technologies, and their use as vectors for drugs has been progressively recorded in medicine (Cole et al., 2011). Primary microplastics typically make their way into the marine environment from land via run-off (Andrady, 2011). In contrast, small plastic particles originating from the degradation of larger plastic pollution, both at sea and on land, are characterized as secondary microplastics. Apart from runoff, microplastic accumulation occurs during the weathering break down of meso- and macro-plastics. The structural integrity of plastic waste can be diminished over time by a combination of physical, biological, and chemical cycles, resulting in deterioration (Cole et al., 2011). The remnants of larger plastic objects, however, are significant contributors (Jiang, 2018) due to increasing pollution on and near beaches. In general, plastics are light in weight and can easily be transported by wind. They become fragile under exposure to ultraviolet light and sun, then break down with both the physical forces of wind and waves (Thompson, 2015).

The Bahamas is a country that relies heavily on the marine environment to bolster its tourism industry; therefore, marine pollution can have a detrimental effect on the marine environment and economy. The Bahamas is susceptible to the impact of marine debris and is prone to acquiring ocean-based plastic debris incompatible with its use and population size (Ambrose, 2018). No studies have been conducted on the presence of microplastics along the high tide line on beaches in The Bahamas. This study was conducted to present an initial assessment of the presence and prevalence of microplastics on three well-visited beaches. This study hypothesized that a greater number of microplastics would be present on beaches with nearby building developments.

Methodology

Study Sites

This study investigated the prevalence of microplastics on three beaches on the island of New Providence, Bahamas: Cabbage Beach, Goodman's Bay, and Montague Beach (see Figure 1). These beaches were selected based on their proximity to nearby developments such as resorts, residences, and restaurants, which are all within a one-mile radius. Goodman's Bay Beach is a public beach located along the central coast of New Providence. Cabbage Beach is a public beach on Paradise Island that extends from the western side of the Atlantis Resort all the way east, beyond the Paradise Island Beach Club, and Montague Beach is a public beach located on East Bay Street.

Figure 1
Satellite Image Indicating the Location of 1. Goodman's Bay, 2. Cabbage Beach and 3. Montague Beach

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Sample Collection

At each beach, 10 samples were collected, for a total of 30 samples. The location for sample collection was based on the high tide line, as high tidal energy promotes the long-term suspension and deterioration of low density, extremely buoyant, or relatively large plastic debris, resulting in favorable accumulation at the high tide line (Ho & Not, 2019). Sample locations were selected using systematic sampling. After locating the high tide line, a 300-foot transect line was placed along the high tide line, and samples were collected in 30-foot intervals, using a metal spoon. Surface sediment was collected in 4-oz. (118 mL) mason jars, until the jars were filled, avoiding large pieces of organic matter and macro-plastics.

Sample Extraction

Sample extractions were adapted from Baker et al. (2012). In the laboratory, samples were transferred from the sample jars to 250 mL beakers and covered with aluminum foil to avoid contamination. Then, 80 mL of distilled water was added to the samples, which was then homogenized. Approximately 70 g of sediment was separated, allowed to settle, and then sieved. The sediment sample was transferred to customized stacked sieves of 4.75 mm, 1 mm and 0.33 mm. Larger materials (greater than 4.75 mm sieved) were discarded, and the material atop the 0.33 mm was sieved. Materials that passed through the 0.33 mm sieve were dehydrated in a drying oven at 75 ºC for 2 days, with one side of the foil partially raised to aid drying.

After dehydration, 20 mL of aqueous 0.05 M Fe (II) solution and 20 mL of 30% hydrogen peroxide were added to the sample. The sample was heated to ~75 ºC until no organic matter was visible, and then heated for an additional 15 minutes to ensure the reaction was completed. Six g of salt was added per 20 mL of the sample volume, and the mixture was heated until the salt dissolved.

The sample was then transferred to a funnel and the beaker was rinsed with a salt solution (70 g NaCl, 200 mL distilled water) to minimize the dilution of the sample and to ensure that all microplastics were transferred to the funnel. The funnel was covered with aluminum foil while the particulates settled. After 60 minutes had passed, the sediments were drained into an aluminum weigh boat and covered with foil, without draining the liquid part of the sample. The aluminum weigh boat was placed into the drying oven at 75 ºC to dry for 2 days.

Quadrant lines were drawn on a glass fibre filter using a permanent marker and ruler. The sediments were then transferred onto the filter paper and rinsed with 100 mL of distilled water to rid the sample of salt. Pressure was applied to the Buchner funnel to facilitate the vacuum. Rinsed forceps were then used to slide the filter paper onto the labeled aluminum weigh boat, which was subsequently covered with aluminum foil and placed into the drying oven at 75 ºC to dry overnight. They were covered until quantification under the microscope.

Sample Analysis

The filter paper was visually observed using a dissecting microscope under a magnification of 25x and zoomed in to 30x magnification when necessary. The filter paper was assessed in the quadrants to avoid duplicate counts. A general observation of microplastic types such as film, fragments, fibres, and pellets were documented, and the size and colour were also visualized. Through descriptive analysis, the total, mean, mode, range, and standard deviation were recorded. Sample dates, number, beach locations and the number of microplastics found were also recorded.

Results

In the Cabbage Beach samples, an average of $\bar{X}$ = 13.5 (*SD* = 7.53) microplastics were identified per sample. Although the film, fragments, and pellets were all identified, microplastic fibres were the most abundant and identified among these samples (Figure 2). The main colours present were navy blue, clear/transparent, white, dark green, and black (Figure 3).

In the Montague Beach samples, an average of $\bar{X}$ = 16.3 (*SD* = 3.83) microplastics were identified per sample. Microplastics were the most prevalent although pellets and fragments were both identified (Figure 2). In the Montague Beach samples, clear/transparent, navy blue, blue, yellow, green, violet, red, and black were all documented (Figure 3).

In Goodman's Bay’s samples, an average of $\bar{X}$ = 15.8 (*SD* = 7.52) microplastics were identified per sample. In these samples microplastic fibres were the most predominant, although pellets were identified (Figure 2). Red, transparent/clear, tie-dye, navy blue, and white were the most prevalent colours documented (Figure 3). Through descriptive analysis the total, mean, mode, range, and standard deviation were recorded. Sample dates, numbers, beach locations and the number of microplastics found were also recorded (see Table 1).

Although the measurement of microplastics was not the main investigation of this study, they all appeared to be the same approximate size and less than 5 mm. A total of 456 microplastics were identified over all samples, and they exhibited similarities and differences such as size and colour, see Table 2 and Figure 1.

Table 1
Microplastics per Sample, Location and Collection Date

Sample Number	Cabbage Beach Collected 28 February, 2021	Goodman's Bay Beach Collected 25 February, 2021	Montague Beach Collected 28 February, 2021
1	19	22	10
2	6	18	17
3	9	14	19
4	10	8	12
5	18	26	20
6	21	12	16
7	11	27	17
8	7	17	15
9	6	6	23
10	28	8	14

Table 2
Comparison of Microplastics Collected from Three Beaches in New Providence.

	Cabbage Beach	Goodman's Bay Beach	Montague Beach
$\bar{X}$	13.5	15.8	16.3
SD	7.53	7.52	3.83
Mode	6	8	17
Range	26	21	13
N =	135	158	163

Figure 1

Average Number of Microplastics found on Three Beaches in New Providence.

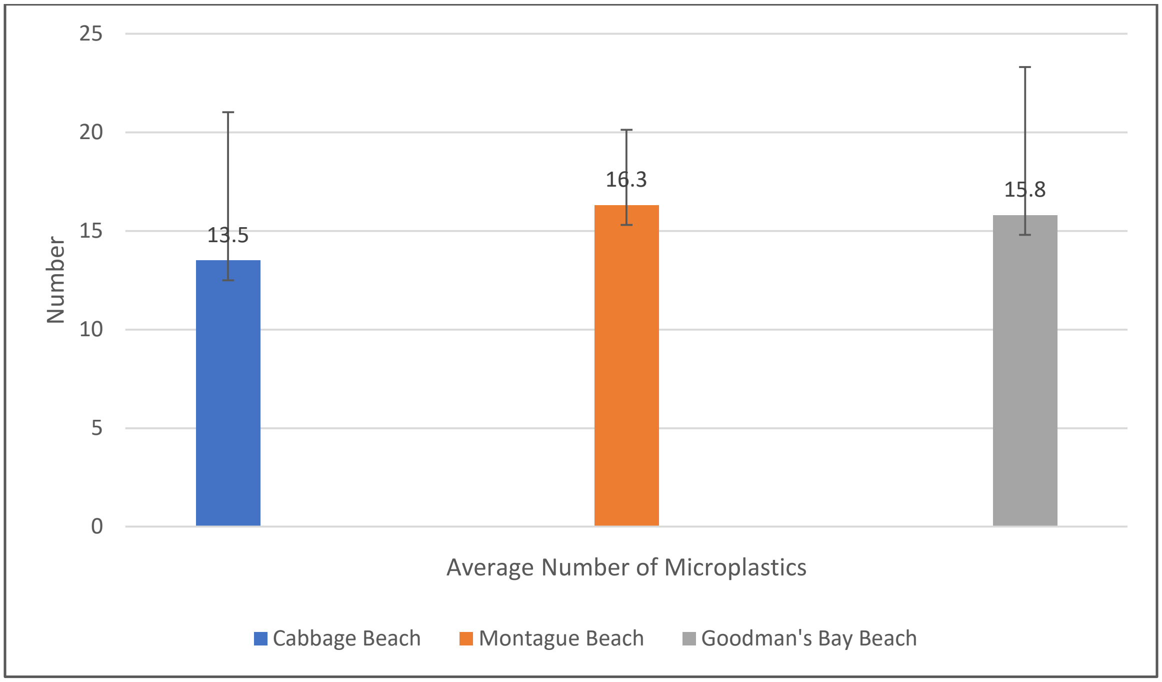


Figure 2

Microplastic Type Frequency

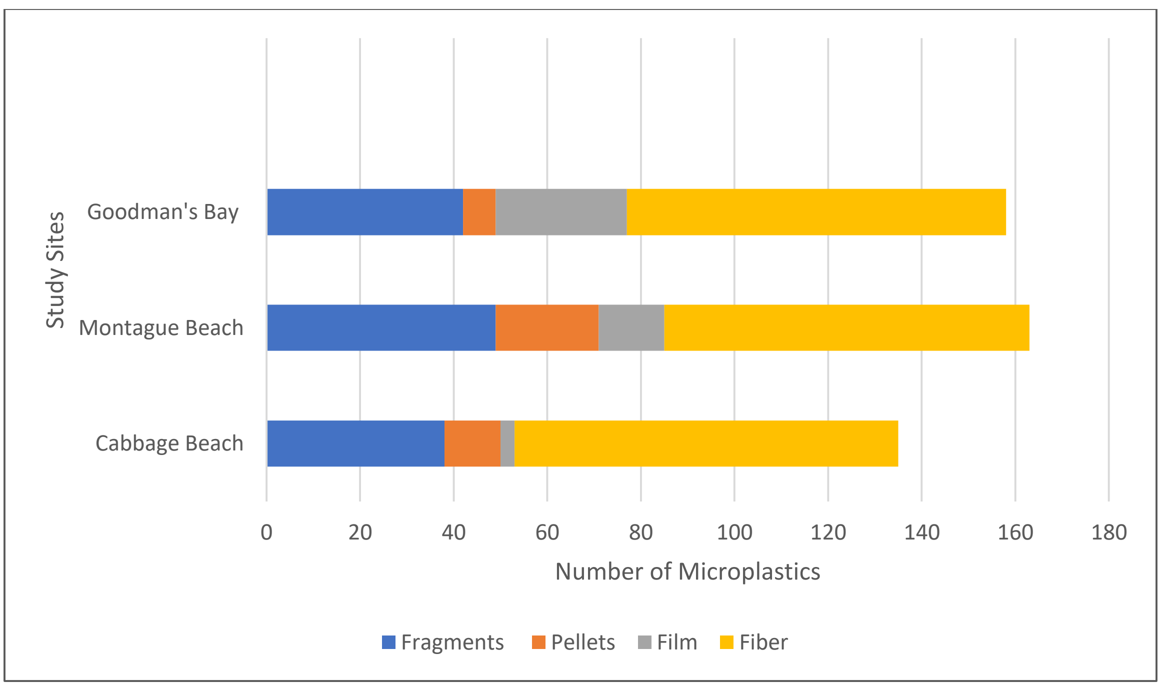
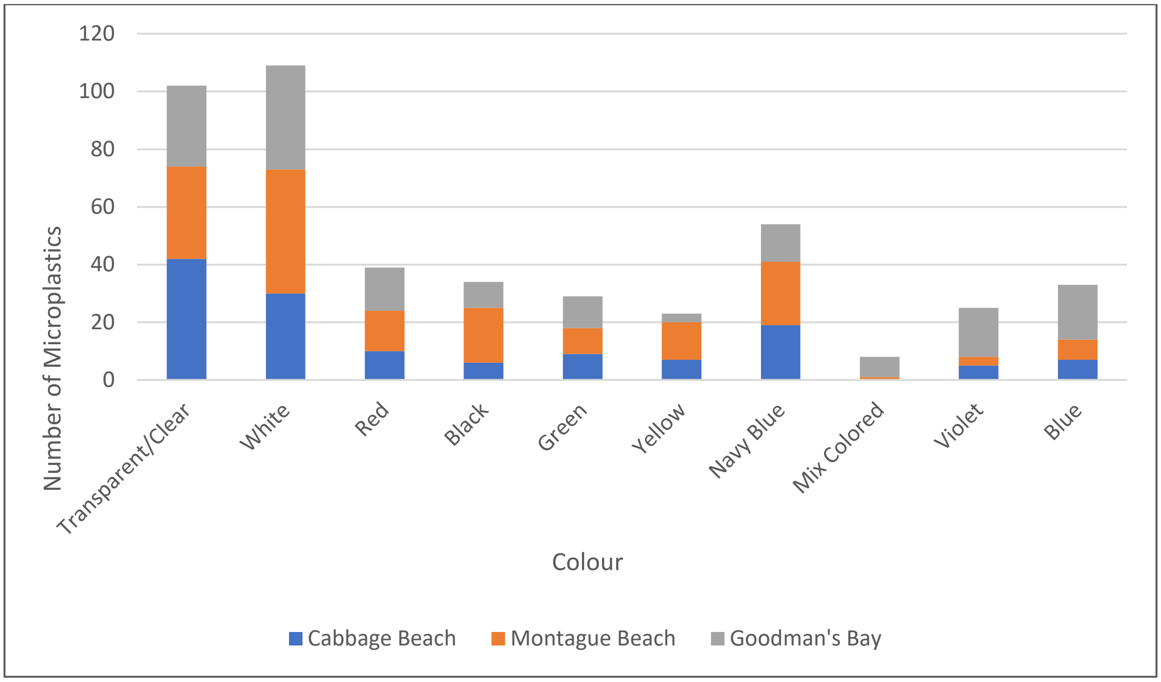


Figure 3
Microplastic Colour Frequency



Discussion

The results indicate that microplastics were found in all sediment samples, and they fell into the categories of film, fragments, pellets, and fibres, which were the most prevalent. While scientific research has shown that all aquatic ecosystems are vulnerable to microplastic pollution, which in turn affects marine biodiversity at all trophic stages, new measures should be taken such as the study of deposition in marine organisms (Deudero & Alomar, 2015). The most common types of plastics found in the marine environment include polyethylene terephthalate (PETE or PET), low- and high-density polyethylene (LDPE and HDPE respectively), polyvinyl chloride (PVC), polypropylene (PP), polystyrene (PS), and nylon (PA, Mertes, 2020).

Macroplastics were observed drifting on the water's surface in many instances, along the shore and high tide line, during the collection period for this analysis and, thus, may be the main contributing factor for the accumulation of microplastics. Another contributing factor can be the strong currents and winds that potentially carry debris a considerable distance away from the source, particularly if it is buoyant. The difference in the microplastic abundance and characteristics of samples is comparable to the results of Martin et al. (2017). This study was conducted on the Irish Continental Shelf and investigated the deposition and accumulation of microplastics in marine sediments. The results of this study indicated that all microplastics identified were secondary microplastics. Martin et al. (2017) also indicated that fibres made up 85% of these microplastics, and fragments made up the other 15%; the most predominant colours were blue, transparent, white and red, like the findings of this study. While more samples were collected and more study sites and locations were assessed in the study by Martin et al. (2017), the results indicate that fibres were the most abundant microplastics found across both studies. Another recent study conducted by Dodson et al. (2020) investigated the accumulation of microplastics in marine sediment on estuarine and barrier islands located in the states of North Carolina and Virginia. Their objectives were to identify microplastic fragments and fibres and determine the amount found at each study site. Their results indicated that a large percentage of the microplastic particles were identified to be fibres, with fragments comprising the remaining amount (Dodson et al., 2020) like the results of this study and Martin et al. (2017). Microplastic particles were found in significant quantities in the beach sediments at each of the four study sites in Virginia and North Carolina. Additionally, the microplastics obtained in both studies suggest that the main cause of microplastic pollution was the degradation of larger plastic products into the marine environment, suggesting that this could be the source of microplastics in this study.

A considerable amount of microplastics were found along the high tide line of the beaches in proximity to developments which were all within a one-mile radius. There can be many conclusions drawn concerning the accumulation of microplastics at these beaches. Unfortunately, the exact origin or source of these microplastics discovered in this study cannot be pinpointed. However, prevailing winds, sea transport, and surface waves likely play a role in accumulation as they varied across the study sites. Given the extent of development, and the amenities surrounding and offered at the study sites, there is still no evidence of a significant impact from locals and tourists, but the risk of anthropogenic influence, especially given the considerably high levels of plastic and general pollution at the selected beaches can also play a role. The results also indicate that there could be substantial amounts of microplastics identified if the entire beach area were assessed, which calls for future research throughout The Bahamas. The findings of this study also supported the hypothesis that there were greater amounts of microplastics found along the high tide line of the selected study sites with nearby building developments.

In conclusion, the findings described in this study serve as a starting point for further studies into microplastics in coastal sediment ecosystems and habitats in New Providence and the family islands. Furthermore, efforts should be made to improve testing methods, as well as to consider the importance of researching the form and chemical composition of microplastics in order to understand the sink and origin (Alomar et al., 2016) of this emerging and critical pollutant in the environment, as well as the impact on fauna and flora. There is a scarcity of data on the occurrence and diversity of marine debris, in particular plastic, on beaches in The Bahamas, making it difficult to advise policies to reduce debris concentrations (Ambrose, 2018). Recently, The Bahamas government implemented a ban on single-use plastic items such as plastic bags, cutlery, straws, and Styrofoam to get ahead of the environmental consequences of plastic pollution. With this recent implementation and further research on the behavior and consequences of plastics within Small Island Developing States, there can be substantial changes made to combat environmental damage. The results of this study solidify the need for advanced research to be done on the presence and accumulation of microplastics across beaches in New Providence and throughout The Bahamas.

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