MICROPLASTIC DENSITY AT MULTIPLE DEPTHS IN TWO SOUTHERN NEW YORK BEACHES

By

Matthew Graham

Submitted to the Board of Environmental Studies
School of Environmental Studies
in partial fulfillment of the requirements
for the degree of Bachelor of Arts
Purchase College
State University of New York

May 2021

Sponsor: George Kraemer, Ph.D.

Second Reader: Ryan Taylor, Ph.D.

Abstract

Microplastics are a growing issue in all bodies of water worldwide, and their effects are finally being studied on a larger scale across the planet. Currently there are very few studies investigating the abundance of microplastics along the northeast coast of the United States. A total of two sampling beaches were selected for this study, one being on the south shore of Long Island, New York and one on the waters of the north side. Along both beaches, five sites were selected at random along the wrack line. Samples of sand were collected at each site from six centimeter interval depths (0-6 cm, 6-12 cm and 12-18 cm). Microplastics were brought back on site to Purchase College and separated using density methodology. Microplastic density was higher on the Northside of Long Island, close to double the density as opposed to the south shore. A higher concentration was found in this location due to the beach being in a more urban setting. It was concluded that the 0-6 cm measurements produced the least amount of microplastics, and the 6-12 cm marks produced the most. There was much more of a site and depth pattern at the south shore beach, while the north shore beach was found to be more random.

Keywords: Microplastics, sand, density, filter.

Introduction

Since social media has taken over all aspects of social life, pollution issues have begun to gain more and more attention. Environmental organizations have taken to Twitter, Facebook, Instagram etc. over the last few years, showing videos of macro plastic pollution in oceans, towns, and ecosystems (Segerberg et al. 2011). Macro plastics are described as plastics larger than six millimeters. These are the common plastics such as bottles, bags, and other garbage (Barboza et al. 2014). These pictures and videos grab people's attention, because a once clean and beautiful place can turn into a wasteland to people and to animals. So thankfully macro plastic pollution awareness is gaining traction, and progress is being made to combat this pollution, but the same cannot be said about microplastic pollution (Eriksen et al. 2013 & Foley et al. 2018).

Microplastics, are described as plastics that have a length of five millimeters or less. What makes these microplastics dangerous is the chemicals they potentially trap, which in large amounts could affect many organic objects (Hidalgo-Ruz et al. 2012 & Barboza et al. 2014). Microplastics in waterways can absorb polluted chemicals such as pesticides, and while microplastics are tiny, any organism ingesting an amount of pesticide is dangerous for its health (Browne et al. 2013).

The density of microplastics in our waters directly influences the reaction of the environment and its inhabitants, so collecting data to predict the future as well as address the immediate issues, is critical in limiting those future problems (Lusher et al. 2014). What we have learned from the macro plastic pollution epidemic is that this type of issue can become dangerous fast, and the only way progress is made to solving the problems is when there is a public outcry (Horejs 2020). The more research that is put into microplastics, the more widely distributed that information will become (Katznelson 2015). Microplastic pollution, left untreated, may get to the point where humans will be affected, because of what was mentioned earlier, aquifers. In the U.S, an estimated 38% of people rely on groundwater for their water supply, so what would happen to those people should contaminated waters make it into those wells and aquifers (Browne et al. 2013).

Unfortunately, the study of microplastics does not go far back in time, with the oldest studies being conducted in the 2000s and early 2010s such as Hidalgo-Ruz et al. 2012 and Thompson et al. 2004. So, the consequences of a large density of microplastics in our waters, have yet to be revealed. However, studies that have been published thus far, have been conducted all over the world. which have revealed an alarming amount of microplastics already found on beaches, specifically in Asia where the most research has been conducted (Yu et al. 2016 & Eo et al. 2018). That research has led researchers to create models to predict a potential future with these levels. What the future hold is an overall microplastic density increase all over the world, with the sharpest increases in bodies of water nearest to urban centers (Eriksen et al. 2013 & Ogonowski et al. 2018). But there have been very few projects dedicated to microplastics that have come out of the United States. Data collected from select sites in North Carolina and Virginia show that while the levels of microplastics are not yet dangerous, they are higher than anticipated and may lead to health and ecosystem damaging problems in the future (Dodson et al. 2020 & Ivar do Sul et al. 2014).

Because of the data collected from around the world, there are models that have projected potential outcomes should the contamination get worse. The main reasoning being population increase, which leads to more waste produced, leading to more pollution, macro, and micro plastic pollution (Ivar do Sul et al. 2014 & Horejs 2020). It is important to note that there will most likely be many unforeseen issues that will occur due to this pollution, but some potential contamination consequences include contaminated ecosystems, contaminated drinking water and potential compromise of aquifers (Ogonowski et al. 2018 & Law et al. 2014). Another major issue that we are already seeing in marine environments today is the lowering of biodiversity as well as decrease in reproduction levels and overall survivability (Lusher et al. 2014). These issues may spread to healthy ecosystems should microplastic pollution continue to increase (Law et al. 2014 & Foley et al. 2018). As time goes on, the density of microplastics in marine environments will only go up, leading to more and more populations of sea creatures being directly affected (Galloway et al. 2017 & Thompson et al. 2004).

For this project, the primary objectives were to measure the density of microplastics on each beach, examine the distribution with microplastics through depth, then compare the beaches to one another to try and find a correlation or a difference between north and south shore beaches in terms of microplastic density. Each section will produce multiple samples based on depth into the sand. Every six centimeters, a different sample will be collected, hoping to see a difference of density per depth. The goal is to collect enough sand to estimate an average level of microplastic distribution along that section of beach. As well as calculating a density average for each six centimeter sample. The calculations will reveal if there is a correlation between beaches, sites, and depths.

Materials and Methods

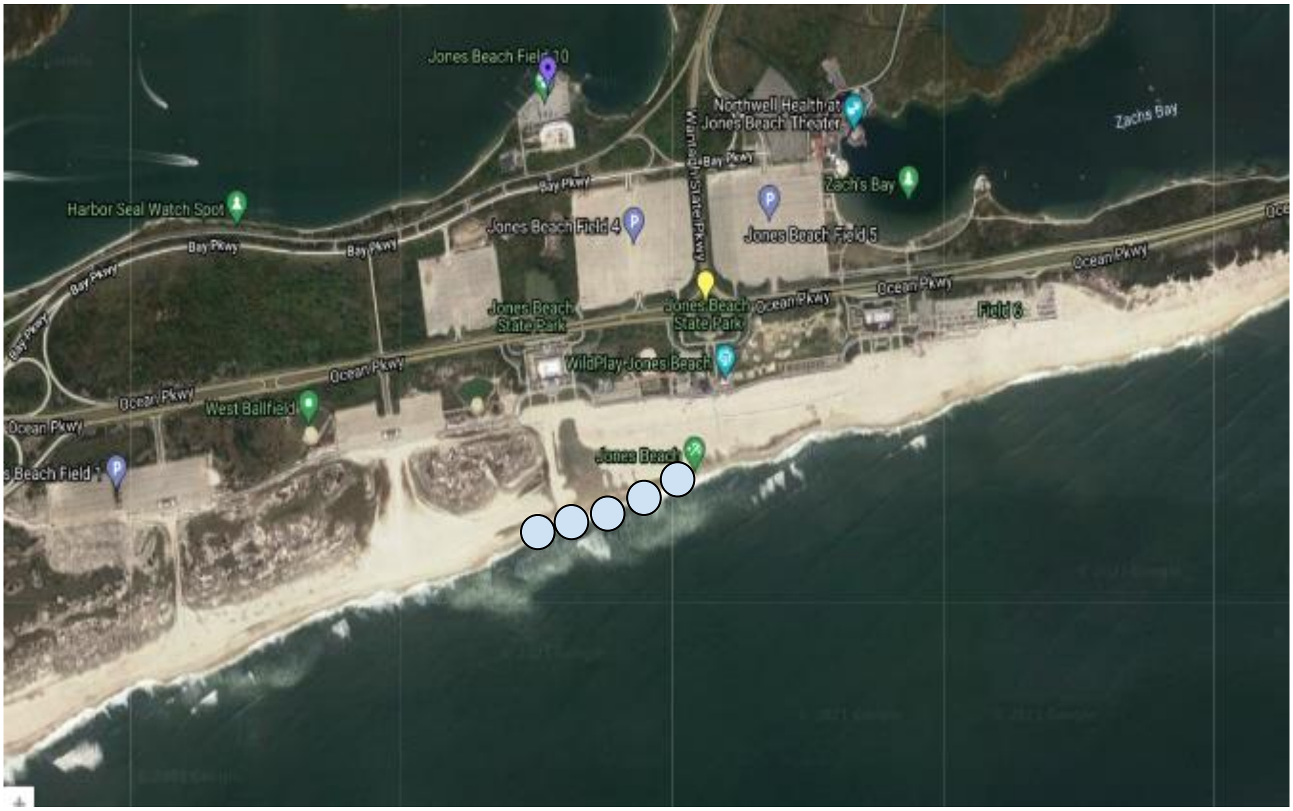

Figure 1. Jones Beach Site collection site. Circles represent the 5 collection sites along the beach.

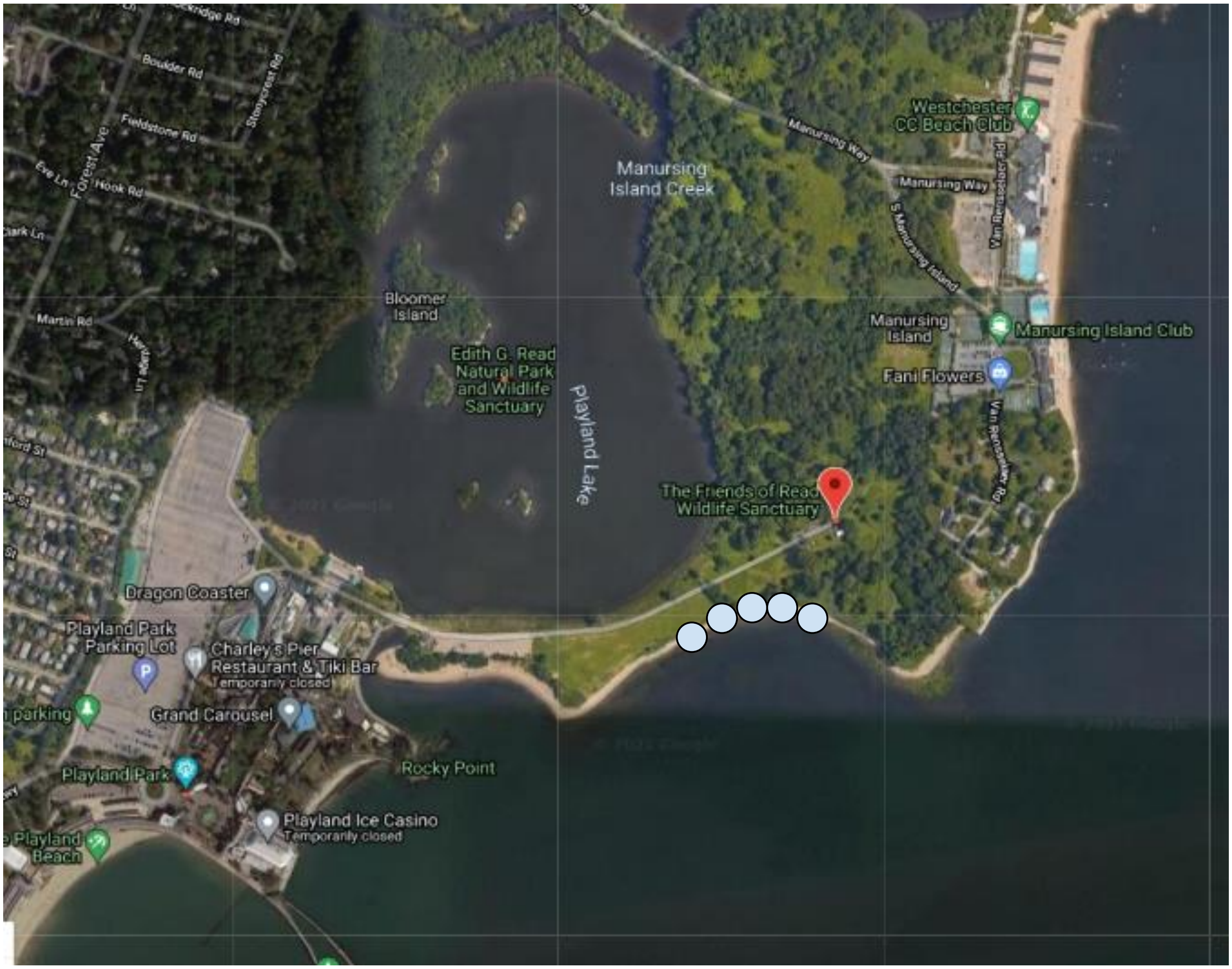

Figure 2. Read Sanctuary collection site. Circles represent the 5 sample sites.

Two sites were chosen, Jones Beach in Suffolk County on the South Side of Long Island and Read Sanctuary in Westchester County on the North Side of Long Island Sound. These sites were chosen because of relative distance from the school as well as differing beach makeups, hoping to show potential correlations or differences in data. The north shore waters are being affected by the Long Island Sound, while the south shore is being directly affected by the Atlantic Ocean.

Samples were collected in October and November. These were not ideal times for data collection because data was collected when local bird populations were the most active, causing slight disturbance.

Each sample site was located on the wrack line of the beach. A total of five sites were selected along each beach, to remove the sand every six vertical centimeters down. Simple shovels, a PVC pipe with a line drawn six cm from the bottom of the pipe as shown in Figure 3, a plexiglass square to trap the sand inside the tube also shown in Figure 3, and plastic bags to hold the collected sand. In total 18 centimeters of sand were removed per site along the beach, taking around 1000 grams every six centimeters, so 3000 grams per site along each beach. A total of 30 labeled samples were collected in total across both beaches and brought back to campus to separate the microplastics.

Figure 3. The plexiglass sheet and PVC pipe used to collect the sand from the beaches.

Figure 4. The sieved material, after the sand had been dried in the lab oven. Majority of the material from Read Sanctuary samples.

The separation process took place over three runs. Each run accounted for 100g of samples from each bag being processed. To begin the separation process, about 100g of wet sand and small rocks were taken from all 30 bags and placed into weigh boats. Every sample was weighed, then placed in a lab oven overnight at 60 °C to remove any moisture from the sample. After the samples had dried overnight, they were removed from the lab oven. From there, the samples were sieved through a three millimeter filter. This removed any rocks or other debris that may be in the sand, leaving just the sand to be separated as shown in Figure 4. The majority of the rocks in the bucket were from Read Sanctuary sand, as the sand there was much rockier than the sand located in Jones Beach. The sieved samples were weighed once again to determine a dry weight for each sample. At this point, they are ready to be combined with the separation mixture. The mixture contained approximately 1600 grams of 1.7 g/ml reef crystals, mixed with about 4000 mL of warm water in a flask. This solution was put onto a magnetic stirrer, a stir bar was added, and was left to stir overnight. The next day, after the stirring was complete, the supernatant was transferred to another flask in order to separate the leftover reef crystals that didn't dissolve. At this point, the solution was ready. Multiple flasks worth of solution was made across the three runs.

Each dry boat containing dried sand, was added to separately labeled 400, 500 or 600 mL beakers. After the sand was in, 200 mL of the reef crystal solution was also added to each beaker. Each beaker containing sand and solution was put on a stir plate, had a stir rod added and left to stir for 15 minutes. After the 15 minutes was up, the new mixture was left to settle overnight. Since the material density (g cm^{-3}) of the microplastics was less than that of the saturated salt solution, the plastics floated on the supernatant.

Figure 5. The vacuum filter extractor used.

The next day, one by one the samples were filtered using a vacuum filter as seen in Figure 5. A small filter was placed on a glass piece, and the settled mixture was slowly poured on top of it. The mixture was poured until nearly all the liquid was gone, making sure not to dump any sand or debris onto the filter since the liquid is what the microplastics were in. The leftover liquid and sand were discarded in a bucket. About 100 mL of distilled water as well as five mL of concentrated 35% H_2O_2 were poured onto the filter. The distilled water to clean the filter and the hydrogen peroxide to eliminate as many organic materials on the filter as possible. After the filters had been washed, they were removed and placed on a piece of labeled tinfoil. The tinfoil with filter was placed in a lab oven and left to dry overnight as seen in Figure 6.

Figure 6. Tinfoil, with microplastic filters inside drying in a lab oven.

Figure 7. The microscope to computer setup used.

The next day, one at a time the filters were examined under a Wild M8 Heerbrugg microscope. The microscope had a camera attached to the eyepiece and that camera was connected to a laptop via Wi-Fi, so the zoomed in picture was viewed on the laptop instead of looking through the eyepieces, as seen in Figure 7. The amount of microplastics on each filter was counted under 12x magnification. A small glass container was used to hold the filter. The container had eight dots drawn onto it. The dots were used to standardize how many microplastics were in each filter. The eight random dots were moved to the top left corner of the magnified view on the computer, and the number of microplastics visible from that specific spot were counted. The number of microplastics found from the view from the eight dots were added up to find the total. Each filter was counted individually, and in total 90 filters were examined and the amount of microplastics were found based on the eight dots totals on each filter. Figure 8 shows four examples of filaments found in sand from Jones Beach. The filaments vary in size and shape. Figure 9 shows five examples of filaments found in sand from Read Sanctuary. The filaments vary in size and shape. Figure 10 shows three examples of non-filament microplastics. Not every object in the picture is a microplastic, but there are three microplastics present.

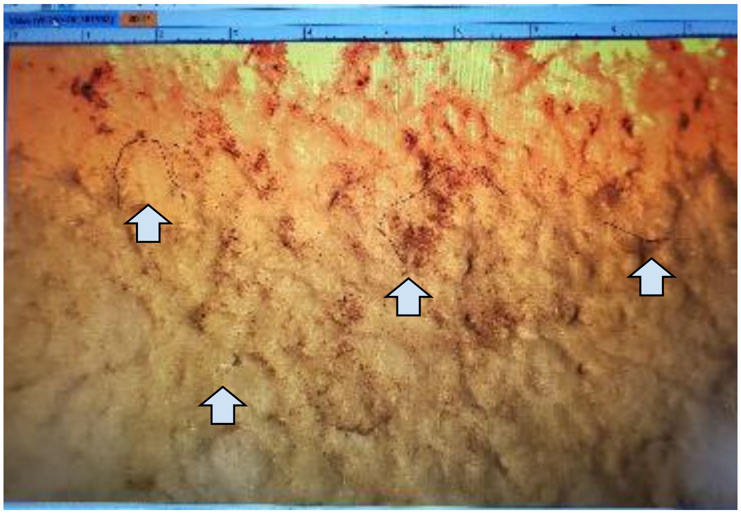

Figure 8. Example of filter from Jones Beach. Multiple microplastics shown, with the majority being filaments, shown by arrows.

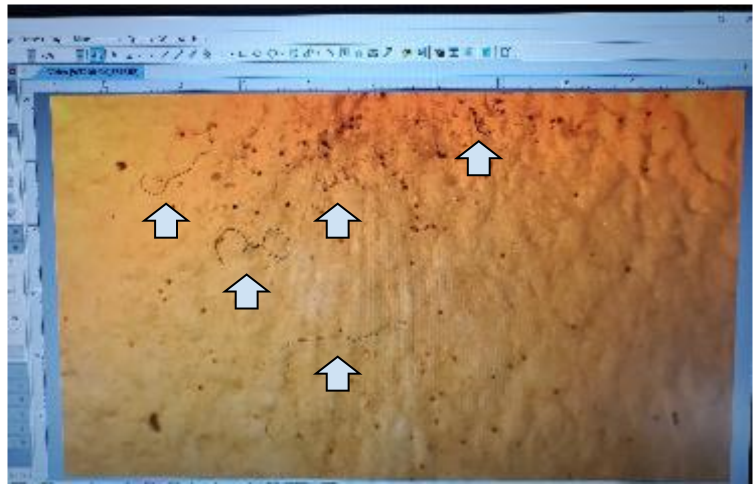

Figure 9. Example of filter from Read Sanctuary. Multiple microplastics shown, with the majority being filaments, shown by arrows.

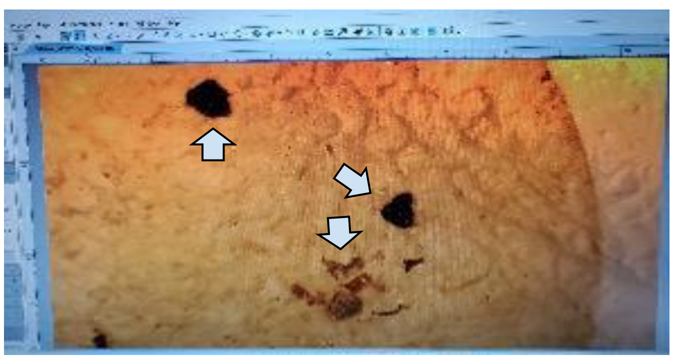

Figure 10. Example of a few unidentified microplastics, meaning microplastics other than filaments, shown with arrows.

All pieces of lab equipment used for extraction were washed after use and left to dry naturally overnight. The excess sand and reef salt solution were safely disposed of after use. The extra sand remaining in the bags was dumped in a local beach, so nothing would be displaced.

Results

Figure 11 shows sand from Read Sanctuary and sand from Jones Beach side by side. Notice the color different of the sand. Read Sanctuary had much darker sand due to it being much rockier.

Figure 11. The sand on the left is from Read Sanctuary and the sand on the right is from Jones Beach.

Figure 12 shows samples from only Jones Beach. These samples showed differences, density wise through sites and depths. The only pattern shown in the data was that four of the five sites had their highest microplastic densities at the 12 cm depth. The highest density found was at site 4, at 12 cm deep, with a density of 7.83 microplastics per 100g of sand. The smallest density found was at site 2, at 6 cm deep, with a density of 5.40 microplastics per 100g of sand. It was found that the smallest density of microplastics was in 0-6 cm deep sand, and the highest density 6-12 cm deep sand.

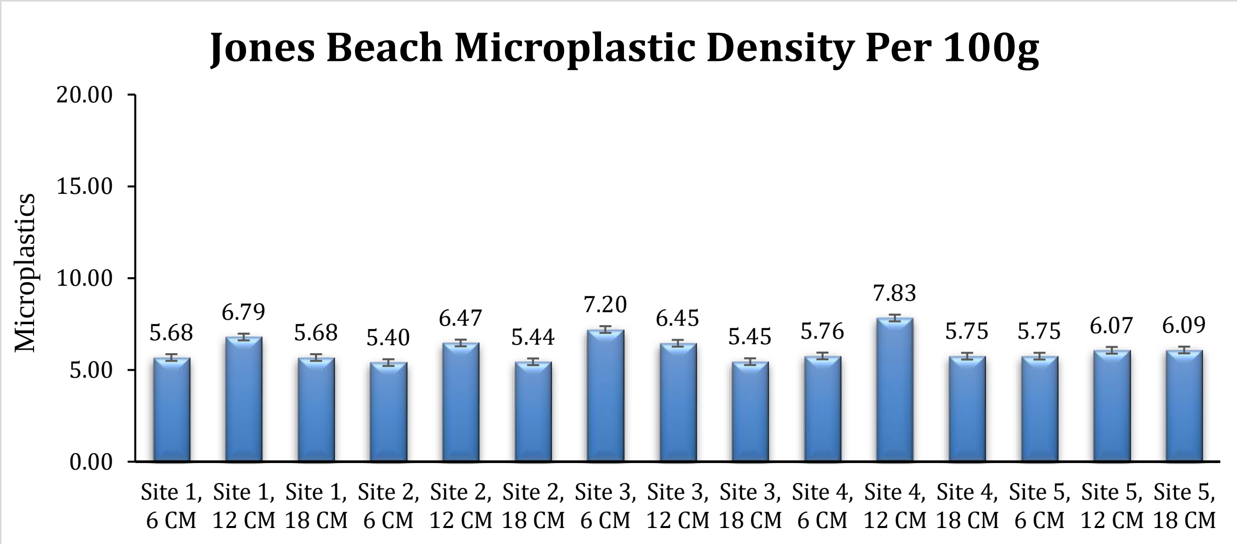

Figure 12. Microplastic densities per 100g, at Jones beach, compared to one another at each site and depth.

Figure 13 shows samples from only Read Sanctuary. These samples had a wider range in density variance than that of Jones beach. The density number across every site and depth were almost always higher than that of Jones Beach. The highest density found was at site 4, at 12 cm deep with a density of 18.33 microplastics per 100g of sand. The smallest density found was at site 2, at 18 cm deep with a density of 7.21 microplastics per 100g of sand. The 6-12 cm samples almost always had the highest of 3 densities per site. While the 0-6 cm and 12-18 cm measurements each had the smallest densities at different sites. The smallest density found at Read Sanctuary was nearly the same as the highest density found at Jones beach.

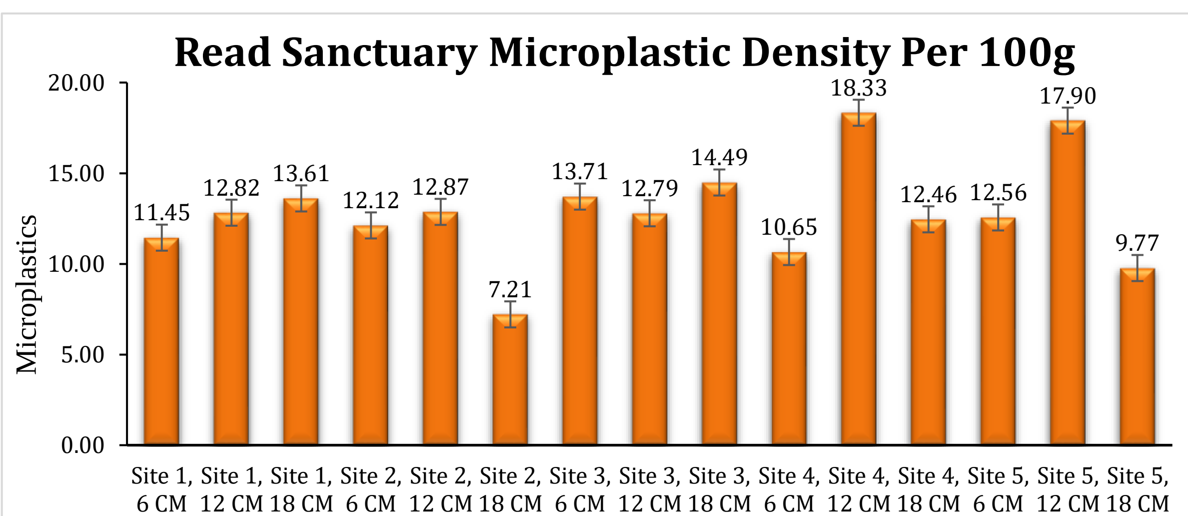

Figure 13. Microplastic densities per 100g, at Read Sanctuary, compared to one another at each site and depth.

Figure 14 compared the average density of every sample from both beaches. The data shows that the average density from Read Sanctuary is 12.8 microplastics per 100g of sand, while the average density from Jones Beach is 6.1 microplastics per 100g of sand.

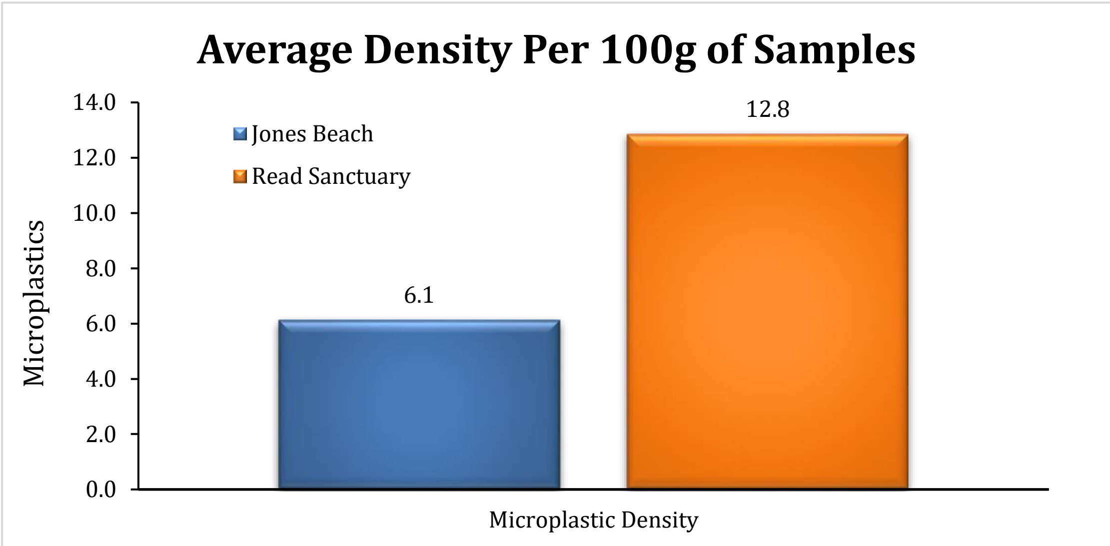

Figure 14. Average microplastic density of all sites and depths at both beaches.

Figure 15 compared the total amount of microplastics per site and depth at Jones Beach compared to one another. The data shows a slight pattern across the first 3 sites then the pattern dissapears.

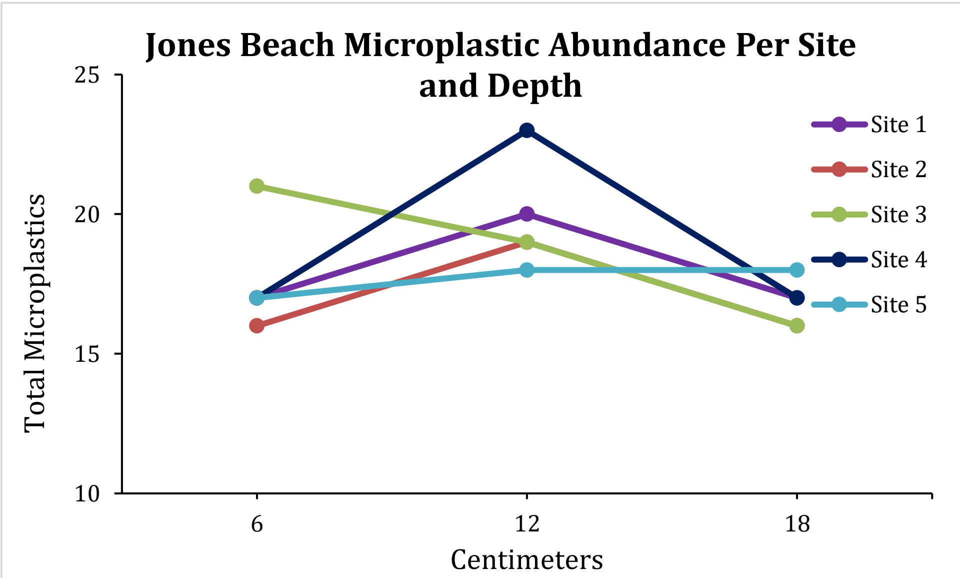

Figure 15. Abundance of Microplastics per site and at their depth at Jones Beach.

Figure 16 compared the total amount of microplastics per site and depth at Read Sanctuary compared to one another. The data shows little to no pattern at all between sites and depths.

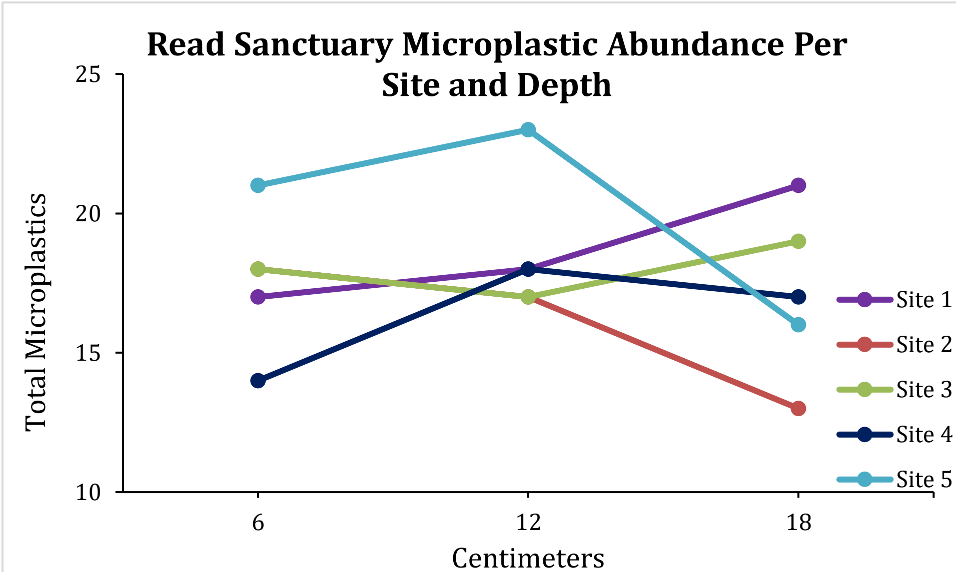

Figure 16. Abundance of Microplastics per site and at their depth at Read Sanctuary

---

Discussion

The data showed that the microplastic density was close to twice as much at Read Sanctuary as opposed to Jones Beach. This is most likely the case due to Read Sanctuary being located much closer to an urban setting, which in this case is southern Westchester County, specifically behind Playland Amusement Park. The population density of the surrounding area is 2,730 people/sq mi. While Jones Beach is in a state park, where the population density is 1,637 people/sq mi. Urban areas have a much greater chance of having polluted waters due to a much higher population density.

It is interesting to note that at both sites 90% of microplastics found were that of filaments of different sizes, measuring five mm or less. Filaments are in basically everything that is made up of plastic and can slip through the cracks much more easily than hard microplastics. A total of 56% of the filters had non-filament microplastics present.

The sands shown in Figure 11 had very little in common. Different color, texture and makeup with the Read Sanctuary sand being much rockier. The rocks got sieved out, but that left a much smaller dry weight per sample for the Read Sanctuary sand. This is shown in Figures 15 and 16. The total microplastic counts are similar, but because of the weight differences per sample, Read Sanctuary sand had a much higher density of microplastics.

These numbers are quite alarming, especially the number from Read Sanctuary as that is a very high concentration of small plastic in 100g of sand. That much is only a handful sized amount of sand. Microplastics on beaches come from the ocean, so since they have yet to be fully studied through beach sand, or through collecting samples in waterways, we do not know what effects these microplastics will have (Katznelson 2015).

Compared to the density numbers from Dodson et al. 2020 and Yu et al. 2016, the numbers found at Jones Beach are lower than coastal beaches in China and coastal beaches in Virginia and North Carolina. Read Sanctuary had a lower density than the beaches in China but a higher density than in Virginia and North Carolina. The Chinese beaches had an average of about 16.3 microplastics per 100g, while the Virginia and North Carolina beaches had an average of 11.7 microplastics per 100g (Dodson et al. 2020 and Yu et al. 2016). This makes sense since Chinese population density is far greater than any density in North Carolina, Virginia or New York.

Since Jones Beach is secluded away from any major urban center, the numbers produced from there will likely remain lower than that from Read unless the population density were to increase around Jones Beach. Regardless, people from all over the world come to Jones Beach to see what it is like, and to have this amount of microplastics around everyone is cause for concern. Should these waters get further contaminated with a higher density of microplastics, we may see a rise in illnesses coming out of beachgoers due to the potential chemical risks (Law et al. 2014 & Ivar do Sul et al. 2014). Not to mention local wildlife populations may decrease to due the potential consumption.

It is also important to note the potential environmental effects of these findings. Jones Beach is a wide-open beach with lots of opportunity for marine and wildlife species to survive, and Read Sanctuary is a safe haven for many young and old plants and animals. It is a protected zone for these creatures, and it will not be safe for much longer should contamination levels grow higher. Evidence of what may come has occurred elsewhere in the world. Lack of biodiversity, disruptions of food chains and potential loss of habitats are all at risk due to microplastics (Law et al. 2014 & Foley et al. 2018). And with our current trends as a population, it is safe to assume that the numbers will get worse, so we need to be prepared to face what is ahead (Hidalgo-Ruz et al. 2012 & Barboza et al. 2014).

Conclusion

This is one of the first studies looking into the distribution of microplastics in southern New York. While studies like this are popping up from all around the world, it is important to know exactly what is going on at your own local beaches. This study confirmed the presence of microplastics in our local ecosystems, showing that microplastic pollution is happening even in our nearby beaches. These are numbers that need to be continually monitored in order to help keep our local animals, food chains and habitats safe. Cleaning systems should be put in place, to try and either limit microplastic pollution on beaches, or to directly get them out of our major waterways. While plants and animals will be the first affected by a rise in microplastic contamination, humans would soon come after. What would happen if our aquifers got contaminated and become undrinkable? Crisis would ensue. We need to take the fight now, while we know what we are up against. Some years down the line, it may be too late.

Acknowledgements

I would like to express my gratitude towards my advisor Professor Kraemer as well as the rest of the environmental studies department for helping me get through this tough project. I would also like to thank Purchase College for allowing me on campus, even in these tough times.

Works Cited

Barboza, L. G. A., & Gimenez, B. C. G. (2015). *Microplastics in the marine environment: Current trends and future perspectives. Marine Pollution Bulletin*. 97(1-2), 5–12.

Browne, M. A., Niven, S. J., Galloway, T. S., Rowland, S. J., & Thompson, R. C. (2013). *Microplastic Moves Pollutants and Additives to Worms, Reducing Functions Linked to Health and Biodiversity.* Current Biology. 23(23), 2388–2392.

Dodson, G. Z., Shotorban, A. K., Hatcher, P. G., Waggoner, D. C., Ghosal, S., & Noffke, N. (2020). *Microplastic fragment and fiber contamination of beach sediments from selected sites in Virginia and North Carolina, USA.* Marine Pollution Bulletin. 151, 110869.

Eriksen, M., Mason, S., Wilson, S., Box, C., Zellers, A., Edwards, W., Farley, H., Amato, S. (2013). *Microplastic pollution in the surface waters of the Laurentian Great Lakes.* Marine Pollution Bulletin. 77(1-2), 177–182.

Eo, S., Hong, S. H., Song, Y. K., Lee, J., Lee, J., & Shim, W. J. (2018). *Abundance, composition, and distribution of microplastics larger than 20 µm in sand beaches of South Korea.* Environmental Pollution. 238, 894–902.

Foley, C. J., Feiner, Z. S., Malinich, T. D., & Höök, T. O. (2018). *A meta-analysis of the effects of exposure to microplastics on fish and aquatic invertebrates.* Science of The Total Environment. 631-632, 550–559.

Galloway, T. S., Cole, M., & Lewis, C. (2017). *Interactions of microplastic debris throughout the marine ecosystem.* Nature Ecology & Evolution. 1(5).

Horejs, C. (2020). *Solutions to plastic pollution.* Nature Reviews Materials.

Hidalgo-Ruz, V., Gutow, L., Thompson, R. C., & Thiel, M. (2012). *Microplastics in the Marine Environment: A Review of the Methods Used for Identification and Quantification.* Environmental Science & Technology. 46(6), 3060–3075.

Ivar do Sul, J. A., & Costa, M. F. (2014). *The present and future of microplastic pollution in the marine environment.* Environmental Pollution. 185, 352–364.

Katsnelson, A. (2015). *Microplastics present pollution puzzle.* National Academy of Sciences. 112(18), 5547–5549.

Law, K. L., & Thompson, R. C. (2014). *Microplastics in the seas*. Science Magazine. 345(6193), 144–145.

Lusher, A. L., Burke, A., O'Connor, I., & Officer, R. (2014). *Microplastic pollution in the Northeast Atlantic Ocean: Validated and opportunistic sampling.* Marine Pollution Bulletin. 88(1-2), 325–333.

Ogononwski, M., Gerdes, Z., & Gorokhova, E. (2018). *What we know and what we think we know about microplastic effects–A critical perspective.* Current Opinion in Environmental Science and Health. 1:41-46.

Segerberg, A., & Bennett, W. L. (2011). *Social Media and the Organization of Collective Action: Using Twitter to Explore the Ecologies of Two Climate Change Protests.* The Communication Review. 14(3), 197–215.

Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W. G., McGonigle, D., Russell, A. E. (2004) *Lost at sea: Where is all the plastic?* Science 2004. 304 (5672), 838.

Yu, X., Peng, J., Wang, J., Wang, K., & Bao, S. (2016). *Occurrence of microplastics in the beach sand of the Chinese inner sea: the Bohai Sea.* Environmental Pollution. 214, 722–730.