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A Comparative Analysis of Microplastics Consumed by White Perch in Two Locations Along The Hudson River, USA.

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Abstract

Aquatic environments are known to be extremely susceptible to anthropogenic contaminants. Microplastics, plastic particulates defined as being < 5mm in size, are a diverse and harmful emerging contaminant in freshwater systems. The more these pollutants are presented in aquatic ecosystems, the more available they become for passive and active trophic uptake. The aim of this study was to compare a fish species captured from two locations along the Hudson River, USA that vary in anthropogenic inputs and likely particulate abundance. A total of 43 White Perch samples were collected from South Coxsackie, NY and South Poughkeepsie, NY. Fish were dissected and complete digestive tracts were processed for microplastics using a wet peroxide oxidation digestion method and size-separated before being characterized to type (*e.g.*, bead, fragment, fiber, film, foam). A total of 117 anthropogenic particles were found with only 15 (13%) associated with the Coxsackie locale. Results show that in areas estimated to have higher concentrations of microfibers, there were more occurrences of microfibers in the fish tissue. The average number of fibers found in the perch at sites in Poughkeepsie and Coxsackie corresponds well with the relative high and low prevalence of fibers estimated to flow along the river in those locations. The increasing amount of anthropogenic particles consumed by aquatic species prompts urgent reform in the way humans use and dispose of plastics and calls for more sustainable practices.

Introduction

Globally, plastic use continues to increase and many countries have become accustomed to single use-and-dispose culture. Plastic debris is ubiquitous in terrestrial and marine environments; it is estimated that 4.8-12.7 million metric tons of plastic enters our ocean annually (Jambeck et al., 2015) The sources and pathways of this pollutant are diverse and include loss from waste management streams, fishing operations, illegal dumping, run-off, atmospheric deposition, and natural disasters (Dris et al., 2016). The longer plastic stays in the marine environment, the more susceptible it is to photo- and mechanical degradation, and weather.

Plastic accounts for 92% of all encounters between organisms and marine debris (Phillips and Bonner 2015). The negative effects large plastic items have on wildlife are widely reported, however, a large percent of this plastic pollution is microscopic. Pieces of plastic 5mm and under are known as microplastics and are classified as primary (created small) and secondary (large and become small over time). They can be characterized by type (*e.g.*, bead, bead, fragment, fiber, film, and foam), size, weight, and polymer type. These plastic fragments are bioavailable to many species (Kühn et al. 2015), mimic a wide range of natural food sources and therefore are easily ingested by smaller organisms. Microplastics in the digestive tracts of fish pose several physiological concerns such as injury or blockage. Other negative effects on fish health can be attributed to the toxic nature of the plastic itself and other pollutants absorbed by the plastic. Plastics consist of synthetic organic polymers that are transport medium for persistent organic pollutants (Phillips and Bonner 2015). They act as a sponge and can absorb toxins such as PCBs, pesticides, flame-retardants, and carcinogens found in the marine environment (Rochman, 2013). This can have adverse effects on the condition of fish. The concern of fish and water quality health prompts an increased level of regulations on plastics and their disposal.

Freshwater environments, like marine environments, are susceptible to microplastic pollution with rivers serving as a major pathway for plastic transport from terrestrial to marine environments.

The objective of this study was to document the abundance of microplastic and characterize it to type in white perch (*Morone americana*) in freshwater stretches along the Hudson River, New York. The white perch is a year-round resident throughout the 243 km tidal portion of the Hudson River estuary and are widely distributed in brackish and freshwater habitats (Klauda et al. 1988). Major components of white perch diet include other fish, fish eggs, plankton, and larvae. Due to their buoyant and persistent properties, microplastics are typically found at subsurface water levels (Claessens et al. 2011) which makes them bioavailable to white perch who reside in more shallow water.

This study aims to characterize potential microplastic particles in digestive tracts of fish captured in Poughkeepsie and South Coxsackie, areas that differ in population densities, industry, and surrounding land-use patterns.

Methodology

Sample Collection. A 2017 study (Miller et al. 2017) determined that microfiber pollution in the Hudson River does not have a north to south linear increase. As such, we selected sample locations that had previously been deemed to have relatively high (South

Poughkeepsie) and low (South Coxsackie) microfiber abundance (Fig. 1; Miller et al. 2017). White perch (n=43), 33 from Poughkeepsie and 10 from S. Coxsackie were obtained from the New York Department of Environmental Conservation (DEC) for purposes of this study between 9/2/2020 and 10/29/2020. The study area encompasses the Hudson River, New York State, USA; from South Poughkeepsie (river mile 69) to South Coxsackie (river mile 121). The samples were stored frozen in freezer bags labeled by river mile (RM) until the date of dissection.

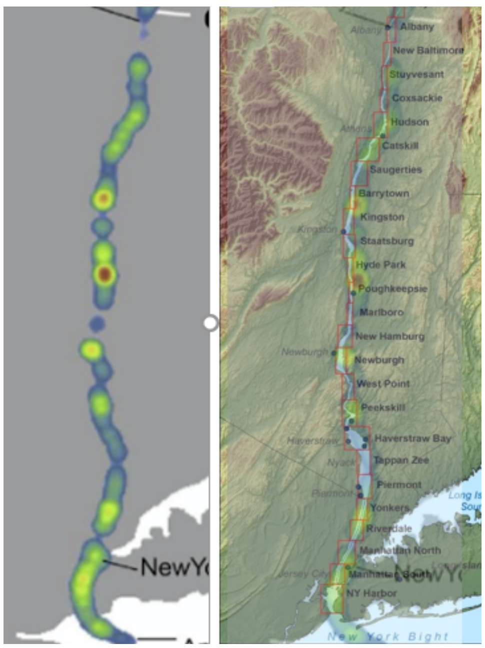


Figure 1. Scaled map of sampling locations deemed to have an abundance of microfibers from (Miller et al. 2017)

Site description. The Town of Poughkeepsie is approximately 31.3 square miles or 20,032 acres, of which approximately 16,914 acres, or 84.4 percent of the Town's land is contained in property tax parcels. The remainder of the Town's land area is included within the Hudson River, various creeks, and road rights-of-way. Poughkeepsie is an urban town with a population of 30,515 (Census Bureau, 2019). The town of Coxsackie is 36.9 square miles with a population of 8,485 (Census Bureau, 2018) The population growth rate has been decreasing (-1.97) since 2010. Poughkeepsie has two secondary WWTP in NYS with >1 MGD flow and capacities of 0.74 and 0.75 (based on NYSERDA 2008) (Wightman et., al). Coxsackie has 1 secondary WWTP with a capacity of 0.86.

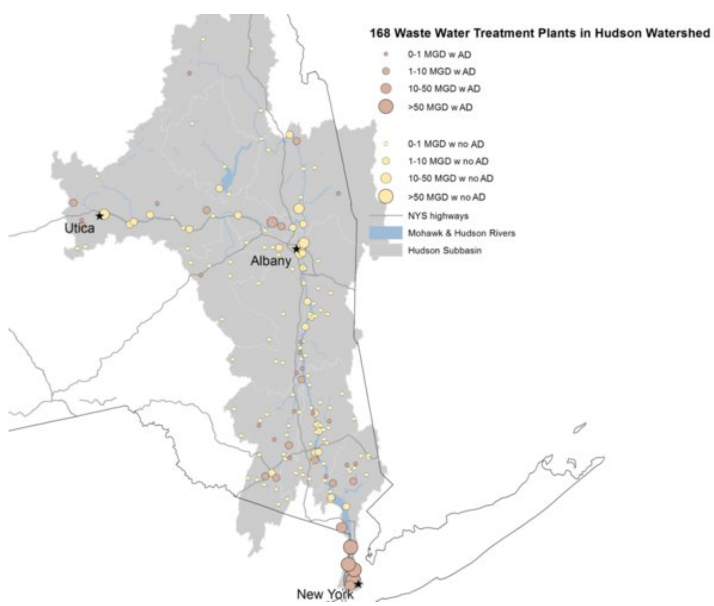


Fig. 2. 168 WWTP in the Hudson watershed in varying capacities (Wightman et., al).

Fig. 3. White Perch (Morone Americana) samples

Sample processing. Methodology for processing samples followed the NOAA recommended wet peroxide oxidation methodology in consultation with on-going research at SUNY Fredonia and SUNY Plattsburgh (Mason, S.A., et al., 2016). After measuring the length (cm) and weight (g) of each fish, the complete digestive tract was removed and individually measured and weighed. To eliminate airborne contamination, each sample was kept covered while being processed. Each digestive tract was placed in a beaker labeled with its ID code. To dissolve any organic material each beaker was filled with 4 (M) potassium hydroxide (KOH) and 30% hydrogen peroxide (H_2O_2) solution and spun on a stir plate at 350rpm for 1 hour. To separate the biomaterials from the chemicals the samples were strained through a 125µ sieve to prepare for wet peroxide oxidation. Deionized water (DI) in a squirt bottle helps loosen the material as it is decanted into its labeled beaker to ensure no particles are lost. The sieves were washed between each collection to eliminate contamination. Organic matter within each sieve sample was further digested using 30% H_2O_2 with an iron (II) catalyst. (Figure 5) Plastic debris is considered to be resistant to this wet peroxide oxidation (WPO) processing (Masura et al., 2015). The samples were spun again at 350rpm for 30 minutes to dissolve any other organic material. All samples were size-separated through 2mm, 255µ, and 63µ stackable sieves. Once decanted into corresponding size-specific Petri dishes (Figure 4), they were set aside for microscopic characterization.

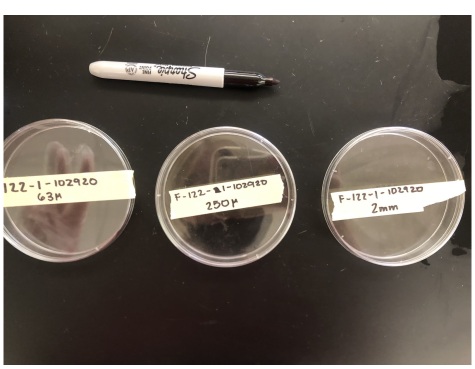


Fig. 4. Size separated petri dishes

Fig. 5. Wet peroxide oxidation taking place within the fume hood

Data Analysis. Using a dissection microscope, each sample was characterized to type, color, and size. Once recorded, the particle was discarded as laboratory restrictions did not allow for use of any machines such as FTIR for future analysis that gives confirmation of the particle compounds.

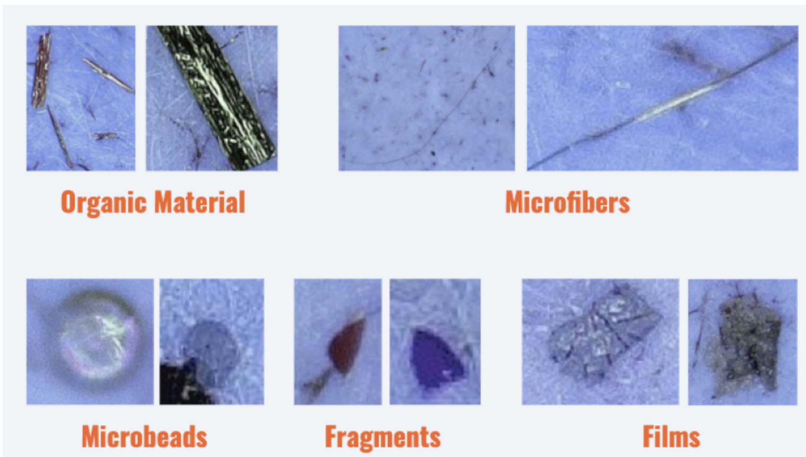


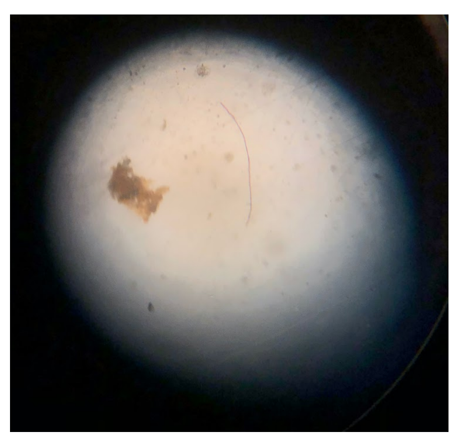
Fig. 6. Microplastics and non-plastic organic material identified in samples from the Hudson River, shown at 200x resolution. (Earth Institute, Columbia University 2020)

Results

There was at least one particle found in 35 (81%) out of the 43 fish. Of the 129 samples which were size-separated, 56 samples (43%) contained particulate. A total of 117 anthropogenic particles were found, 59 (50%) , 57 (49%) 1 (1%) were fragments, fibers, and films, respectively.

Only 15 (13%) particles found were in fish sampled from Coxsackie, whereas the majority derive from the Poughkeepsie locale (Figures 9,10). The most prominent particulate color was transparent followed by red, black, green, then blue (Figures 7,8)

Fig. 7. / Fig. 8. Blue and red microfibers under the microscope



Poughkeepsie had 2.3 times more particulates per fish than in Coxsackie (Fig. 2). Regression lines indicated that there was a stronger linear relationship between fish size and plastic count in Poughkeepsie than in Coxsackie; however, both are considered weak correlations. (Fig. 3, r^2=0.0987, r^2=0.0017)

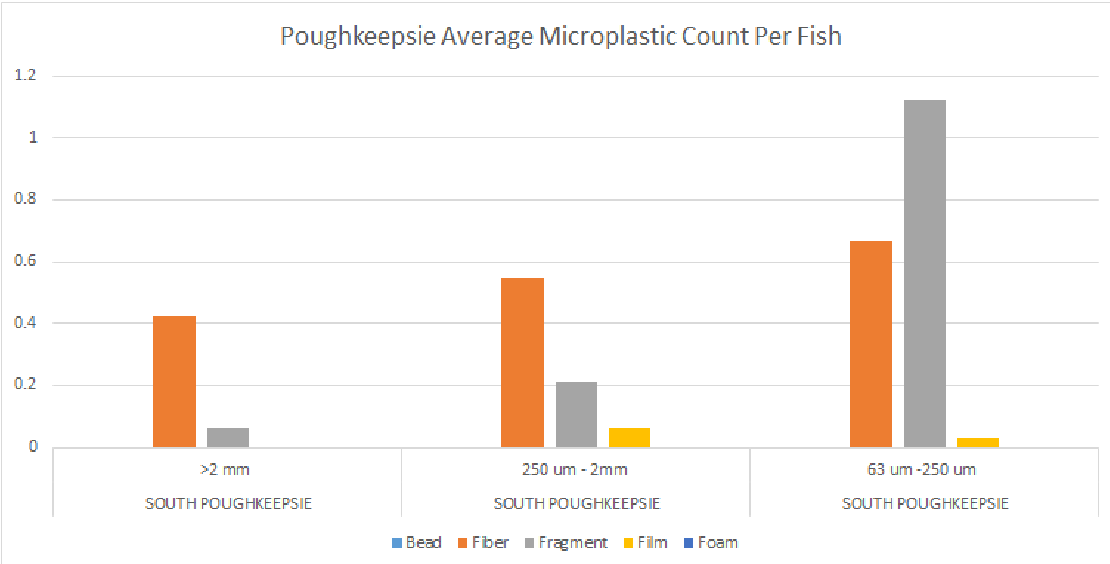


Fig.9. Size-specific average particulate abundance for Poughkeepsie

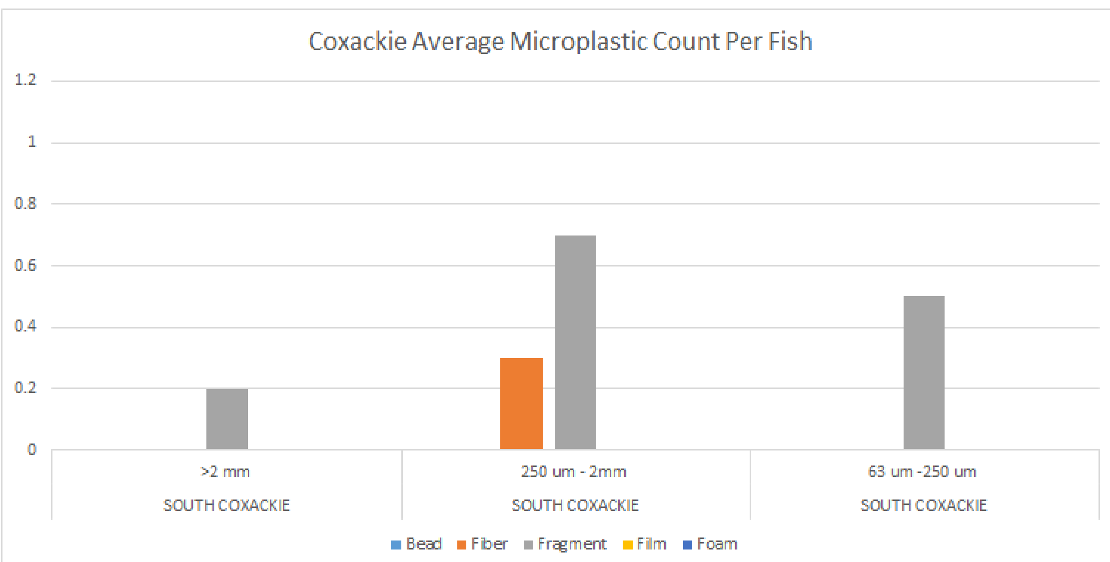


Fig.10. Sze-specific average particulate abundance for Coxsackie

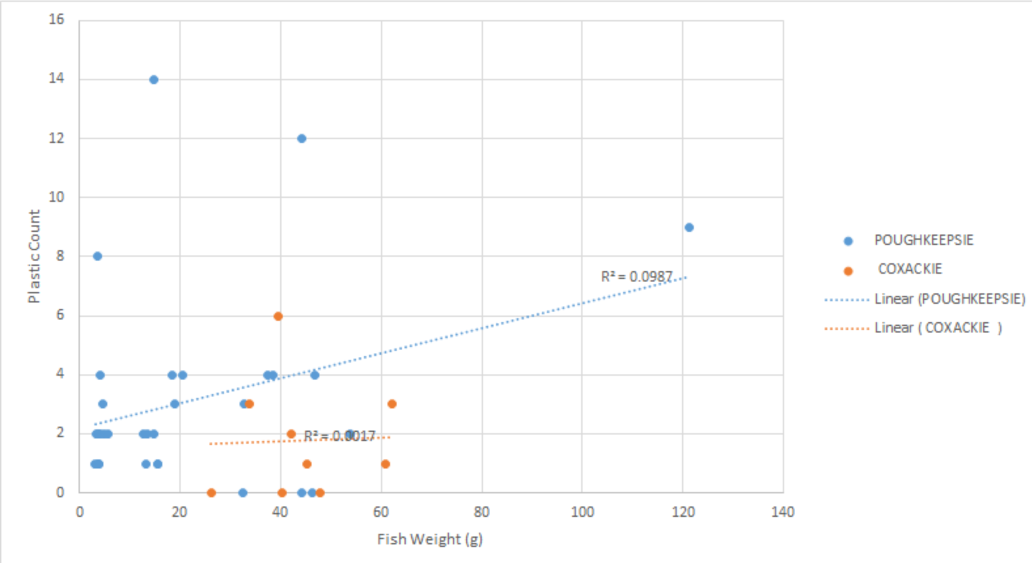


Fig. 11. Particulate abundance as a function of fish weight (g)

Discussion

This study aimed to determine whether there were differences in particulate loading in white perch from two locales along the Hudson River. Our findings indicate that white perch sampled from Poughkeepsie contained 2.3 times more microfibers than those sampled from Coxsackie. Previous studies have shown that the discharge of microfibers per liter of water is more concentrated in some waterbody regions associated with variations in land-use, associated population densities, and discharge points (Miller et al. 2017). The study noted that locations with close proximity to a wastewater treatment plant (WWTP), busy trailhead, or sewer system have been shown to have higher frequencies of fibers (Miller et al., 2017). Studies have indicated that WWPs were widely found to represent one pathway for microplastics to enter the aquatic environment due to the prevalence of influent plastics from personal care products and fabrics that release fibers from being washed (Mason et al., 2016). It has been noted that while efficient, it is uncertain that WWTPs have the advanced filtration to remove all microplastics from entering the waterway, increasing encounters with aquatic organisms. Poughkeepsie has a close proximity to a wastewater treatment plant, is a sizable community with lots of human activity which could contribute to pollutant load. There are far fewer trailheads as a source for contamination in Coxsackie as long as no large scale WWPs which makes sense as to why there were less fibers found in the digestive tissue.

Freshwater organisms have been known to uptake microparticulate from water bodies. Findings suggesting that the frequency of fragments was not significantly different across the two locations could be attributed to the fact that the background data used to determine sampling sites was based specifically on micro*fiber* pollution. The lack of studies done on micro fragments along the Hudson River makes it harder to hypothesize how the locations would vary based on this type of microplastic and future studies will need to be done.

Data suggests that bigger fish in Poughkeepsie may be consuming more plastics than smaller ones. White perch are predatory fish. Garneau et al. (2020) found that five times more plastic particles were found in predatory versus planktonic feeding fish providing further support for trophic transfer. However with such a weak correlation for fish size and number of particles in Coxsackie it is difficult to confirm that trophic transfer is the main source for plastic accumulation in this study.

Particulate composition is an important aspect of microplastic pollution studies, as it determines which organisms will be impacted. Less dense particles like polypropylene and polyethylene will float and macroinvertebrates and fish at the top of the water column would be exposed more often, than those in the benthos where heavier particles such as PVC might reside. Because there was no confirmation of compounds making up the anthropogenic particles estimates that the particles found were plastic must be conservative. A recent study of aquatic invertebrates' digestive tracts indicates that some anthropogenic fibers may be cellulose-based rather than plastic (Remy et al., 2015). (Carr et al. 2016) Many of the translucent fragments found had glass like characteristics and their composition was ambiguous. Without future analysis it is hard to confirm that all particles found can be confirmed as polymers. Despite this variability, the average number of fibers found in the perch at sites in Poughkeepsie and Coxsackie corresponds well with the relative high and low prevalence of fibers estimated to flow along the river in those locations (Miller et al. 2017).

Conclusion

Results demonstrate that white perch sampled from locations along the river estimated to have a higher prevalence of microfibers, consumed more microfibers than those in locations estimated to have fewer. Given that the more bioavailable an element is in the environment, the more likely it is to be accessible for uptake by a consumer (Hamelink et al., 1994), this finding is consistent with expectations. These findings must be evaluated with the consideration that laboratory restrictions did not allow for the confirmation of particle compositions and that there is little research done on the frequency and volume of plastic fragments found along the Hudson River. Although few studies have been done to examine the long-term effects of ingesting plastics, they are known to have toxic properties and can have adverse effects on any wildlife that consume them. The high frequency of particles found per fish in this study suggests that many aquatic species are at risk of uptake and calls for regulations that will reduce the danger that the pollutants pose on aquatic ecosystems. Reducing the amount of plastic we produce as a society and improving upon ways to dispose of it can help eliminate the amount found in the environment by stopping it from the source. Awareness of the unnecessary use and disposal of plastic and its negative effects on the environment could collectively improve ecosystem health.

Acknowledgments

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