Quantification & Source Identification of Microplastic Pollution in the Hudson River

2017 Report

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Acknowledgements

This report was prepared for NYS Water Resources Institute at Cornell University and the NYS Department of Environmental Conservation Hudson River Estuary Program, with support from the NYS Environmental Protection Fund.

Abstract

Microplastic pollution in freshwater is increasingly studied in the waterways of New York State. Detrimental to organisms, both through physical mechanisms such as false satiation and through chemical mechanisms due to contaminant adsorption and particle leaching, microplastics originate from a variety of yet-to-be-quantified sources. This ongoing study aims to support the quantification and source identification of microplastic pollution in the Hudson River through investigative studies to uncover patterns in microplasic concentrations. Over the past funding cycle, we found evidence to suggest that microplastic concentrations do change in time and that the change differs between streams with wastewater treatment plant contributions and streams without, depending on the flow conditions at the time of the sampling session. Ongoing work continues to compare results found using different sampling methods, investigate the influence of dams on plastic transport in rivers, and link fish diets with fish consumption of microplastics in Hudson River estuaries.

Background and Justification

Plastic pollution is an emerging problem in waterways across the globe. Of highest concern are particles known as "microplastics", the size fraction made of plastics less than five millimeters in diameter, typically between 0.333-5.0mm. These particles have been detected in waterbodies ranging from oceans and estuaries, to rivers, lakes and streams. Microplastic particles begin as a variety of products: exfoliating agents in facewashes or toothpastes, known as microbeads; larger plastic goods, such as grocery bags, fishing nets, synthetic clothing, dock floats, or milk jugs; or pellets used in manufacturing.

Most research quantifying the amount and the impact of microplastic pollution has focused thus far on ocean gyres, where microplastic concentrations have been measured as high as 20,328 plastic particles per square km of ocean surface (Law, et al. 2010). With an estimated 80% (Andrady 2011) of those marine particles originating in terrestrial sources, studies have increasingly turned to quantifying microplastic abundance in freshwater systems, as well. Only in recent years have papers been published with surveys of microplastic abundance in lakes, rivers, or streams across the globe. The majority of those quantification studies, with the exception of a few storm-event collections (Moore, et al. 2011), address questions of spatial distribution but ignore temporal trends in concentration that may affect whether spatial samples collected are representative of dynamic systems such as rivers.

The presence of these particles is of ecological concern because of their negative effects on aquatic organisms. Contaminants such as polychlorinated biphenyls (PCB's) have been found to readily adsorb to plastic particles (Rios, et al. 2010). Additionally, aquatic organisms such as fish and oysters have been shown to consume microplastics, increasing the risk of physical harm to the organism through false satiation, starvation, or choking, as well as introducing the contaminants into the food chain.

Objectives

The goal of this project for the past funding cycle was to better inform future sampling efforts in the Hudson River system and provide insight into how microplastic concentrations may affect fish health there. Specific objectives include 1) investigating correlations between watershed land use and microplastic concentration, 2) uncovering daily and seasonal variability in microplastics concentrations in streams with and without wastewater treatment plant influence, 3) comparing concentrations resulting from grab and neuston net sampling in rivers to identify best field sampling methods, and 4) investigate the role microplastics have in fish diets.

Methods

For all stream studies, a neuston net was used to sample the stream. The net used had a 0.5 x 1m rectangular opening and 335 micron mesh was deployed in the thalweg of each stream for 10 minutes, with stream velocity measurements being taken at the net opening at the start and end of net deployment and averaged to provide the volume of water sampled. All collected solids were rinsed into a glass jar for transport. Regardless of stream sampling technique, samples were processed in the laboratory in accordance to NOAA methods (Masura, et al., 2015), and using a dissecting microscope, the type of microplastic (i.e. film, fiber, bead, etc.) as well as its size class were determined for each particle after two independent counts.

1) Land Use vs Concentration: Microplastics were sampled at ten sites on widely distributed, wade-able tributaries of the Hudson River in summer of 2016. Concentrations calculated from the counts of the neuston net samples will be compared using GIS to upstream watershed land use characteristics.

2) Temporal Variability: Samples were taken every three hours over one 24hr period in a single, designated location in both Fall Creek (downstream of a wastewater treatment plant outfall) and Six Mile Creek in Ithaca, NY in low flow conditions of Fall 2016 and again in high flow conditions of Spring 2017.

3) Methods Comparison: In the thalweg of multiple streams local to Ithaca, NY, including Fall Creek, Six Mile Creek, Cascadilla Creek, and Enfield Creek, two paired microplastics samples were taken: one using the neuston net method described above and the other as a 2L grab sample. In the lab, the grab sample was sieved such that only the size fraction larger than 335um, the mesh size of the neuston net, was preserved in order to ensure the same size fraction was being compared across methods.

4) Fish Diet: With the help of New York State Fish and Wildlife Service employees, >100 small fish were collected in 2016 from Hudson River tributaries. These specimens were dissected and gut content analyzed following protocols developed with Cornell fisheries professors. Following overall diet survey, the gut content of each fish individually underwent a wet peroxide oxidation, following the same NOAA protocols as followed with stream microplastics samples.

Results

Results for Land Use vs Concentration, Methods Comparison, and Fish Diet studies will be shared in the form of journal publication and/or senior thesis once sample collection and laboratory analysis has been completed for each of them.

Preliminary results from the *Temporal Variability* project, included as figure 1, show that both Fall Creek and Six Mile Creek concentrations are significantly different between high and low flows, as found by using a student's t-test. Similar analysis found that there is not a significant difference between concentrations in the two streams at high flows nor at low flows. Concentrations are negatively correlated with flow for both streams and using a Generalized Additive Model (GAM) were not found to be significantly different over time. The GAM revealed that Fall Creek at high flow was the only sampling session to indicate a significant difference between concentrations over the course of the 24 hour sampling period.

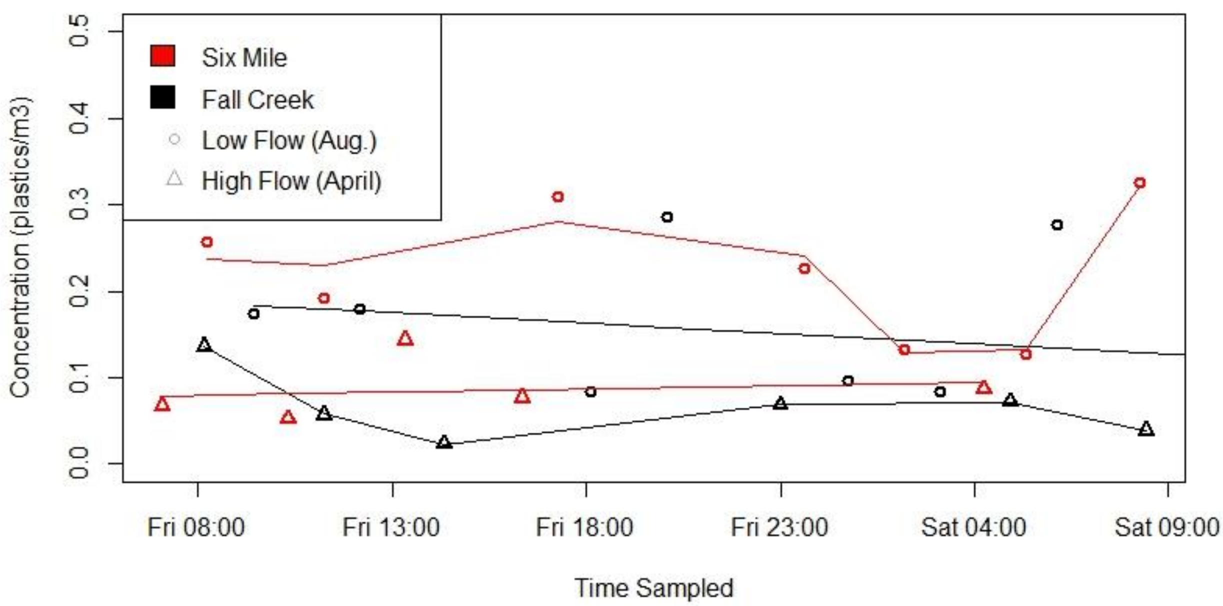

Figure 1. *Measured concentrations of microplastics found in Six Mile Creek and in Fall Creek during 24hr sampling sessions that took place in August 2016 and April 2017. Values constitute a preliminary, single, visual count of the samples and may be adjusted following further visual analysis of samples in the laboratory. Lines are a Generalized Additive Model fit to each of the sampling efforts.*

Comparing the two streams' flow ratios alongside flux (plastics/second) and area ratios, as depicted in table 1, reveals two main points. The first is that at high flows, the streamflow ratio and plastic flux ratio are approximately equal, indicating that both Fall Creek and Six Mile Creek carry nearly equal concentrations of plastics, as supported by the student t-test. These ratios, however, are both lower than the ratio of watershed areas. At low flows, the streamflow ratio is nearly equal to the watershed area ratio, but the plastic flux ratio is approximately one half of these ratios indicating that in this flow condition, Six Mile Creek carries more plastics per time.

Table 1. *Comparison of Fall Creek/Six Mile Creek ratios during high and low flow conditions.*

	Watershed Area Ratio	**Streamflow Ratio**	**Plastic Flux Ratio**
High Flow	2.8	2.0	2.1
Low Flow		3.2	1.5

Discussion and conclusion

This funding cycle, data was collected to support four different studies to inform how microplastic travels and affects ecosystems in the Hudson River system and other rivers of New York State. While sample collection and analysis is ongoing for many of these projects, the initial findings from the *Temporal Variability* study suggest that sampling time does matter when it comes to flow conditions. The results of the study also point at potential differences between plastic inputs in the wastewater treatment effluent-fed Fall Creek and the septic system-populated watershed of Six Mile Creek. As indicated in Table 1, while during high flow conditions both streams behave similarly, during low flow conditions Six Mile Creek may have some additional plastic contribution, unrelated to the system's hydrology, that Fall Creek does not have. These findings suggest future spatial studies of microplastic concentrations should report flow conditions at sampling time and consider them when planning sampling events. Future work will continue to investigate additional trends in the newest data and will be shared via journal publication.

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