Microplastic pollution in the main channel of the Mohawk River: Final results of the 2016 sampling program

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Introduction

The Mohawk River is the largest tributary to the Hudson River and the second largest channelized waterbody in New York State. The Mohawk has a long history of human use, and with humans have come various contaminants that have affected water quality. Among the emerging contaminants threatening the Mohawk River are microplastics, typically defined as plastic particles smaller than 5 mm. Microplastic particles represent a threat to the health and well-being of organisms living within the river and those that feed on them, including humans (Baldwin et al., 2016, and references therein). The majority of wastewater treatment plants (WWTPs) in New York State are not equipped to filter out small plastic particles (Office of the NYS Attorney General, 2015), and combined sewer systems (CSSs) provide a direct means for plastic waste to enter waterways during heavy precipitation events. Microplastic particles can also be introduced directly to the river in runoff and from tributaries. The main goal of this project was to quantify the microplastic load in the Mohawk River as a starting point for assessing the level of environmental risk represented by microplastic pollution. Field work was completed during the summer and fall of 2016 and laboratory analyses followed (Smith et al., 2017a).

Methodology

In total, 63 trawl samples were collected between Rome (west) and the Crescent Dam in Cohoes (east). GPS was used to mark trawl paths. Sampling was conducted from a 4-m (13'5") Zodiac Futura Mark II rigid inflatable boat that towed a manta trawl with a 333-µm net (Eriksen et al., 2013) approximately 12 m behind the boat. Trawls were conducted upstream for an average trawl length of 1.71 km (1.06 mi), with actual trawl lengths ranging from 1.17 km to 2.34 km. Material captured in the net was transferred to a Zip-loc sample bag and labeled with the trawl number and the location information (typically navigation marker IDs from start and finish of the trawl). GPS recorded the starting point, the path, and the endpoint of each trawl.

In addition, 64 grab samples of channel sediment were collected between Rome and Cohoes. GPS was used to mark locations of grab samples. An Ekman 6-inch grab sampler was used for sediment sampling. Grab samples were collected where bottom sediment was sufficiently fine for the jaws of the sampler to close. Some sampling attempts were unsuccessful because rocks propped the jaws open and sediment was lost. Sediment was scooped from the sampler into a zip-loc bag and labeled with sample ID, GPS waypoint, and location indicators such as nearby navigation markers.

Samples were processed using a modified version of NOAA laboratory protocol (Masura et al., 2015. Wet peroxide oxidation (WPO) removed much of the organic material. Sediment samples underwent a density separation with salt water before WPO.

Visual examination of non-organic particles remaining after processing allowed us to distinguish some of the anthropogenic particles by the presence of dyes and/or by their shape, rigidity, and overall appearance. Definitive identification of plastic polymers was accomplished primarily by Raman spectroscopy, with additional analyses by scanning electron microscope (SEM) with energy-dispersive X-ray spectroscopy (EDS). Raman spectroscopy was conducted using a Bruker Senterra µ-Raman spectrometer with a 633-µm helium-neon (green) laser. Raman spectra from trawl particles were compared to spectra from in-house plastic standards acquired using the same instrument. Polyethylene, polypropylene, and polystyrene (Styrofoam) were the most common polymers encountered. We used a Zeiss® EVO-MA15 SEM with a back-scattered electron (BSE) detector and a Bruker EDX system with a Peltier-cooled XFlash 6/30 silicon drift detector to acquire images and perform elemental analyses of particles. The SEM was operated at high vacuum and an accelerating voltage (EHT) of 15 keV. For EDX, a target square measuring approximately 100 μm on each side was outlined on the side of the particle most directly illuminated by the beam.

Findings

Abundance of particles in trawl samples (particles per trawl)

Microplastic particles were found in all of the 63 trawl samples (Figure 1). Abundance ranged from 3 particles to 521 particles, with 30 samples having 3-18 particles, 11 samples having 20-28 particles, 14 samples having 37-86 particles, and the remaining eight samples having 110-521 particles. Although none of the trawl samples lacked microplastic particles completely, relatively low particle counts (<30) prevailed between Herkimer and Tribes Hill.

The two highest abundances (521 and 512 particles) were found in samples taken from the natural channel of the Mohawk River downstream from the Utica WWTP and CSS outfalls (MT32 and MT31, respectively). The Utica samples were collected during a heavy rainstorm and contained the highest number of foam (polystyrene) particles among the 63 trawl samples by an order of magnitude.

The third highest abundance (439 particles) was found in a sample (MT58) collected between 5.0 and 6.7 km downstream from the Schenectady WWTP. The adjacent upstream sample (MT59), which was collected 1.8-3.9 km downstream from the Schenectady WWTP, contained 202 particles (fifth highest), while the adjacent downstream sample (MT57) contained 110 particles (eighth highest). The Schenectady samples are notable for containing the highest number of spherical beads (16 in MT-57, 20 in MT-58, and 11 in MT-59) among the 63 trawl samples.

Some of the samples with high particle counts are not near WWTPs or CSS outfalls, so their microplastic loads are more enigmatic. Sample MT62 (2.5-4.5 km upstream of Amsterdam, between Lock 11 and Lock 12) had a microplastic particle count of 268 (fourth highest), of which 265 particles were fibers. No other trawl sample had a similar abundance of fibers; the next highest fiber count was 88 in MT32 (Utica). Sample MT25, which was collected 0.200-1.65 km downstream from Lock 9 in Rotterdam Junction, had a microplastic particle count of 135 (sixth highest), whereas the adjacent samples from upstream (MT26) and downstream (MT24) had lower particle abundances (37 and 40 particles, respectively). The particle count in MT25 was even slightly higher than that of upstream sample MT29, which was collected between the Amsterdam WWTP and Lock 10 and had a microplastic particle count of 122 (seventh highest).

Adjusted abundance of microplastic particles in trawl samples (particles/m^2)

To compare particle abundance between samples collected over different trawl lengths, abundance of microplastic particles per square meter (adjusted abundance) was calculated by dividing particle count by trawl area [width of trawl opening (0.6 m) multiplied by length of trawled section of river (in m)]. The resulting adjusted abundance assumes that microplastics were collected from the surface of the river at a constant net water velocity of 9.66 kph [8.05 kph (boat) plus 1.61 kph (river)].

The ranking of the nine highest particle counts and nine highest adjusted abundances are the same. Adjusted abundances range from a minimum of 0.003 particles/m^2 (MT5, collected 2.0-3.7 km downstream from Fonda-Fultonville WWTP) to a maximum of 0.743 particles/m^2 (MT32, collected in the natural channel of the Mohawk River on a trawl that ended at the boat launch across the street from the Utica WWTP). As for particle count, the sample with the second highest adjusted abundance is MT31 (0.594 particles/m^2), which was collected downstream from MT32 in Utica, and the third highest adjusted abundance is for MT58 (downstream from Schenectady WWTP) with 0.460 particles/m^2.

Sediment grab samples

All of the 64 sediment grab samples contained at least one microplastic particle, but abundance in general was lower than in the trawl samples (Figure 2). The great majority of the sediment samples (51, or ~80%) contained fewer than 10 particles, 11 (~17%) contained 10 to 21 inclusive, and the remaining two contained 66 (fragments of film) and 75 (clump of fibers). Overall, fibers dominate the microplastic content of the sediment samples, with minor contributions from fragments and films. Foams and pellets/beads were not found.

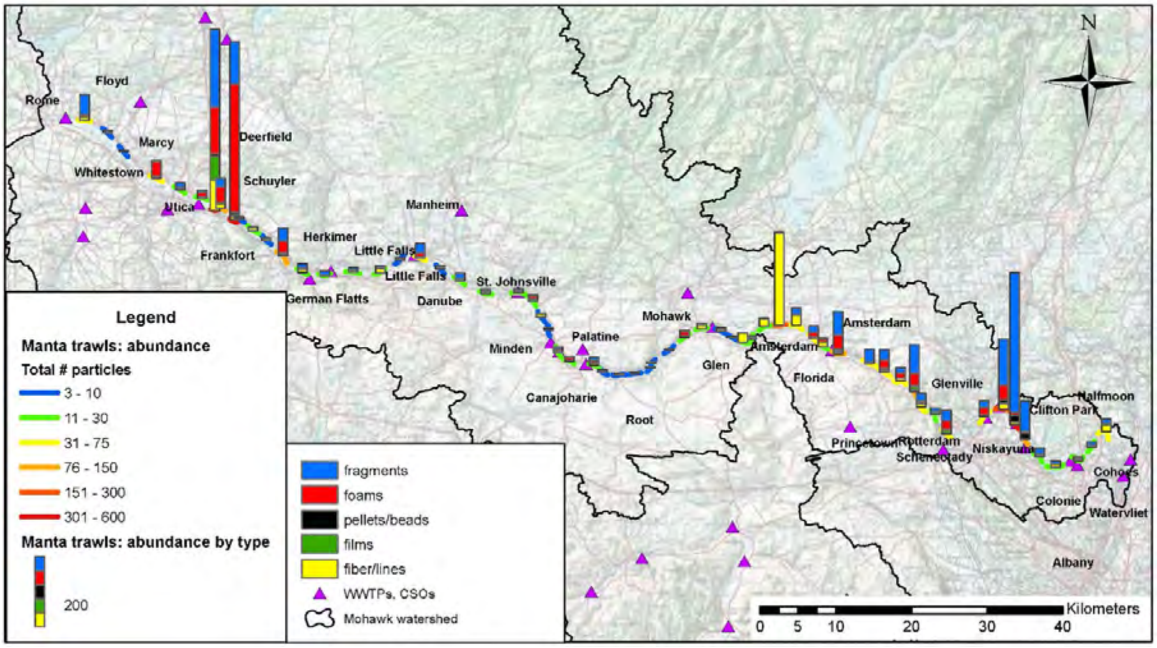

Figure 1: Abundance of microplastic particles in manta trawl samples collected between Rome and Cohoes in the Mohawk River and Erie Canal June-October 2016. Highest abundances were found in samples from Utica/Frankfort and Schenectady/Niskayuna. Vertical bar graphs show samples broken done by morphological type of particle (fragment, foam, pellet/bead, film, fiber/line).

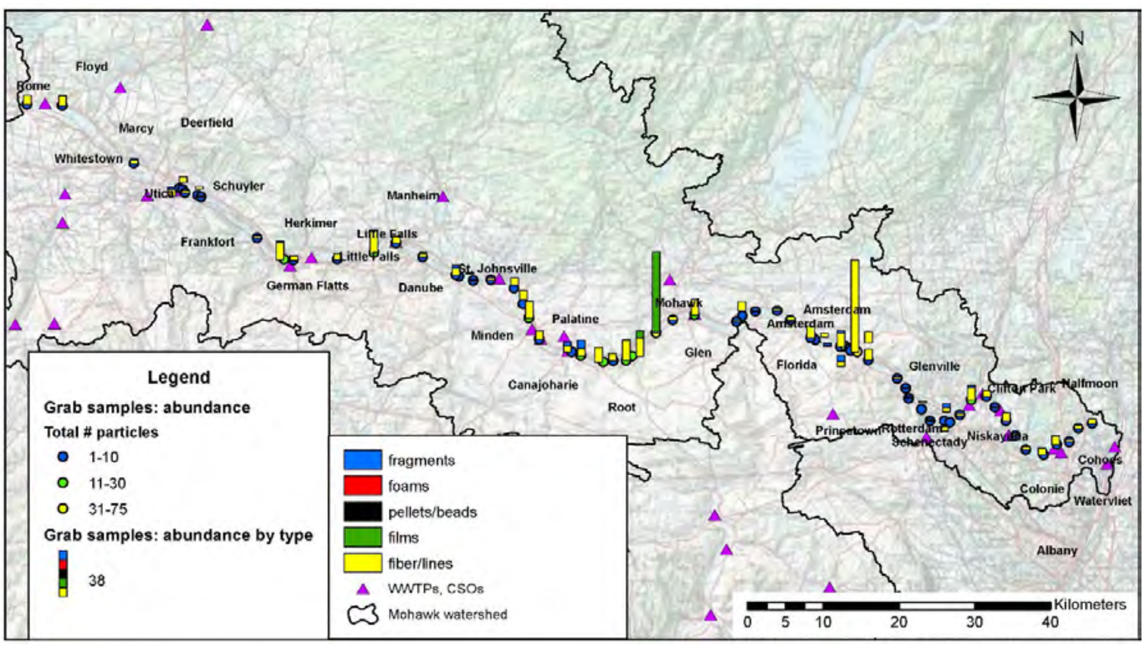

Figure 2: Abundance of microplastic particles in sediment grab samples collected between Rome and Cohoes in the Mohawk River and Erie Canal June-July 2016. The majority (~80%) of sediment samples contain fewer than 10 microplastic particles. Vertical bar graphs show samples broken down by morphological type of particle (fragment, foam, pellet/bead, film, fiber/line). Fibers are the dominant particle type in the sediment samples.

Other microplastics in the Mohawk River

Fly ash particles, and to a lesser extent coal ash particles, were found in 89% (56/63) of the trawl samples (Smith et al., 2017b). Fly ash was present in approximately 50% of sediment grab samples while all of the sediment grab samples contained black particulate material that may be coal ash, unburned coal, or inertinite (fossilized charcoal).

Discussion

We found microplastic particles in surface water along the entire sampled length of the Mohawk River and the Erie Canal. The abundance and the proportions of plastic types in surface water varied along the river, but not systematically. The lack of monotonic downstream increase in abundance of microplastic particles suggests that one or more processes is at work to sequester and/or dilute the concentration of particles. Similarly, high abundance correlates with the location of WWTPs or CSSs in some cases, such as MT31 and MT32 in Utica, MT29 in Amsterdam (122 particles), and MT43 in Rome (74 particles), but not in others. For example, MT37 in the Erie Canal in Schuyler (86 particles) is not near a WWTP or identified CSS outfall, although the trawl ended at a tributary stream that may contribute runoff from urbanized areas on the north bank (Figure 1).

The variability in proportions of plastic types within the surface water of the channel suggests the effects of distinct local inputs. For example, the abundance of spherical beads (so-called microbeads, including blue ones) and colorless fragments in samples taken downstream from the Schenectady WWTP could be interpreted as a signal for discharge of microplastics originally sourced from personal care products in the treated wastewater stream. Microbeads (particularly blue ones), which were used in personal care products such as facial scrubs prior to the 2017 federal ban, are perhaps the most distinctive and easily recognizable form of microplastic particle found in the river. Similarly, the abundance of foam particles and plastic fragments in the samples collected downstream from the Utica WWTP and CSS outfalls may represent a substantial contribution from stormwater runoff. Some areas with relatively high particle counts have more obscure potential sources, however, including the Rotterdam Junction/Lock 9 sample (MT25).

The dominance of fibers as the type of microplastic particle found in sediment grab samples is similar to the findings of Ballent et al. (2016) in their study of nearshore sediments and tributaries of Canadian Lake Ontario. In the Lake Ontario study, fibers and fragments were the dominant particle type among microplastics <2 mm in all depositional settings. A combination of negative buoyancy in some or all of the fibers and sufficiently calm flow conditions permitted the deposition of fibers – almost to the exclusion of other particle types – along with the silt and sand that composed the sediment grab samples collected in the Mohawk channel.

Conclusion

Microplastic particles are pervasive in surface waters of the lower Mohawk River. Both abundance (particles/sample and particles/m^2) and proportions of particle type in each sample vary non-systematically, however, along the sampled length of the river. Notwithstanding the inherent potential for variability associated with any sampling campaign that occurs over multiple days, the variations in abundance suggest that microplastics are being sequestered within the river, perhaps in wetland areas, and diluted to some extent at the pooled eastern end of the river.

Variations in proportions of plastic types in surface water likely reflect the influence of local inputs, such as surface runoff, combined sewer overflows, and WWTP effluent, which deliver pulses or streams of particles with characteristic features (e.g., Styrofoam particles in Utica, blue microbeads in Schenectady). In some cases, high abundance of microplastic particles corresponds closely to proximity to WWTP outflow, but not in all cases. In contrast, the near-uniformity of microplastics in sediment samples suggests control by physical parameters. The presence of microplastics in both water and sediment increases the potential risk to ecosystems and organisms in the Mohawk River.

Teasing apart the variables that combine to produce the microplastic load at any given location in the lower Mohawk River is the primary goal of using microplastic pollution to better understand the pollution load in the river. Educating the public and the future stewards of the environmental are fundamental components of a successful environmental investigation.

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Poster Presentation