The Distribution of Microplastic Pollution in the Mohawk River

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Introduction

The Mohawk River is the second largest channelized waterbody in New York State and the largest tributary to the Hudson River. The Mohawk has a long history of human use, and with humans have come various contaminants that have affected water quality (NYSDEC, 2010). Among the emerging contaminants threatening the Mohawk River are microplastics, typically defined as "… plastic smaller than 5 millimeters, whether intentionally manufactured to be that size or as a result of the fragmentation and breakdown of larger plastic products." (Office of the NYS Attorney General, 2014). 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), such as those in Utica, Little Falls, and Amsterdam, 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.

The main goal of this project is 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.

Methodology

In total, 63 trawl samples were collected between Rome (west) and the Crescent Dam in Cohoes (east). Sampling was conducted from a 4-m (13'5") Zodiac Futura Mark II rigid inflatable boat that towed 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. 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 undergo 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. Shape, plasticity, and overall appearance formed the basis for preliminary identification of particles as plastic. Definitive identification of particles as 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 He-Ne 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 the 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 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. We concentrated on particles suspected of being fly ash and coal ash, but also included some plastic particles for comparison.

Findings

Abundance of particles (particles per trawl)

Microplastic particles were found in all of the 63 trawl samples (Table 1, Figures 1 and 2). 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.

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 Lock12) 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 (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).

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). The ranking of the nine highest particle counts and nine highest adjusted abundances are the same. 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. In seven cases among the remaining 54 samples (those with <86 particles), samples move up or down in ranking (generally by one spot) between particle count and adjusted abundance.

Other microparticles 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 (see Smith et al., this volume). We previously identified some green particles collected from the Mohawk River as paint that is spectrographically similar to paint from Lock 9 in Rotterdam, NY (Hodge et al., 2016).

Preliminary findings: Sediment Samples

Analytical work on the sediment samples is underway. Microplastic content in the 25 completed sediment samples is generally low to zero.

Discussion

Microplastic particles are present along the entire sampled length of the Mohawk River and the Erie Canal. Both the abundance and the proportions of plastic types vary along the river, but not systematically. The lack of monotonic increase in abundance of microplastic particles downstream 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 near Deerfield (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.

The variability in proportions of plastic types within 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. Blue microbeads, which are used in personal care products such as facial scrubs, are perhaps the most distinctive and easily recognizable form of microplastic particle found in the river. Similarly, the abundance of styrofoam 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).

Conclusions

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 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. 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.

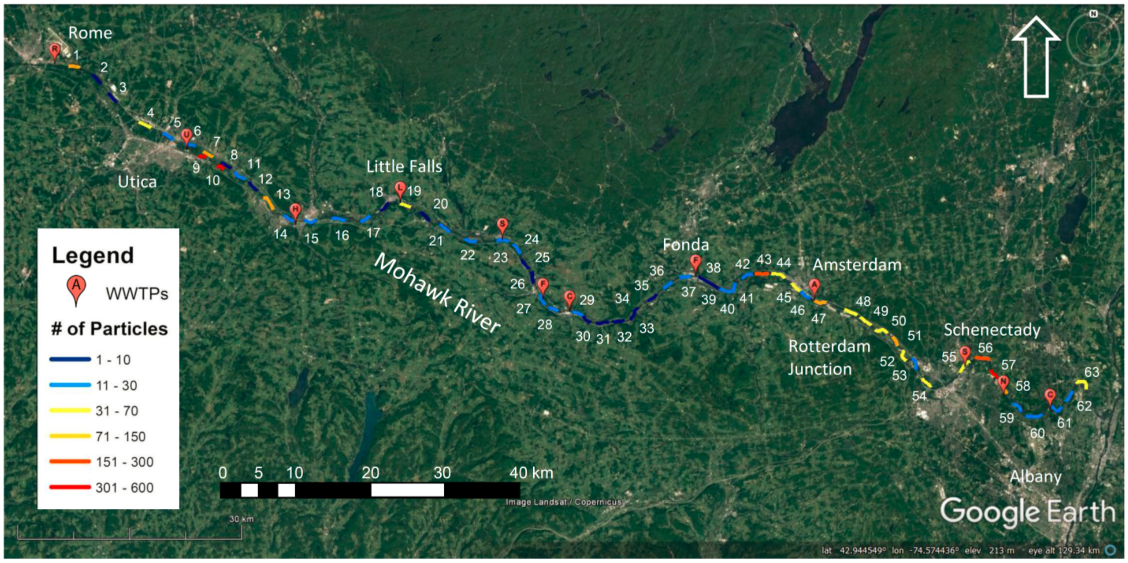

Figure 1. Google Earth image of the lower Mohawk River showing 63 manta trawl tracks color-coded to indicate abundance of microplastic particles found in each sample (MT1-MT63; Figure 2). Numbers 1-63 adjacent to trawl tracks are sequential from west to east and correspond to numbers in gray on Figure 2. Wastewater treatment plants (WWTPs) are indicated by markers. Samples were collected in summer/fall 2016. The three highest microplastic particle counts (521, 512, and 439) were found in samples from tracks 9 and 10 (MT32 and MT31) downstream of the Utica WWTP and combined sewer system (CSS) outfalls, and track 57 (MT58) downstream of the Schenectady WWTP, respectively.

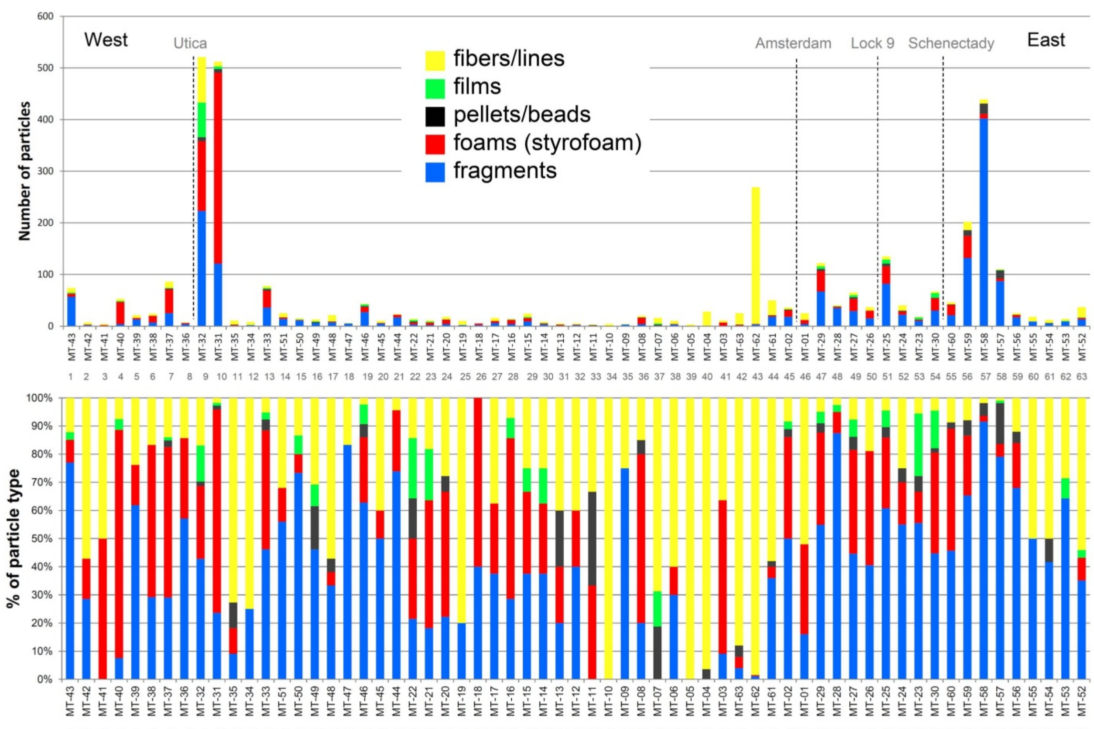

Figure 2. Upper plot: Total microplastic particle counts in 63 trawl samples, broken down by type of particle (fragments, foams, pellets/beads, films, fibers/lines). Sample IDs for each manta trawl sample (MT1-MT63) are ordered from west to east; numbers 1-63 in gray below the sample IDs correspond to track numbers on Figure 1. Approximate centers of three urban areas and Lock 9 in Rotterdam Junction are indicated by dashed vertical lines. Sampling indicates that microplastic particles are pervasive in the lower Mohawk River, although the abundance varies non-systematically between Rome (west) and the Crescent Dam in Cohoes (east). The highest particle counts are found in MT32 (521) and MT31 (512) in the natural channel of the Mohawk River in Utica, and in MT58 (439) in Schenectady.
Lower plot: Percentage of each of the five microplastic particle types in the trawl samples. The order of the samples is the same as in the upper plot. The variation in proportions of plastic types from sample to sample suggests the influence of local inputs. For example, the abundance of foam particles in the Utica samples (MT31 and MT32) may indicate a substantial contribution from stormwater and surface runoff, whereas the notable abundance of microbeads and colorless fragments in the sample collected downstream from the Schenectady WWTP (MT58) suggests that one source may be plastic abrasive particles in personal care products that were discharged with treated wastewater.

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Invited Oral Presentation