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Assessing Microplastic Pollution in Four Mile Run, an Urban Stream in Northern Virginia

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ABSTRACT

Microplastics are pollutants of concern in waterways and oceans for their persistence and impact on aquatic life and food webs. This study demonstrates a low-cost land-based sampling method to assess the extent of microplastic pollution found in Four Mile Run, an urban stream in Northern Virginia. Microplastic particle counts in environmental and treated wastewater ranged from 0.01-0.24 particles L^{-1} (mean 0.08 particles L^{-1}) and from 2 to 446 μg L^{-1} (mean 70 μg L^{-1}), with fibers found to be the most common microplastic category. Treated wastewater effluent was found to be a significant source of microplastic pollution, though microplastics were also found upstream of any influence from wastewater or tide-borne materials. The sampling method proved effective for collecting and analyzing microplastic pollution, though the sample size of 100 L was deemed insufficient for reliable measurement of total mass of microplastics.

Keywords: Microplastic, Pollution, Urban, Water

INTRODUCTION

Plastic has been an important material for humankind in the last century, and it is ubiquitous in daily life. Often used for packaging and other single-use applications, plastic is an inexpensive material with favorable properties such as strength, light weight, durability, and water resistance. Rather than breaking down chemically when weathered, plastic items (e.g., litter) break apart into smaller and smaller fragments, persisting in the environment. While there is no scientific standard for the size at which such fragments are designated microplastics, many authors have adopted an upper size threshhold of 5 mm, with particles smaller than 100 nm considered nanoplastics (Koelmans et al. 2019, Prata 2018, Horton et al. 2017, Koelmans et al 2015, Masura et al. 2015). Microplastics are *primary microplastics* when they originate in the size class, as is the case with virgin plastic

pellets used as raw material in manufacturing, and with so-called 'microbeads' used in cosmetic and abrasive products (Horton et al. 2017). *Secondary microplastics* are fragments derived from plastic products such as single-use plastic containers and bags (e.g., litter), broken plastic tools, toys, or household items, and fibers shed from synthetic fabrics, carpets, and other textiles (Ibid).

Microplastics have received recent attention for their presence in natural environments, notably in areas of concentrated floating debris, as in subtropical gyres of the world's major oceans (Ryan 2015), but as a human-created product, plastics originate on land. When plastic and plastic waste are mismanaged they are often transported and weathered in freshwater systems prior to reaching the ocean. We thus expect streams and rivers to transport and contain microplastics, and there is a growing body of evidence to show it. Microplastics have been found in large freshwater lakes (Eriksen et al. 2013), river sediments (Castaneda et al. 2014), and in smaller water bodies, even ones far removed from human activity (Horton et al. 2017). They have also been found in drinking water and its sources (Koelmans et al. 2019).

With mounting concern over the widespread microplastic contamination of aquatic ecosystems, some studies have explored the effects and potential impact of microplastics on ecosystem and organism health, either through intrinsic chemical toxicity or as a vector for organic pollutants and heavy metals (Chae & An 2017). Microplastics are ingested by a variety of marine and freshwater organisms and incorporated into tissues, affecting feeding behavior, reproduction, viability, and mortality (Chae & An 2017, Herzke et al. 2016, Sussarellu et al. 2016, Tanaka & Takada 2016, Hall et al. 2015). In marine and freshwater studies, microplastics have been shown to absorb toxic pollutants readily (Nguyen et al. 2019, Chae & An 2017, Mato et al. 2001). Through bioaccumulation, microplastics and any associated toxins may concentrate higher up the food chain, potentially finding their way onto the plates of consumers (Smith et al. 2018, Rochman et al. 2015, Tanaka et al. 2013).

High concentrations of microplastics have been found in waterways in urban settings (Vermaire et al. 2017, Dris et al. 2015, McCormick et al. 2014, Moore et al. 2011), and microplastic loads to surface waters appear to increase with urban density (Rhoades et al. 2019, Baldwin et al. 2016, Yonkos 2014). In populated areas with sanitary sewer systems, treated wastewater can also be a source of microplastics, particularly fibers, to receiving waters, even though treatment systems are capable of removing a large proportion of microplastics borne in raw sewage (Le Tarte et al. 2019, Burns et al. 2018, Leslie et al. 2017, McCormick et al. 2016).

The present study examines microplastic pollution in Four Mile Run, a Potomac River tributary that flows through Arlington and Fairfax counties and the cities of Falls Church and Alexandria in northern Virginia, USA (Figure 1). The Four Mile Run watershed drains a highly urbanized area of 51 km^2, with estimates of impervious surface cover exceeding 35% (Davey Resource Group 2017, Fry et al. 2011). Four Mile Run's annual-mean discharge ranges from 0.23 to 1.16 $m^3\ s^{-1}$ upstream of tidal influence (USGS 2019). During rainfall events, however, peak flows routinely exceed 90 $m^3\ s^{-1}$, reflecting

its urban hydrology. With more than 200,000 people living in the watershed, human impacts are inevitable. Arlington County's wastewater treatment plant discharges treated water into the tidal channel at an average rate of 87,000 m^3 d^{-1}, or roughly 1 m^3 s^{-1} (Arlington County, 2019). The Virginia Department of Environmental Quality has listed Four Mile Run as impaired under section 303(d) of the Clean Water Act for bacteria and for PCB and chlordane contamination in fish tissue (Virginia DEQ 2018, NVRC 2004). The Run is also significantly impacted by litter. Each year volunteers with the Four Mile Run Conservatory Foundation remove more than two tons of litter, much of which is plastic. In seventeen years of Arlington community clean-ups upstream on the Run, three quarters of the litter items collected have been plastic, a third of which were in the form of plastic/foam fragments (EcoAction Arlington 2019).

The goal of the present study is to document the extent of microplastic pollution in Four Mile Run, describing the quantities and types of microplastics found, using a land-based method for sampling in urban streams that are too shallow for the use of conventional tow-net protocols. Our research questions include how the microplastic pollution compares to that found in other freshwater settings and what types or sources of microplastics can be found. Four Mile Run is an outlier among the kinds of freshwater streams that have been studied: it is one of the smallest in terms of watershed area and discharge, yet possibly the highest in population density, compared to tidal and non-tidal waterways in existing studies covering more than 50 freshwater rivers and streams (Rhoades et al. 2019, Horton et al. 2017, Vermaire et al. 2017, Baldwin et al. 2016, McCormick et al. 2016, Dris et al. 2015, McCormick et al. 2014, Yonkos 2014, Moore et al. 2011). Because so few studies have examined freshwater streams of Four Mile Run's small size or extent of urbanization, the results of this study can inform future research, particularly studies that could be conducted by volunteers or nonprofit groups using inexpensive equipment and analytical techniques suited to a school chemistry lab or comparable small facility.

METHODS

Sampling was conducted in June 2018 and in May/June 2019 during the course of the Four Mile Run Conservatory Foundation's summer intern field season, as schedule, weather, and safety conditions allowed. Water samples were collected from locations at lower Four Mile Run in the City of Alexandria and Arlington County, Virginia (Figure 2). Sample locations were all within a 1 km radius of the Mount Vernon Avenue bridge, ranging from tidal to non-tidal waters within the flood control levee system. Samples were collected from four general locations: on upstream non-tidal main stem and tributary waters above the confluence of Lower Long Branch Creek (UP); near the head of tide on the main stem of Four Mile Run near the Mount Vernon Avenue bridge (FM); at the Hume Spring tributary mouth and at the large stormwater outfall near its head (HS); and from treated wastewater effluent at the Arlington Water Pollution Control Plant outfall (TP).

With modifications noted below, the methods used in this study follow the procedures outlined by the National Oceanic and Atmospheric Administration for microplastic sampling and analysis (Masura et al. 2015). Precautions were taken at every stage of sample collection, handling, processing, and analysis to avoid and minimize microplastic contamination of samples, though it would be impractical to eliminate every

potential microplastic contaminant source. Non-plastic materials were used as much as possible, and where plastic equipment was considered necessary, it was inspected to ensure it was in good condition, without apparent wear or likelihood of material loss. Specific precautions are additionally described below. Equipment/materials made of plastic or with plastic components included: sample jar caps/liners, rinse bottles, spray bottle, bungee cords, portable field table, equipment transport buckets, hip waders, eyeglasses, safety goggles, lab smocks and gloves, reagent bottles, digital thermometers, magnetic stir bars, custom sieves, vial caps, and microscopes.

Field protocol

Precautions taken to avoid microplastic contamination during sample collection included wearing non-synthetic clothing while sampling, rinsing the sample collection bucket with stream water several times at each sampling site, collecting samples up-current of where the researcher and field equipment were located, applying rinse water (tap water) only from the reverse side of the sieve, and using new, clean glass sample jars. At each sampling site, equipment was checked to ensure it was free of extraneous material and in good condition.

Water samples were collected by repeated draws of a galvanized steel bucket which had been modified so that twelve draws of the bucket resulted in 100 L of water sampled. The sample volume was arbitrarily selected as practical for land-based hand sampling, while sufficiently large to ensure a measurable amount of solid material after sieve filtration. Modification of the bucket, of approximately 10 L nominal size, consisted of filling it with 8.33 L measured volume of tap water, marking the water level while the bucket was lifted/supported by its handle, then drilling holes on one side at and above the marked water line, so that sample water could be poured from the opposite side in a controlled manner. Samples were reduced in volume by sieve filtration, pouring from the bucket through two stacked sieves, the upper sieve a #3.5 mesh stainless steel test sieve, allowing only materials of size approximately 5 mm or less to pass through, and the lower sieve a #50 mesh brass test sieve, retaining particles larger than 300 µm. As in microplastic studies that commonly use towed neuston nets, materials in the microplastic size range of 300 µm to 5 mm were thus retained from the lower sieve. All other materials were discarded. Sieved materials were transferred from the lower sieve into 240-mL glass sample collection jars by careful rinsing with tap water filled rinse bottles from the reverse side of the sieve, with material scraped with a metal scoopula and/or bamboo scraper where needed, until no microplastic or other materials were visible in the sieve. Each finished sample consisted of solid materials in approximately 40-100 mL of rinse water.

Laboratory protocol

Field-collected samples were analyzed using the procedure outlined in NOAA guidance for microplastic analysis of water samples (Masura et al. 2015) by wet peroxide oxidation/digestion, without the iron catalyst (Figure 3). We chose not to use the catalyst because we believed it to be a simpler and safer procedure, suitable for volunteers, and because our samples contained far less material than is typical for tow-net collected samples. To minimize post-sampling contamination from indoor air, samples were kept covered with foil when not in use, and as much as practical, non-synthetic materials were

utilized, such as paper tape, foil, natural fiber clothing, and metal tools, with deionized water used for solutions and rinsing glassware. Glassware was washed and rinsed with deionized water immediately prior to use. Where plastic equipment was used during lab procedures, as with squirt bottles for rinsing samples and equipment, it was inspected visually to ensure it was in good condition and unlikely to be a source of contaminants.

The samples were transferred into clean pre-weighed 150-mL beakers, using a spatula and minimal rinsing with deionized water. The beakers were loosely covered with foil and samples then air-dried in drying ovens at 90-95°C for 24 hours or longer, to sample dryness, allowed to cool, and weighed for total mass of solids. In a fume hood, 20 mL of 30% hydrogen peroxide was added to each beaker. The beaker was allowed to stand at ambient temperature for at least five minutes before adding a stir bar and heating to 75°C on a hot plate. The temperature was then maintained at 75°C for at least 30 minutes, with 30% hydrogen peroxide added as needed to replenish evaporated liquid, and until much of the natural material (e.g., algae, leaf material) was no longer visible in the beaker. When oxidation/digestion was complete, approximately 6 g salt (NaCl) per 20 mL of sample was added to increase the density of the solution, before transferring the solution to a density separator, covering, and allowing it to settle for at least 24 hours. Settled solids (non-plastic) were drained, inspected, and discarded, with floating and suspended solids collected/rinsed onto a clean 300-µm custom sieve, covered with foil, and air-dried. The custom sieves were made from approximate 25-mm lengths of 52-mm inner-diameter PVC pipe (nominal 2-inch), to which 300-µm nylon mesh screening was affixed using a multi-material gel adhesive, as per Masura et al. 2015.

The 300-µm custom sieves were examined under a dissecting microscope. Microplastic items were visually discerned by color and/or shape, distinct from plant materials such as seed coats or plant fibers. Hard plastic materials were additionally discerned by their durability and resistance to light pressure from metal forceps, whereas natural materials tended to come apart easily. Plastic foam materials also resisted pressure, returning to form readily, whereas natural foam-like materials deformed or broke apart. Items identified as microplastics were removed from the sieve and transferred using forceps into a clean and pre-weighed 4-mL vial. Total mass of microplastics was then determined to the nearest 0.1 mg. Microplastic particles were counted and classified into five categories: pellet, fragment, fiber, film, and sponge/foam.

RESULTS

Microplastics were found in every sample, in spite of the small sample sizes (Table 1). Particle counts ranged from 1 to 24 microplastic particles per 100 L sample, with a median of 7 and mean of 8 particles per sample. The concentrations of microplastic materials ranged from 2 to 446 µg L^{-1}, with a median of 13 and a mean of 70 µg L^{-1}.

Fibers accounted for the majority of microplastic particles, followed by fragments and sponge/foam pieces (Figure 4). Although the method used would be expected to capture particles in sizes up to 5.6 mm, based on the mesh size, the microplastic particles recovered from the procedure were all sized 1 mm or less, though a few of the tangled fiber particles, if fully extended, would have been of length greater than 1 mm. No pellet-type

microplastics were found. The sites at which the samples were collected differed somewhat in their composition by microplastic category. For example, foam particles were a more prominent component of the tidal Hume Spring samples, though the nature of tidal influence could not be effectively determined, as the number of samples collected was insufficient for comparison, given the variety of tidal conditions (incoming/outgoing, various stages) during sampling.

Because some samples were collected within a day of localized rainfall, it was expected that they might contain higher concentrations of microplastics due to stormwater pollutants and re-suspension of stream sediments. The non-wastewater samples collected in 2019 were compared to determine whether they differed depending on whether or not they had been collected within 24 hours after rain events, as recorded at the USGS gage station 01652500 (USGS 2019), located 1.9 km upstream from the Mount Vernon Avenue bridge. Because the variances differed between the rain (n=5) and no-rain (n=5) groups, for both the number of microplastic particles and the masses of microplastics, the non-parametric Wilcoxon rank-sum test was used to compare the two groups. For both tests, the critical value for $\alpha = .05$ (two-tail) is $W_{crit} = 17$. Both tests resulted in $W = 24.5$, thus the null hypothesis is not rejected, and no significant difference was found.

DISCUSSION

Microplastics in Four Mile Run

Secondary microplastics, derived from the breakdown of larger plastic items, were evident in all Four Mile Run samples, while primary microplastics, associated with manufacturing (e.g., pellets) and cosmetics/abrasives (e.g., microbeads) were not found. Among the microplastic particles, fibers were the most prevalent category. They were present in 11 of 14 samples, from tidal and non-tidal sites and from wastewater effluent. This is consistent with the assessment that fibers are abundant and often prevalent in aquatic settings (Horton et al. 2017, Koelmans et al. 2019). These results, however, are not in concordance with results reported for the Potomac River, to which Four Mile Run is a tributary (Rhoades et al. 2019). Fibers have been shown to be a major component of treated wastewater effluent (Le Tarte et al. 2019, Leslie et al. 2017), and they account for the overwhelming majority of airborne microplastics (Dris et al. 2017, Dris et al. 2016). Since fibers were abundant in Four Mile Run well above the influence of the tide at the confluence of Long Branch Creek, sources other than treated wastewater are implicated.

The microplastic particle counts, expressed as 0.01-0.24 particles L^{-1} (mean 0.08, median 0.07) show that Four Mile Run has relatively high levels of microplastic pollution compared to similarly situated urban streams. The counts are higher than those reported for waterways in the Chicago metropolitan area (≤0.006 particles L^{-1}, Hoellein et al. 2017; and ≤0.018 particles L^{-1}, McCormick et al. 2016, McCormick et al. 2014) and urban tributaries to the Great Lakes (≤0.013 particles L^{-1}, Baldwin et al. 2016), though very similar in range to findings for the Ottawa River (0.05-0.24 particles L^{-1}, Vermaire et al. 2017). They are substantially lower than results obtained for the heavily-urban San Gabriel River (0.411 particles L^{-1} for the comparable microplastic particle size class, Moore et al. 2014), and

somewhat lower than those obtained in a small non-peer-reviewed study conducted at Four Mile Run (0.2-0.9 particles L^{-1}, Libelo and Gallagher 2018).

The counts from the present study are higher than those reported for the nearby waters of Great Hunting Creek and the Potomac and Anacostia rivers (≤0.005 particles L^{-1}, Rhoades et al. 2019), and substantially higher than those for tributaries of the Chesapeake Bay (≤0.001 particles L^{-1}, Yonkos et al. 2014). Some of the difference may be because the sampling in the latter two studies was conducted from boats, from the surface of higher-order waterways. Another likely factor is that the watersheds in those studies had lower population densities and less impervious land surface cover than at Four Mile Run, which is more toward the urban end of an urban-rural land use gradient.

Particle counts for samples taken well upstream of Arlington's wastewater facility and above any tidal influence contained microplastics in abundance, demonstrating that wastewater is not the only important source. Although the present study was unable to show a difference between samples based on recent rainfall, litter and other plastic items washed from streets to storm drains are a potential source, and there are numerous storm drain outfalls throughout the Run. Airborne microplastics may also be important (Prata 2018, Dehghani et al. 2017, Dris et al. 2017, Dris et al. 2016).

Our two wastewater effluent samples had particle counts far exceeding those reported in a comparable study for six wastewater treatment plants discharging to Lake Champlain (means ranging between 0.0006 and 0.0026 particles L^{-1}, with a maximum count of 0.018 particles L^{-1}, Le Tarte et al. 2019). It is possible that our samples were not representative of the typical discharge concentration, and/or the results may reflect differences in the treatment facilities themselves; among other differences, the daily discharge from Arlington's Water Pollution Control Plant is five times that of the largest of the Lake Champlain treatment plants. In contrast, a study of wastewater treatment facilities in the Netherlands reported particle counts for the equivalent particle size class (0.3-5.0 mm) that were much higher (ranging from 0-101 particles L^{-1}, mean 26 particles L^{-1}, Leslie et al. 2017). That study differed significantly in methodology, with neither wet peroxide digestion nor density separation prior to filtration and visual identification, and again, differences in treatment systems may be a factor in the higher counts.

A rough approximation of the amount of microplastic carried by Four Mile Run annually is estimated from the median microplastic concentration in the environmental water samples (12 μg L^{-1}, with the wastewater treatment effluent samples excluded) and multiplying by the median annual flow of the run (16,524,864 m^3 yr^{-1} at the USGS gauge, above the wastewater treatment plant and tide), to reach an estimate of 200 kg yr^{-1}, excluding the amount conveyed by the wastewater treatment plant. This figure is likely an overestimation, as the samples in the tidal reach would be a mixture of Four Mile Run water and wastewater treatment effluent, influenced by tidal mixing.

A similar estimate of the annual microplastic contribution of the wastewater treatment plant is made using the low microplastic figure (100 μg L^{-1}) and the daily wastewater treatment flow to reach a total of 3,200 kg yr^{-1}, an order of magnitude above

the preceding estimate. Further study could verify the extent to which treated wastewater effluent accounts for the total amount of microplastic flowing from Four Mile Run to the Potomac River, but our data suggest it is substantial, especially because the treatment plant's annual outflow is nearly double the median annual flow of the Run itself.

Implications of study method for volunteer-based and citizen science

Modifying a metal bucket by drilling holes or cutting notches so that it drains to a known/measured volume is a low-cost approach well-suited to field sampling by volunteers. It is important to make cuts/holes on only one side, so that the sample can easily be poured from the opposite side without spilling. A watering can could be similarly modified, though it would be more difficult to inspect/clean. The sample size of 100 L is easily collected by this method; a larger sample size, however, would be less practical, due to potential for fatigue while hoisting/pouring repeatedly and for mis-counting the number of draws.

The 100 L samples used in the present study were sufficient for detecting microplastics in quantities that can be easily counted and classified in a basic chemistry lab, such as a school facility. In a less urban setting, the sample amount would surely need to be larger, consistent with the recommendations of Koelmans et al. 2019. Although it worked well for particle counts, the sample size was too small for a good comparison of microplastics by weight. Measured mass is a proper quantitative measure, whereas particle counts are only semi-quantitative, since otherwise identical samples could differ due to breakage of fragments during sampling/processing. Nonetheless, particle counts are a practical and commonly-used methodology that is useful for examining the types and proportions of microplastic materials.

Conducting wet peroxide oxidation without the iron catalyst was chosen to reduce cost and enhance the safety of the lab procedure for volunteers, intended to avoid the higher temperatures and risk of overheating associated with the catalyzed reaction (Masura et al. 2015). For most of the samples, this was indeed the case. However, some of the samples themselves contained iron in sufficient quantity to catalyze the reaction, with the resulting elevated temperature and violent bubbling. A strong such reaction was observed for sample HS 3, which had been collected directly from a large-diameter steel culvert pipe. Because there are many situations which might lead to iron being present in urban streams, we recommend that the wet peroxide oxidation be performed with the iron catalyst, so that the stronger reaction doesn't come as a surprise.

Koelmans et al. (2019) provide guidance on conducting high-reliability microplastic studies. While some of their recommendations are perhaps beyond what a non-profit or citizen-science study would find practical, we believe that incorporating negative and positive controls is a low-cost measure that would help quantify errors attributable to sample contamination and material loss during processing. Although we took pains to minimize the use of synthetic materials, notably clothing, in the field and in the lab, and to keep samples covered as much as possible, it was apparent that microplastic fibers float/drift easily on the slightest of air currents. Loss of microplastic particles through collection/sampling is also possible.

Klein et al. (2018) discuss two potential points of microplastic material loss during wet peroxide oxidation process and sodium chloride density separation. First, hydrogen peroxide is capable of chemical degradation of some plastics (though more characteristically when applied in combination with strong acids or bases), thus it might degrade and reduce the size of particles that otherwise would be in the microplastic size class. Second, during density separation the saturated sodium chloride solution is less dense than some plastics, such as polyvinyl chloride (PVC), so these microplastic particles might settle and be discarded with non-plastic materials. High density particles that might be lost during density separation wouldn't ordinarily be expected to be found in freshwater samples collected at the surface, as with the present study, as the density difference is even greater. Alternatives to simple wet peroxide oxidation and saturated sodium chloride for density separation tend to use materials that are more costly, more toxic, or both, perhaps less feasible for organizations with limited resources.

Visual classification of microplastic materials is commonly used and it demands little in terms of equipment, but it depends on the capabilities of the observer and it may not have the accuracy of other classification methods (Koelmans et al. 2019, Klein et al. 2018). Ideally, visual classification of microplastics could be augmented by spectroscopy or spectrometry, which would also identify the composition of microplastic materials.

CONCLUSIONS

This study provides some insight into the extent of microplastic pollution in a densely populated smaller-order urban stream. It suggests that wastewater treatment effluent is a significant source of microplastic pollution at Four Mile Run, but that it is by no means the only source. Further study of similar smaller-order streams would help determine whether Four Mile Run's level of microplastic pollution is typical for urban impact, and/or whether there are settings from which best practices in preventing microplastic pollution can be learned. Such studies could also shed light on how differences in the categories of microplastics (e.g., fibers) reflect conditions in the watersheds.

Non-profits, friends groups, and citizen scientists can play a role in determining the extent of microplastic contamination of smaller waterways, and they may be able to use this data to sharpen their advocacy and outreach. Though it has limitations as discussed above, the method used in this study is affordable and practical, and it can be enhanced where additional analytical techniques, such as Fourier transform infrared spectroscopy, Raman spectroscopy, and/or mass spectrometry are available to further characterize microplastic samples. Studies using the method here described can help define the problem for waterways too small to sample using conventional towed/stationary nets.

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STATEMENT OF RESPONSIBILITIES

Kurt Moser, corresponding author, conducted and supervised field/lab procedures as principal investigator. Tessa Naughton-Rockwell collected water samples and field data in summer 2019. Ethan Litmans and Louisa Wang collected field samples/data and performed lab analysis in summer 2019. Amanda Manoogian collected field samples/data and performed lab analysis in summer 2018.

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TABLE 1: Results of Four Mile Run microplastic sampling, with precipitation data from the Four Mile Run USGS gage station, microplastic amounts by mass and by particle counts. Sites FM(1-6) are at different locations in the vicinity of the Mount Vernon Avenue bridge; sites HS(1-3) are tidal sites at the Hume Spring tributary; site HS4 is at the Hume Spring stormwater outfall; sites TP(1-2) are at the Arlington Water Pollution Control Plant outfall; sites above the tidal extent are UP1 on Lower Long Branch Creek and site UP2 on the main stem of Four Mile Run, above the confluence of Lower Long Branch Creek.

Site	Date	Rainfall previous 24 hours	Concentration (µg/L)	Total # particles	Fragments	Fibers	Film	Sponge/Foam
Four Mile Run locations near head of tide								
FM1	2018-06-11	1.5cm	55	6	2	1	1	2
FM2	2019-05-20	none	12	8		8		
FM3	2019-05-20	none	21	1		1		
FM4	2019-05-28	0.6 cm	12	13	5	6		2
FM5	2019-06-04	none	12	13		12	1	
FM6	2019-06-08	2.5cm	2	7	1	5		1
Hume Spring tributary locations								
HS1	2018-06-11	1.5cm	265	9	2	4		3
HS2	2019-05-30	0.6 cm	24	24	6	12	2	4
HS3	2019-06-05	none	2	7	4			3
HS4	2019-06-06	none	13	2	2			
Arlington Water Pollution Control Plant								
TP1	2018-06-13	N/A	446	3	2			1
TP2	2019-06-18	N/A	100	7		7		
Four Mile Run and Lower Long Branch Creek above their confluence								
UP1	2019-06-18	2.5 cm	11	5		5		
UP2	2019-06-18	2.5 cm	3	6	1	5		

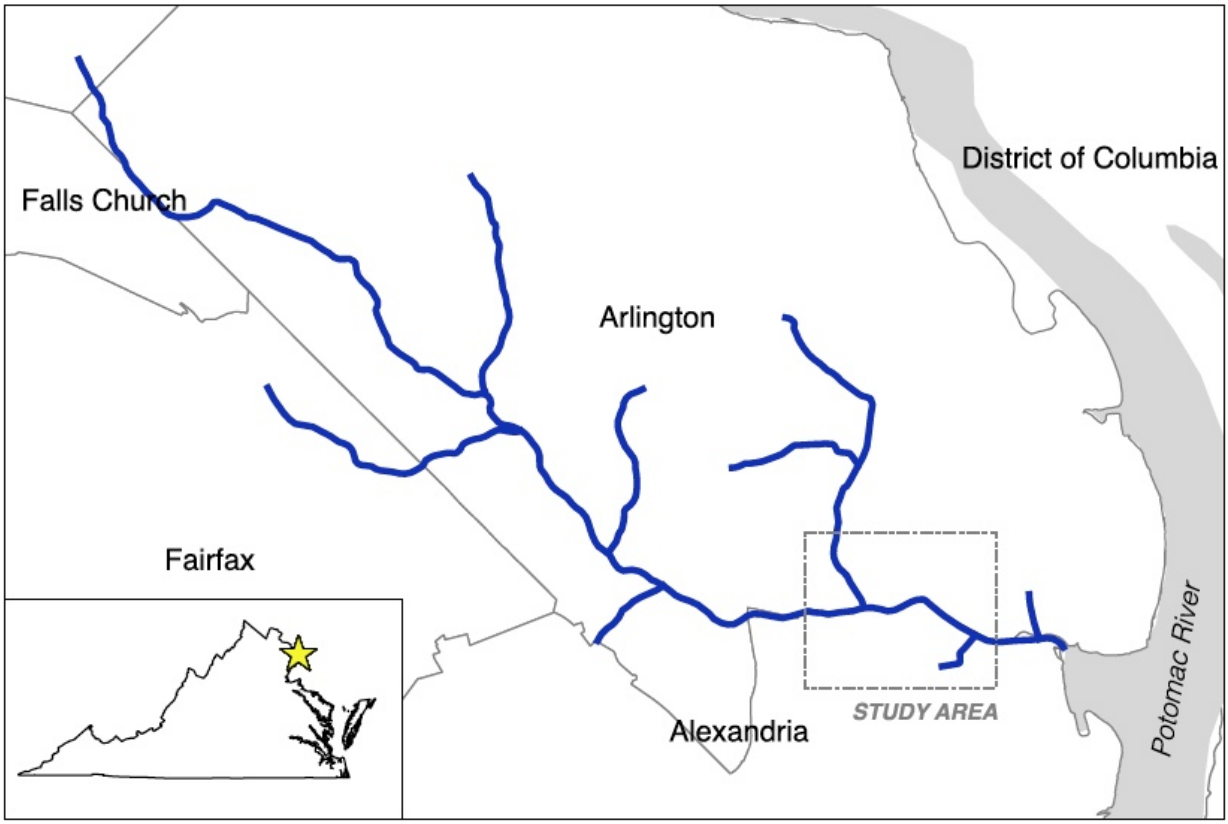


Figure 1: Overview map of Four Mile Run and study area in Alexandria/Arlington, Northern Virginia

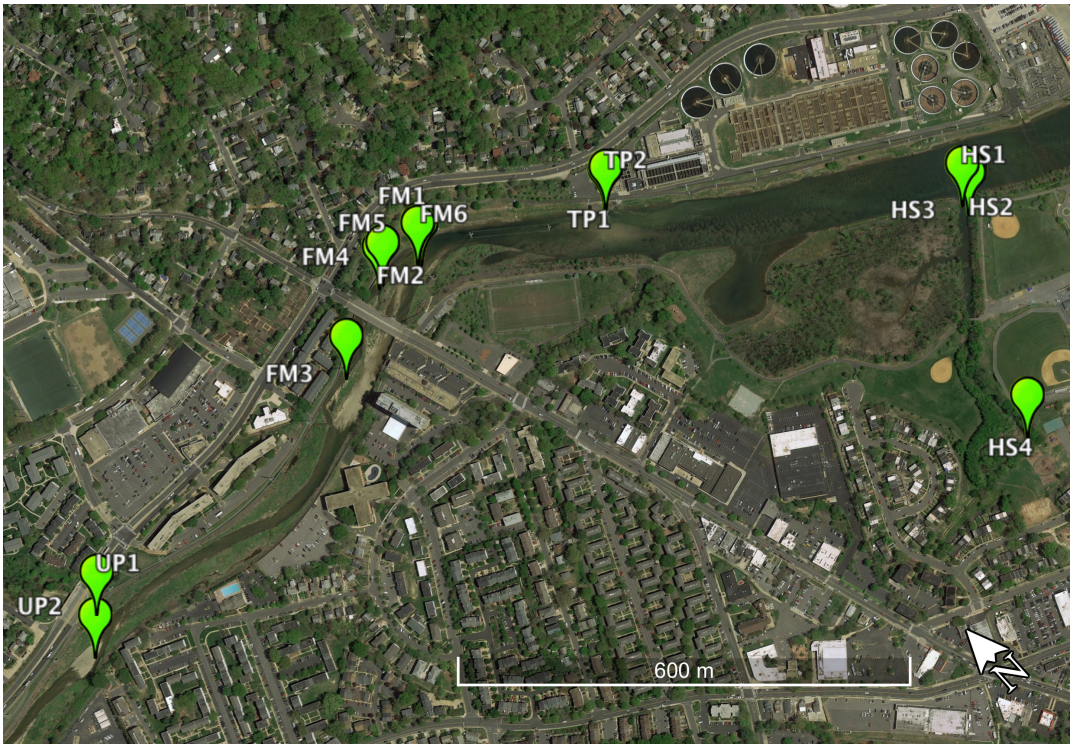


Figure 2: Aerial imagery of Lower Four Mile Run showing microplastic sampling locations

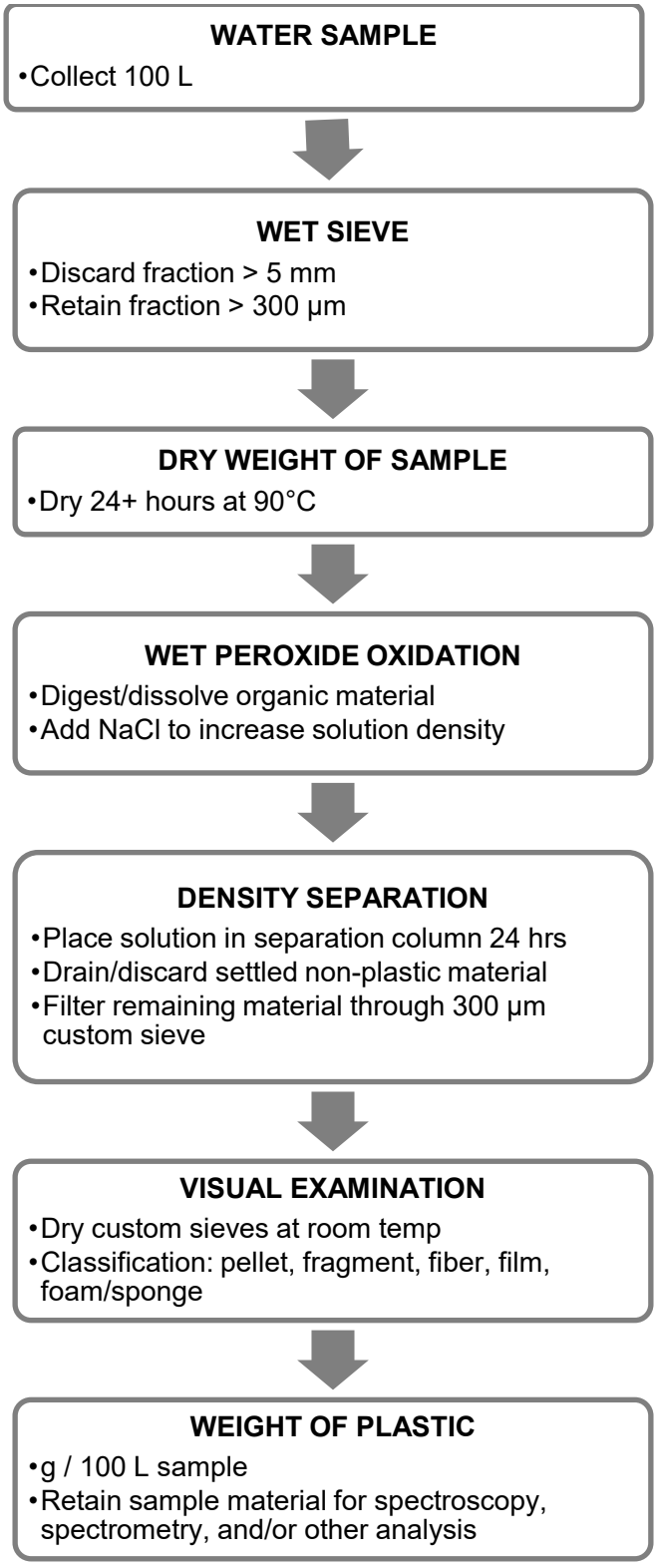
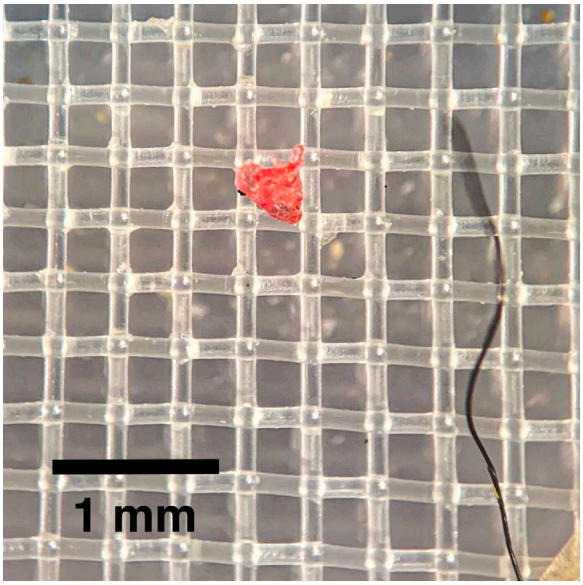
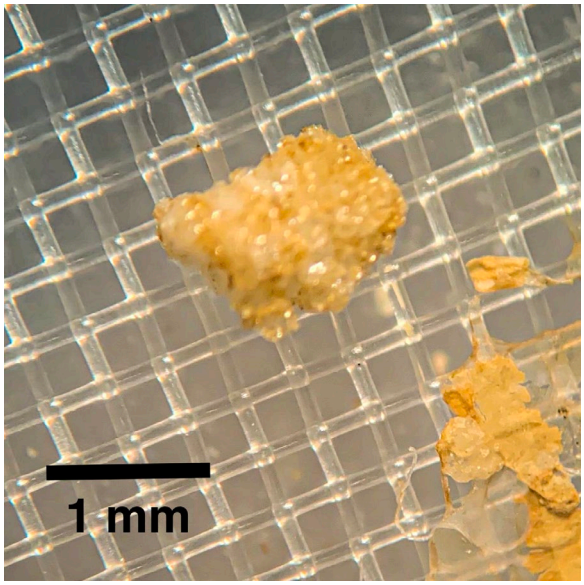


Figure 3: Flow chart of sample collection/analysis procedure



(a)



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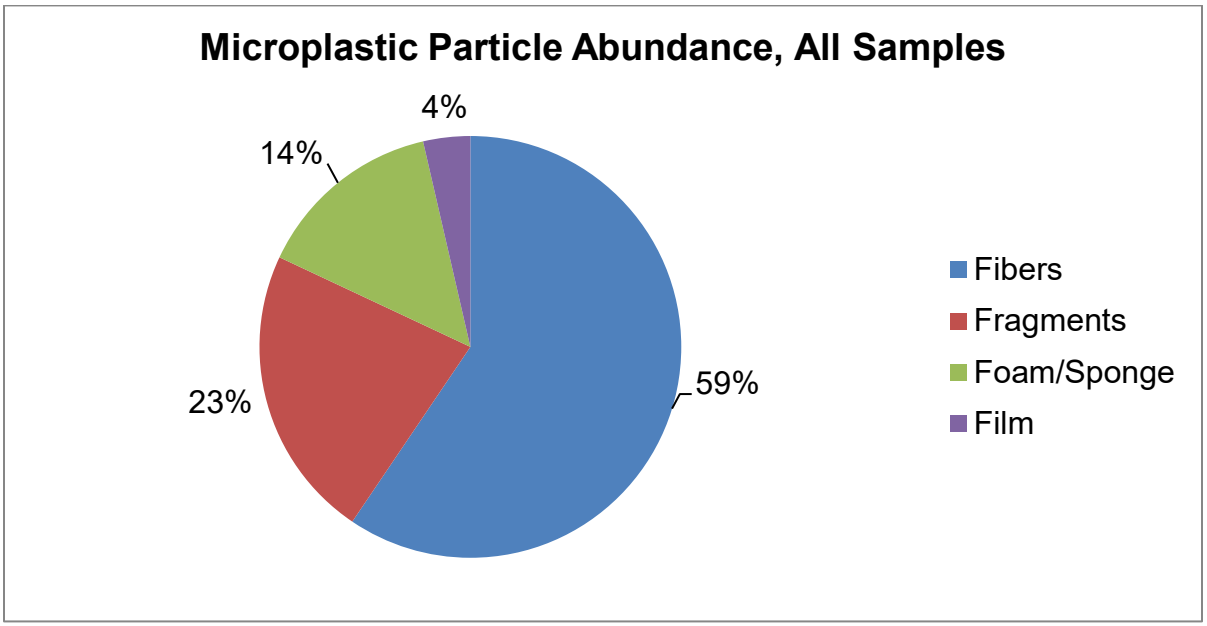

(c)

Figure 4: Microscope photos showing microplastic fragment and fiber (a) and foam particle (b); relative abundances of particles identified for Four Mile Run water samples (c)