Study of Microplastics in Wastewater Treatment Plants in Deep East Texas

Jake Swallow[1], Kefa K. Onchoke[1], and Robert Friedfeld[2]

STEPHEN F. AUSTIN STATE UNIVERSITY
COLLEGE OF SCIENCES AND MATHEMATICS

[1.] Department of Chemistry & Biochemistry, Stephen F. Austin State University, P.O. Box 13006, SFA Station, Nacogdoches, TX 75962-3006
[2.] Department of Physics, Engineering, and Astronomy, Stephen F. Austin State University, P.O. Box 13044, SFA Station, Nacogdoches, TX 75962-3006

Abstract

- Microplastics (MPs) are plastic polymers classified in the size range of 5 mm to 1 µm. MPs are emerging pollutants with the potential to cause health hazards to humans and the environment. Wastewater treatment plants (WWTPs) serve as secondary sources for MP contamination in the environment.
- We investigated the physical and chemical characteristics of MPs from four WWTPs in Deep East Texas using optical microscopy (bright-field microscopy) and spectroscopic techniques (scanning electron microscopy/Energy dispersive X-ray (SEM/EDX) and Fourier transform infrared spectroscopy (FTIR)).
- The most common shapes of MPs were in the order: fragments (396 ± 181 MPs/L) > filaments (131 ± 102 MPs/L) > rods (52 ± 58 MPs/L) > beads (17 ± 29 MPs/L) > fibers (17 ± 44 MPs/L).
- Wastewater samples contained an average of 610 ± 252 MPs/L.
- FTIR spectra indicates the presence of polyvinyl chloride (ν(C-H) = 2918), (ν(C-Cl) = 639 cm^{-1}), polyethylene (ν(C-H) = 2932 cm^{-1}), (ν(C-H) = 2892 cm^{-1}), polypropylene (ν(C-H) = 2919 cm^{-1}), (ν(C-C) = 1156 cm^{-1}), and nylon (ν(N-H) = 3350 cm^{-1}), (ν(C=O) = 1670 cm^{-1}).
- Concentrations of elements carbon, oxygen, and chlorine in SEM-EDX spectra indicate presence of MPs. Many WWTPs discharge treated water into nearby creeks and biosolids are incorporated into soil. Thus, WWTPs are sources of MP contamination in the aquatic and terrestrial environments. The ubiquitous nature of MPs in the environment can negatively impact the functions of plants, animals and humans leading to a significant public health concern.

Objectives for study

- Use microscopic and spectroscopic techniques to physically and chemically characterize MPs in Deep East Texas WWTPs
- Quantify the number of MPs through various stages of wastewater treatment

Sampling Locations

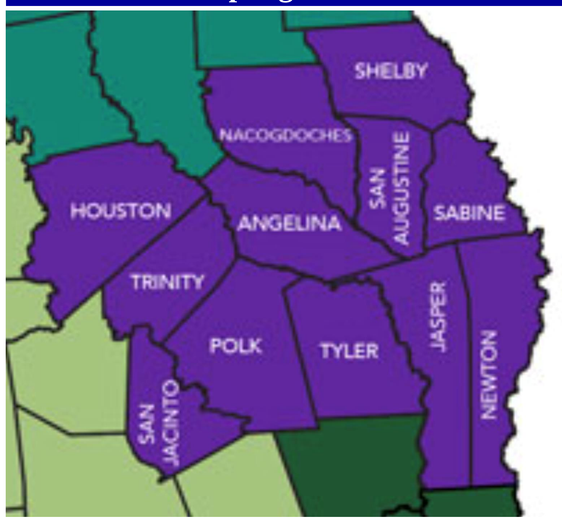

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Figure 1 – Map of Deep East Texas

Materials and Methods

Sample Extraction

40 mL of wastewater samples sieved through pore sizes of 2.36 mm, 1.70 mm, 850 µm, and 150 µm. 20 mL 30% H_2O_2 added to sieved sample and heated at 50 °C for 1 hour. Samples then placed in oven at no higher than 60 °C until liquid fully evaporated.

Instrumentation

a) Olympus CKX53 Inverted Phase Contrast Microscope
b) PerkinElmer Spectrum 100 FTIR Spectrometer
c) JEOL-SEM-JSM-6100

Quality Control

Cotton lab coats and nitrile gloves worn at all times. Glassware and necessary equipment thoroughly cleaned with DI H_2O and nanopure H_2O prior to use. Samples collected in triplicates. Sample blanks prepared for each sampling location. Open database (Open Specy, https://openanalysis.org/openspecy/) used for validation of FTIR.

Results (Brightfield Microscopy)

Figure 2 – Brightfield Microscopy Image of MP Fibers

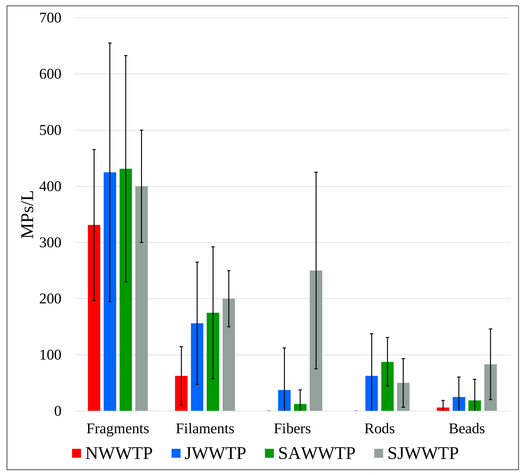


Figure 3 – Average Shape Distribution of MPs/L

Results (FTIR, Cont'd)

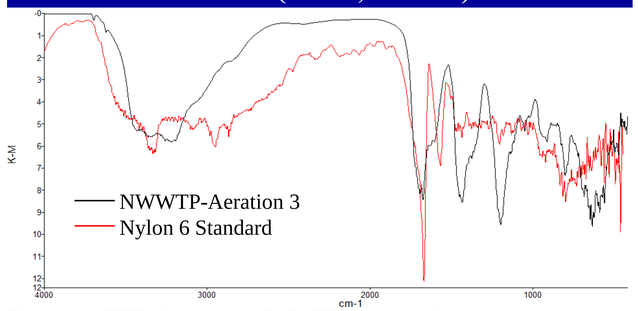


Figure 4 – FTIR Spectra of NWWTP vs. Nylon 6

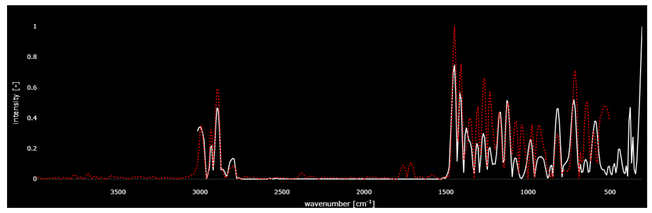


Figure 5 – FTIR Validation with Open Specy Database

Table 1 – Polymers Present in FTIR Spectra; PVC = polyvinyl chloride, PU = polyurethane, PMMA = poly(methyl methacrylate); PS = polystyrene; PP = polypropylene, PE =polyethylene; PET = polyethylene terephthalate; PVP = polyvinylpyrrolidone

	PVC	PU	PMMA	Nylon 6	PS	PP	PE	PET	PVP
Nacogdoches WWTP	✓	X	X	✓	X	X	~	X	~
Jasper WWTP	✓	X	X	X	~	X	~	X	X
San Augustine WWTP	✓	X	X	~	X	~	X	X	X
San Jacinto WWTP	X	X	X	X	~	~	X	X	X

✓ - Presence of polymer; ~ - Further analysis required
X - Polymer not detected; Pearson's r^2 = 0.75

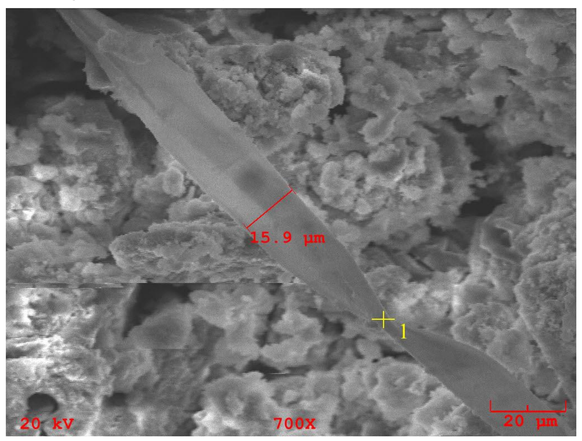


Figure 6 – SEM Micrograph Showing MP Filament

Results (SEM/EDX, Cont'd)

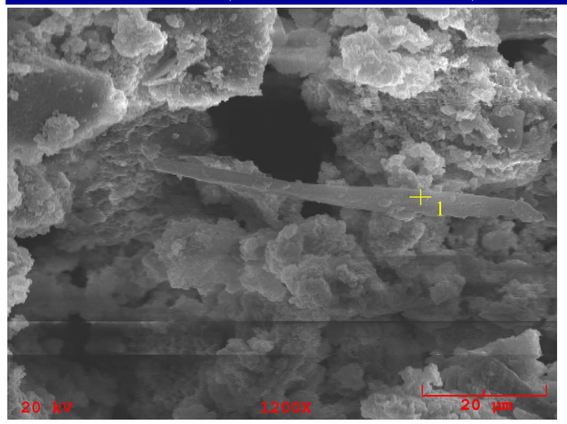
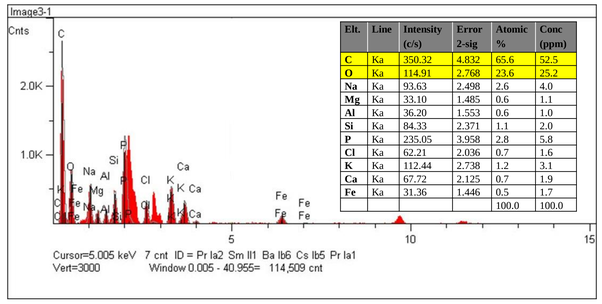


Figure 7 – SEM Micrograph Showing MP Filament



Elt.	Line	Intensity (c/s)	Error 2-sig	Atomic %	Conc (ppm)
C	Ka	350.32	4.832	65.6	52.5
O	Ka	114.91	2.768	23.6	25.2
Na	Ka	93.63	2.498	2.6	4.0
Mg	Ka	33.10	1.485	0.6	1.1
Al	Ka	36.20	1.553	0.6	1.0
Si	Ka	84.33	2.371	1.1	2.0
P	Ka	235.05	3.958	2.8	5.8
Cl	Ka	62.21	2.036	0.7	1.6
K	Ka	112.44	2.738	1.2	3.1
Ca	Ka	67.72	2.125	0.7	1.9
Fe	Ka	31.36	1.446	0.5	1.7
				100.0	100.0

Figure 8 – EDX Spectrum of Above Filament

Conclusions

1. Fragments are the most common shape of MPs
2. Wastewater samples contain polyvinyl chloride (PVC) and Nylon 6. Further analysis is needed to confirm the presence of polyethylene (PE), polypropylene (PP), and polystyrene (PS).
3. High concentrations of carbon, oxygen, and chlorine in SEM/EDX spectra indicate the presence of MPs

References

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2. Hidayaturrahman H & Lee T-G. A study on characteristics of microplastic in wastewater of South Korea: Identification, quantification, and fate of microplastics during treatment process. Marine Pollution Bulletin. 2019 Sep;146:696–702.
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Acknowledgments

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