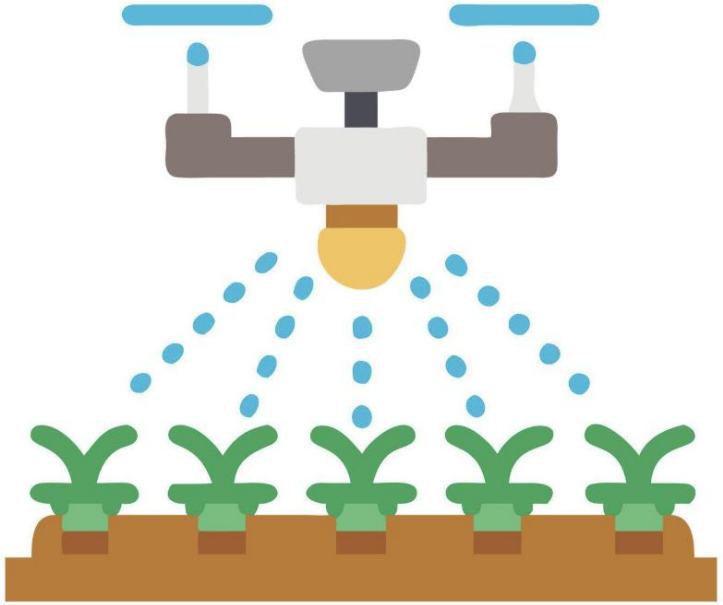
Quantifying Microplastics in Delhi Charter Township's Groundwater



Malavika Ramkumar
Chemistry PhD Candidate
McNeil Group
University of Michigan

Quantifying environmental contaminants in groundwater is important





~50% of US population relies on groundwater as primary source of drinking water

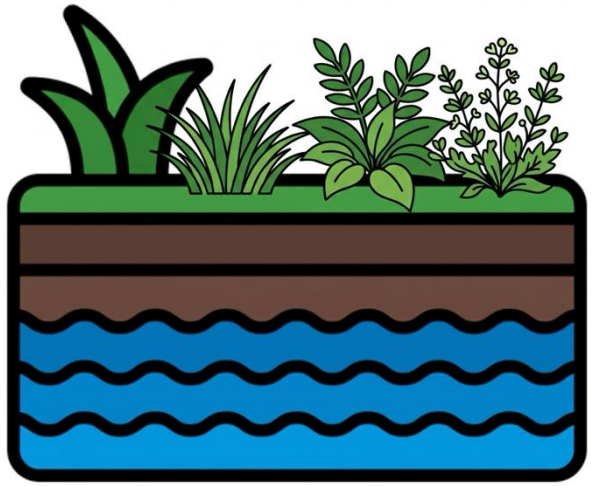
~60% of total groundwater in the US is used for growing crops

(1) https://www.usgs.gov/media/images/groundwater-withdrawals-2015 (accessed on 03/17/2025)
(2) https://groundwater.org/what-is-groundwater/#:~:text=Groundwater%20supplies%20drinking%20water%20for,component%20in%20many%20industrial%20processes. (accessed on 02-09-2024)
(3) Panno, Samuel V. et al. Microplastic contamination in karst groundwater systems. *Groundwater*. **2019**, *5,* 189–196
Icon credits: vecteezy.com

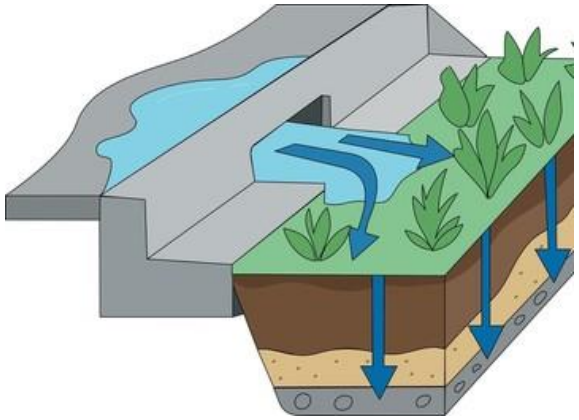
How contaminants get to groundwater



surface water

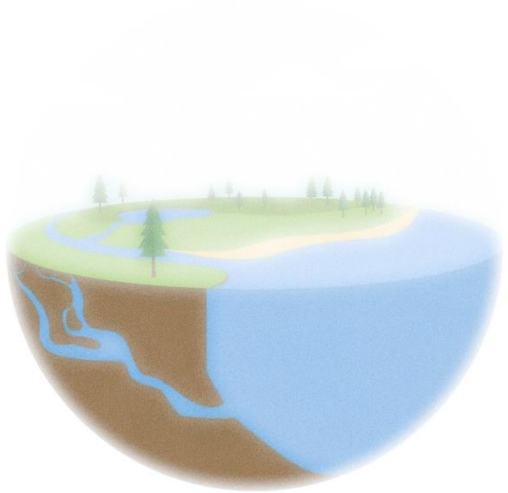


soil

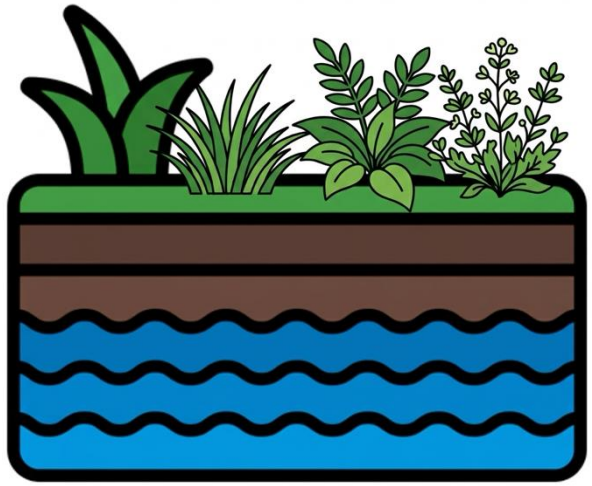


run off

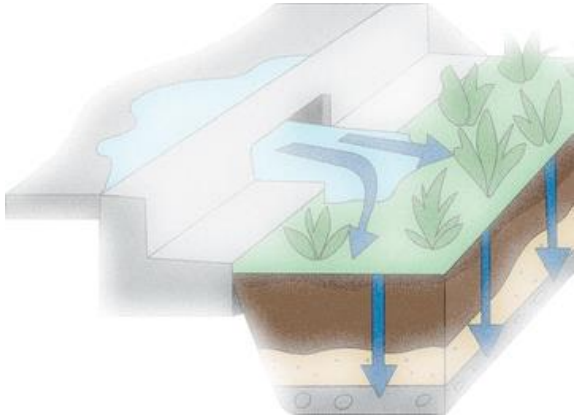
Focusing on contamination from soil



surface water

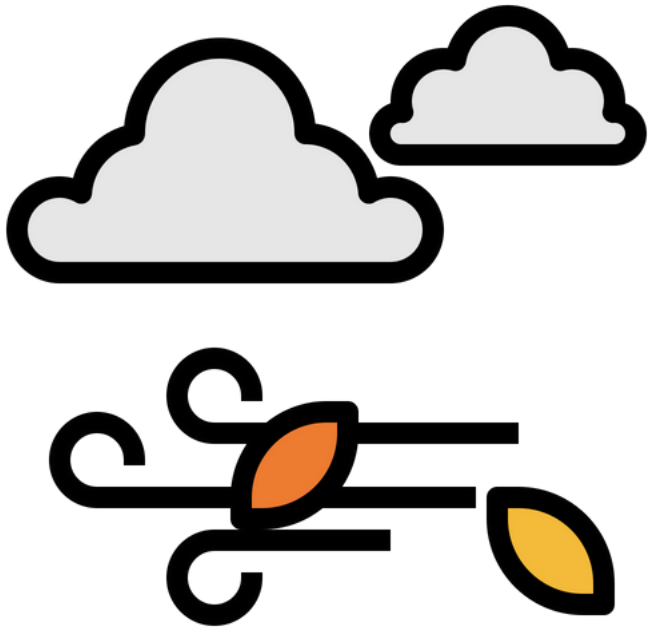


soil



run off

How contaminants get to soil



atmospheric deposition



fertilizer and agricultural plastics



tire wear particles

Icon credits: iconscout.com, vecteezy.com

Focusing on contamination from fertilizer



atmospheric deposition



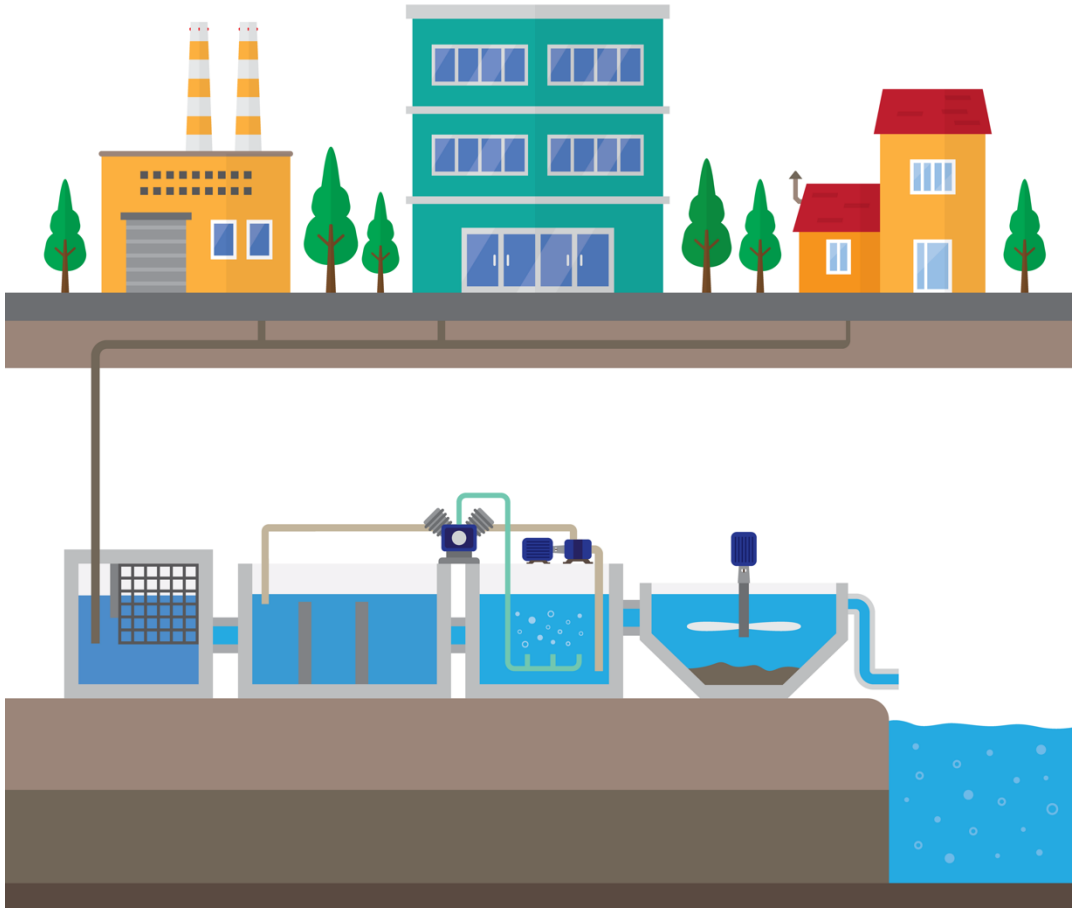
fertilizer



tire wear particles

Icon credits: iconscout.com, vecteezy.com

Wastewater treatment plants are a sink for microplastics



https://www.dreamstime.com/stock-illustration-sewage-treatment-plant-simple-graphic-image94718505

some sources of microplastics in wastewater:

- household goods and chemicals
- personal care products
- laundry effluent
- industrial discharge

Margot, J., Rossi, L., Barry, D. A., & Holliger, C. A review of the fate of micropollutants in wastewater treatment plants. *Wiley Interdisciplinary Reviews: Water*. **2015**, *2*(5), 457-487.

Biosolids are a significant source of microplastics

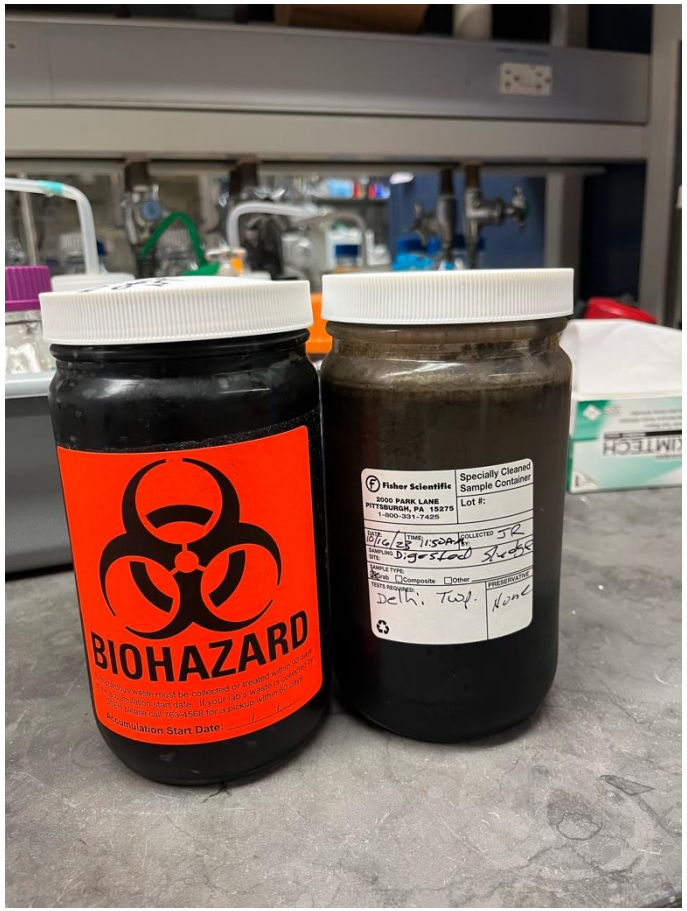
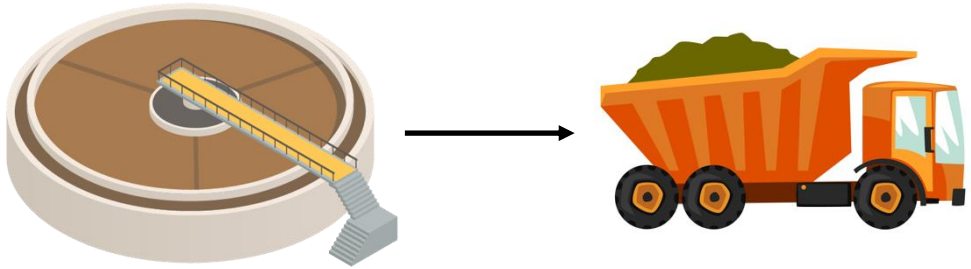


image of biosolids from Delhi Charter Township's WWTP

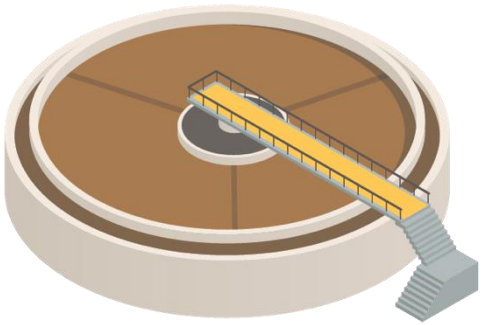
biosolids from Delhi Charter Township have ~14,600 MPs/dry kg (>30 µm)

most common plastics found are PE, PP, PVC, PET



WWTPs biosolids

Where are microplastics dispersing from biosolids?



WWTPs



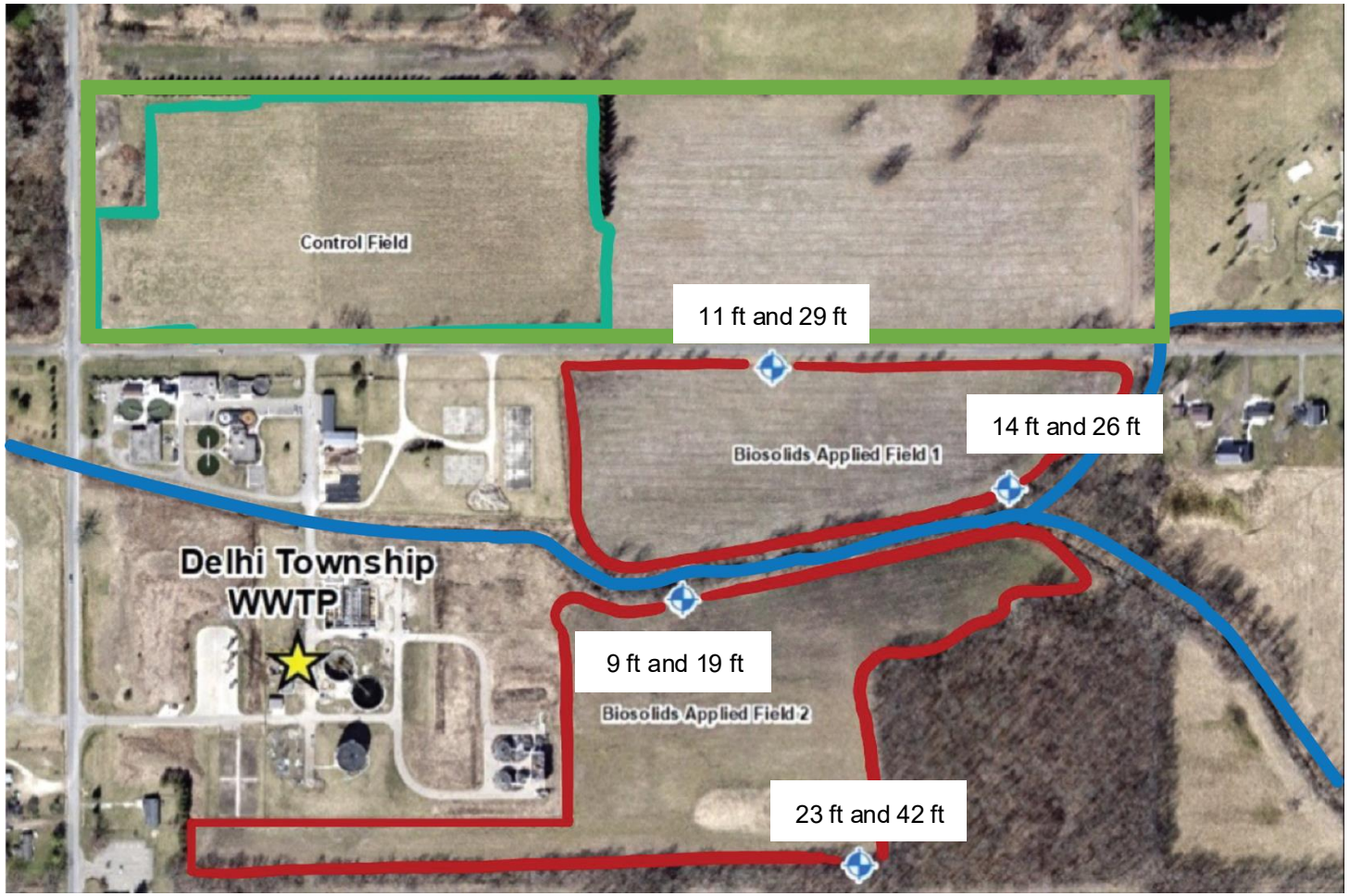
biosolids



farmland soil

?

Case study location: Delhi Charter Township





land applying biosolids since 2003

eight groundwater monitoring wells with depths from 9–42 ft below surface level

two biosolids applied agricultural fields + one control field

Image modified after obtaining from Delhi Charter Township

Sampled groundwater across two years







blinded all samples collected here

Groundwater sampling strategy

purged up to 10 L until parameters stabilize

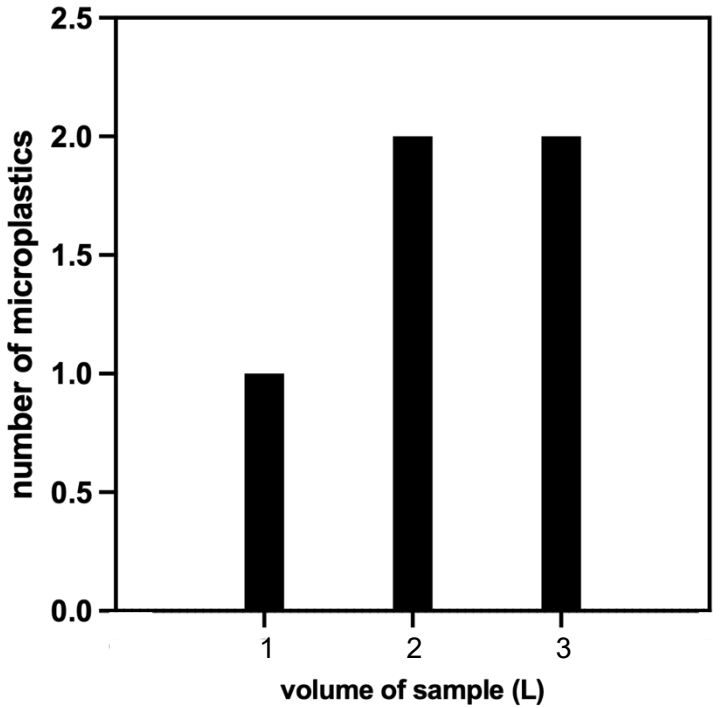
pH | temperature | specific conductivity

RDO | turbidity | depth to water

date, time	elapsed time (min:sec)	pH	temperature (°C)	specific conductivity (mS/cm)	RDO concentration (mg/L)	turbidity (NTU)	ORP (mV)	depth to water (ft)
		+/- 0.1	+/- 5 %	+/- 3 %	+/- 0.3	+/- 10 %	+/- 10	+/- 0.33
10/9/2024 2:25 PM	00:00	6.99	15.68	0.62	6.00	212.14	237.8	15.28
10/9/2024 2:26 PM	01:00	7.06	15.18	0.62	0.79	197.91	225.1	15.28
10/9/2024 2:31 PM	06:00	7.07	15.63	0.62	0.23	172.93	73.7	15.28
10/9/2024 2:36 PM	11:00	7.08	15.58	0.62	0.16	174.34	-33.2	15.28

purging causes groundwater recharge which allows us to sample the “fresh” water

choosing 1 L as sampling volume



unpublished data

Plastic tubing used to collect groundwater samples can shed



LDPE tube from Geotech (#87050501)



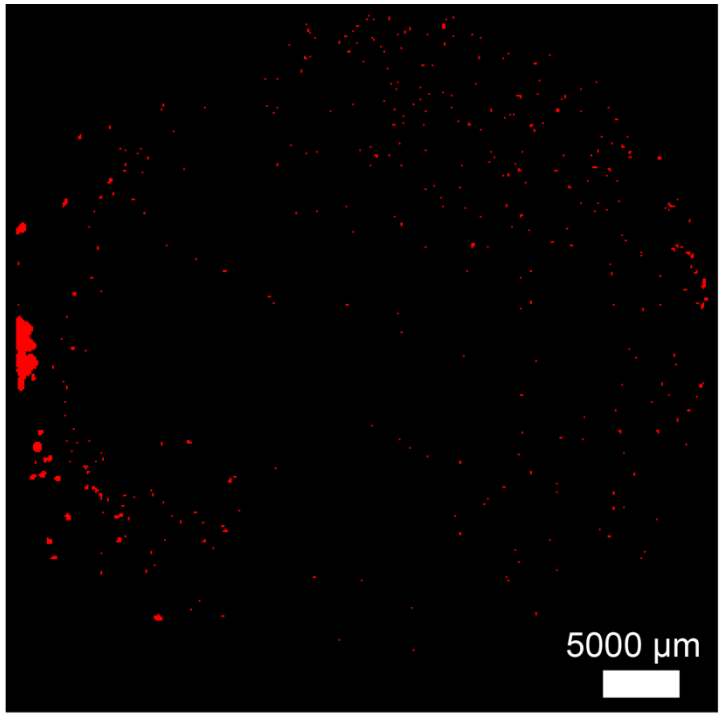
Milli-Q water

water passed through LPDE tubing

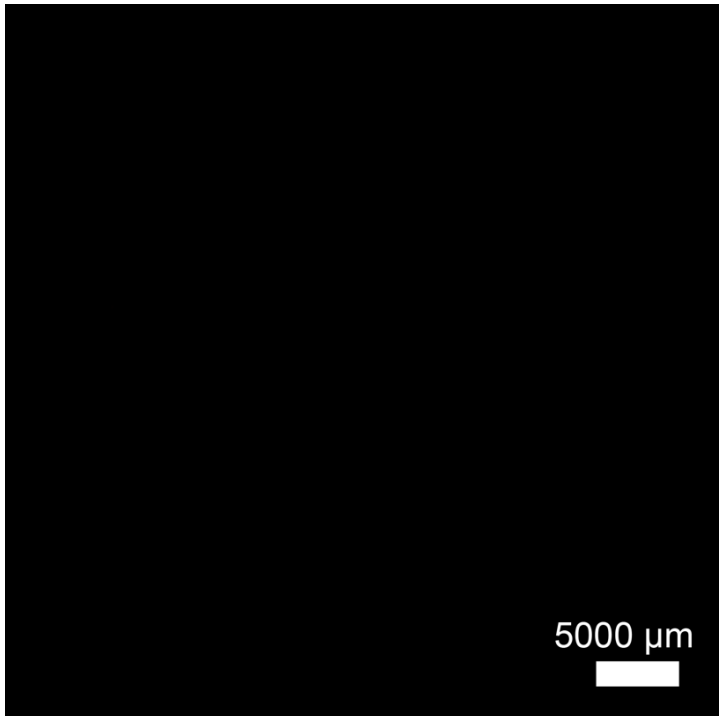
tube length and flow rate match the field sampling protocol

Image created with BioRender

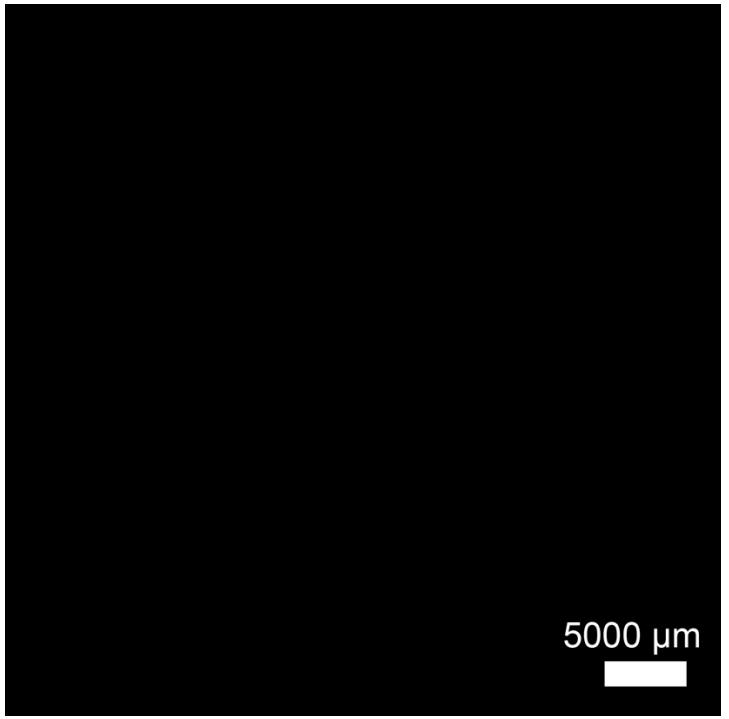
Purging also helps avoid microplastic overestimation



MPs shedding at 7 min (new tube)



no MPs shedding at 20 min (new tube)

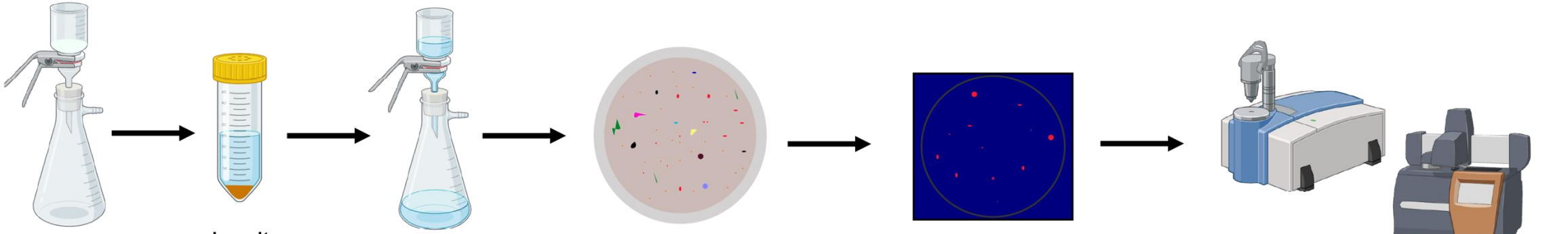


no MPs shedding at 7 min (used tube)

Fluorescent microscope images taken in UM Biological Science Research Building
Purged water first filtered onto 0.02 µm Whatman aluminum oxide filter via a fritted funnel filtration set up
Each filter then stained with 2 mL Nile Red solution (10µg/mL concentration) for 30 min following which 50 mL of water was flushed through via a fritted funnel vacuum filtration set up

unpublished data

Optimized microplastics extraction and analysis protocol



digestion with 30% H_2O_2

(size selection: >0.02 µm)

density separation with 1.5 g/cc $ZnBr_2$

filtration with warm water

optical imaging

fluorescent staining with Nile red

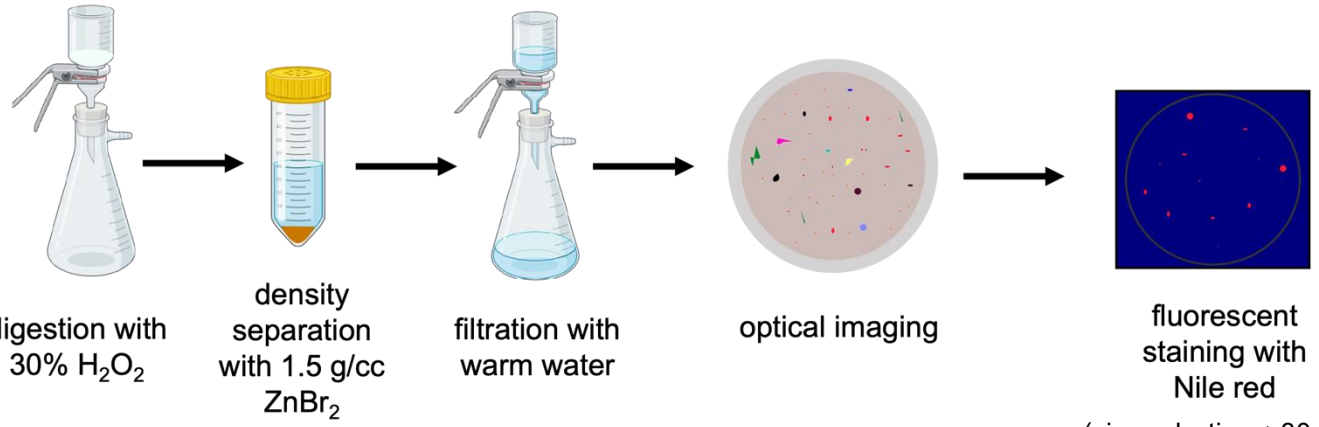
(size selection: >30 µm)

chemical identification via µ-FTIR spectroscopy and DSC

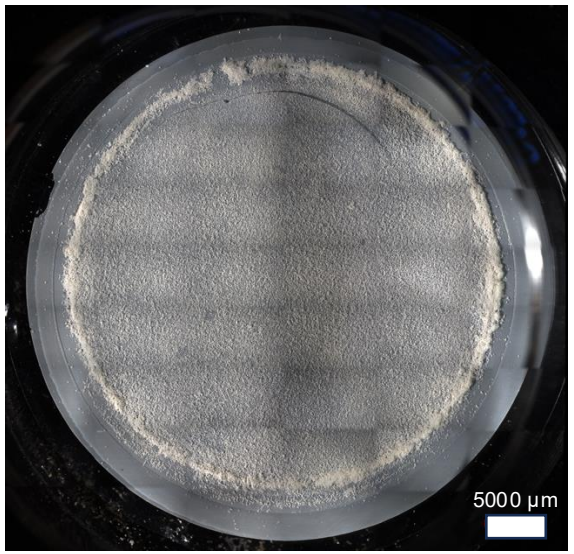
Fluorescent microscope images taken in UM Biological Science Research Building
FTIR spectroscopy in Prof. Adam Matzger's lab; DSC in UM NCRC, Biointerfaces Institute
Image created with BioRender

unpublished data

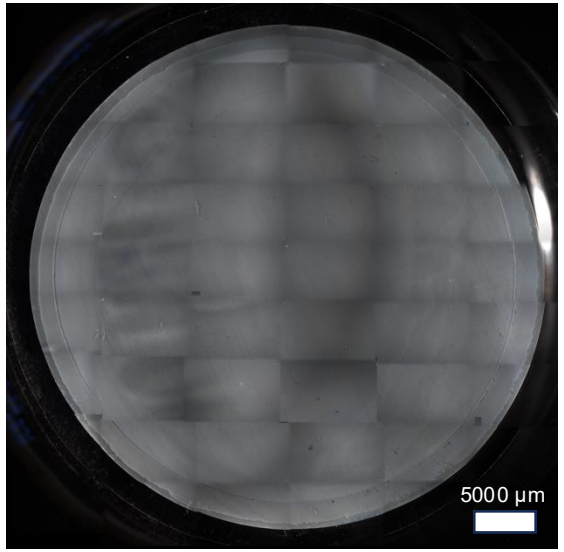
Representative example with real data



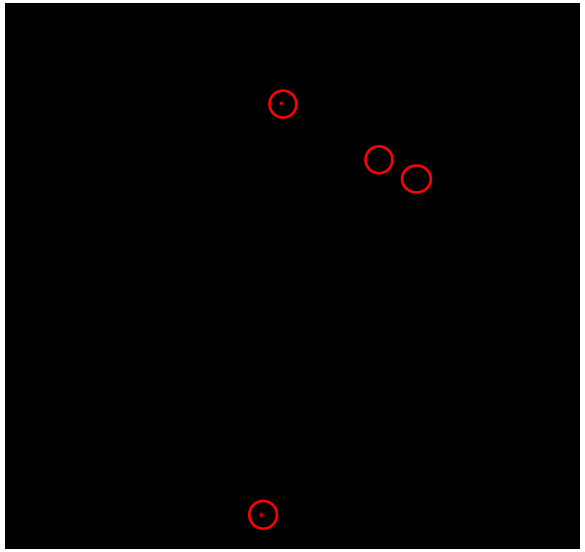
groundwater sample at 11 ft



post digestion



post density separation



fluorescence

Fluorescent microscope images taken in UM Biological Science Research Building
µ-FTIR spectroscopy in Prof. Adam Matzger's lab; DSC in UM NCRC, Biointerfaces Institute
Image created with BioRender

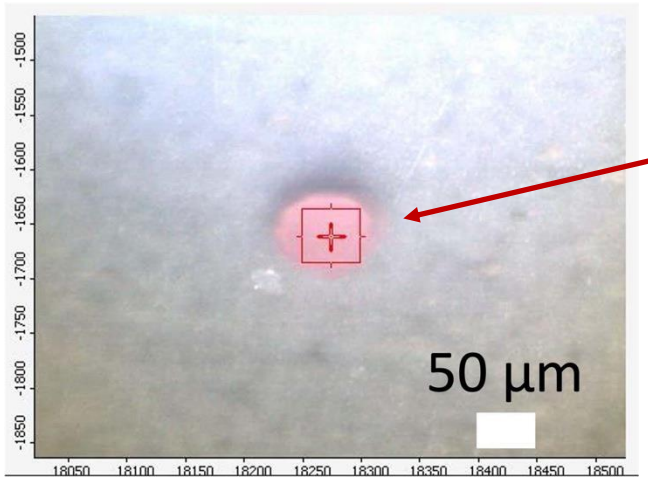
unpublished data

µFTIR spectroscopy for chemical identification

unaffected by fluorescence

non-destructive

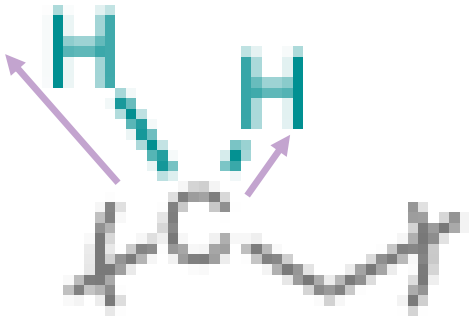
can measure particles down to ~20 µm in size



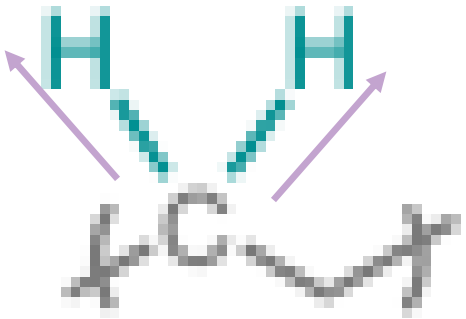
polyethylene microplastic



bonds vibrate at specific frequencies



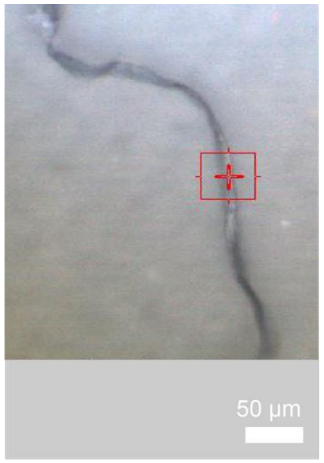
asymmetric C-H stretch
(~2915 cm^{-1})

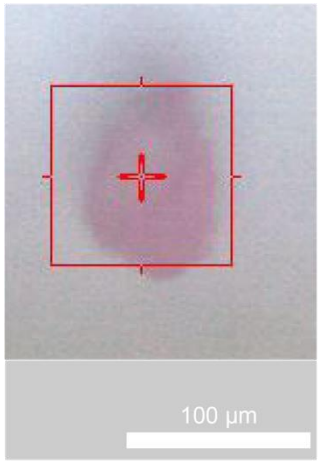


symmetric C-H stretch
(~2850 cm^{-1})

Getting information on microplastic identities

microplastics at 14 ft

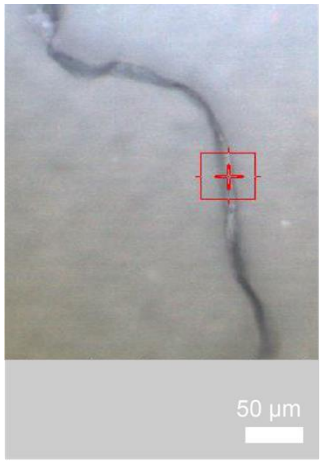


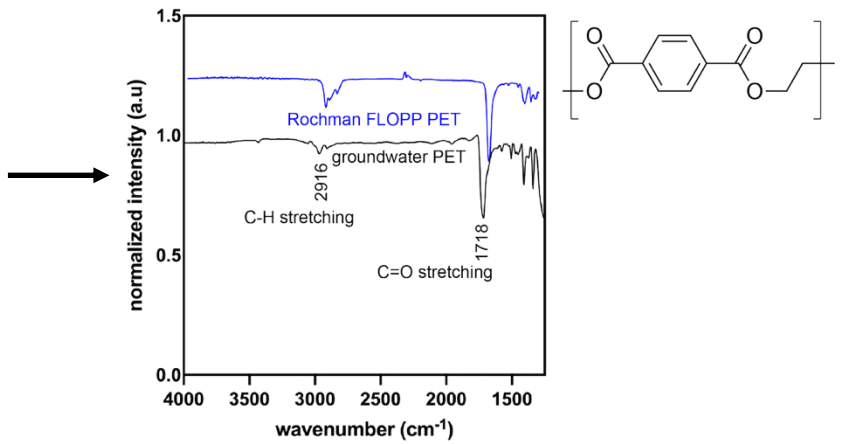


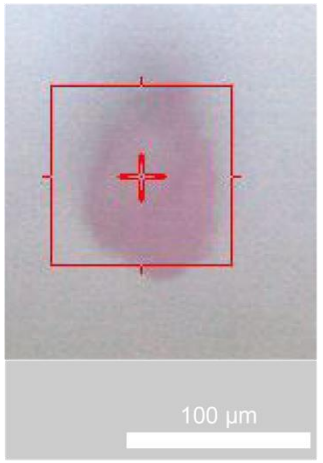
microplastic

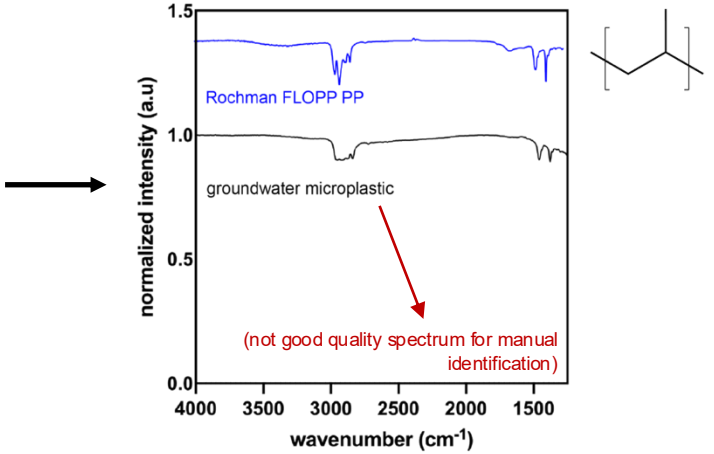
μ-FTIR spectroscopy helps inform microplastic identities

microplastics at 14 ft









microplastic

FTIR spectrum

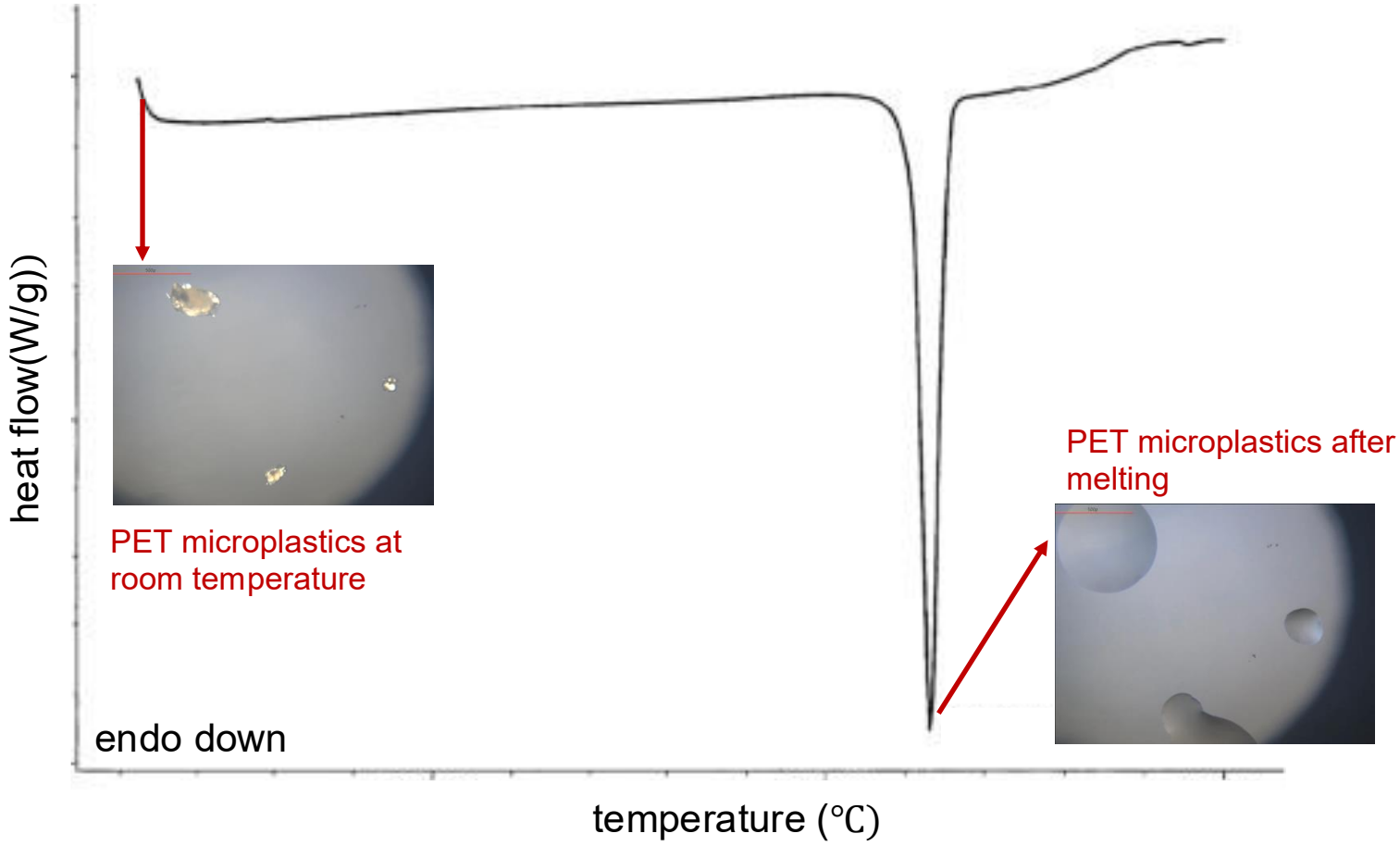
μ-FTIR spectroscopy in Prof. Adam Matzger's lab
Peak assignments made manually by comparing with existing literature values

unpublished data

Differential Scanning Calorimetry for chemical identification

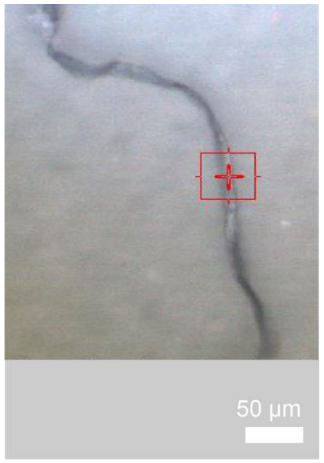
utilizes characteristic thermal transitions to identify plastics

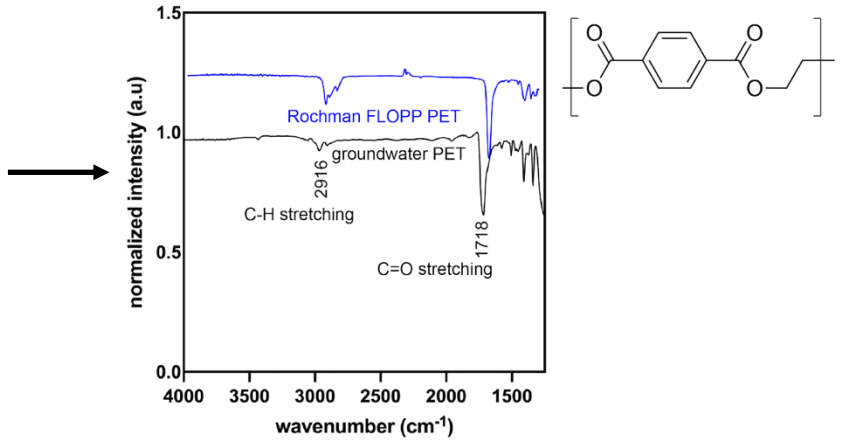
can identify polymer blends

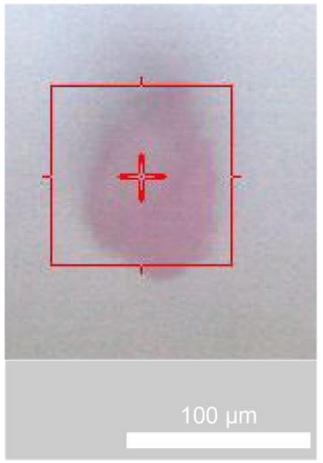


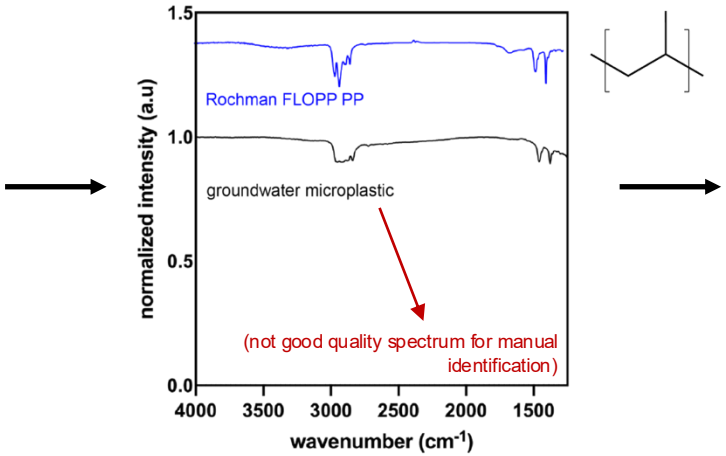
μ-FTIR spectroscopy and DSC helps inform microplastic identities

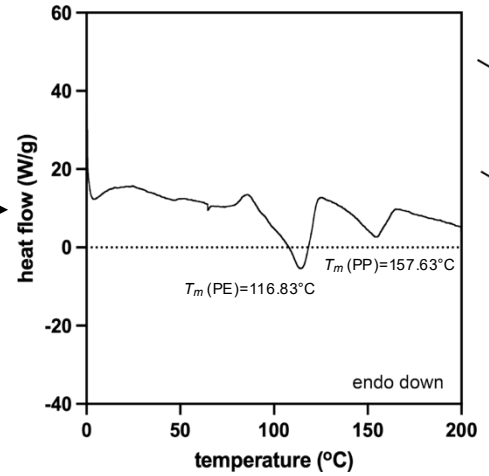
microplastics at 14 ft











microplastic

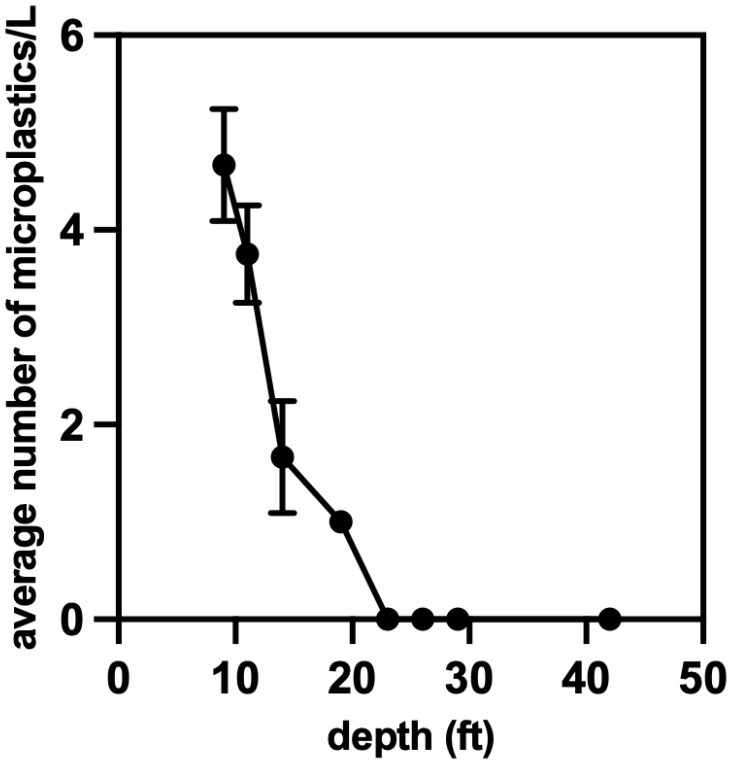
FTIR spectrum

DSC thermogram

μ-FTIR spectroscopy in Prof. Adam Matzger's lab; DSC in UM NCRC, Biointerfaces Institute

unpublished data

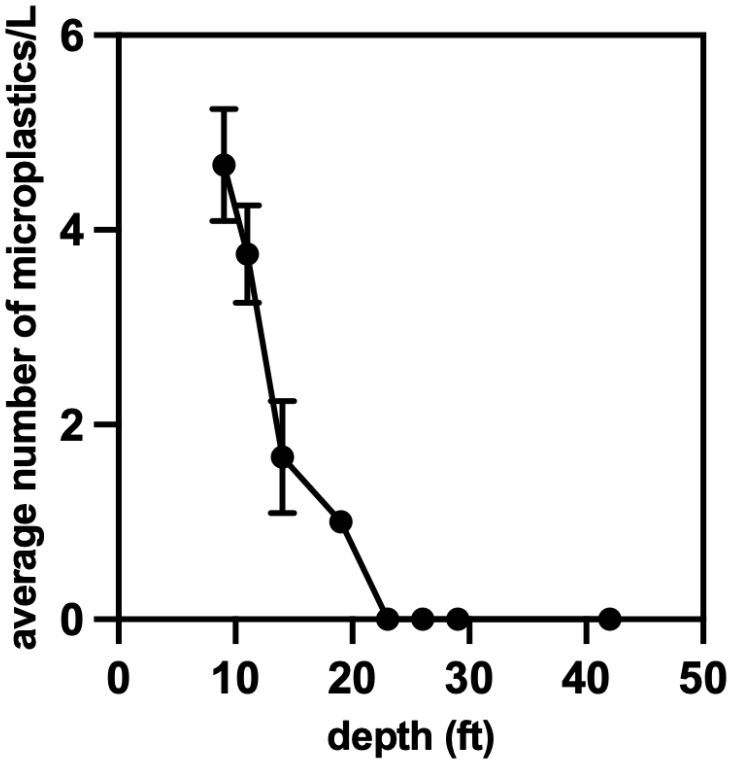
Few microplastics were found in groundwater



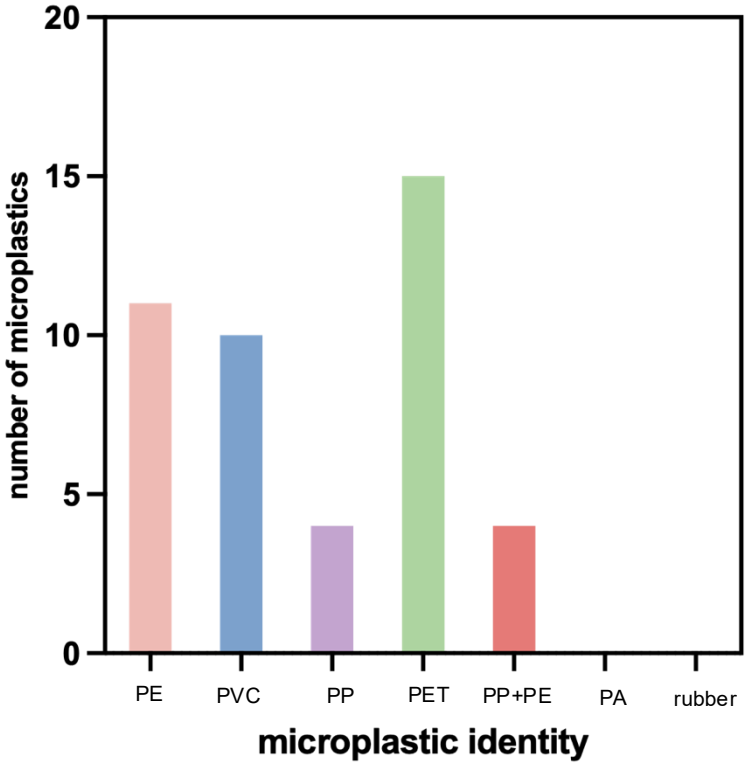
average number of microplastics/L across groundwater depths

unpublished data

Few microplastics were found in groundwater



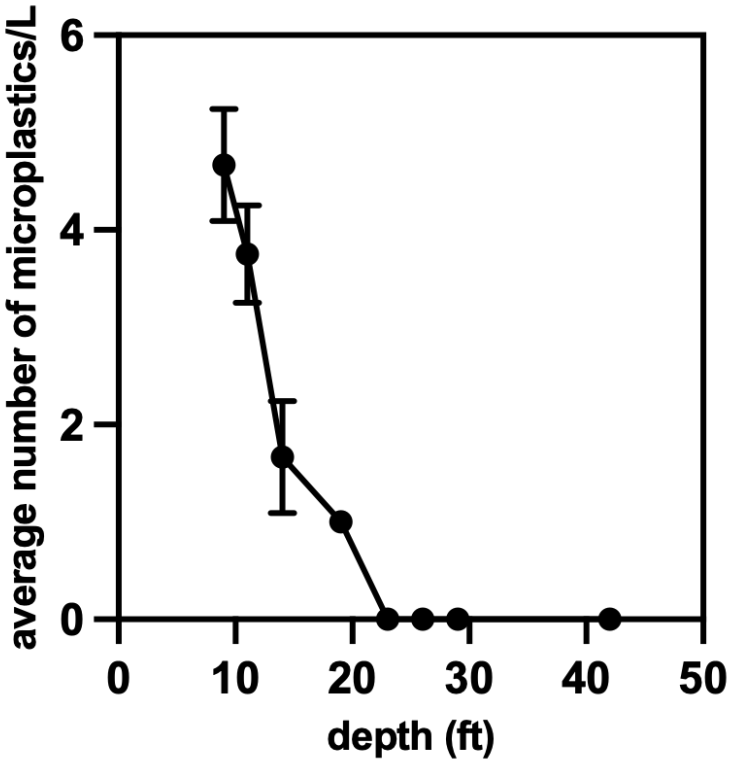
average number of microplastics/L across groundwater depths



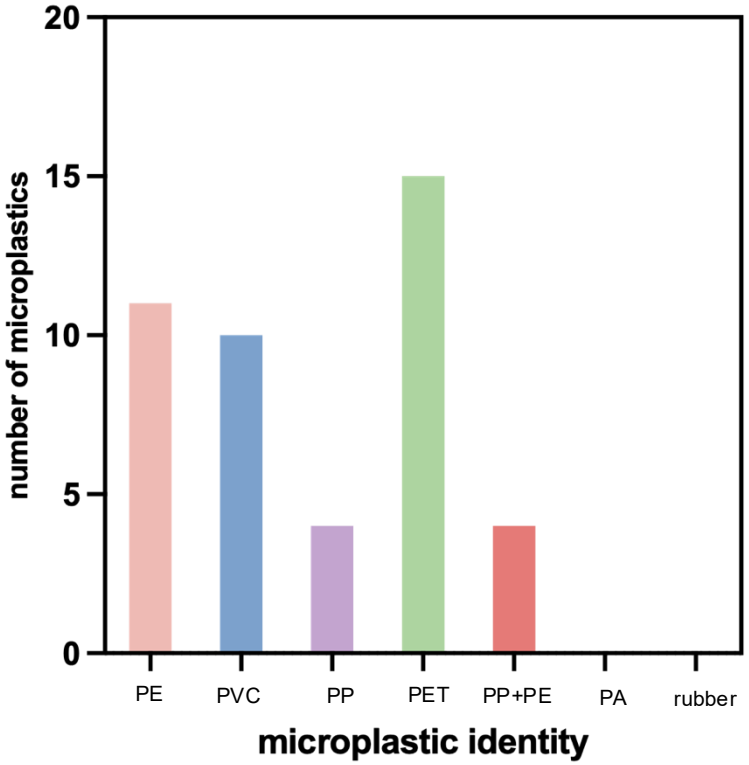
identity of microplastics found across the 34 L of groundwater analyzed

unpublished data

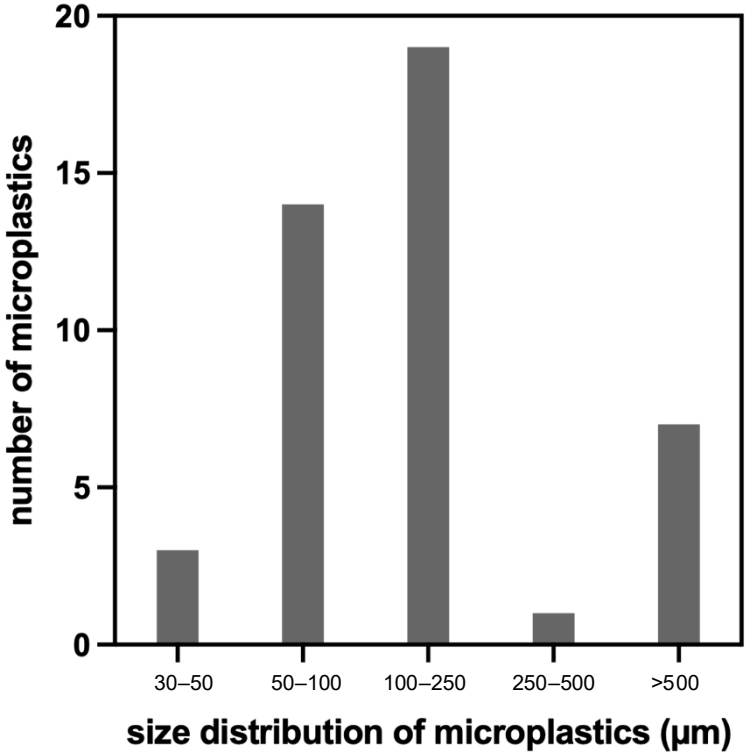
Few microplastics were found in groundwater



average number of microplastics/L across groundwater depths



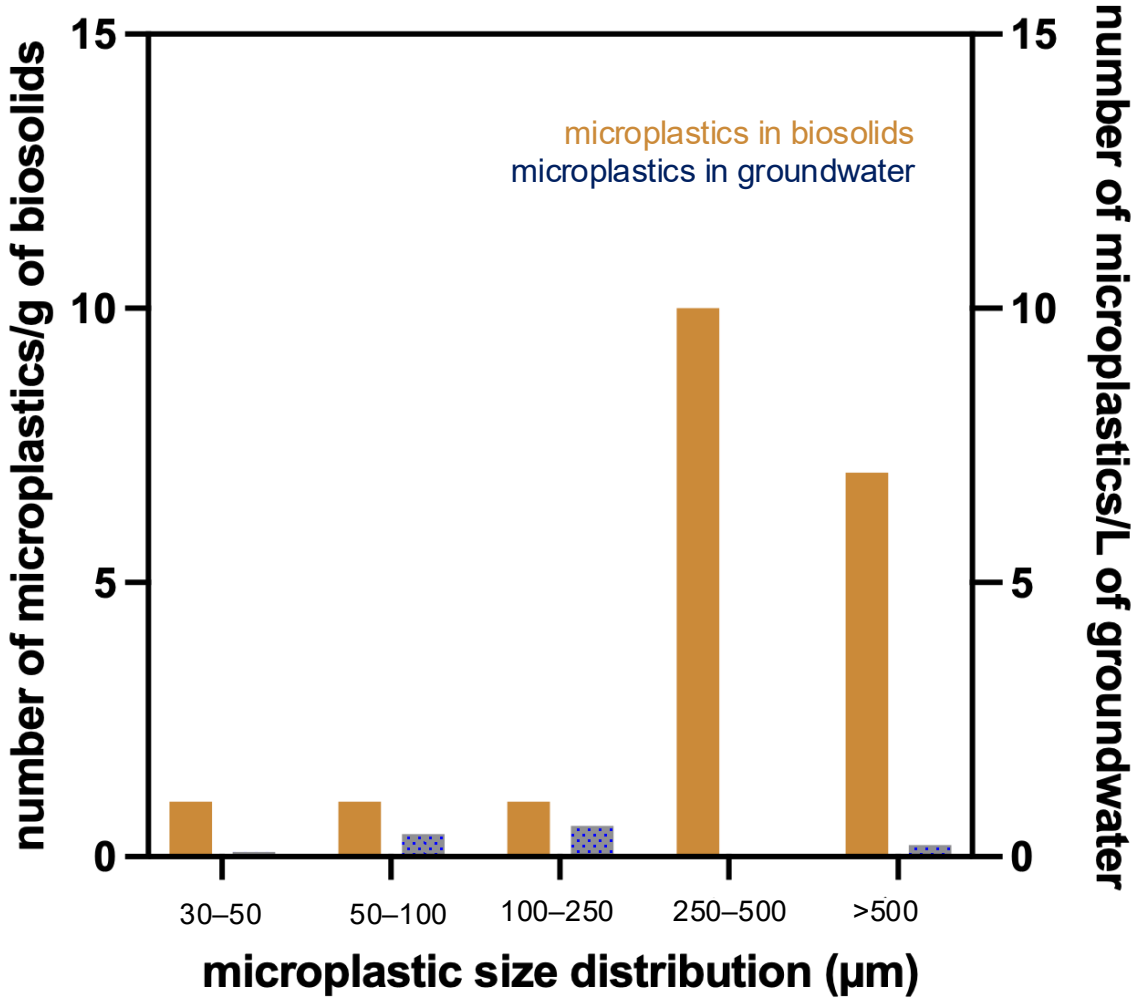
identity of microplastics found across the 34 L of groundwater analyzed



size distribution of microplastics found across the 34 L of groundwater analyzed

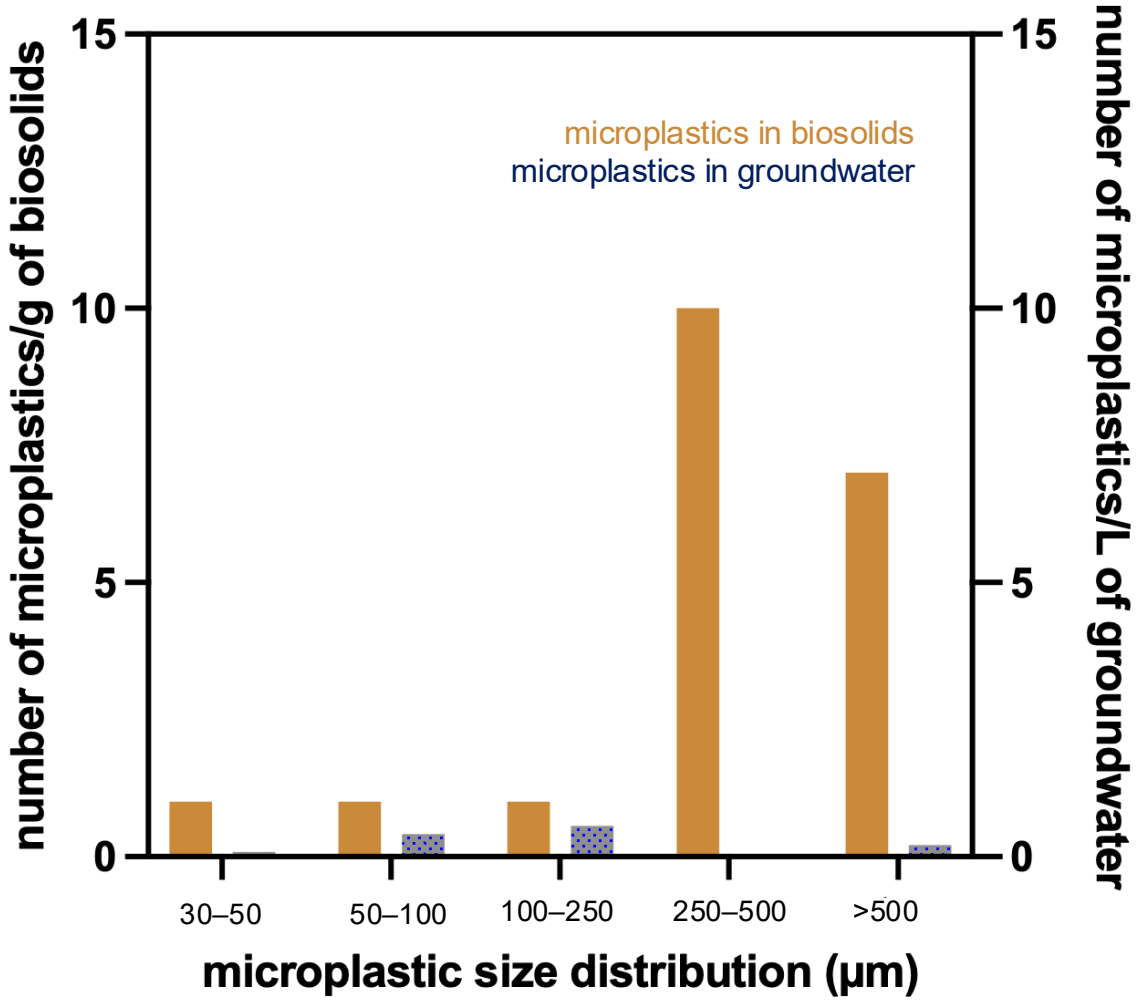
unpublished data

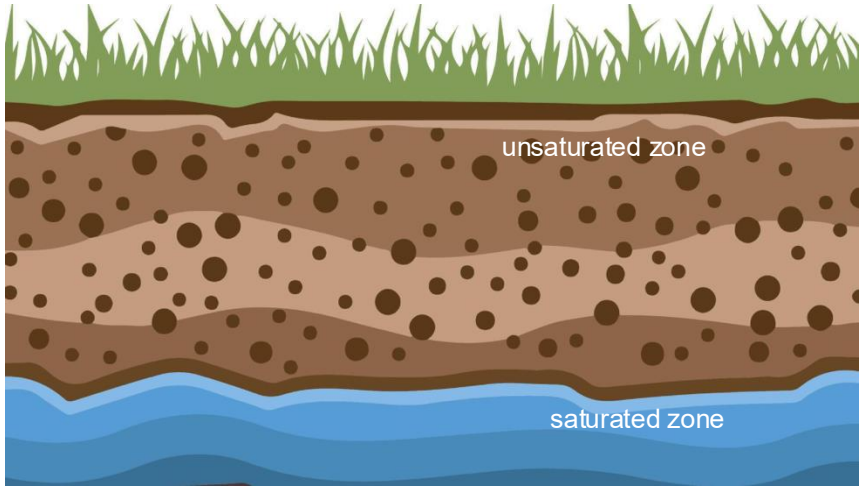
Smaller microplastics reach groundwater from biosolids



preliminary data- confirming sizes for biosolid microplastics

Smaller microplastics reach groundwater from biosolids

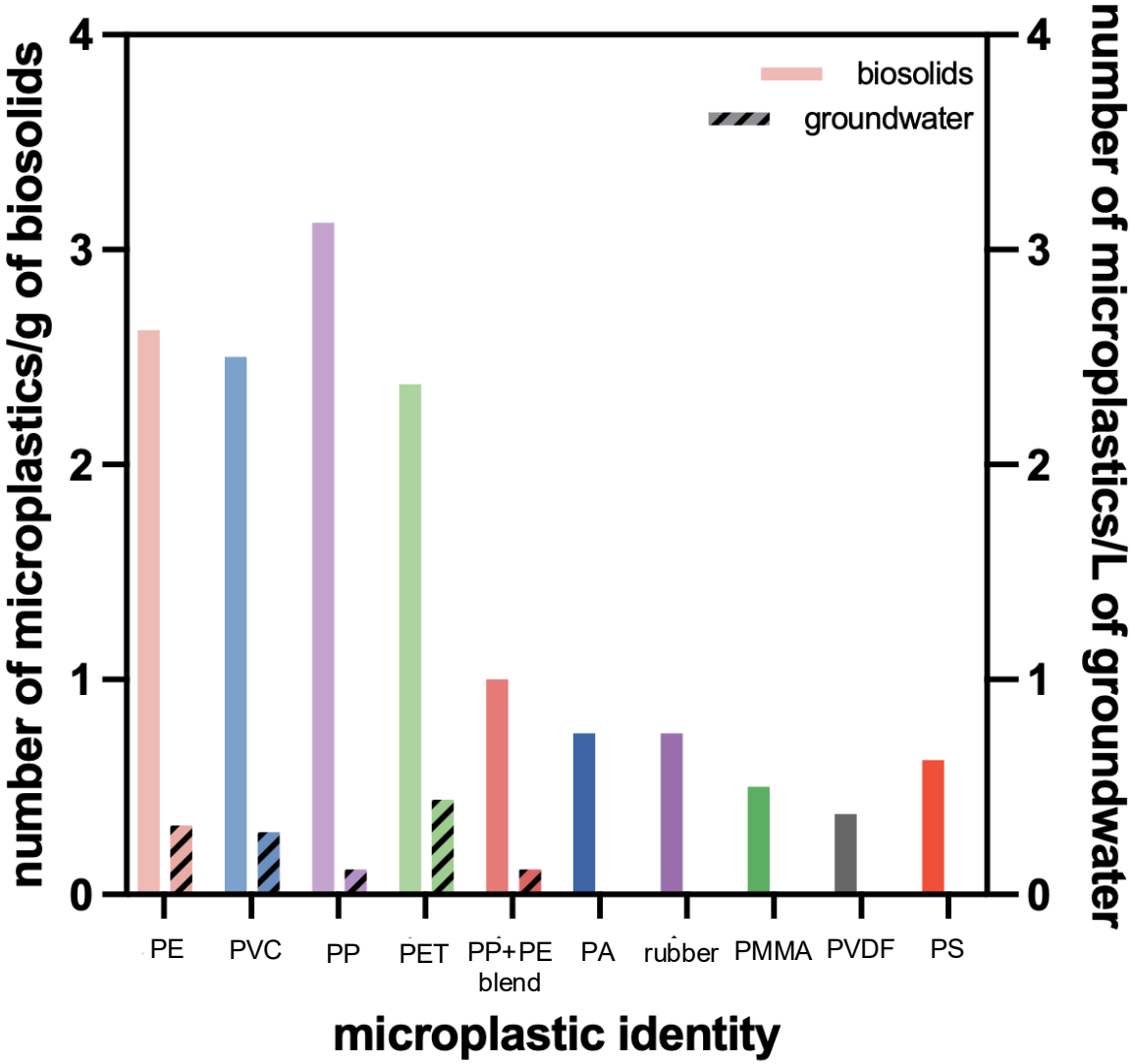




unsaturated groundwater zone is a natural filter

preliminary data- confirming sizes for biosolid microplastics

Common microplastics found remain similar in biosolids and groundwater



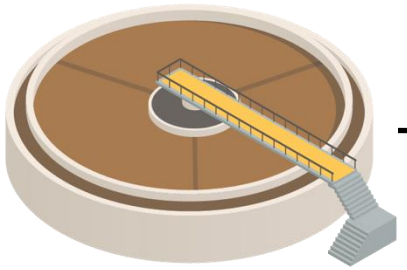
- polypropylene
- polyethylene
- polyvinyl chloride
- polyethylene terephthalate

unpublished data

Where did the rest of the microplastics go?



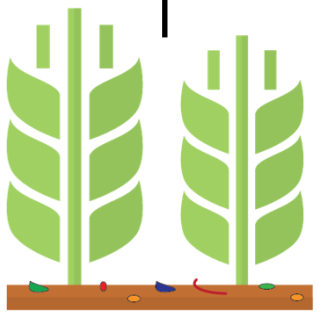
atmosphere
(future)



WWTPs



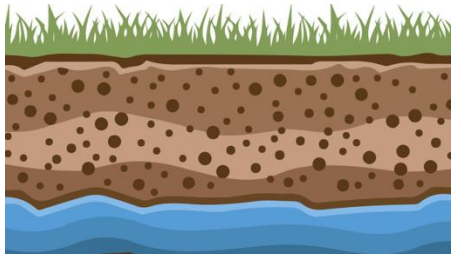
biosolids ☑



soil
(in progress)

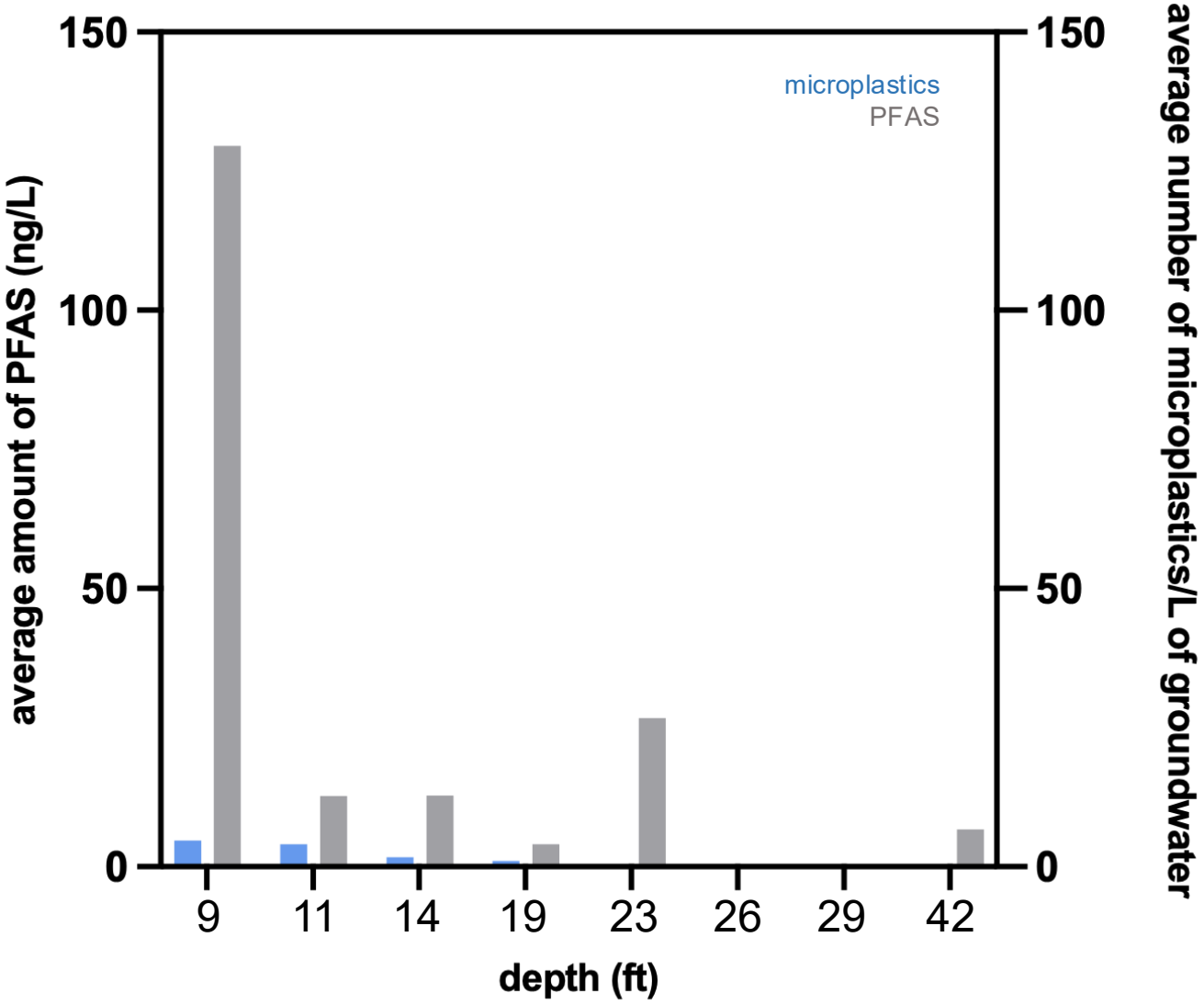


surface water
(future)



groundwater ☑

EGLE has previously quantified PFAS in Delhi's groundwater

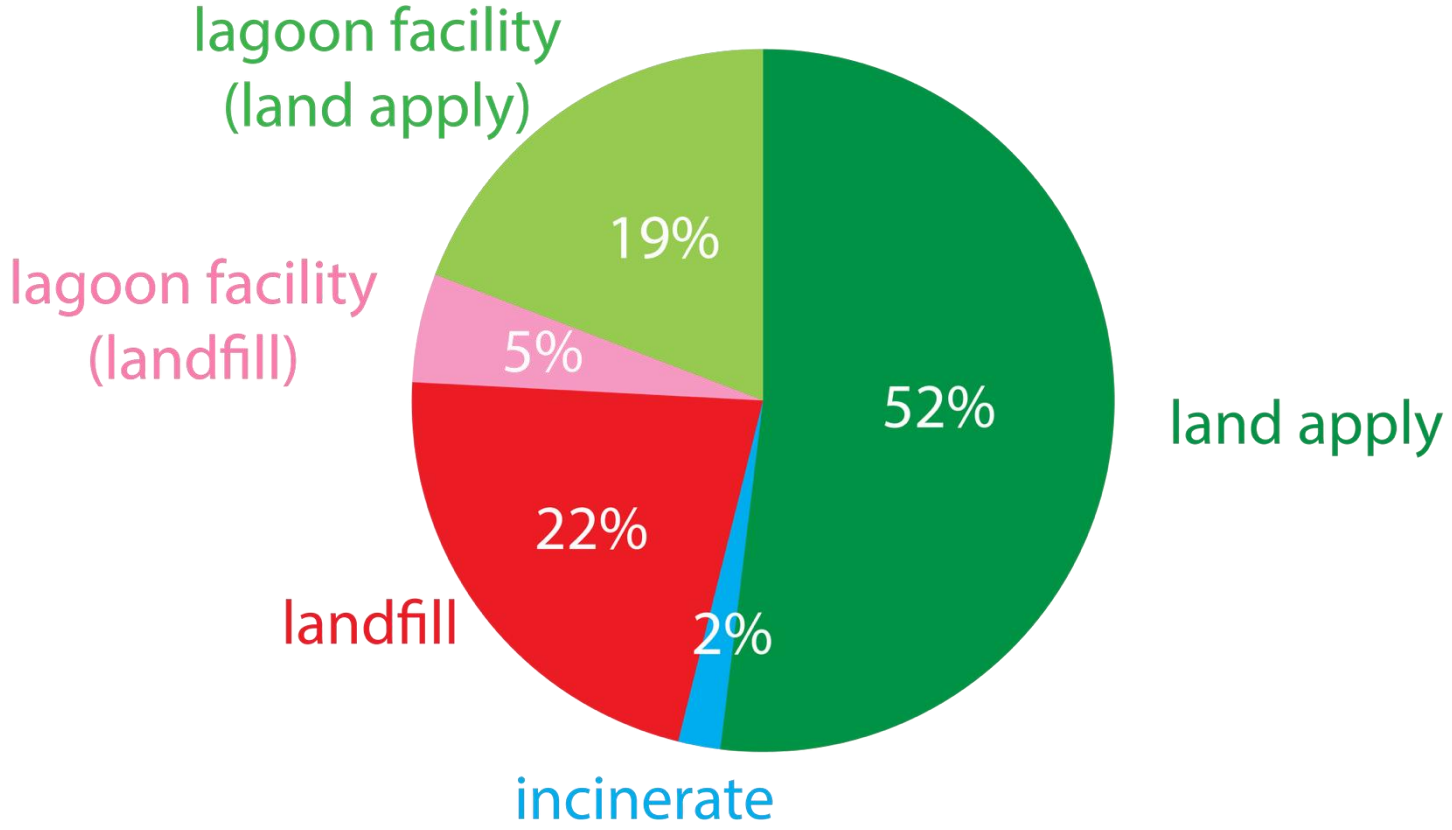


groundwater sampled for PFAS from 2020–2022

highest quantities of PFAS and microplastics found closest to the surface

https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/WRD/Biosolids/PFAS-Biosolids-Field-Report-Delhi-WWTP-Addendum.pdf?rev=a2440d8e05314364a25b513f5c13559c&hash=335CFCE568F52ADA30F7F2305CFD8906 (accessed on 10/05/2026)

Is land application of biosolids the best path?



survey from 110 of 231 total WWTPs in Michigan (as of December 2023)

71% of wastewater treatment plants in Michigan land apply biosolids

https://19january2021snapshot.epa.gov/sites/static/files/2015-05/documents/biosolidswhitepaper-uwash.pdf

unpublished data

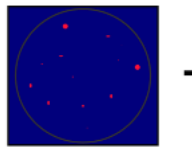
Conclusions and future work

quantified microplastics from biosolids to groundwater at Delhi Charter Township

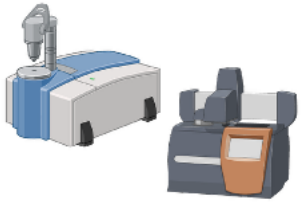




optimized identification protocol



fluorescent staining with Nile red
(size selection: >30 µm)

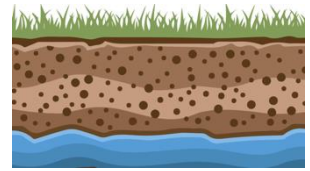


chemical identification via µ-FTIR spectroscopy and DSC

few microplastics reach groundwater from biosolids

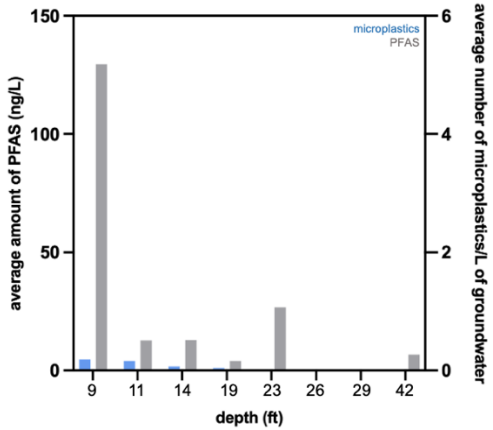


~14,600 MPs/ dry kg

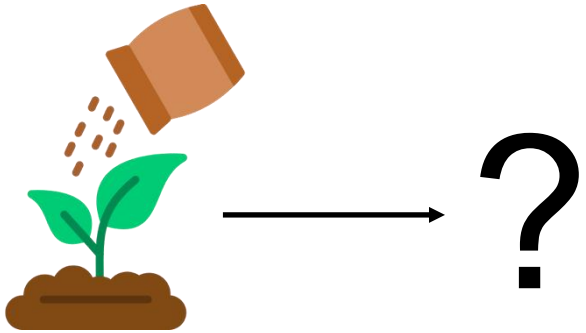


maximum 5 MPs/L

PFAS and microplastics are maximum in groundwater closest to surface



future work will trace microplastics dispersion to other parts of the environment



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