Transport of dynamically fragmented polystyrene (PS) microplastics through saturated porous media

Presentation by

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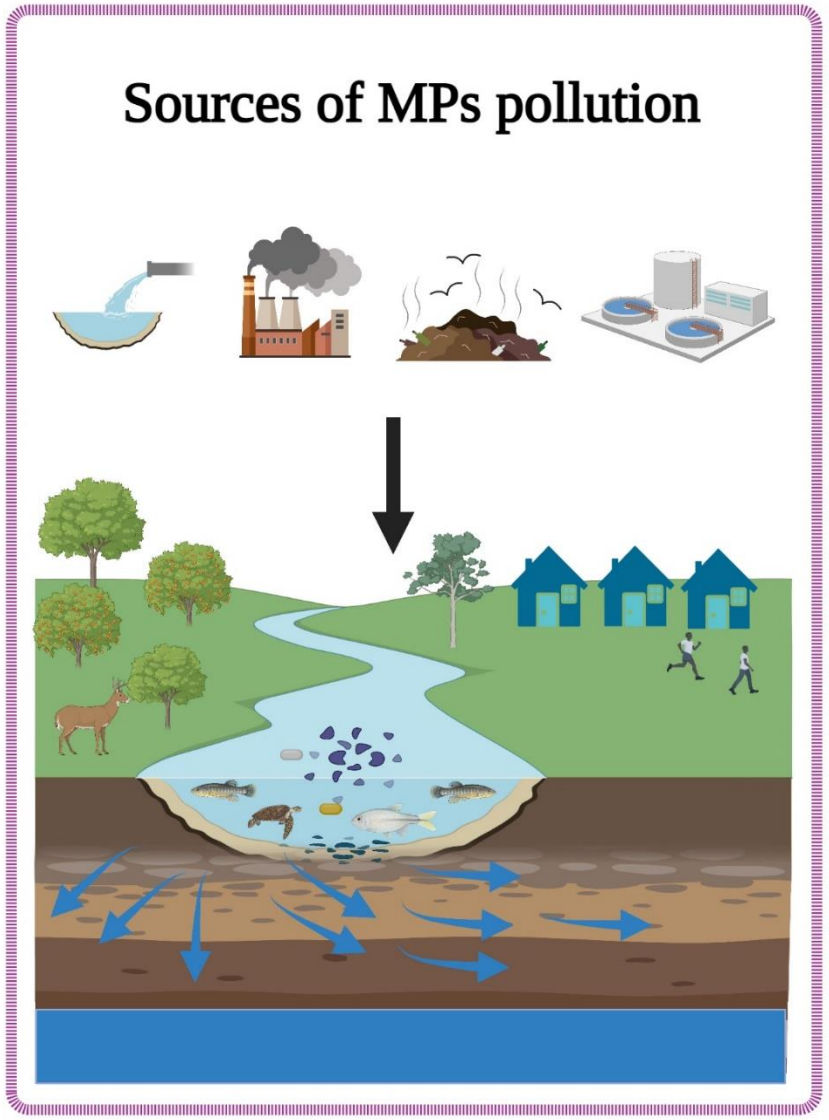
What are microplastics (MPs)?

- As per European Commission, fragmented plastics in a size range of **0.1 µm to 5 mm** *(Mendoza and Balcer 2019)*

Potential threats to groundwater system?

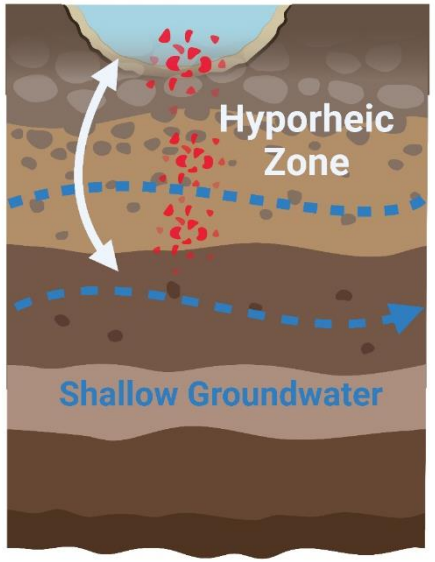
- For groundwater micron-sized MPs are more relevant *(Ameen et., al. 2020)*
- Less than **20% of global studies** considered MPs **size below 20 µm,** which are more relevant for groundwater studies.
- Mobile pore scale MPs in the hyporheic zone can be transferred into the aquifer.
- MPs in shallow groundwater can be a potential threat for drinking water (i.e. riverbank filtration) *(Frei et., al. 2019)*



Motivation

Understand the transport behaviour of MPs in different porous media;

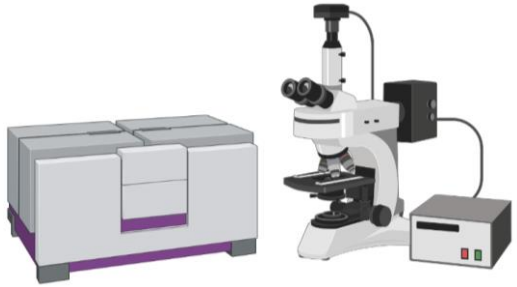
1. Effect of MPs **shape**
2. Effect of **porous media**
3. A **new method of analysing** MPs



Methodology

Dynamic fragmentation of microspheres
(10 & 20 µm)

Column experiment



Identification by Solid-phase Cytometry

Stevenson, et al., 2014

Process of dynamic fragmentation

Preparation

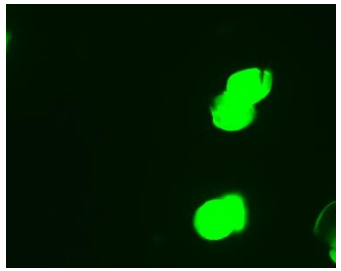
Microspheres
(10 and 20 µm)

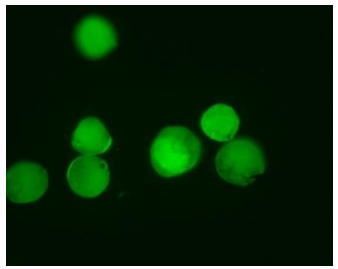
Adding
glass beads

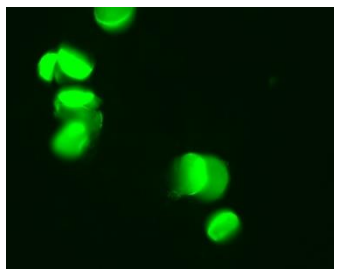
Fragmentation by
Homogenizer

Rev: 10 m/s
Time: 20 s

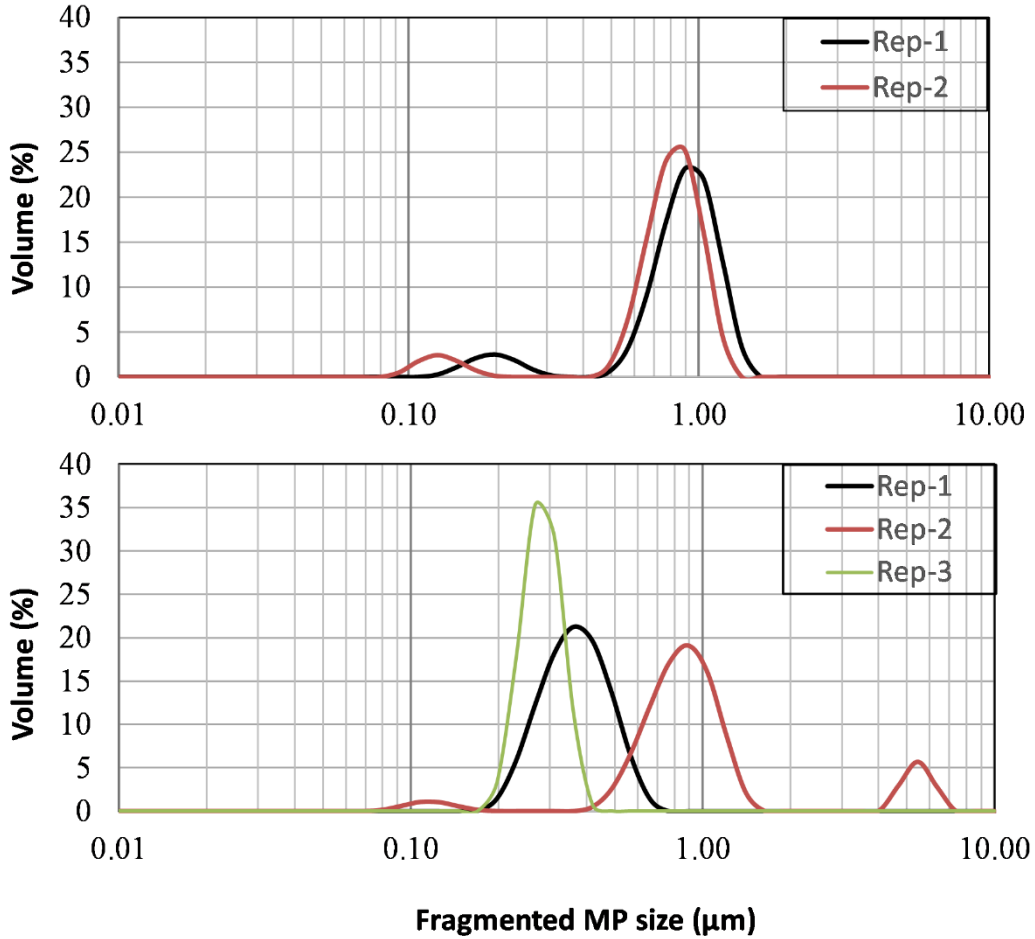
Fragmented MP





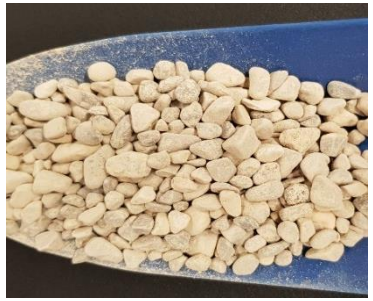


Fragmented MP size distribution



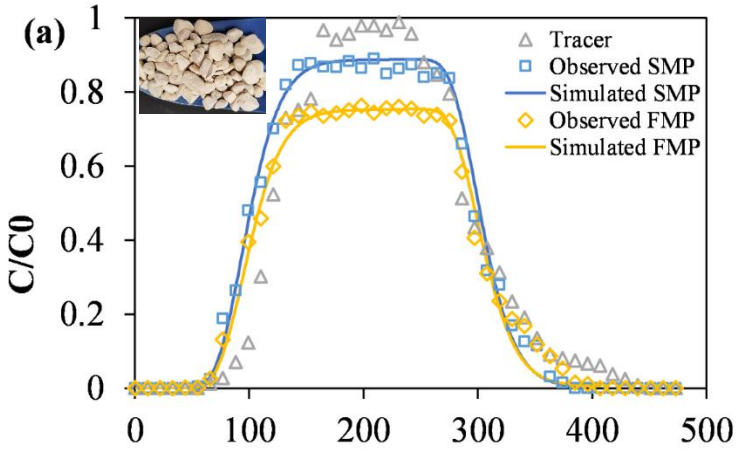
Parameters - column experiments

Column size:
d =7 cm, L = 30 cm

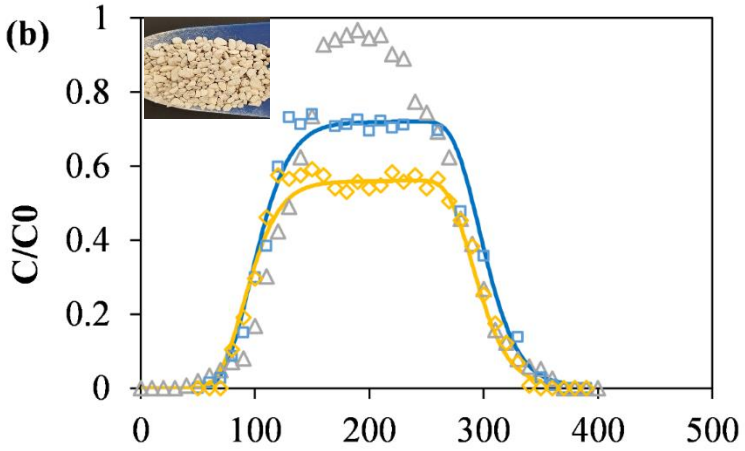
Parameters	Medium Gravel (8 mm)	Fine Gravel (4 mm)	Coarse Quartz (0.6 to 1.3 mm)	Medium Quartz (0.4 to 0.8 mm)
				
Porosity	0.38	0.36	0.41	0.43
Darcy velocity (m/d)	1.5	1.5	1.5	1.5
Flow rate (ml/min)	4	4	4	4
Avg. size FMP (µm)	1.55	1.70	1.44	1.36
FMPs injected (par/ml)	1.65×10^4	5.75×10^4	1.45×10^4	1.72×10^4

Results

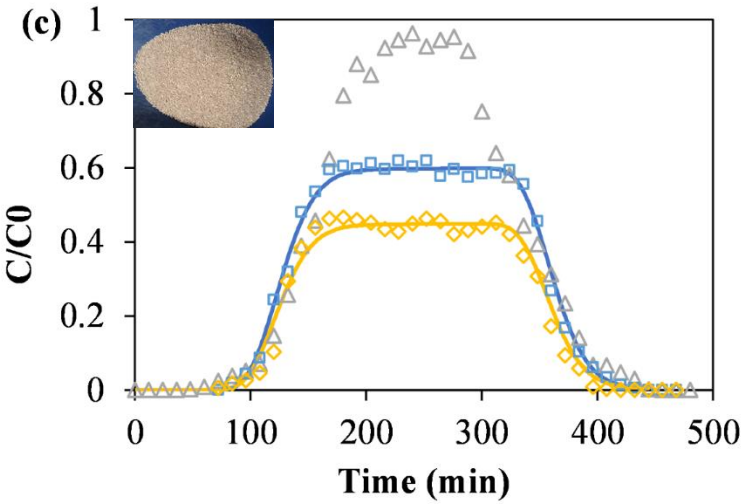
Medium Gravel (8 mm)



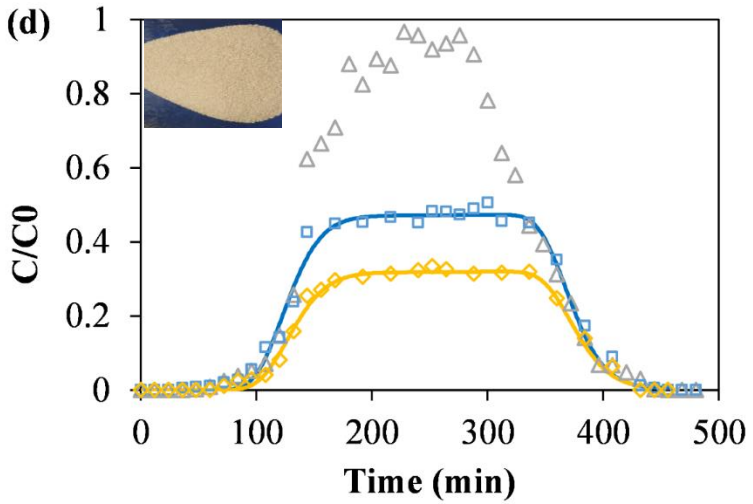
Fine Gravel (4 mm)



Coarse Quartz (0.6-1.3 mm)



Medium Quartz (0.4-0.8 mm)



Key findings

- Higher deposition of fragmented MPs due to
  - uneven shape and surface irregularity (e.g. aspect ratio)
  - Surface heterogeneity of the porous media
- Re-orientation of fragmented MPs near pore-spaces.
- Tumbling (rotational) movement of the fragmented MPs.
- Hydrus 1D - high values of attachment coefficient of fragmented MPs.

Conclusion

- Surface roughness and irregularity of fragmented MPs was more important than straining.
- The impact of grain and pore size on fragmented MPs was evident.
- Non-uniform MPs should be used for realistic groundwater investigations.
- Highly dynamic riverbank filtration systems (often used as a safe drinking water resource) should be investigated for irregular-shaped MPs as tracers.

Thank you for your attention

Questions