Microplastics: From source to sink in freshwater ecosystems

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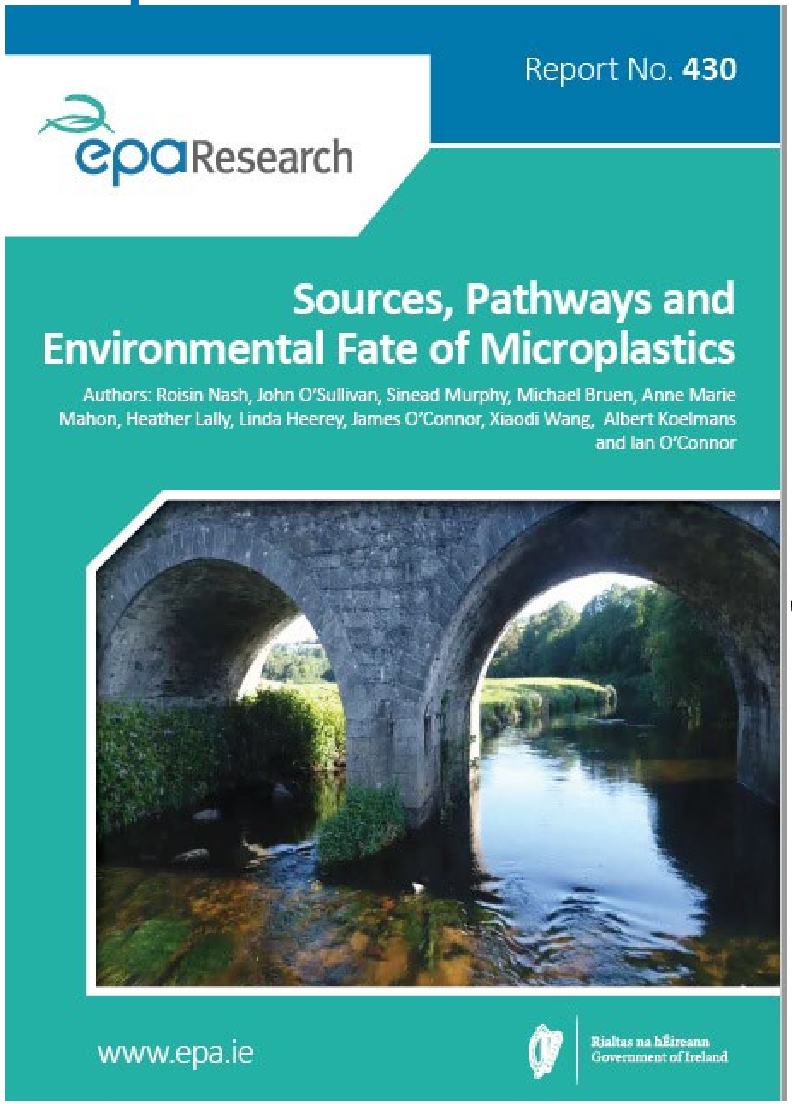
Research Team



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Drivers of the Research

Lack of knowledge on MPs in Freshwater ecosystems

- To further refine MP SOURCES
  - To characterise MPs derived from sources
- Identify pollution PATHWAYS of MPs
  - To determine the influence of variables, such as rainfall and polymer type, on the pathways and distribution.
- To identify the FATE of MPs in freshwater systems
  - To explore potential fate of MP through examining environmental variables including freshwater food webs
- To provide Recommendations for Monitoring of MP

Study Area – River Slaney Catchment

Microplastics – overview

Microplastics (MPs):

Finding a consensus on the definition

*"any **synthetic**, solid particle or polymeric matrix with regular or irregular shape, a size ranging from **1 μm to 5 mm**, of either primary or secondary origin, which is **insoluble** in water".*

Frias and Nash, 2019

Marine Pollution Bulletin

Marine Pollution Bulletin 138 (2019) 145–147

Contents lists available at ScienceDirect

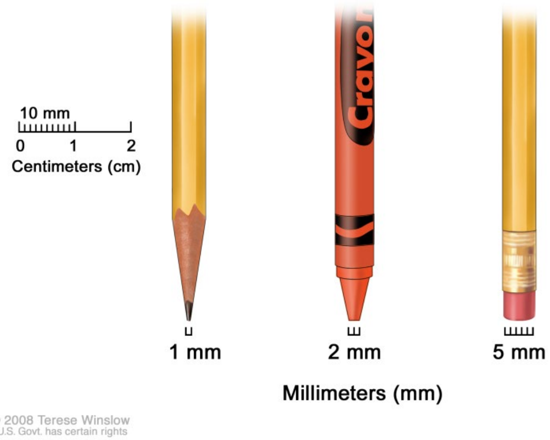
Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Focus

Microplastics: Finding a consensus on the definition

J.P.G.L. Frias, Roisin Nash



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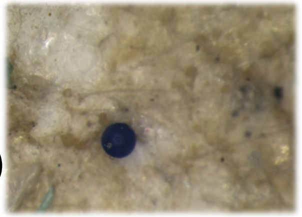
FRESHWATER MICROPLASTICS
PATHWAY ENVIRONMENTAL FATE

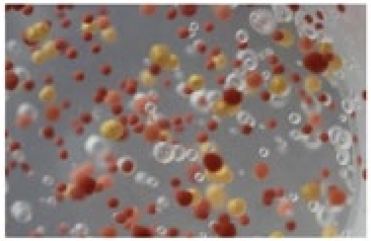
Microplastics

∴ Primary microplastics

(designed to have specific dimensions)



MICROBEADS (Scrub)



NURDLES (Pellets)

Photo credits: Boomerang Alliance

www.beatthemicrobead.org

[Prohibition of Certain Products Containing Plastic Microbeads Bill 2018]

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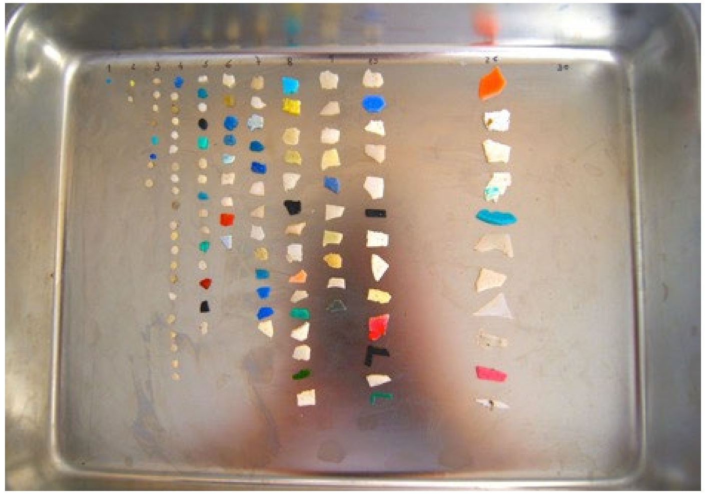
Microplastics

FRESHWATER MICROPLASTICS
SOURCES PATHWAY ENVIRONMENTAL FATE

∴ Secondary microplastics

(breakdown of larger plastic items)

Source: KOBIS and EEA



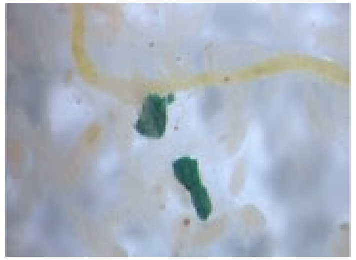


Photo credits: Haleigh Joyce and João Frias

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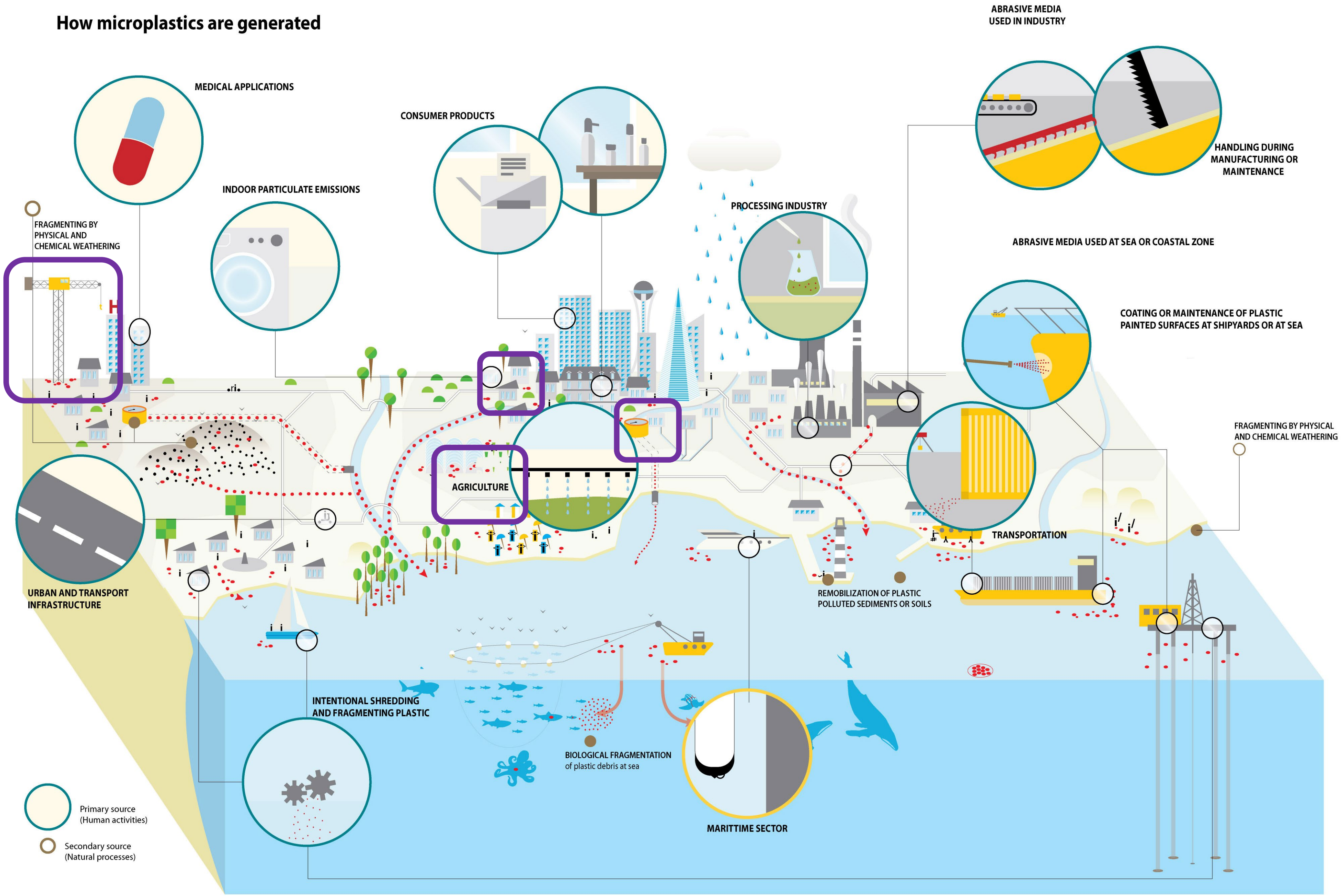
Sources, Pathways and Environmental fate of Microplastics

How microplastics are generated



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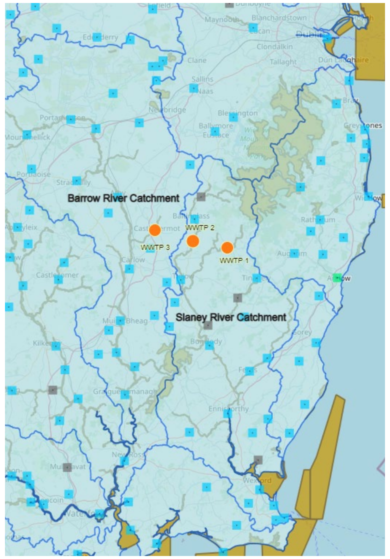
Sources, Pathways and Environmental fate of MPs

FRESHWATER MICROPLASTICS
SOURCES PATHWAY ENVIRONMENTAL FATE

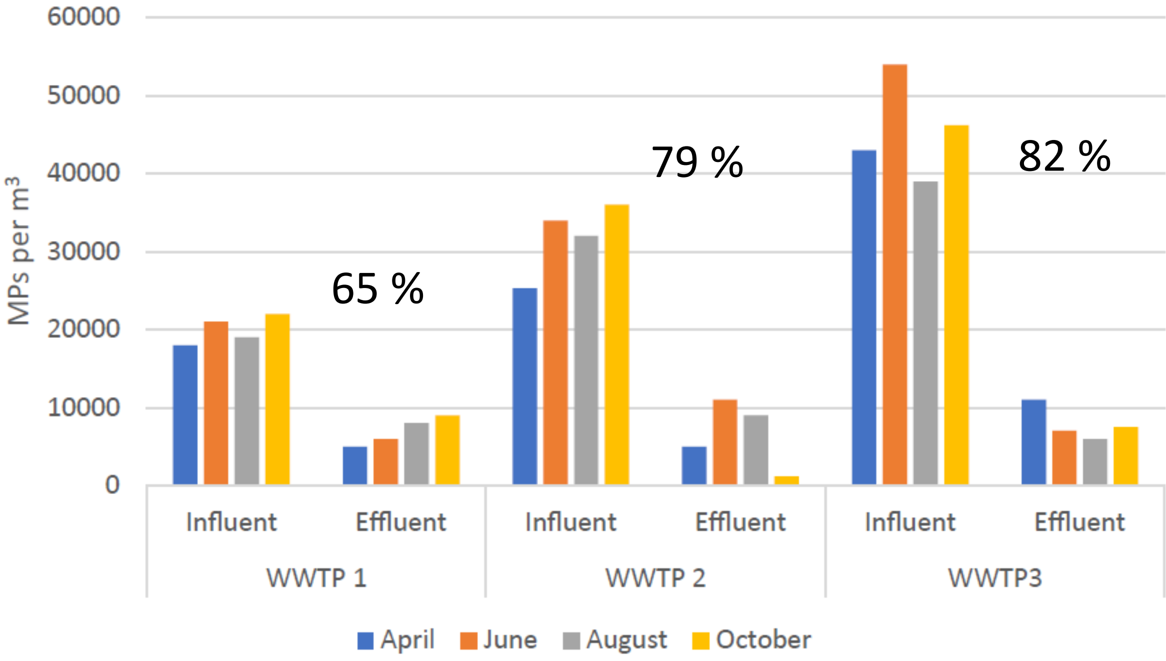
WasteWater Treatment Plants

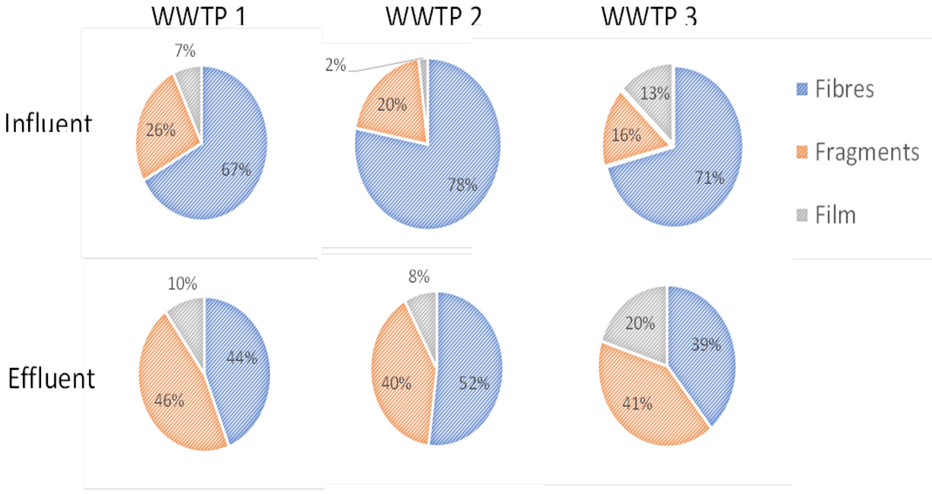
WWTP <2,500 P.E.



(© EPA maps)

Retention %





5L composite sample - at inflow (post preliminary) and final effluent

Mahon et al. 2022

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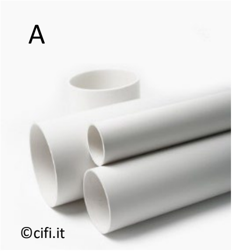
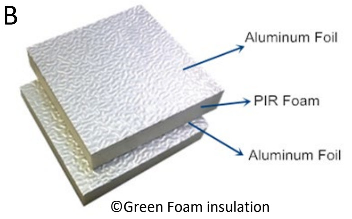
Sources, Pathways and Environmental fate of MPs

FRESHWATER MICROPLASTICS
SOURCES PATHWAY ENVIRONMENTAL FATE

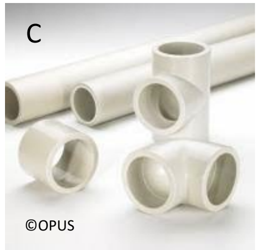
Construction



Polyvinyl chloride (PVC),



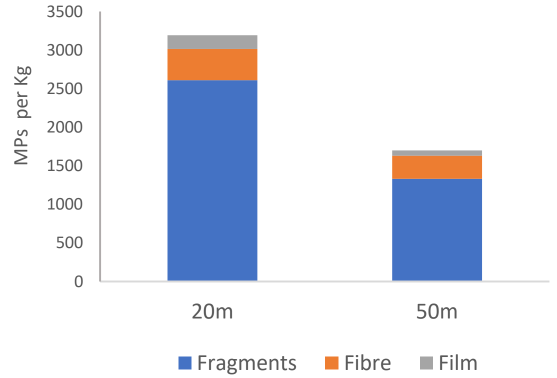
Polyisocyanurate (PIR)

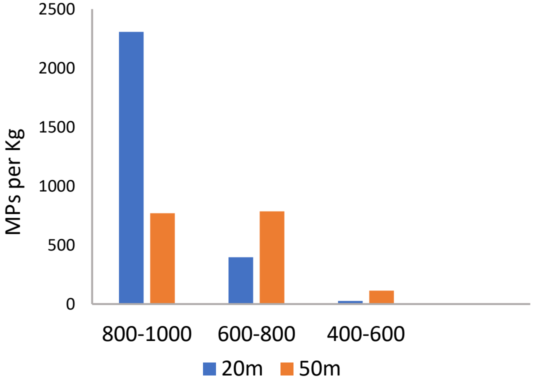


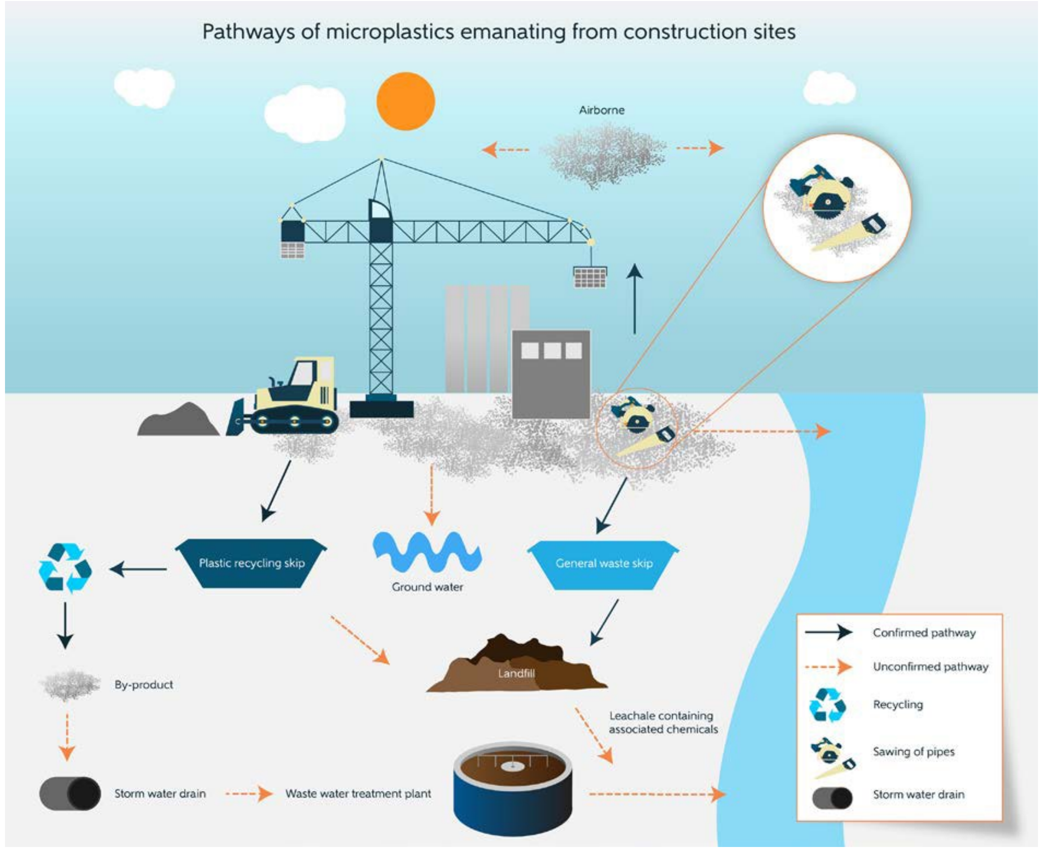
Polypropylene (PP)

Material	Polymer	# of cuts	MPs (g)	MP numbers
Sewer pipe	Polyvinylchloride (PVC)	80	156	1,376,960
Foul water pipe	Polypropylene (PP)	120	295	1,032,500
Insulation board	Polyisocyanurate (PC)	300	193	unknown

Distance from construction site (m)







Source: Nash et al. 2023

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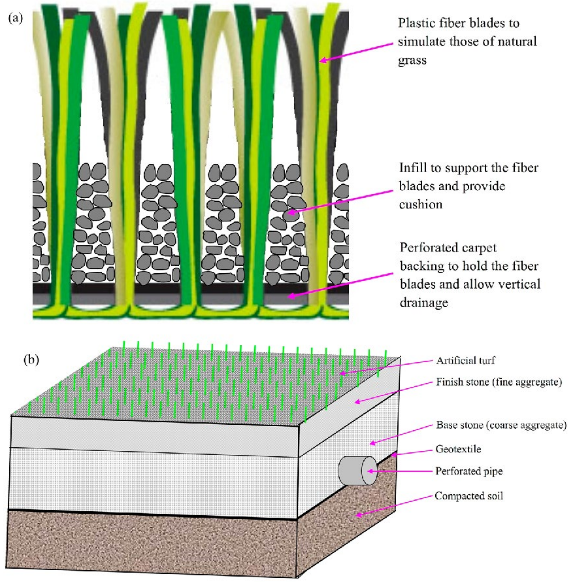
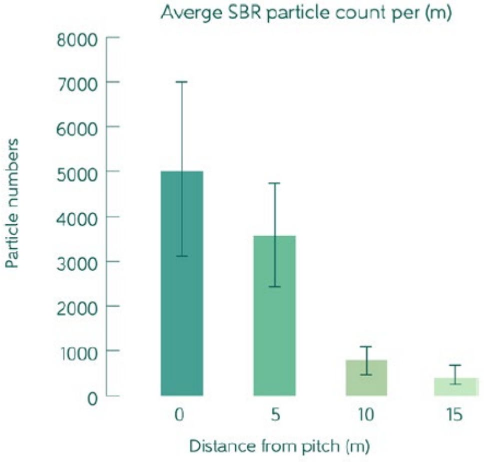
Sources, Pathways and Environmental fate of MPs

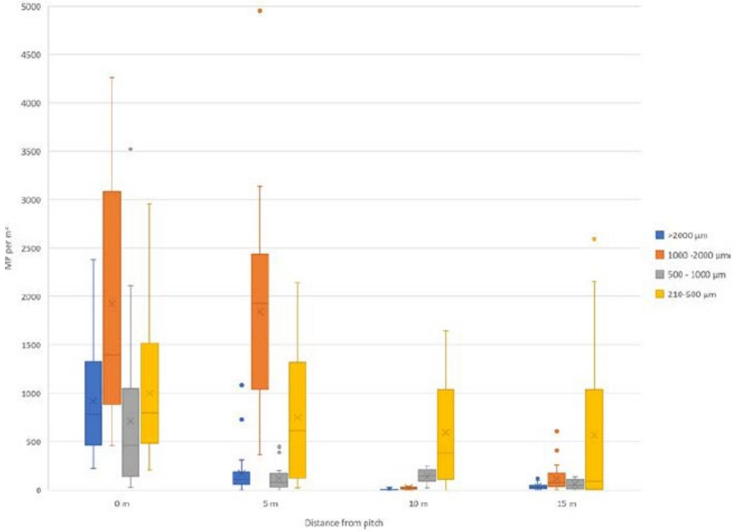
FRESHWATER MICROPLASTICS

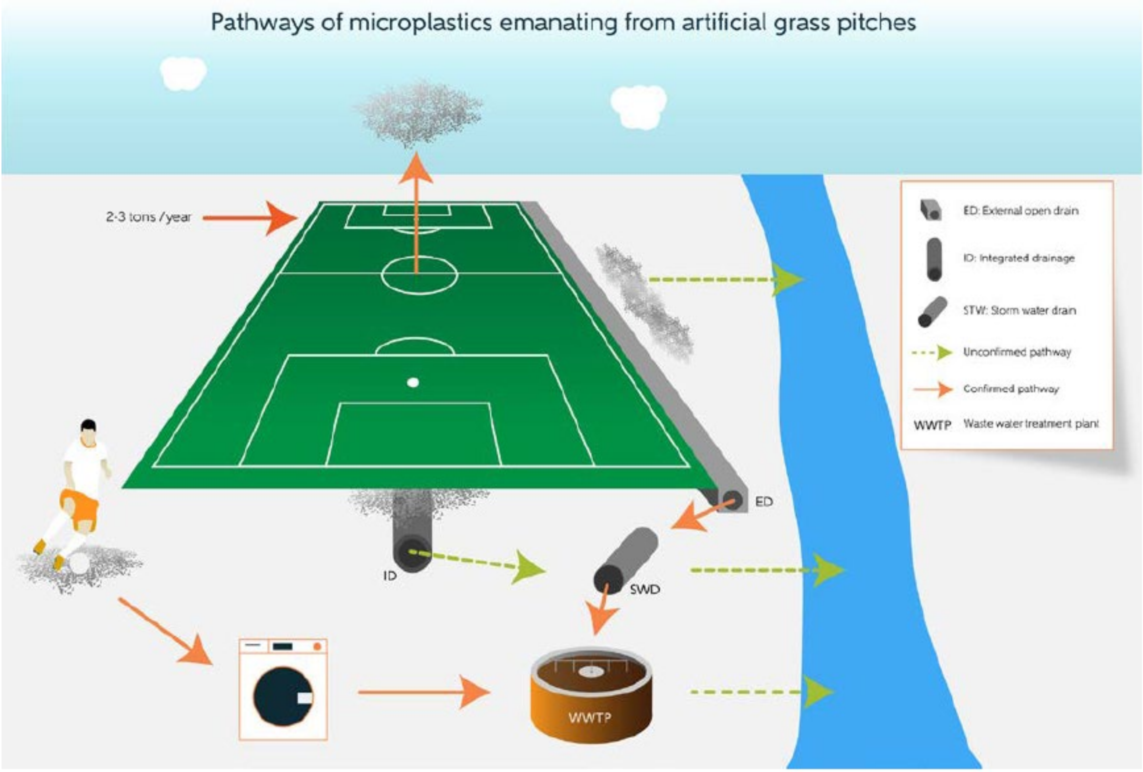
AstroTurf pitches



Source: Cheng et al. 2014







Source: Nash et al. 2023

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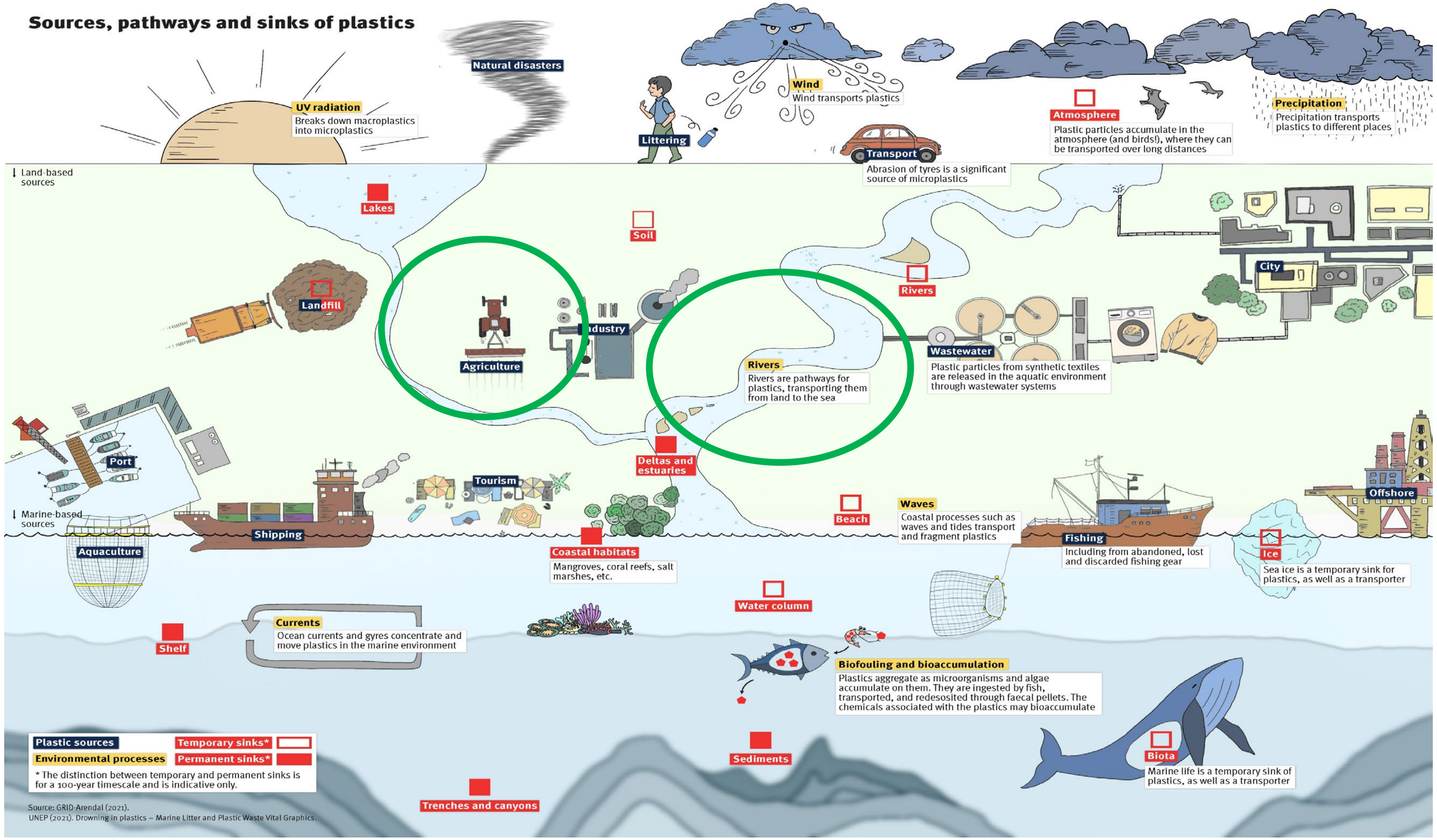
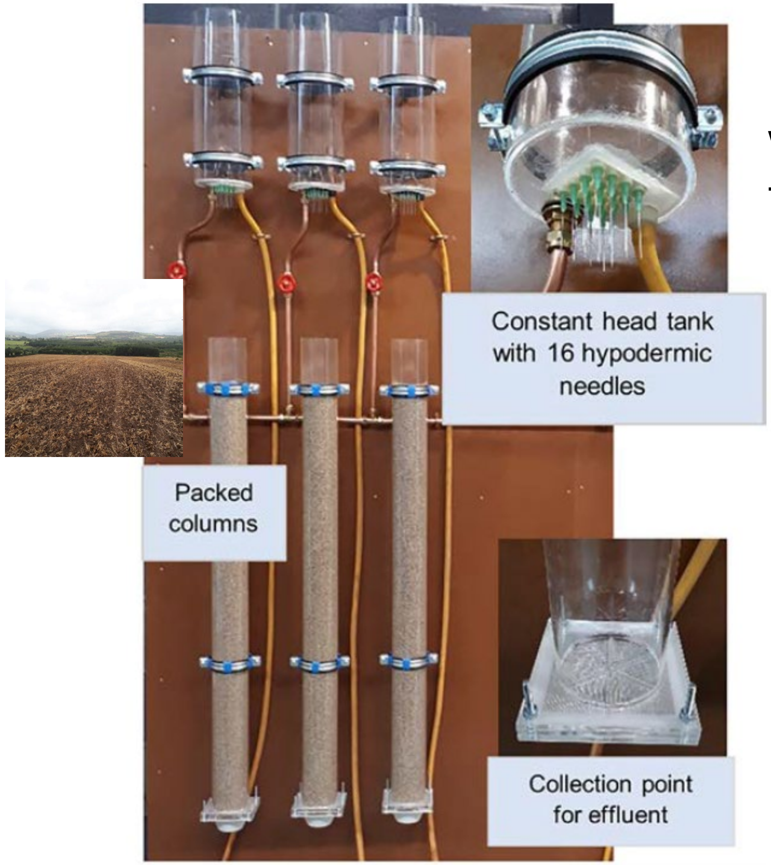
Sources, Pathways and Environmental fate of MPs

Land Based Pathways

Marine Based Pathways



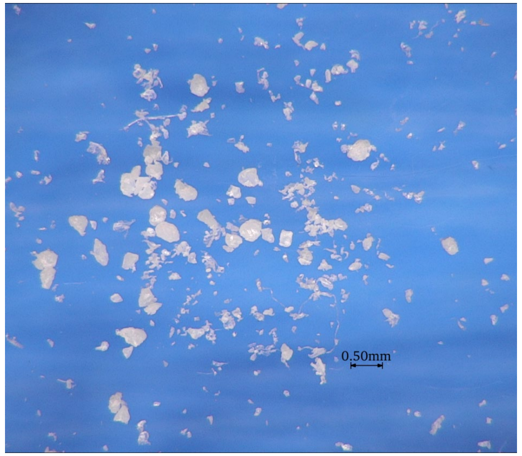
Vertical Migration



Experimental rig for porous media column tests.

rainfall intensity - varied via the water level in the constant-head tanks.

Results - particles remained static



LDPE, PVC and PET powdered particles

Field Cores

Extraction

6 x 2-m-deep cores

(ø = 5 cm)

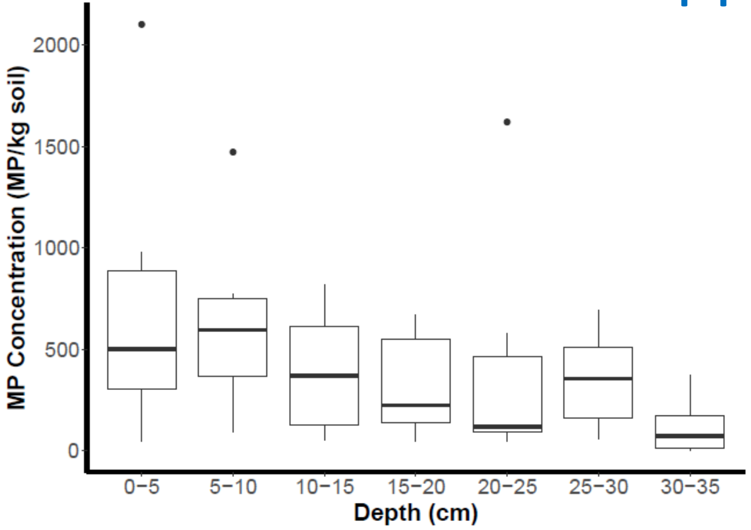
Cobra TT

percussion drill

Source: Heerey et al. 2023

Sources, **Pathways** and Environmental fate of MPs

Land Application from WWTPs & Farm Plastics

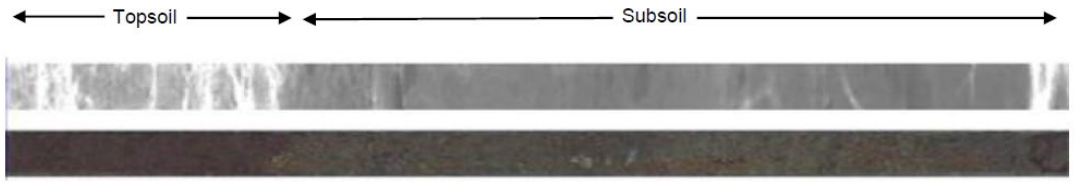


MPs - limited to top 35 cm
(coinciding with the plough zone depth)

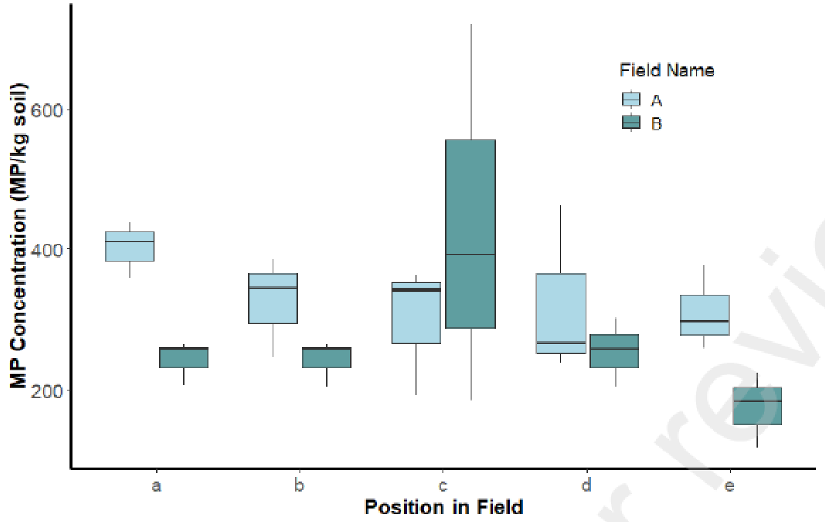
MP abundance

Field A (4.6% gradient) - very slight downward trend

Field B (8.7 % gradient) - Variable distribution



Optical image and X-ray of a soil core to a depth of 1m.



Source: Heerey et al. 2023

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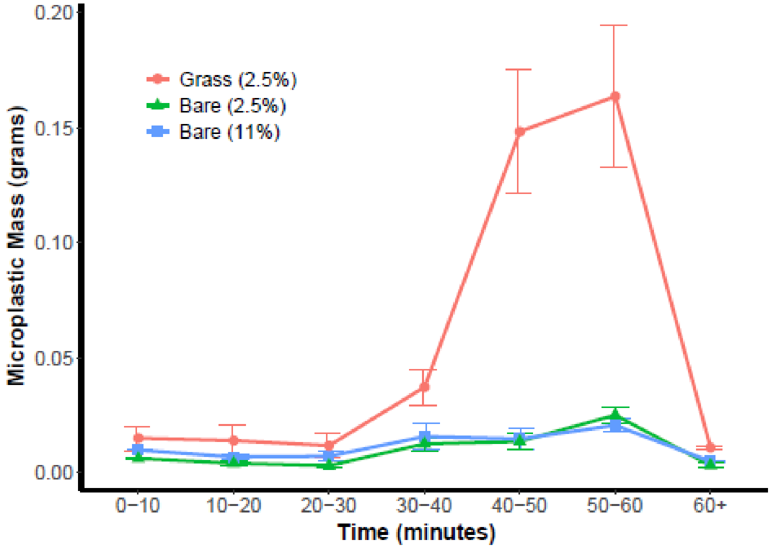
Slope and Rainfall simulation

Source: Heerey et al. 2023

Rainfall intensities showed a significant difference (8 mm h^{-1} and 18 mm h^{-1})



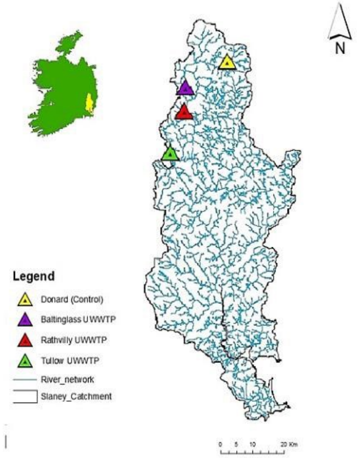
Grass swards reduce the export potential of MPs

Slope was shown to be less influential than rainfall intensity in overland MP transport epa Research

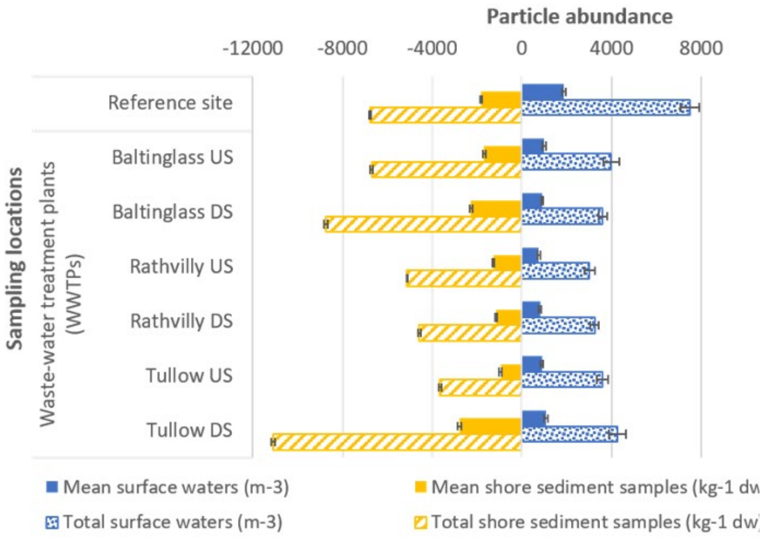
Sources/Pathways:

River Slaney as a Transport Pathway

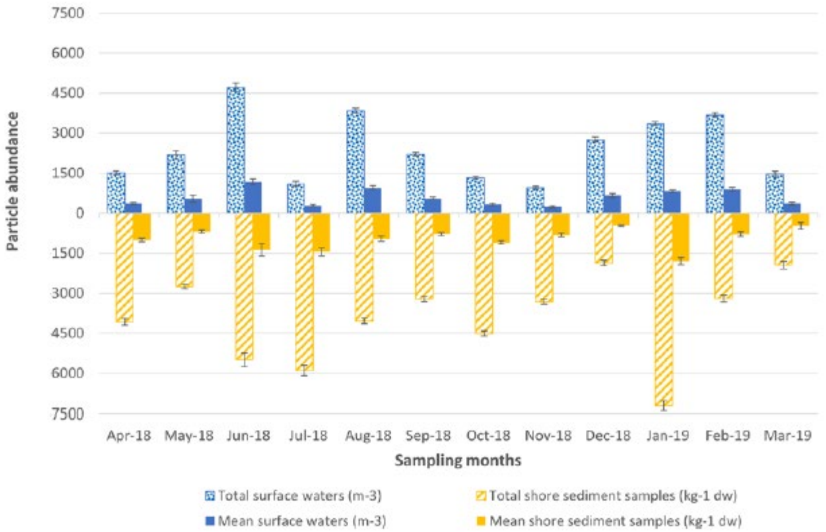
FRESHWATER MICROPLASTICS
SOURCES PATHWAY ENVIRONMENTAL FATE



Total and mean MP abundance in the upper reaches of the River Slaney
surface waters (blue)
shore sediment samples (orange)



Upstream and downstream of WWTPs



12-month (April 2018 to March 2019)

Source: Lally et al. 2023

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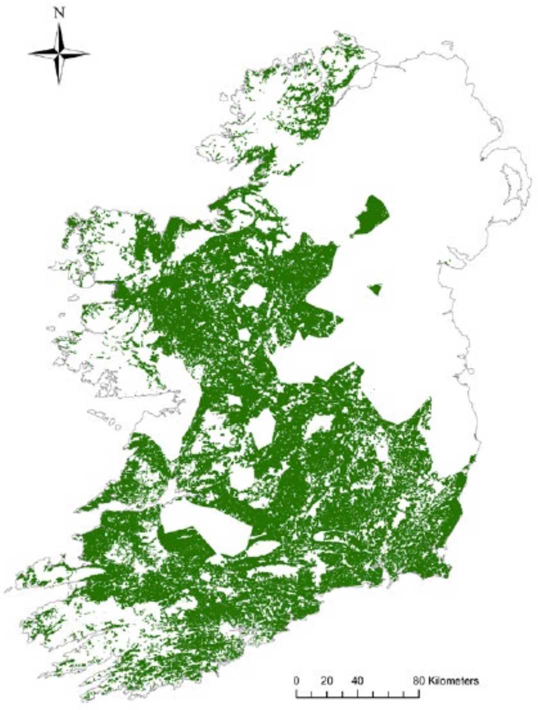
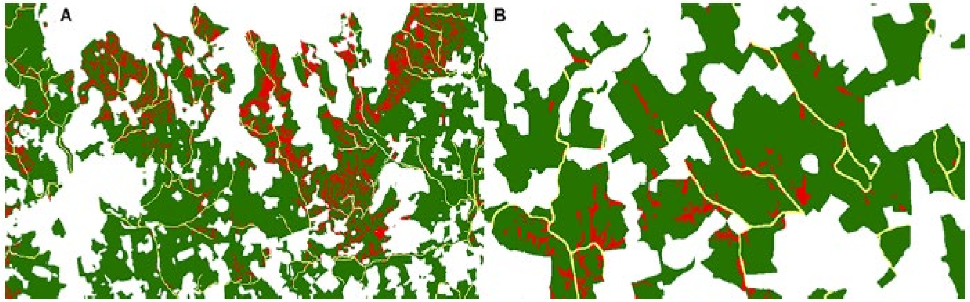
Sources, **Pathways** and Environmental fate of MPs

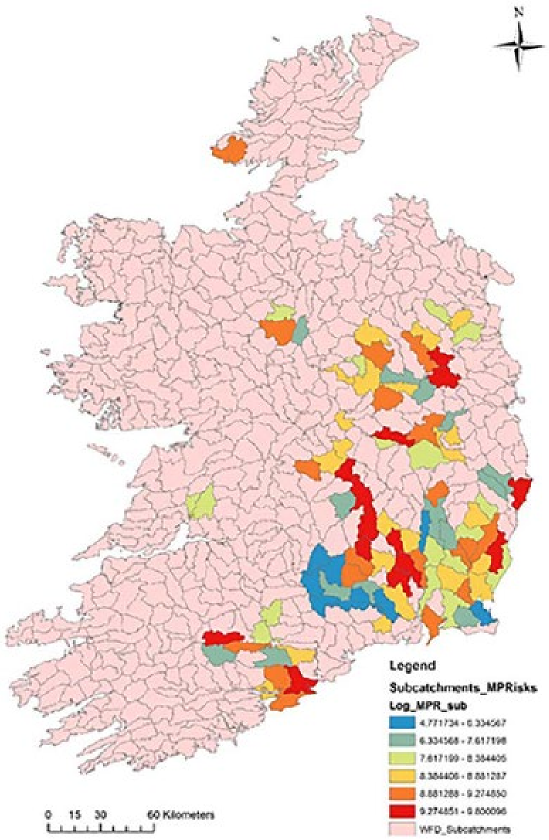
Modelling Microplastic Risks to Waterbodies



Indicative national map of lands potentially suitable for landspreading sludge (with exclusions due to surface runoff risks).



Green areas: landspreading of sludge
(A) Suitable - severe fragmentation
(B) Potentially suitable - less fragmentation.
Red areas: excluded because of surface runoff considerations,
Yellow areas: 20-m buffers around water courses and
White areas : excluded - heavy metals, unsuitable land use or groundwater vulnerability.

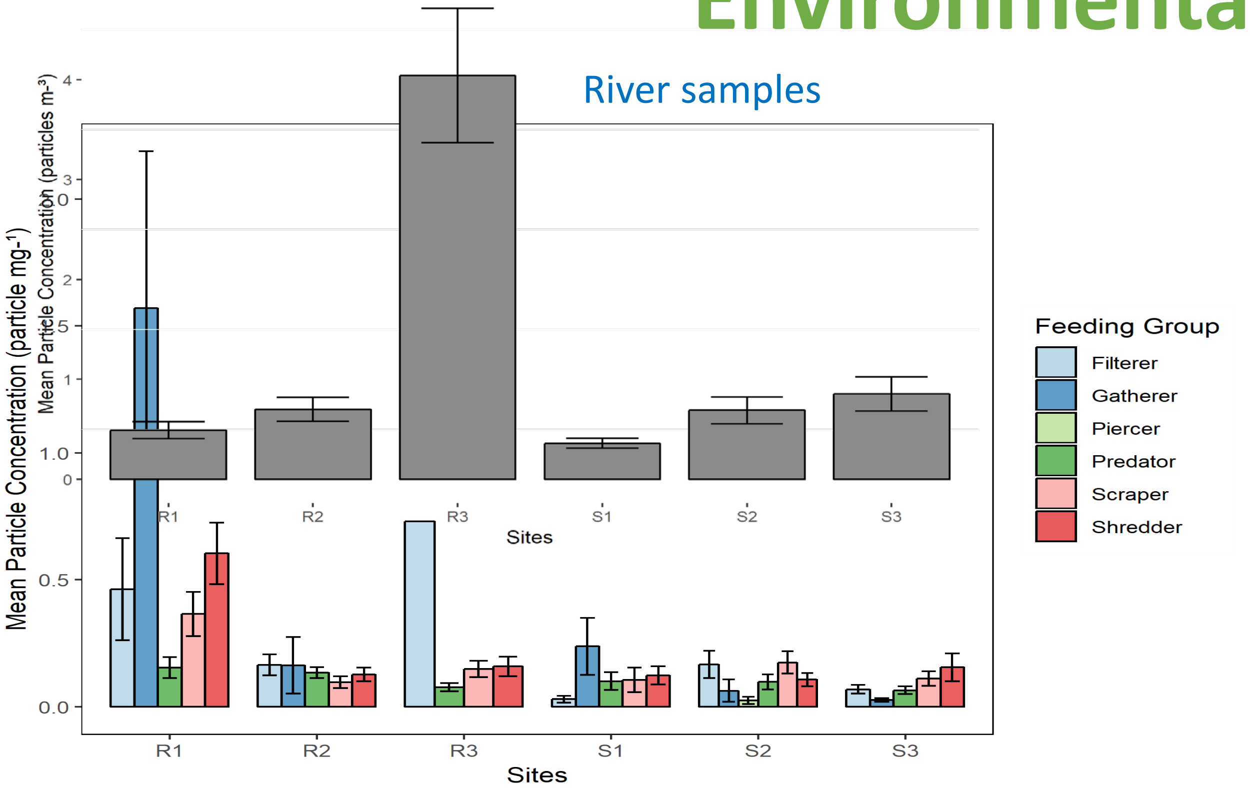


MP risks - should be as a hypothetical example of the type of analysis and outputs possible

Source: Wang et al. 2018, Thomas et al. 2021

Sources, Pathways and **Environmental fate** of MPs

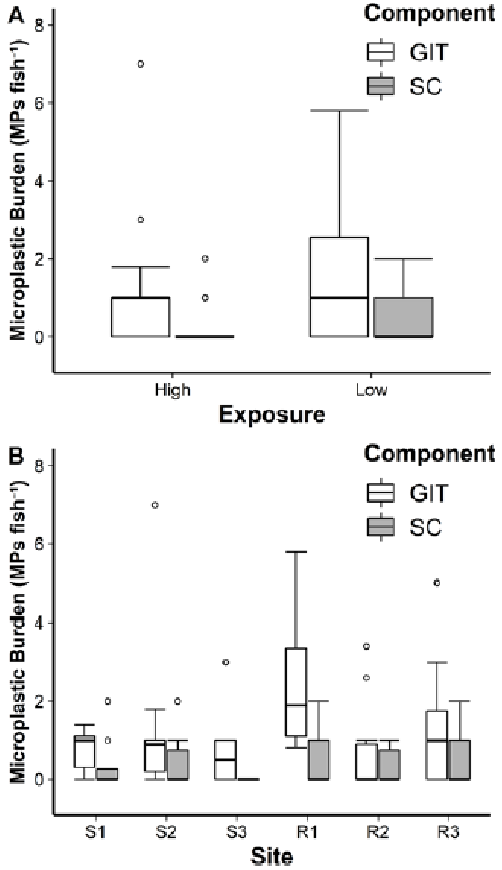
River samples



Benthic Macroinvertebrates

713 aggregated macroinvertebrate (106 kick samples),
73% contained MPs

Brown Trout (*Salmo trutta*)



58 brown trout
(72 to 291 mm)
92 MPs
72% of fish
(gastrointestinal tract
(GIT) stomach contents
(SC) combined),

Source: O'Connor et al. 2020; 2021; 2022

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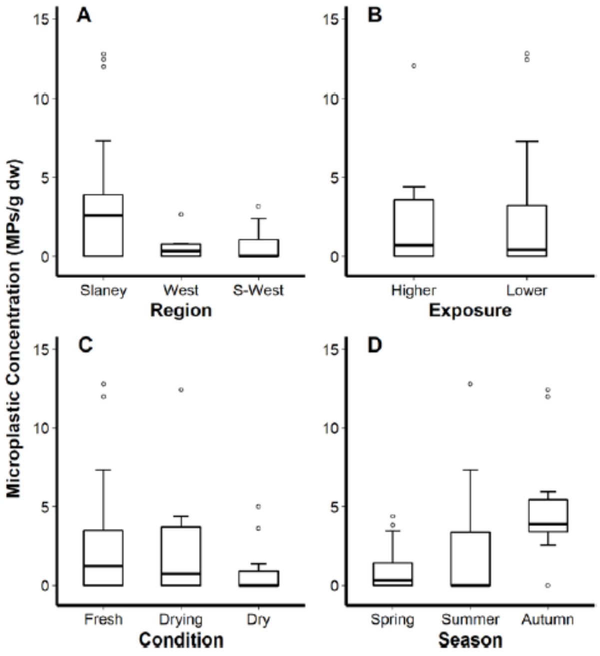
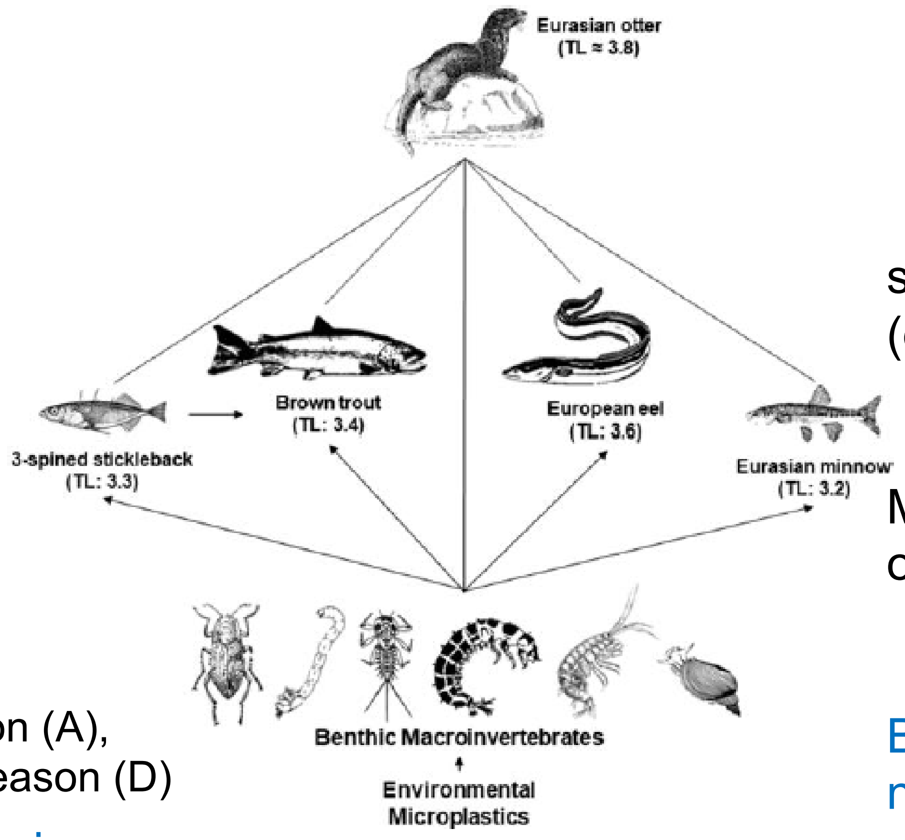
Eurasian Otter *(Lutra lutra)*



(*n* = 53) in spraint samples per region (A), exposure level (B), condition (C) and season (D)

Evidence - most likely pathway is secondary ingestion (i.e. trophic transfer).



River Slaney
Food Web

specific predator–prey interactions (dietary analysis & literature)

MP uptake simulated through feeding of benthic macroinvertebrates

Biomagnification of MPs (> 100 μm) is not currently predicted in aquatic biota

Source: O'Connor et al. 2022

Recommendations for Monitoring

Catchment level

- Introduce **fine-scale, long-term monitoring of riverine waters**, sediment and biota.
- **Align sampling and protocols** for biotic and abiotic components - to reduce methodological biases and provide a better understanding of the bioavailable fractions of MPs in the environment.

Abiotic matrices

- **Sediment** sampling - best indication of overall pollution (medium to long-term exposure).
- Sediment and **Biota** - to determine site-specific exposure levels
    - hence exposure pathways for benthic biota within these sites.
- **Water** sampling, - to improve representativeness and increasing the detection of larger particles.

Biotic matrices

- An **ecosystem-based approach to monitoring** - multiple environmental matrices, to develop our understanding of factors affecting the presence and distribution of MPs in rivers.

Thanks for your attention

Further Information and publications can be found on the website:

https://freshwatermicroplastics.com