

Microplastics: From source to sink in freshwater ecosystems

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Sources, Pathways and Environmental Fate of Microplastics

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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



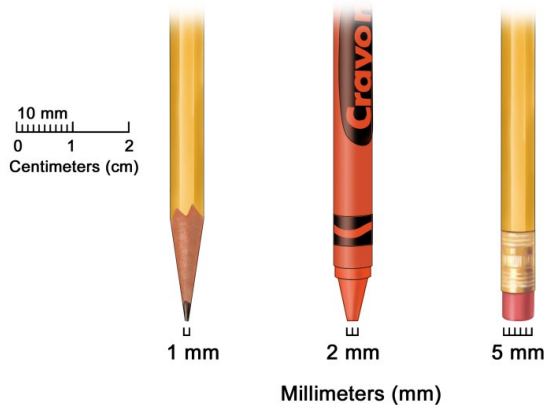
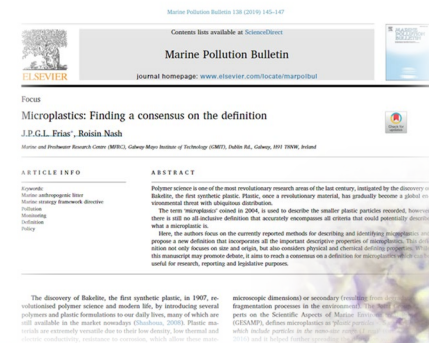
Study Area – River Slaney Catchment

Microplastics (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



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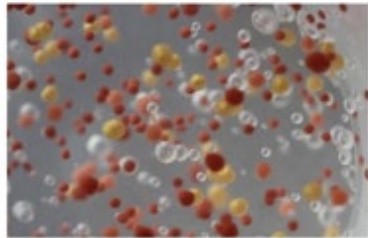
Microplastics



Microplastics

∴ Primary microplastics
(designed to have specific dimensions)

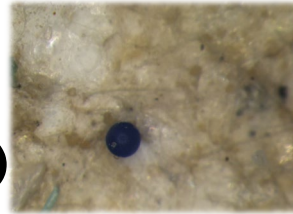
MICROBEADS (Scrub)



NURDLES (Pellets)



Photo credits: Boomerang Alliance



www.beatthemicrobead.org

[Prohibition of Certain Products Containing Plastic Microbeads Bill 2018]

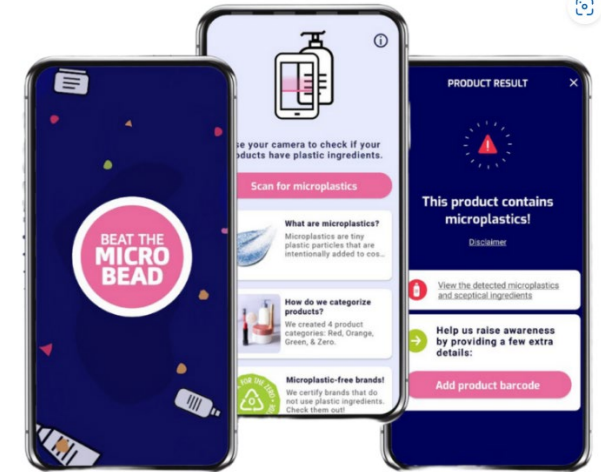


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Microplastics

∴ Secondary microplastics
(breakdown of larger plastic items)

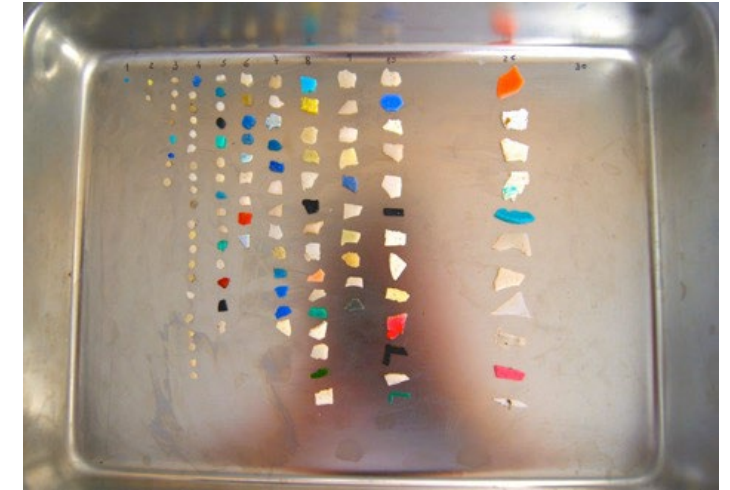
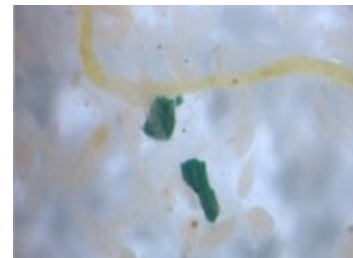
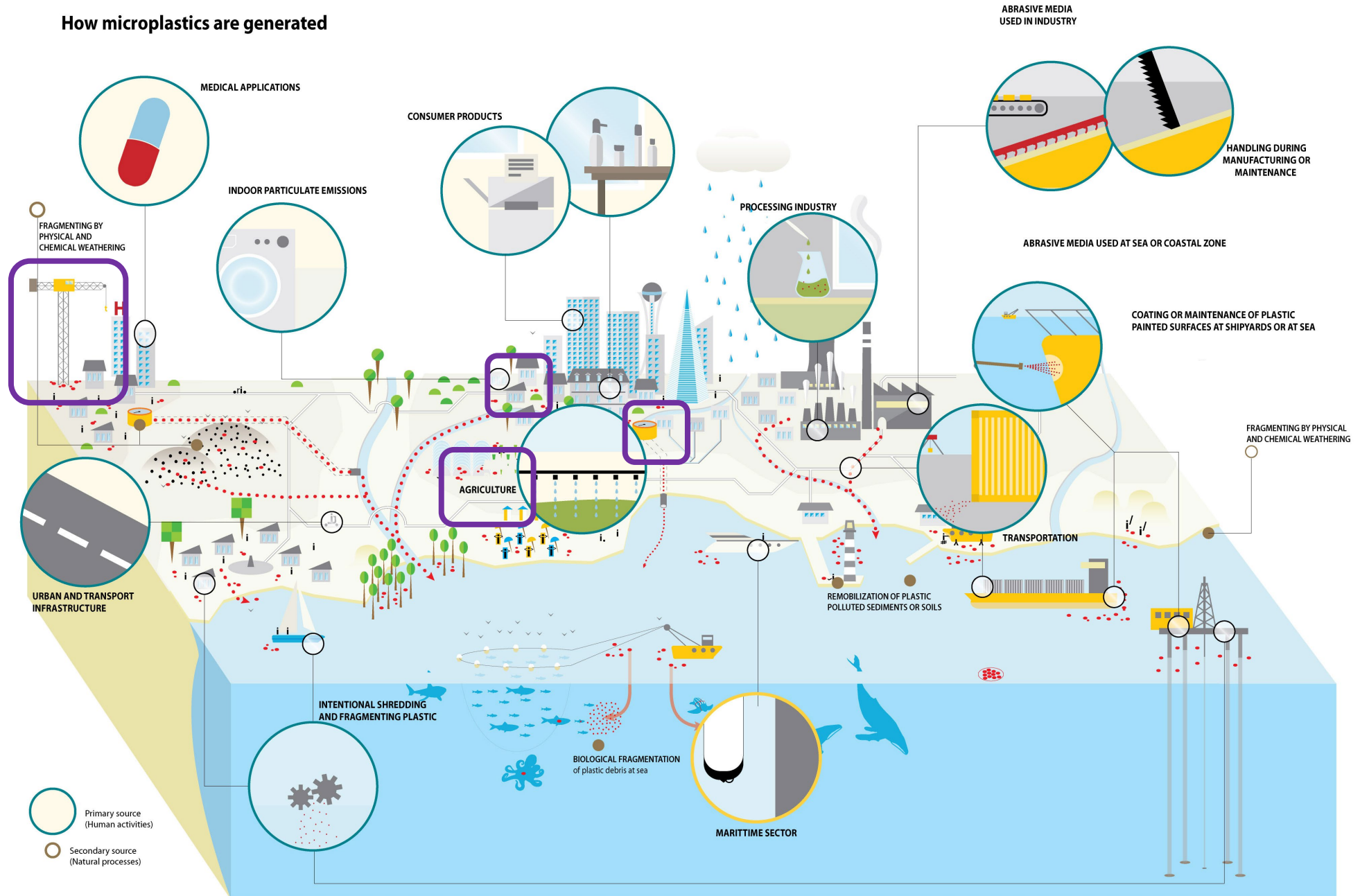


Photo credits: Haleigh Joyce and João Frias

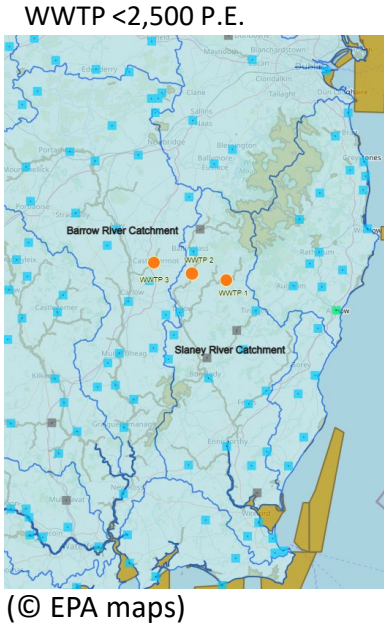
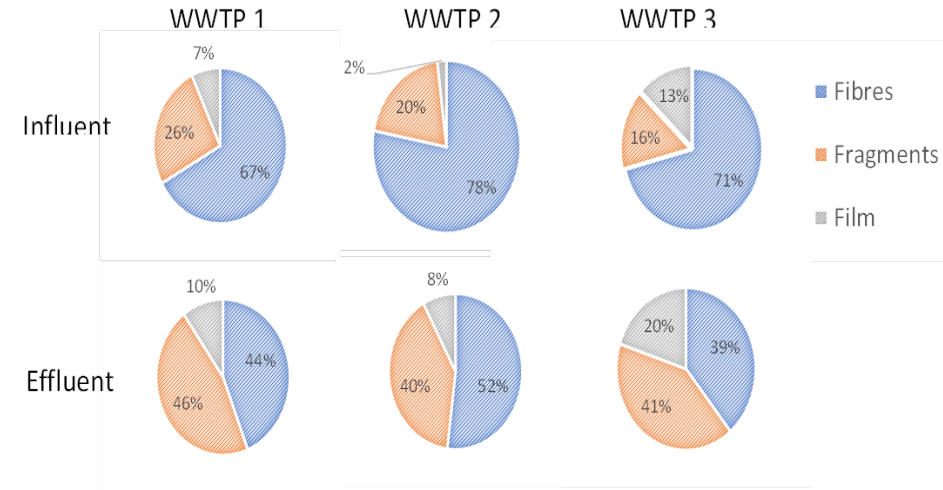
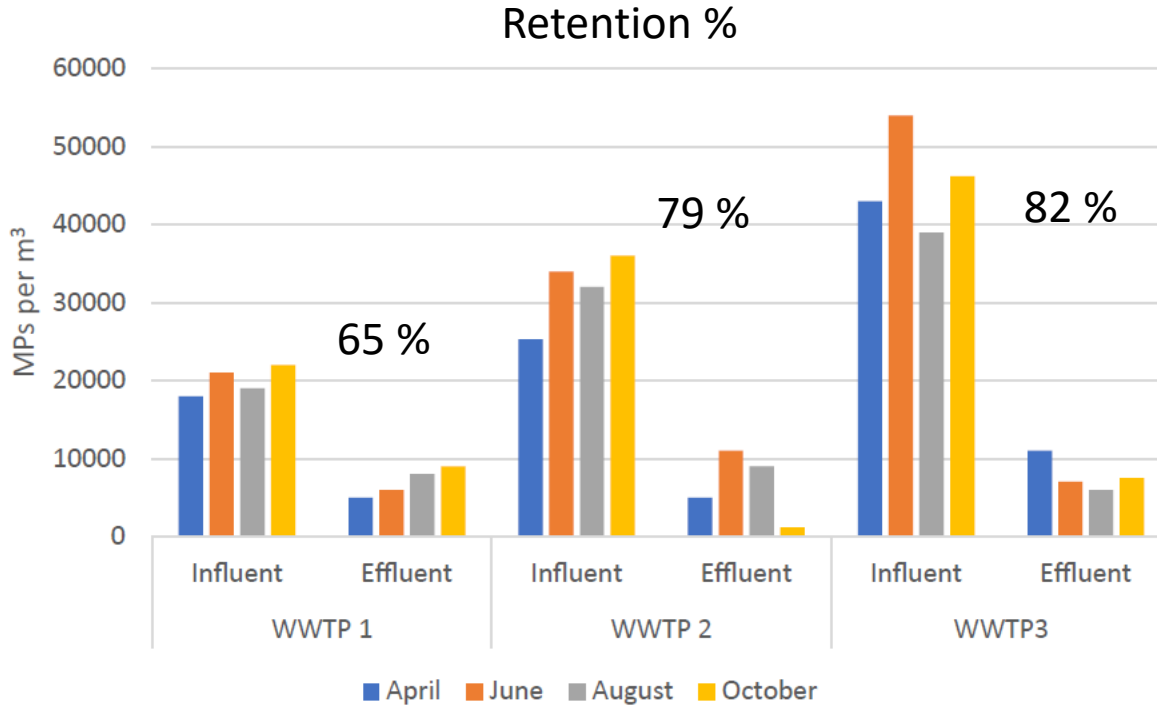
Source: KOBIS and EEA

Sources, Pathways and Environmental fate of Microplastics

How microplastics are generated



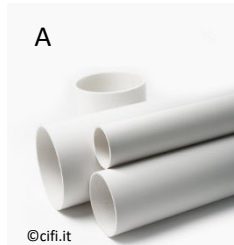
WasteWater Treatment Plants



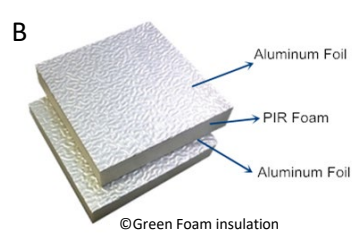
5L composite sample - at inflow (post preliminary) and final effluent

Mahon et al. 2022

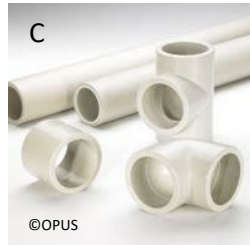
Construction



Polyvinyl chloride (PVC),



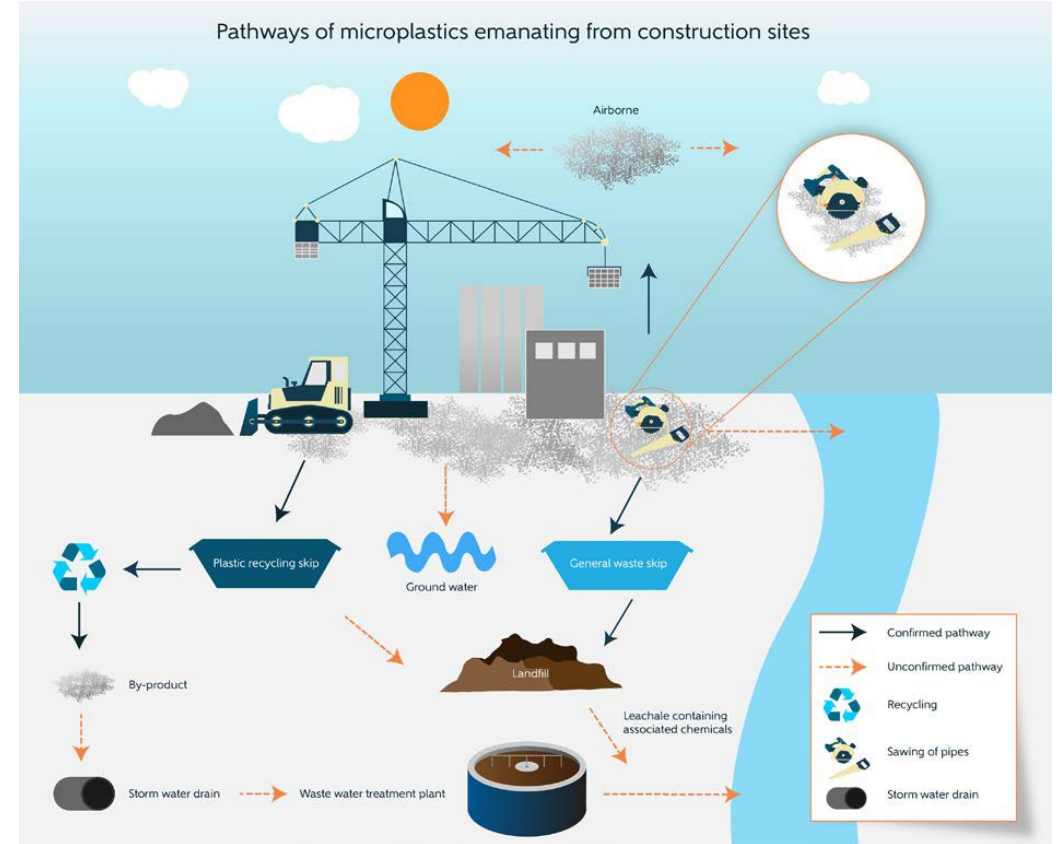
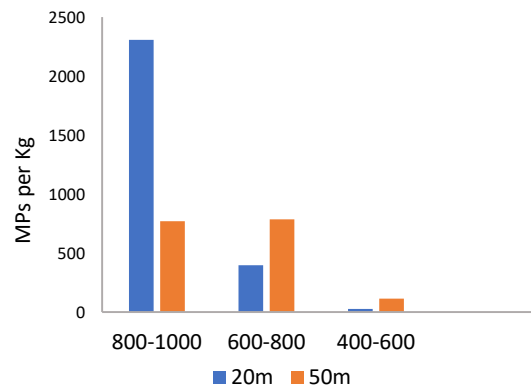
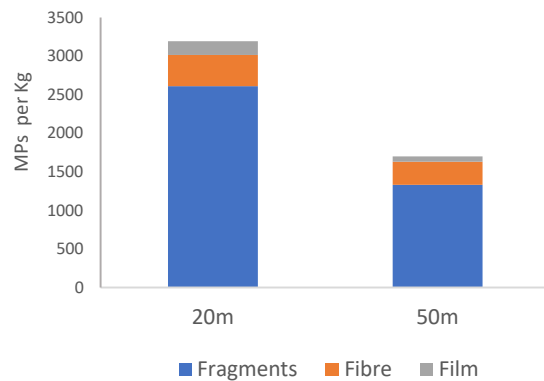
Polyisocyanurate (PIR)



Polypropylene (PP)

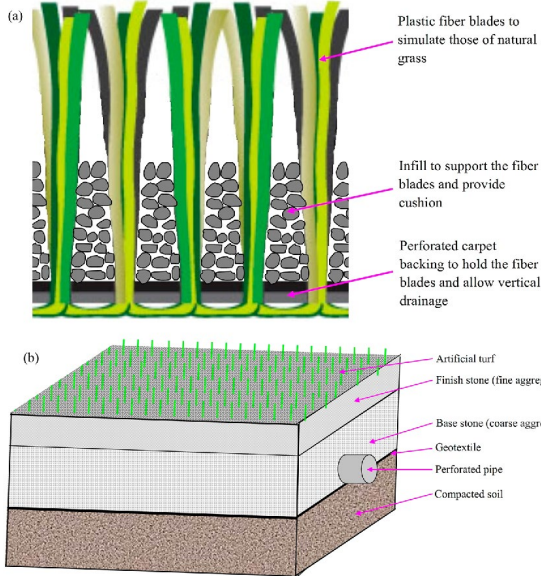
Material	Polymer	# of cuts	MPs (g)	MP numbers
Sewer pipe	Polyvinylchloride (PVC)	80	156	1,376,960
Foul water pipe	Polypropylene (PP)	120	295	1,032,500
Insulation board	Polyisocyanurate (PC)	300	193	unknown

Distance from construction site (m)



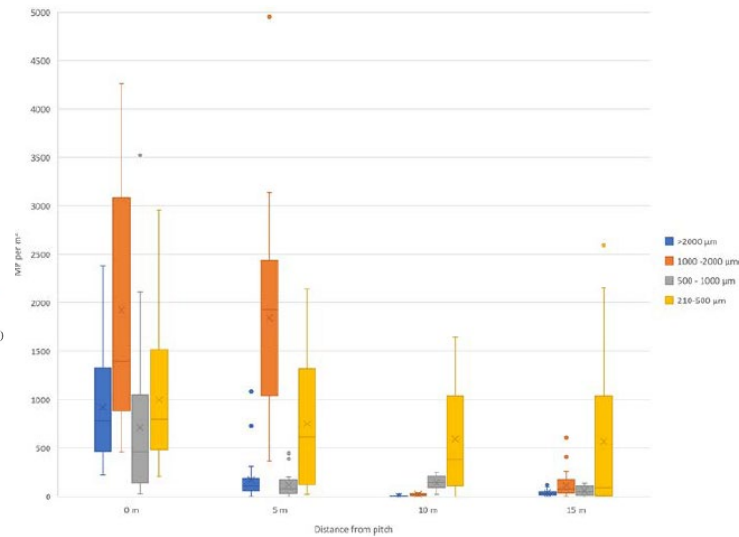
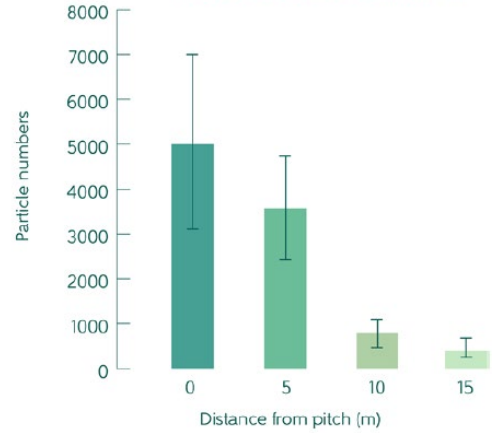
Source: Nash et al. 2023

AstroTurf pitches



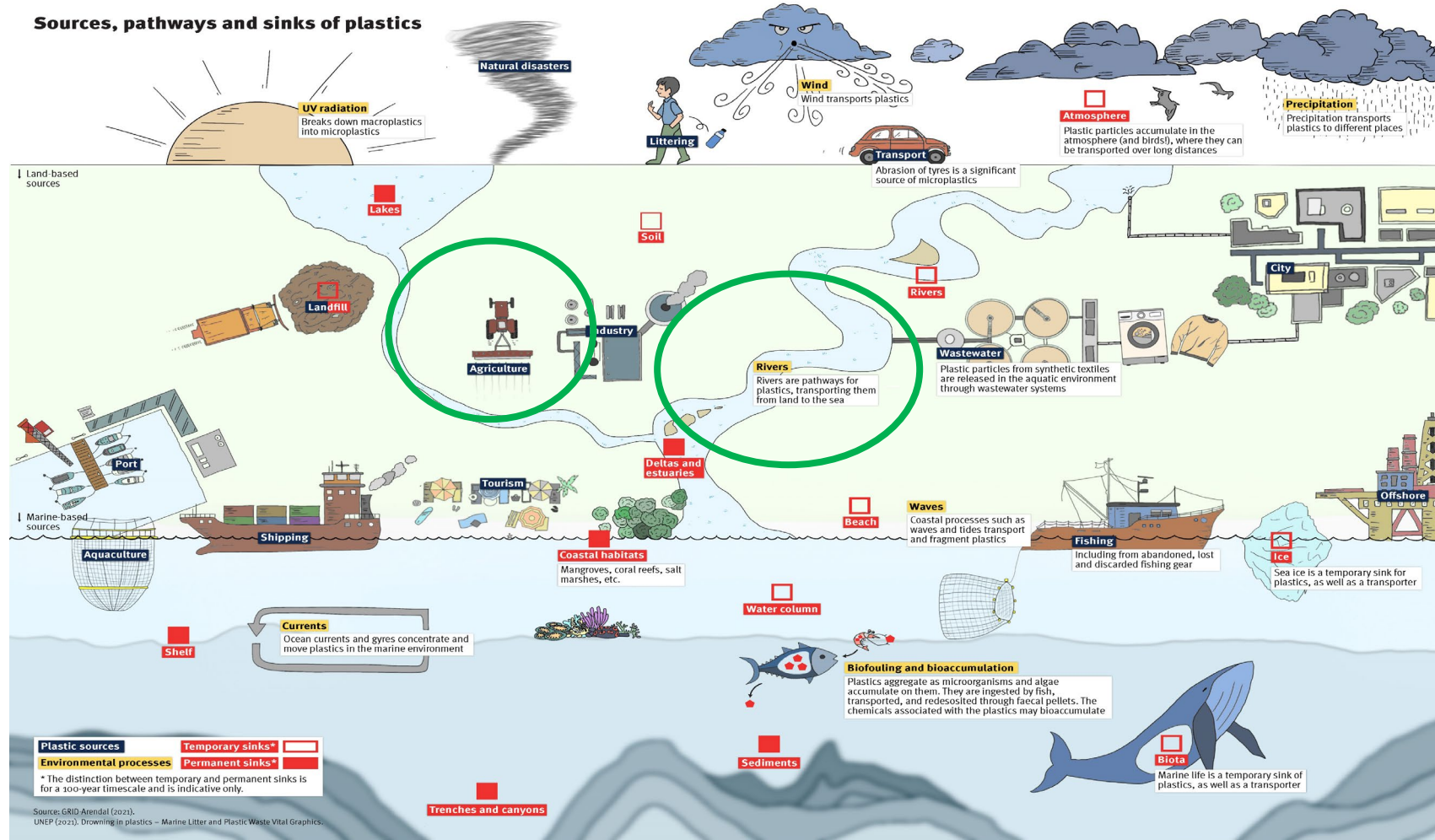
Source: Cheng et al. 2014

Average SBR particle count per (m)



Source: Nash et al. 2023

Sources, pathways and sinks of plastics

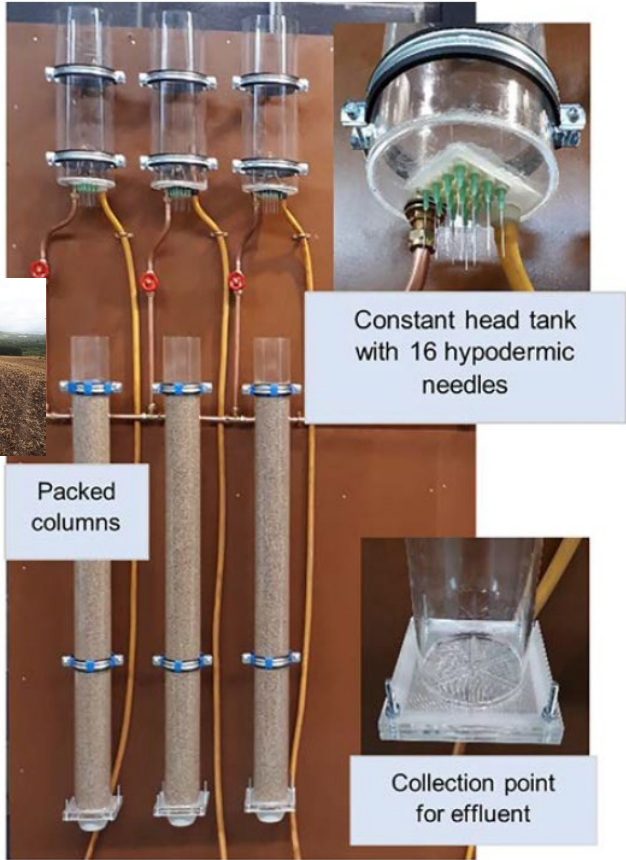


Land Based Pathways

Marine Based Pathways

Vertical Migration

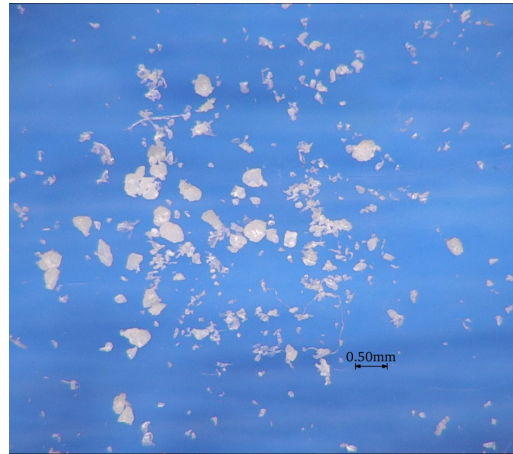
Field Cores



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

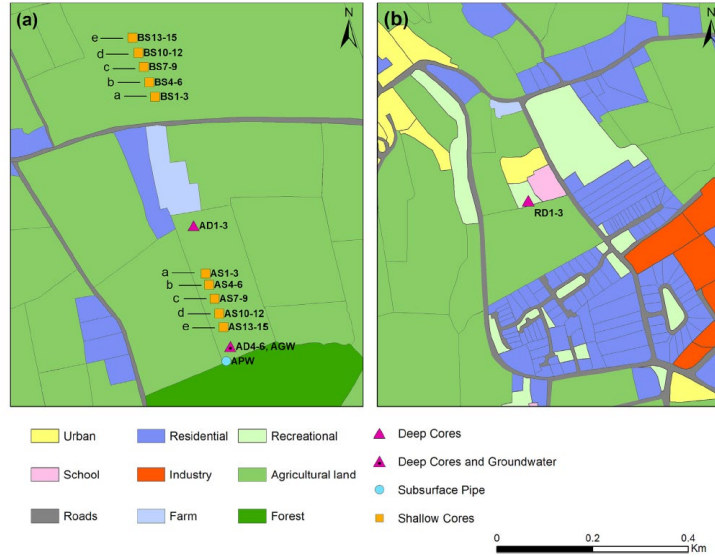
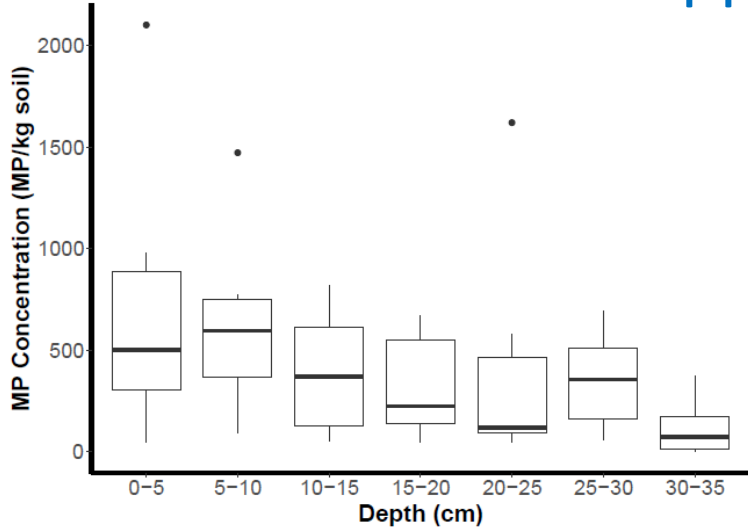


Extraction

6 x 2-m-deep cores (ø = 5 cm)
Cobra TT percussion drill

Source: Heerey et al. 2023

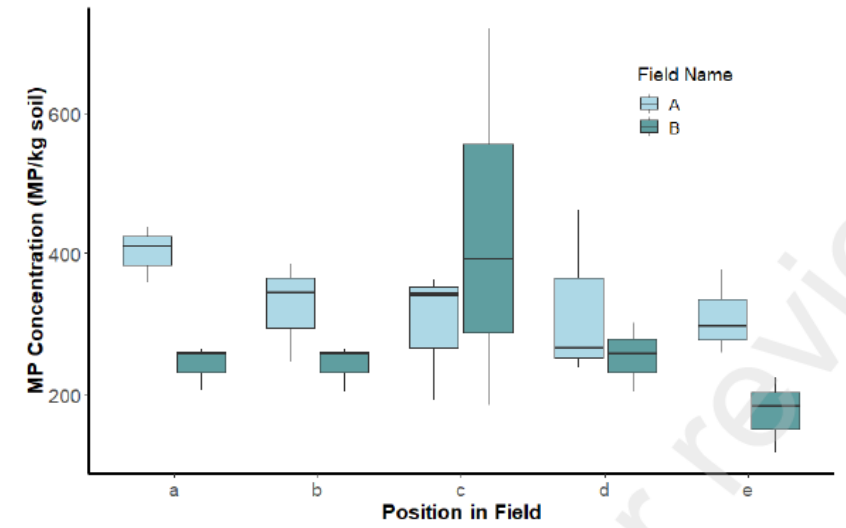
Land Application from WWTPs & Farm Plastics



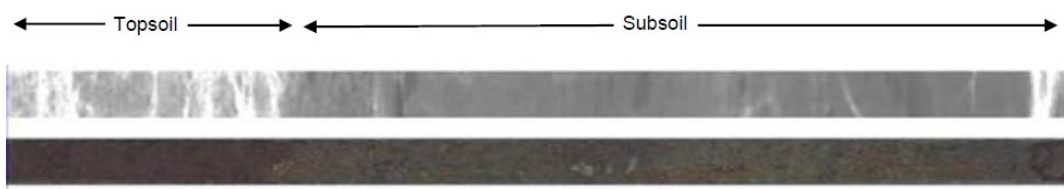
MP abundance

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

Field B (8.7 % gradient) - Variable distribution



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



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

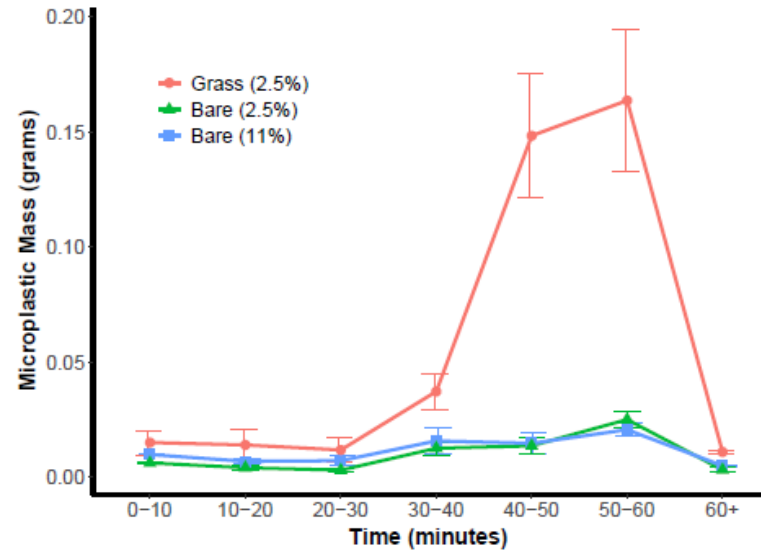
Source: Heerey et al. 2023

Slope and Rainfall simulation



Source: Heerey et al. 2023

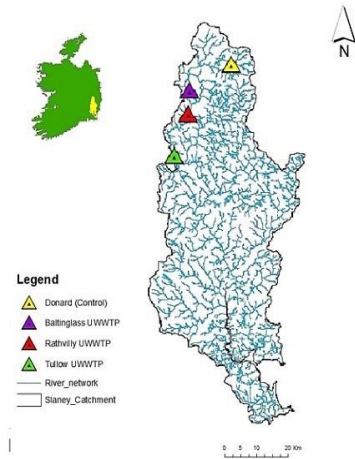
Rainfall intensities showed a significant difference (8 mm h⁻¹ and 18 mm h⁻¹)



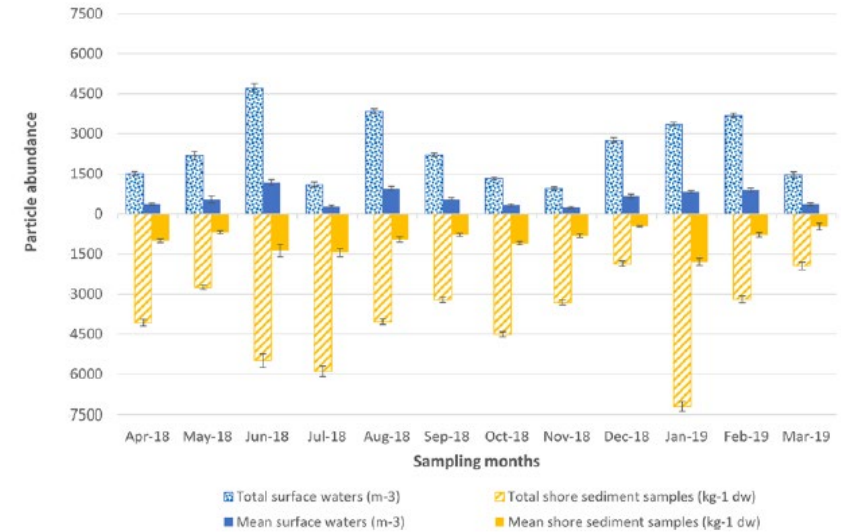
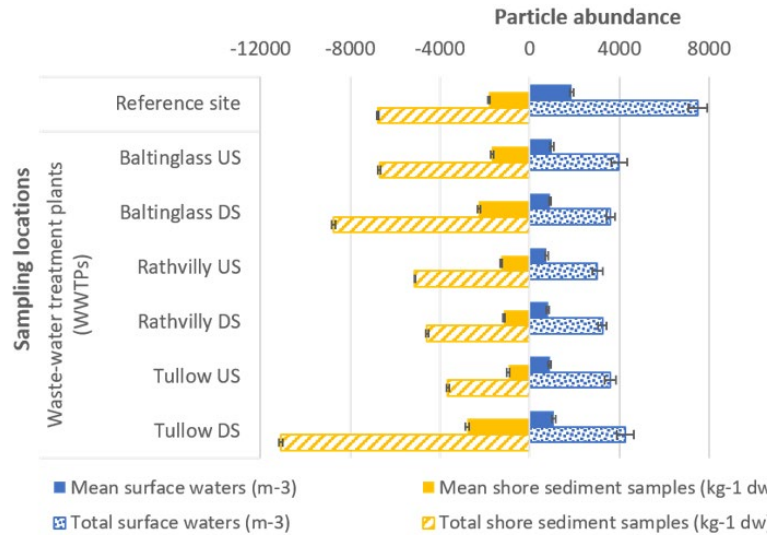
Grass swards reduce the export potential of MPs

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

River Slaney as a Transport Pathway



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

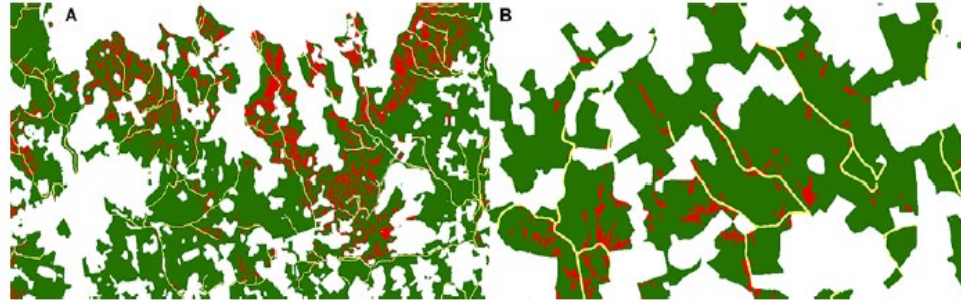
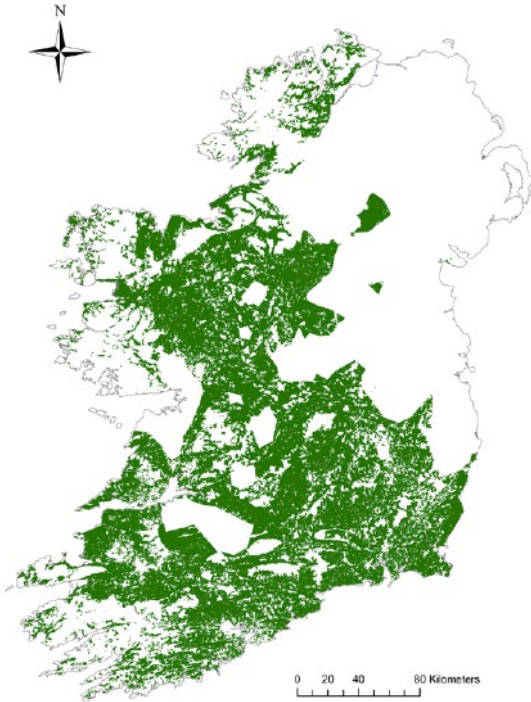


Upstream and downstream of WWTPs

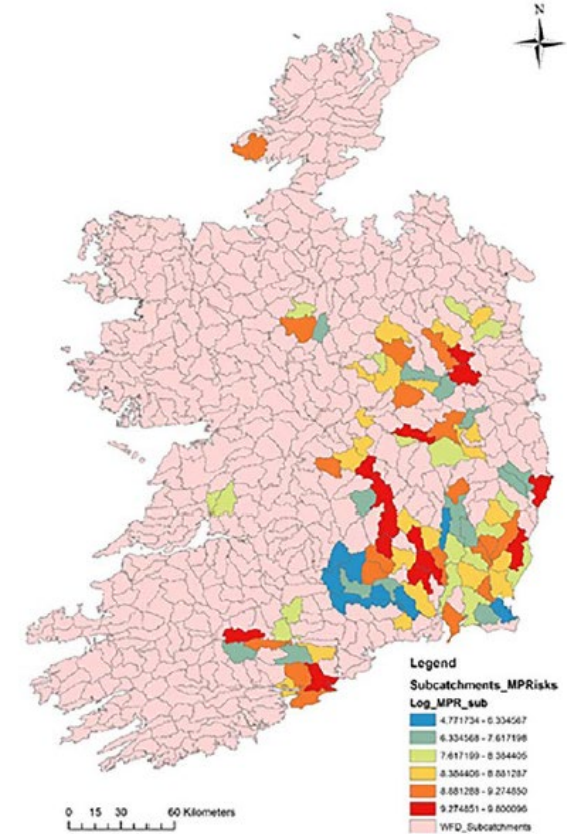
12-month (April 2018 to March 2019)

Source: Lally et al. 2023

Modelling Microplastic Risks to Waterbodies



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.

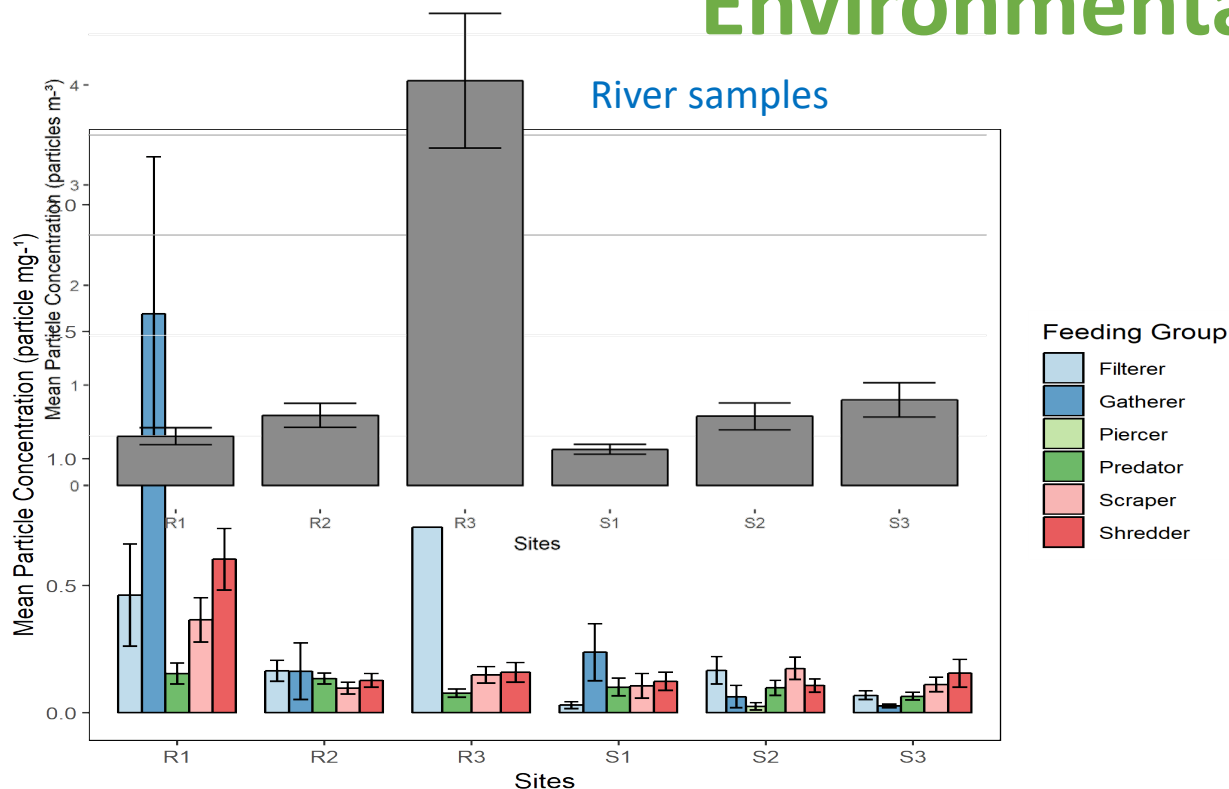


Indicative national map of lands potentially suitable for landspreading sludge (with exclusions due to surface runoff risks).

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

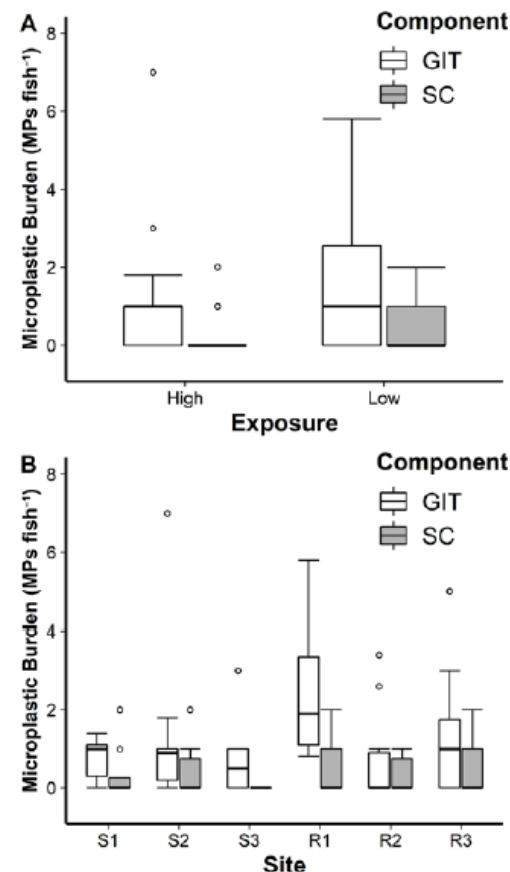
Sources, Pathways and Environmental fate of MPs



Benthic Macroinvertebrates

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

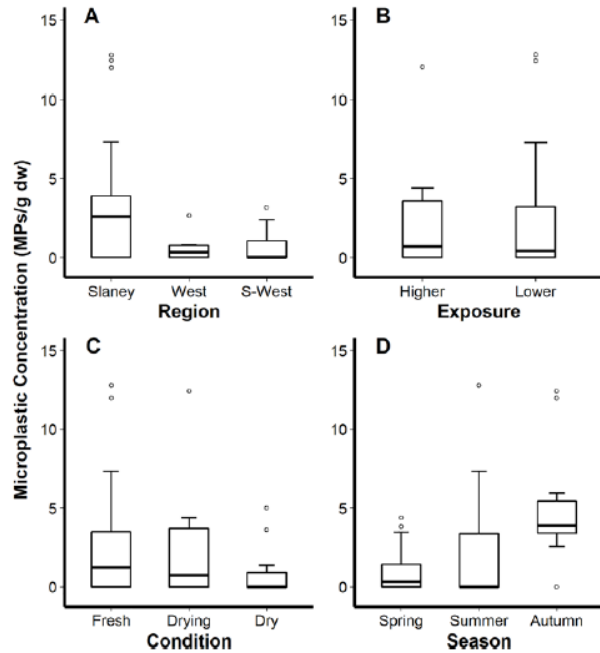
Brown Trout (*Salmo trutta*)



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

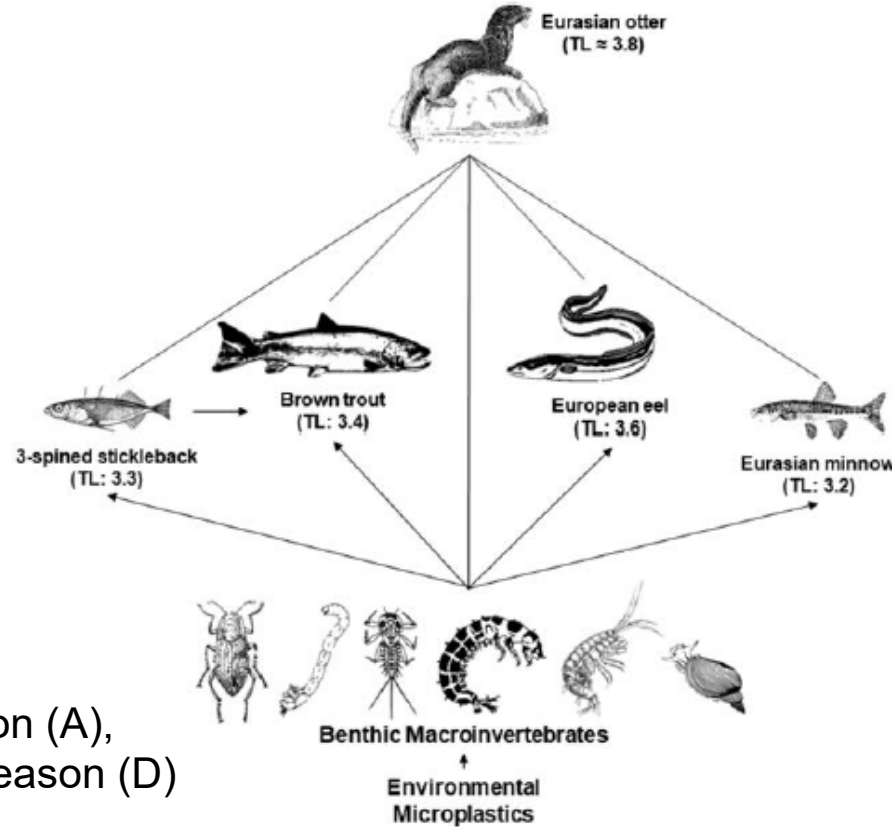
Source: O'Connor et al. 2020; 2021; 2022

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

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.

Further **Information** and **publications** can be found on the **website:**



Welcome Blog Project Description Desk study Featured Interviews & Articles Education



Welcome

Welcome to one of the latest collaborative research projects involving the Marine and Freshwater Research Centre (MFRC), GMTI, the Centre for Water Resources Research (CWRR) and the Earth Institute, UCD, Wageningen University and Carey Building Contractors. This multidisciplinary study will be delivered by a team of biologists, limnologists, environmental engineers and industrial partners. The project aims to inform the development and implementation of policy through improved understanding of microplastic sources, pathways and environmental fate in Irish freshwater systems.

<https://freshwatermicroplastics.com>



Microplastics in brown trout (*Salmo trutta* Linnaeus, 1758) from an Irish riverine system

James D. O'Connor^{a, R. M.}, Sínead Murphy^a, Heather T. Lally^a, Michael Bruen^b, Linda Heery^b, Albert A. Koelmans^c, Alan C.

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Highlights

- Microplastics were found in 72% of 1758 examined.
- No difference in microplastic burden exposure sites.
- Microplastic burden was not explained by catchment characteristics.
- Further analysis is required to assess monitoring.

ARTICLE INFO

Article history: Received 10 June 2020; Accepted 10 June 2020; Available online 10 June 2020

Keywords: Microplastics; Trout; Riverine; Ireland

ABSTRACT

Microplastics are a pervasive pollutant of aquatic ecosystems. This study investigated the presence of microplastics in brown trout (*Salmo trutta*) from an Irish riverine system. The study was conducted in two sites, one in a catchment with a high level of agricultural activity and the other in a catchment with a low level of agricultural activity. The results showed that microplastics were found in 72% of the 1758 trout examined. The microplastic burden was not significantly different between the two sites. The results suggest that microplastics are a pervasive pollutant of Irish riverine systems and that further research is required to assess the potential for microplastic exposure to aquatic organisms.

Introduction

Microplastics (1 µm to 5 mm) are a pervasive pollutant of aquatic ecosystems (Depledge & Aldredge, 2018; Li et al., 2019; Lindahl & Wright, 2015; Li et al., 2020; Li et al., 2020) encompassing a diverse array of morphology types, sizes and polymers (Ferdinand et al., 2019). Bioavailability and fate of microplastics in biota may be complex

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

Modelling the transfer and accumulation of microplastics in a riverine freshwater food web

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Science of the Total Environment 888 (2023) 164028

Science of the Total Environment

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



Export pathways of biosolid derived microplastics in soil systems – Findings from a temperate maritime climate

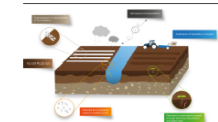
Linda Heery^a, John J. O'Sullivan^{a, R. M.}, Michael Bruen^b, Jonathan Turner^b, Anne Marie Mahon^c, Sínead Murphy^a, Heather T. Lally^a, James D. O'Connor^a, Ian O'Connor^a, Róisín Nash^a

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HIGHLIGHTS

- Field-based evidence of vertical distribution of microplastics in soils is limited.
- Two-year soil cores from agricultural and urban sites show microplastic application and transport through soil into groundwater are considered low.

GRAPHICAL ABSTRACT



ABSTRACT

The environmental fate of microplastics (MPs) added to agricultural soils remains poorly understood, particularly regarding their mobility in soils. Here we investigate the potential for MP export from soil to surface waters and groundwater in two agricultural settings with a 20-year history of biosolid treatment. A field where biosolids had never been applied served as a reference (Field R). The potential for MP export along overland and interflow pathways to surface waters was determined from MP abundance in shallow surface runoff (10 cm) along two down-slope transects (one each for Field A and B), and through MP abundance in effluent from a subsurface land drain. The risk of vertical MP migration was determined from MP abundance in groundwater sampled from the same transects. MP size characterisation was conducted on two of the deep cores to capture high resolution optical and 2-D morphological imaging. Results suggest limited MP mobility at depths >20 cm, with MP largely recovered in surface soils characterised by lower compaction. Furthermore, abundance of MPs across the surface cores were comparable, with no evidence of MP accumulation observed. A single MP abundance in the top 10 cm of soil across Field A and B was 360 ± 200 MP kg⁻¹, with 0.1 MP kg⁻¹ and 1.4 MP kg⁻¹ recovered from the groundwater and field drainage water samples, respectively. MP abundances were significantly higher in fields treated with biosolids than in Field R (0 ± 12 MP kg⁻¹ soil). Findings suggest ploughing is the most significant driver of MP mobility in agricultural soils, however the potential for overland or interflow movement cannot be excluded, particularly for fields that may be agriculturally drained.

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ARTICLE

Freshwater Ecology

Microplastics in Eurasian otter (*Lutra lutra*) spraints and their potential as a biomonitoring tool in freshwater systems

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Science of the Total Environment 888 (2023) 164028

Science of the Total Environment

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

Microplastics (MPs) in aquatic ecosystems may have serious impacts. Microplastic research in freshwater systems has assessed the physical presence of the Eurasian otter (*Lutra lutra*), a top of the most widely distributed otter species. The opportunistic collection of otter spraints offers a unique opportunity to assess pollutants of freshwater systems. Here, we assessed the potential of otter spraints as a biomonitoring tool. Spraint samples collected over eight rivers in Ireland. We found microplastics present in 1.2 ± 0.1 microplastics (MPs)/spraint, 3.8 ± 0.6 MP/g (dry weight). Fibres were 100% (100%), followed by film (10%). No significant differences were detected between the spraints collected from areas upstream or downstream of putative microplastic sources. While microplastic abundance was higher in spraints collected from areas upstream or downstream of putative microplastic sources, otter spraints had a significantly higher concentration of microplastics than surface water. Furthermore, microplastic abundance or conductivity composition based on the items in the spraints showed that the presence of otter spraints may be limited by their presence in the water column. The presence of otter spraints in freshwater systems may be limited by their presence in the water column.