MICRO-PLASTICS IN THE GLOBAL AQUATIC ENVIRONMENT: ANALYSIS, SORPTION MATERIALS , EFFECTS, REMEDIATION AND POLICY SOLUTIONS

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Currents carried nurdles from the *X-Press Pearl* wreck around Sri Lanka's coasts. This graphic shows nurdles spotted by citizen scientists between May 29 and July 11, 2021.

A dead fish with nurdles in its mouth, photographed on May 31, 2021

Outline

- Introduction: Global Pollution Oceans, Coastal Waters,Rivers, Wastewaters , Sludges, Landfill
  - Macro-Plastic (MP) Litter, from Rivers to the Sea
  - RIMMEL. JRCFloating Macro litter in European Rivers,
  - Saudi Arabia , Spain , Europe, China, India
- Sorption (Trojan horse effect) and toxicity of Pharmaceuticals into MPs.
- Sustainable Waste water Reuse. Treatment Solutions
- Bioaccumulation , Toxicity and Toxicotranscriptomics to Fish and other Biota of MPs and Bio-plastics.
- Analytical Methods and Harmonization
  - (μ)FTIR,(μ) Raman, Pyrolisis GC-MS, TG-DSC,NMR, ASTM-standarized
- Human Health Risks and Policy
  - MPs in the Atmosphere, Soil, Plants and Humans:Global risk

MPs in Soil/Sludge/Landfills/ Rivers/WWTPs/Oceans

- Plastics into soil **will** increase from **34- 55 Million T**ons from 2019 to **260** (OECD2022)
- Worldwide stock of MPs in **agricultural soils** (average 2400-3700 items/kg**)** :1.5 to 6.6 MilllionTons (MPs on **Ocean surface** 290-800 KT(Lebreton 2019))
  - **Countries irrigating with wastewater the most ex**posed (Asia) but also in soils of Turkey 84 KT, Spain 38 KT and Italy 28 KT
- **Sources of MP**s in soil/agroecosystems:
  - Reuse of **Sewage Sludge (**1000-300,000 items/Kg**)**, **Wastewater irrigation**,Biosolid , Composting, Degradation and Fragmentation of **Mulching** films and plastics, Plastic waste,i.e single use face masks, Automobile tire wear and **Airborne MPs** in soils, plants
- **River litter plastic input** into the ocean, 35% are synthetic textiles
  - 1000 rivers (**WWTP** input) account 80% GLOBAL plastic into ocean
  - GLOBAL input .0.8-2.7 Millions Tonnes/year size <0.5 cm (Lebre3ton)
  - EUROPEAN input, 1.656 -4.997 Tonnes/year (RIMMEL paper) size > 2.5 cm,Turkey,Italy,UK
  - River plastic transport by extreeme flood x 100 (non-flood)
- **WWTPs**, 1.4 x 10^{15} items/year influent 10-26g/L, untreated 3.8x10^{16} items/year to water,
- **Combined Sewer Overflow (CSO**),i.e. River Tame, (UK) > 200 MPs items/day, 70 MPs/year
- **Landfills leachate**, size 20-5000μm, 10-290 MP MPs items/liter
- EU WFD and MSFD for 2030:reduce 50% plastic litter into sea and 30% MPs into the environment + Monitoring of litter, plastics and MPs
- **First papers** published plastics in ocean, *Science*,1972, MPB 1973,

Plastic Materials Accumulating in Narragansett Bay

A.M. Cundell , Mar.Pollut Bull. 4(1973) 187

This report was contribution No. 1508 of the Rhode Island Agricultural Experiment Station, Kingston, Rhode Island 02881 USA.

A. M. CUNDELL

University of Rhode Island, Kingston, RI 02881, USA.

TABLE 1
Description of the plastic objects found on the beach (first collection).

Objects	Material of Construction	Total Weight
Drinking tumblers, foam (4 plus fragments)	Expanded polystyrene	32·0 g
Drinking tumblers, transparent (2)	High flowgrade polystyrene	29·0 g
Tumbler, red	Nylon	20·0 g
Tumblers, grey (2)	High density polyethylene	10·7 g
Milk shake tops (5)	Low density polyethylene	11·5 g
Vacuum flask caps (2)	Acrylonitrile butadiene styrene	28·5 g
Food container	Polypropylene	22·6 g
Beer can carriers (5)	Low density polyethylene	23·0 g
Plastic jug (gallon)	High density polyethylene	106·4 g
Plastic jug (half-gallon)	High density polyethylene	40·8 g
Plastic jugs (gallon; used as buoy) (3)	High density polyethylene	209·0 g
Floats (2)	Expanded polystyrene	150·2 g
Bread and candy wrappings	Cellophane	11·2 g
Rope (4 lengths)	Nylon	294·5 g
Plastic drinking straws (3)	Polypropylene	2·7 g
Sheeting and bags	Low density polyethylene	207·5 g
Fish-hook bags (5)	Nylon	29·0 g
Sheeting, plasticized	Polyvinylchloride	1·5 g
Packing blusters (2)	Polymethylarylate	9·0 g
	Total	1,237·5 g

TABLE 2
Description of the plastic objects found on the beach (1 month accumulation).

Objects	Material of Construction	Total Weight
Drinking tumblers, foam (16 fragments)	Expanded polystyrene	14·0 g
Beer can carriers (2)	Low density polyethylene	11·0 g
Plastic jugs (gallon; household bleach) (2)	High density polyethylene	226·0 g
Plastic jugs (gallon; beverage) (2)	High density polyethylene	179·0 g
Plastic jug (fragment used as buoy)	High density polyethylene	30·0 g
Candy wrappings	Cellophane	12·25 g
Twine (6 lengths)	Nylon	54·5 g
Plastic drinking straws (2)	Polypropylene	1·0 g
Sheeting and bags	Low density polyethylene	167·5 g
Fishing line reel	Acrylonitrile butadiene styrene (ABS)	24·0 g
Doll's arm	Polyvinylchloride	13·5 g
Fragment of a tray	ABS	21·5 g
Vinyl glove	Polyvinylchloride	34·0 g
Monofilament	Nylon	6·5 g
Packing case strap	Polyvinylchloride	10·0 g
Shotgun pellet holders (3)	Polyethylene	8·0 g
Fragment of plastic basket	ABS	3·0 g
Cable coating	Polyvinylchloride	12·0 g
Plastic fork	ABS	2·0 g
Cocktail sticks	Polyethylene	0·5 g
	Total	830·25 g

Effects of MPs in the Caribbean Large Ecosystem

Environmental Pollution 300 (2022) 118919

Contents lists available at ScienceDirect

Environmental Pollution

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

The status of marine debris/litter and plastic pollution in the Caribbean Large Marine Ecosystem (CLME): 1980–2020☆

La Daana K. Kanhai [a,*], Hamish Asmath [b], Judith F. Gobin [a]

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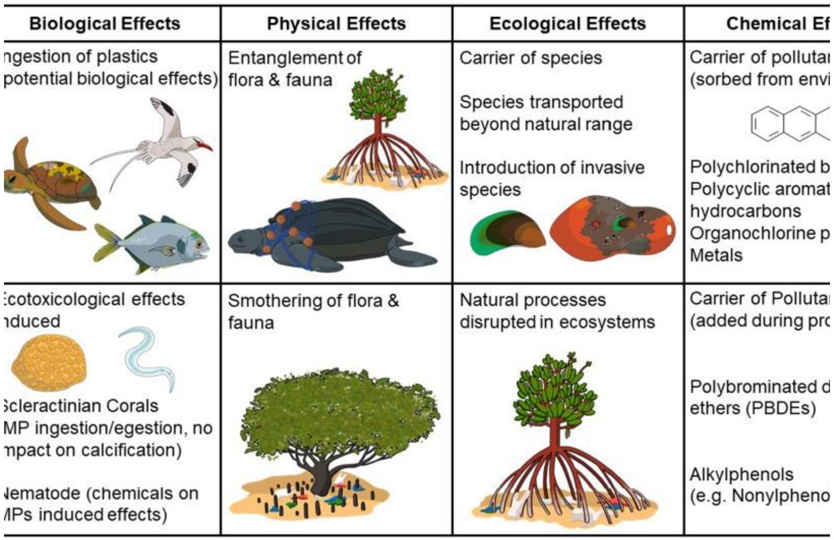
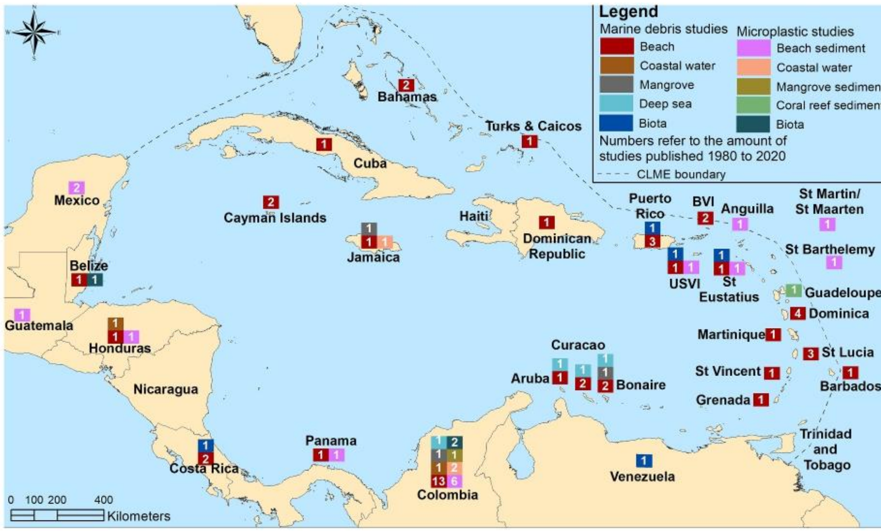


Fig. 3. Effects of plastics on biodiversity in the CLME.



g. 1. Countries within the CLME with peer-reviewed studies on marine debris and microplastics. Note that studies that reported on microplastics in co... anning multiple Exclusive Economic Zones (Law et al., 2010; Morét-Ferguson et al., 2010; Barrows et al., 2018) were not represented on this map.

Science of the Total Environment 954 (2024) 176847

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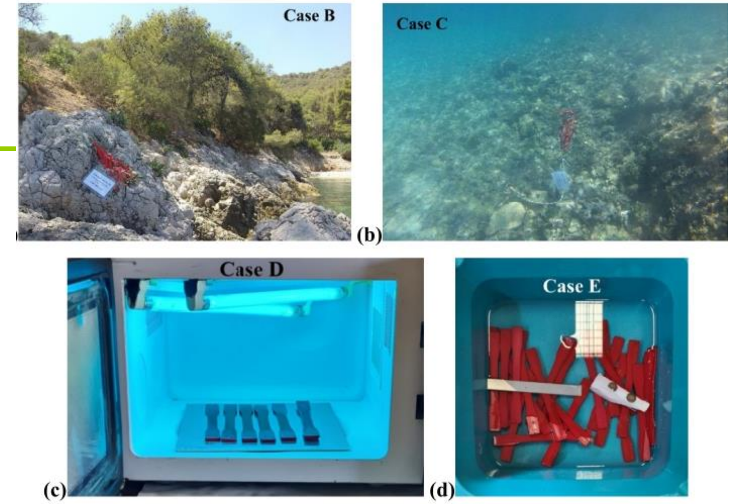

ositioning of the HDPE specimens exposed to (a) Case B - natural atmospheric conditions near a coast, (

Degradation assessment of high-density polyethylene (HDPE) debris after long exposure to marine conditions

Nikitas Lourmpas [a], Paraskevas Papanikos [b], Eleni K. Efthimiadou [c], Anastasios Fillipidis [d], Demetris F. Lekkas [e], Nikolaos D. Alexopoulos [a,*]

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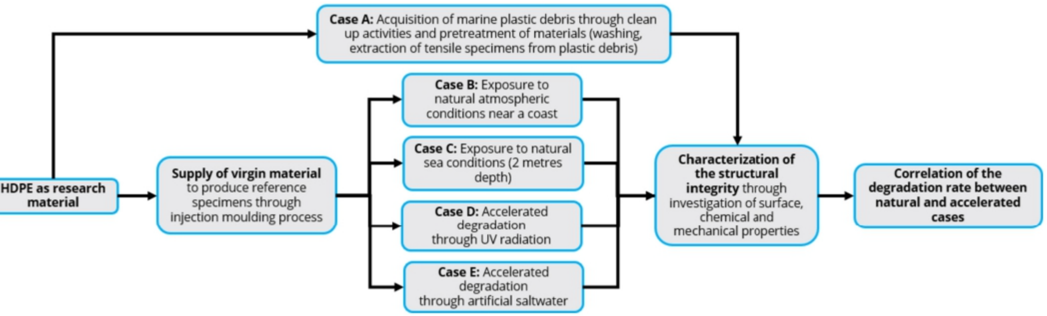
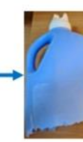


Fig. 1. Experimental procedure flow chart of the present investigation.


High Density Polyethylene (HDPE)			
No.	Colour	Source	Age estimation (years)
1	Red	Engine oil bottle	~15
2	Dark green	Engine oil bottle	~25
3	Blue	Detergent	30+
4	Baige	Detergent	5~10
5	White	Liquid dish detergent	40+
6	White	Liquid dish detergent	40+
7	White	Detergent	~15
8	Blue	Engine oil bottle	~15
9	White	Liquid hand soap	~10
10	Yellow	Child's toy	~10
11	Blue	Detergent	10~15
12	Light blue	Detergent	10~15
13	Yellow	Liquid dish detergent	40+
	'hite	Liquid dish detergent	20~30
	'hite	Dairy Products	< 1
	reen	Engine oil bottle	12~17
	3lue	Hair shampoo	12~17
	3lue	Hair shampoo	12~17
	lack	Engine oil bottle	23~28
	t green	Child's toy	~10
	'hite	Engine oil bottle	10~20
	3lue	Engine oil bottle	16~22
	lack	Plastic pipes	10~30
	k grey	Engine oil bottle	20~25
	3lue	Cleaning products	12~15
	rasparent	Cleaning products	5~15
	rasparent	Engine oil bottle	5~9
	'hite	Pesticide	5~15
	'hite	Small flask	5~15
	rasparent	Deionized Water Bottles x8	Unexposed
	s colours	Caps	1~50

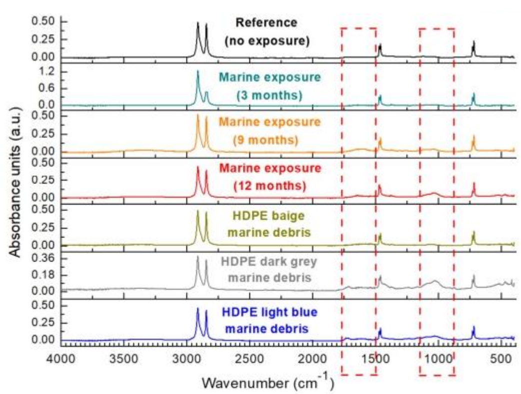


Fig. 9. FTIR spectra of three types of HDPE samples, virgin (unexposed), controlled marine exposure for specific UV irradiation times (i.e., 3 months, 10 months, and 12 months) and HDPE marine debris.

Fig. 2. Marine plastic waste collection process on the coast of Korinthos.

ehensive inventory of all HDPE debris collected, categorized by colour, source (e.g., soap containers, industrial pallets etc.), an initial e hering conditions, accompanied by illustrative examples of the specific HDPE debris items referenced in the inventory.

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Vertical distribution of microplastics in sediment columns along the coastline of China

Peng Zhao[a,1], Xiaodan Wang[b,c,1], Hongyou Jiang[d], Bin Zhang[e], Liang Chen[e], Jianmin Zhao[b,c], Jia Teng[b,c], Qing Wang[b,c,*]

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[b] Research and Development Center for Efficient Utilization of Coastal Bioresources, Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences, Yantai

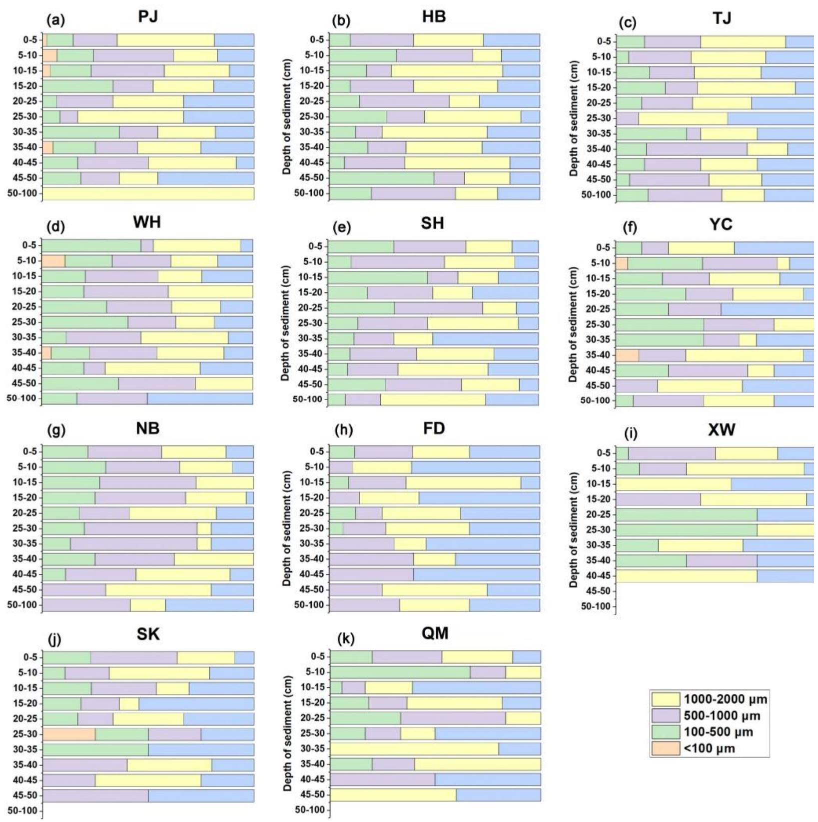
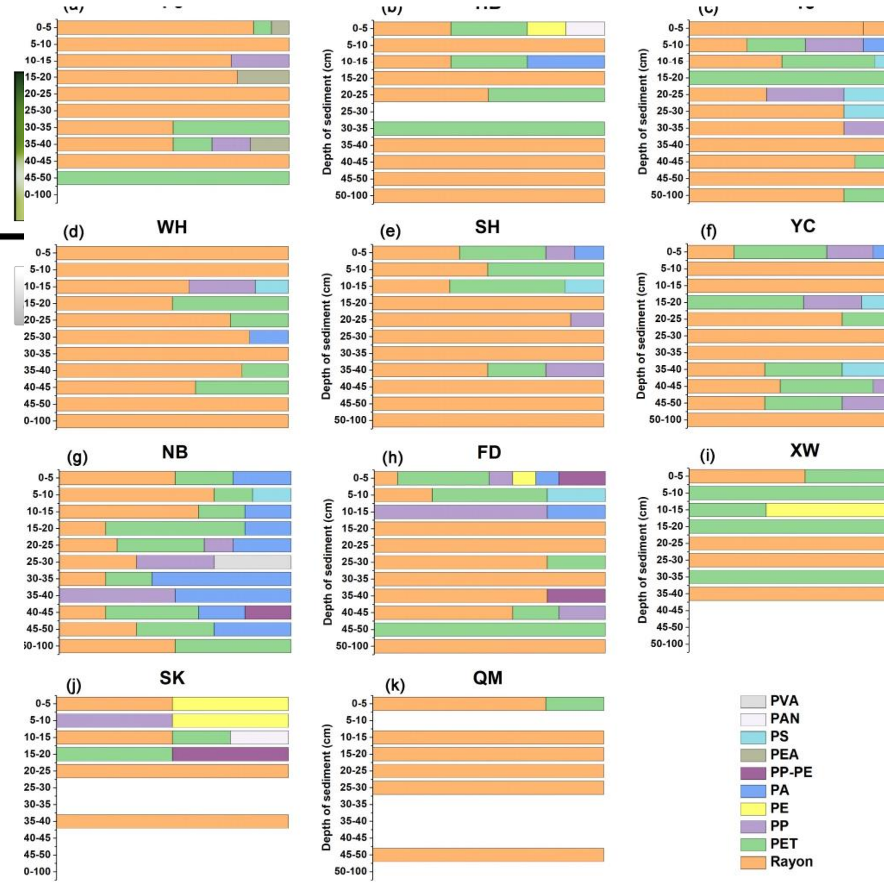


Fig. 5. Size of MPs in sediment columns. The figure illustrates the percentage of MPs of varying sizes at different depths across 11 sampling sites.



ig. 7. Polymer of MPs in sediment columns. The figure illustrates the percentage of MPs of varying polymers at different depths across 11 sampling sit

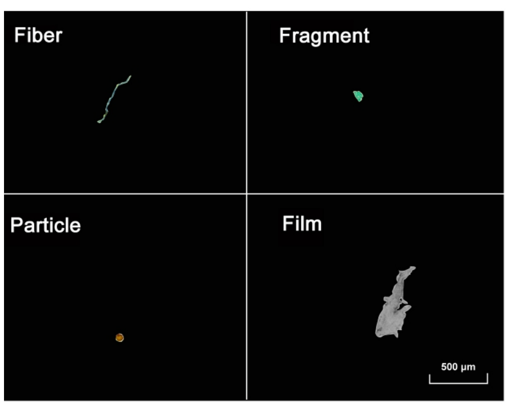
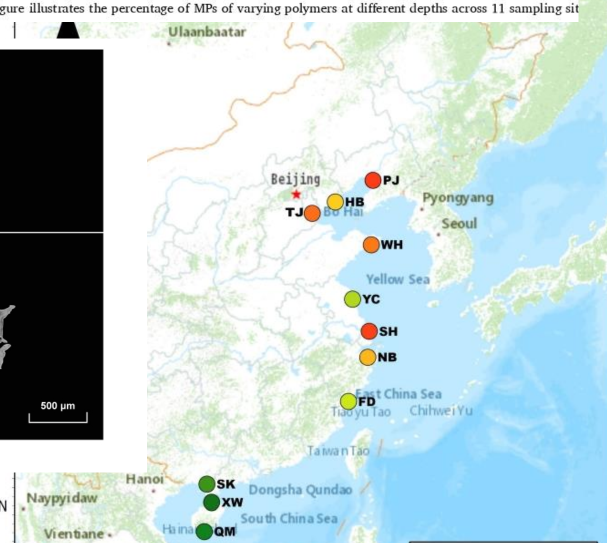


Fig. 4. Four shapes of MPs.



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Density and distribution patterns of seafloor macrolitter in the eastern Red Sea

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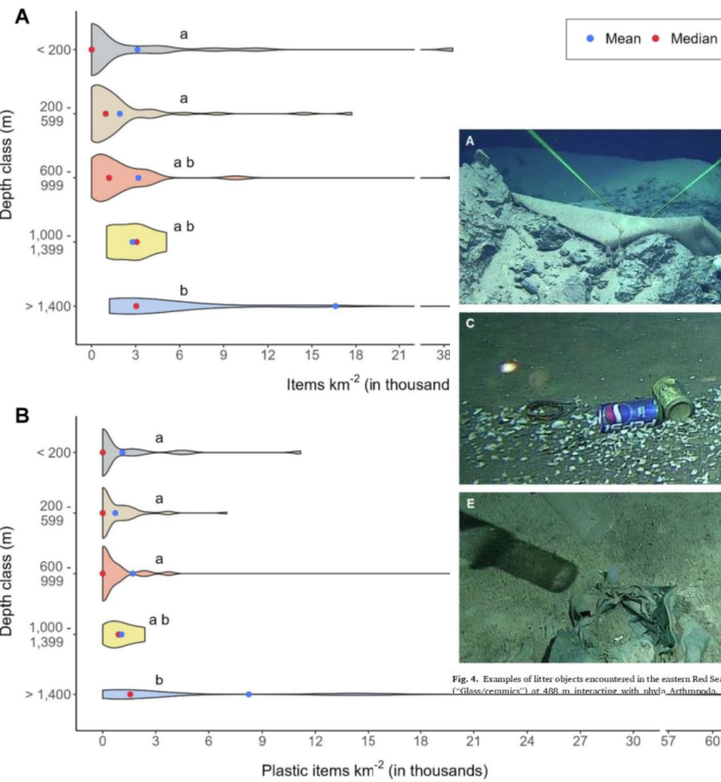
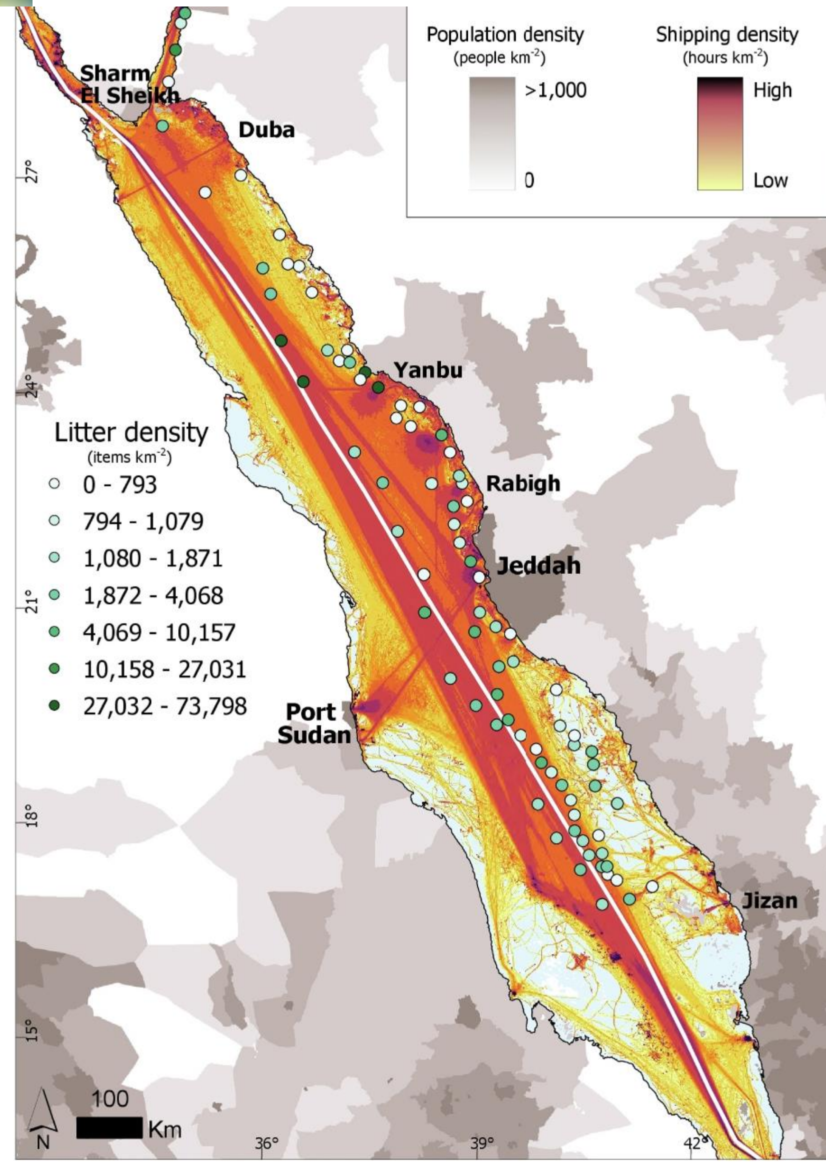


Fig. 4. Examples of litter objects encountered in the eastern Red Sea. (A) Carpet (category "Textile") at 1856 m. (B) Plastic strapping band ("Glass/ceramics") at 488 m interacting with phyla Arthropoda, Porifera, and Annelida. (C) Two metal beverage cans ("Metals") and

g. 2. Distribution of litter density within five water depth classes for (A) all observed litter and (B) plastic litter. The dots represent mean (blue) and median alues. The same letter indicates no significant difference between depth classes. Note the x-axis breaks.



;. 7. Litter density distribution in relation to distance to the main shipping route (white line) in the Red Sea. The main shipping route was plotted base

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Plastic litter in the environment

ARTICLES
https://doi.org/10.1038/s41893-021-00722-6
nature sustainability
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Floating macrolitter leaked from Europe into the ocean

Daniel González-Fernández[1], Andrés Cózar[1], Georg Hanke[2], Josué Viejo[1], Carmen Morales-Caselles[1], Rigers Bakiu[3], Damià Barceló[4,5], Filipa Bessa[6], Antoine Bruge[7], María Cabrera[8], Javier Castro-Jiménez[9,26], Mel Constant[10], Roberto Crosti[11], Yuri Galletti[12], Ahmet E. Kideys[13], Nino Machitadze[14], Joana Pereira de Brito[15], Maria Pogojeva[16], Nuno Ratola[17], Júlia Rigueira[18], Elisa Rojo-Nieto[19,27], Oksana Savenko[20,21], Rosanna I. Schöneich-Argent[22,28], Grzegorz Siedlewicz[23], Giuseppe Suaria[24] and Myrto Tourgeli[25]

- Between **307 and 925 million litter items** are **released** annually **from Europe into the ocean**
- 82% observed litter is formed by **fragments** and **single-use plastics**

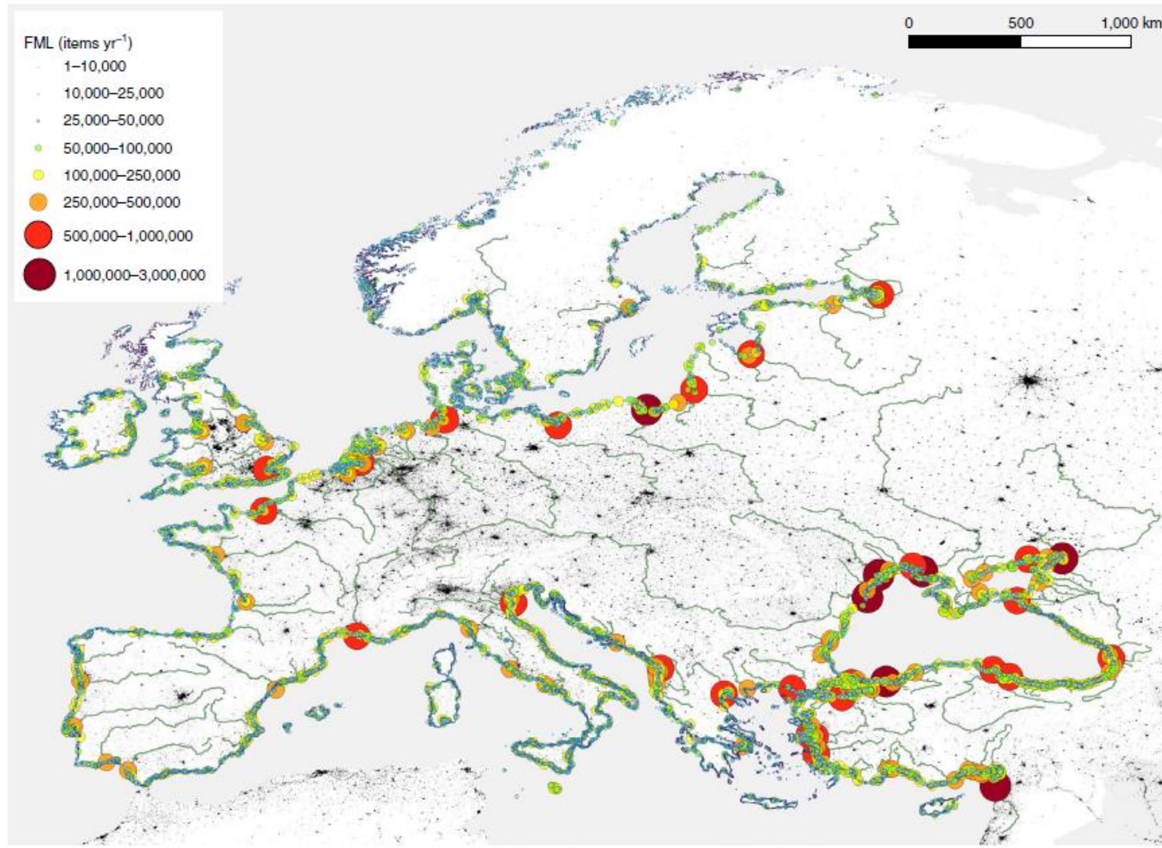
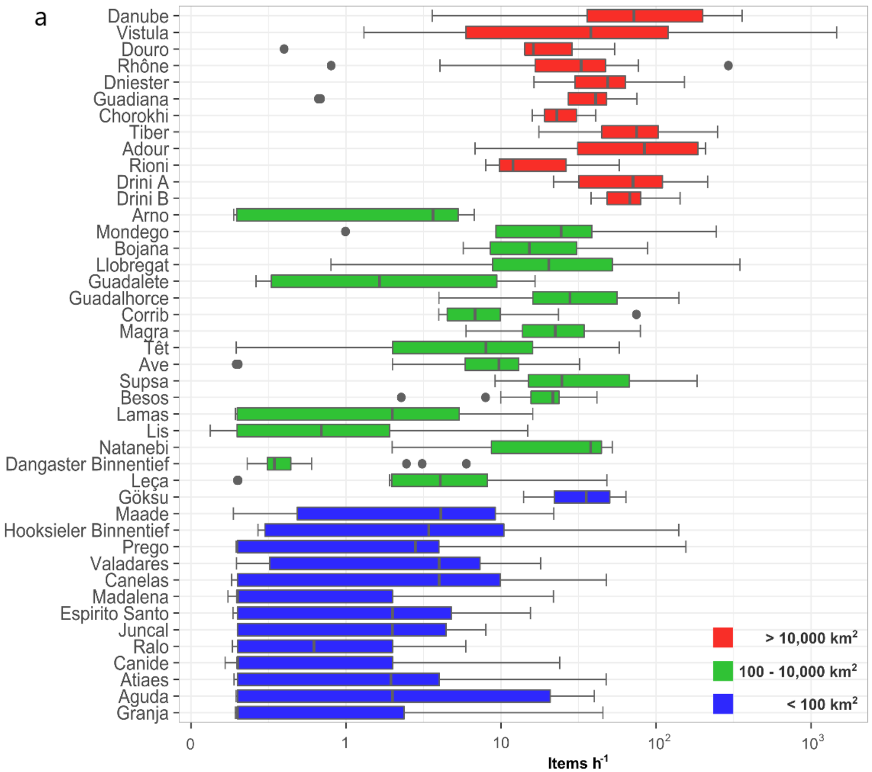
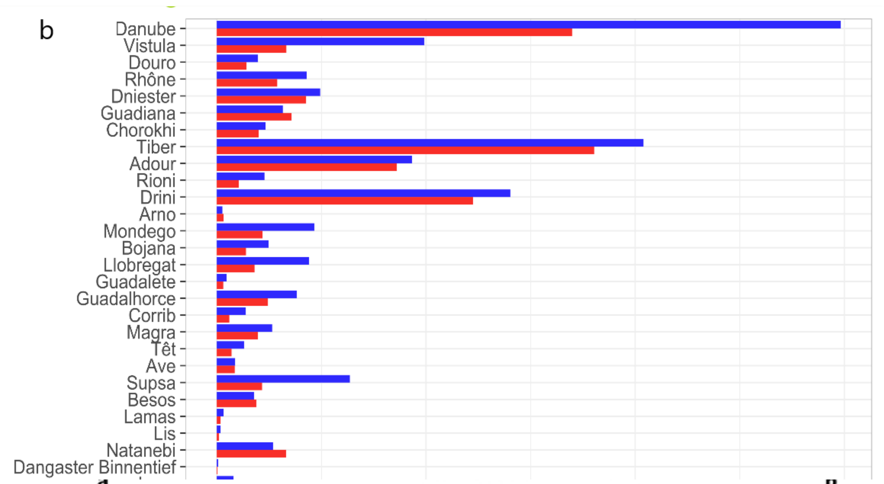


Fig. 4 | Spatial distribution of FML from Europe into the ocean. Spatial distribution of FML from Europe into the ocean based on mean-based modelled estimates. The coloured dots represent litter inputs predicted on the basis of the MW in each individual drainage basin.

Floating macro-litter flux (items h^{-1})

Annual floating macro-litter loading (items y^{-1})





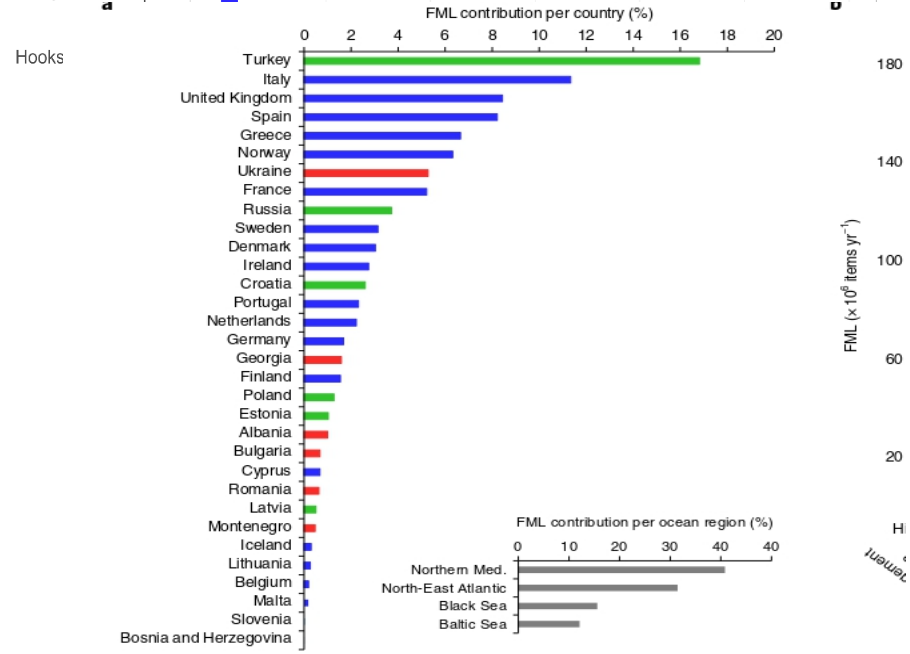


Fig. 5 | Distribution of FML per country, ocean region and drainage basin categories. a,

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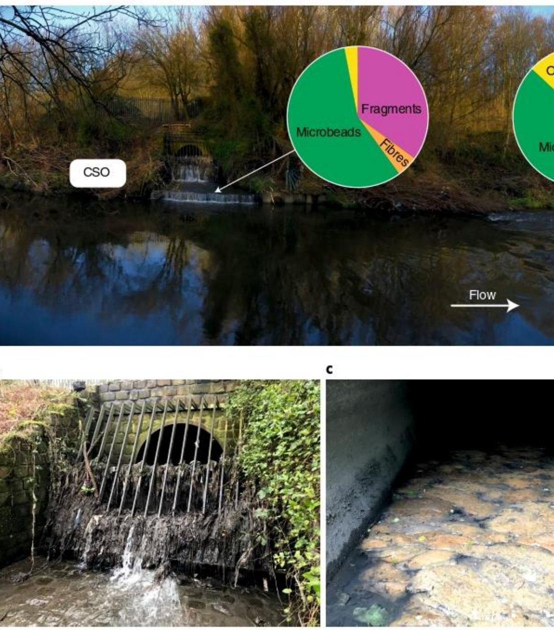
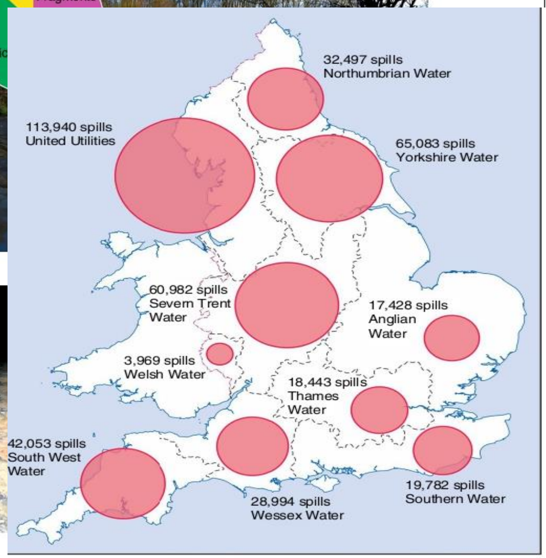
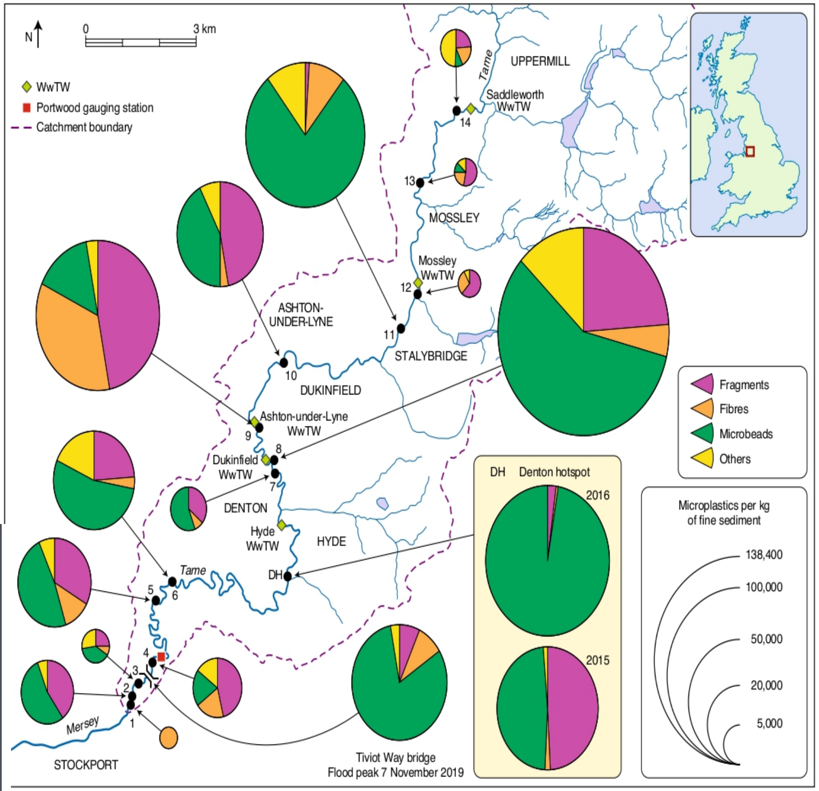
cute riverine microplastic contamination due to voidable releases of untreated wastewater

ie Woodward[1]✉, Jiawei Li[1], James Rothwell[1] and Rachel Hurley[1,2]







ig. 2 | **Microplastic concentrations and assemblages on the channel bed of the River Tame.** Data are shown for all sites (sites 1–14) sampled in summer 019 and for the Denton hotspot (DH) identified in the wider 2015 and 2016 regional surveys of ten rivers in northwest England[2]. The microplastic ssemblage recovered from the bulk suspended sediment sample collected at the flood peak on 7 November 2019 is also shown. See Supplementary able 3 for connected population data and treatment class for the five WwTWs in this catchment. The location of CSOs and industrial premises using lastics are shown in Extended Data Figs. 2 and 3. The 2019 River Tame survey showed that microplastic contamination hotspots are far more numerous han documented in 2015 and 2016 and this is very likely to be the case in other rivers of this region (Extended Data Fig. 1). Base map redrawn from ttps://nrfa.ceh.ac.uk/data/station/info/69027.html.

g. 4 | **CSO outfall and channel bed microplastic contamination.** **a**, Site 8 is the most he most identical microplastic signatures in the CSO effluent and on the channel bed some getated mid-channel bar. The CSO is next to Dukinfield WwTW (Fig. 2). **b**, The CSO grill clogged with wet wipes and sanitary products on 31 January 020 from storm events in the summer and autumn of 2019. This CSO is also an outlet for a small culverted stream. See Supplementary Table 5 for effluent ow and microplastic flux estimates from this CSO. **c**, Untreated effluent ponded behind the blocked grill on 2 June 2020. **d**, Thick carpet of filamentous omass (sewage fungus) on the channel bed gravels at site 8 on 2 June 2020.

ig. 5 | **Discharge of raw sewage and untreated wastewater into vers and coastal waters across England in 2020.** The five WwTWs

nature water

Article https://doi.org/10.1038/s44221-023-00092-7

River plastic transport and deposition amplified by extreme flood

A list of authors and their affiliations appears at the end of the paper

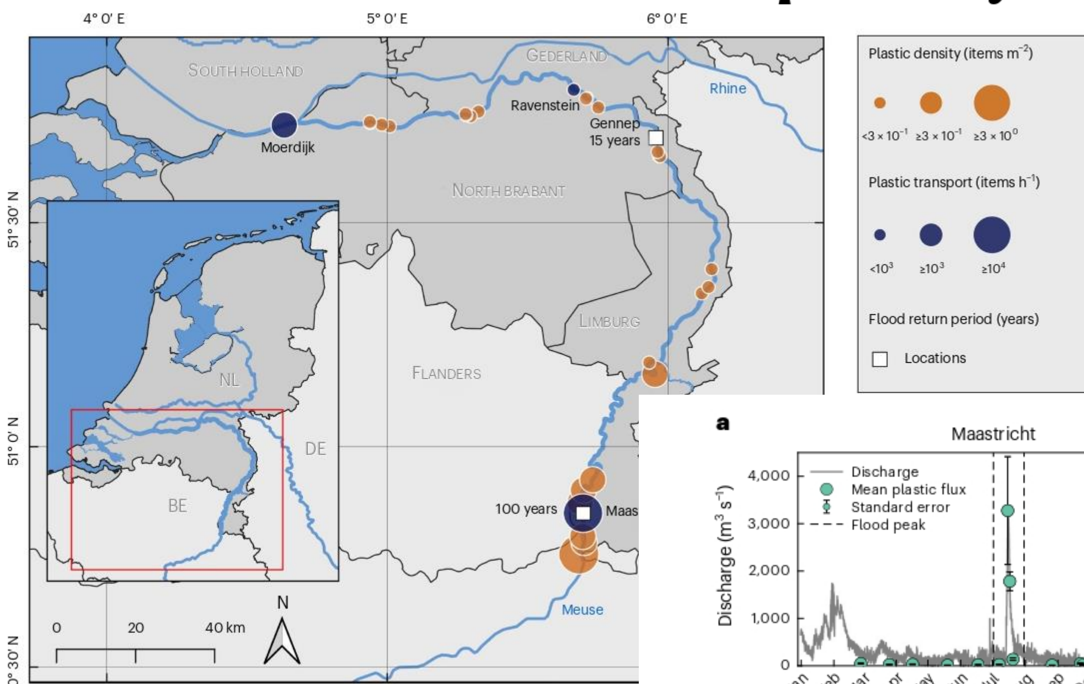
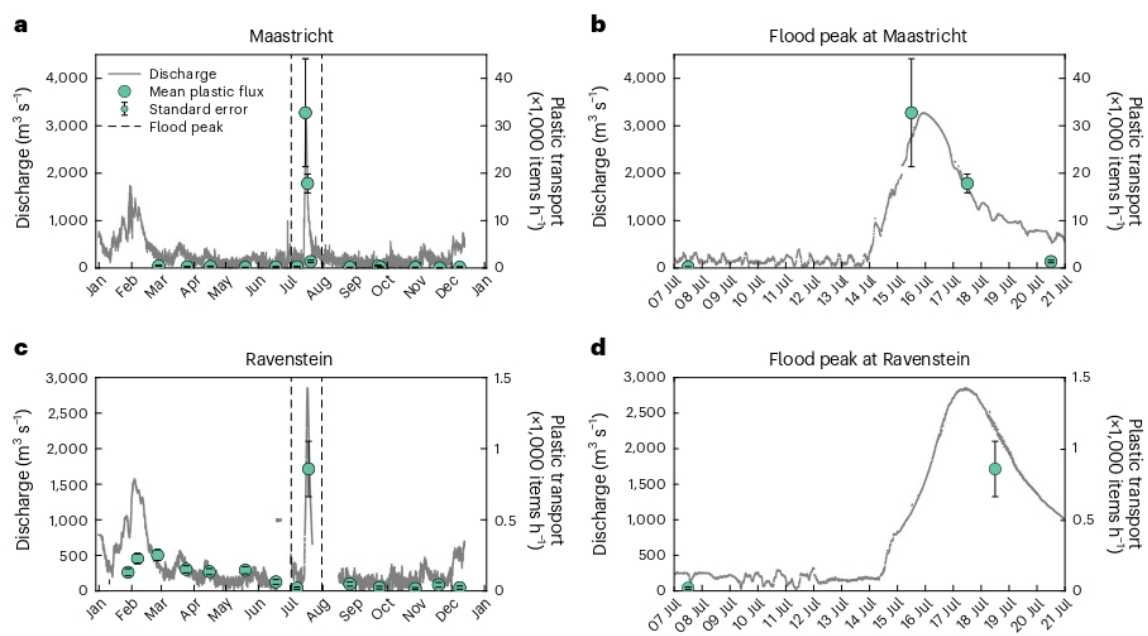


Fig. 3 | Mean floating plastic transport and riverbank plastic density along the Meuse. Mean fl… (18 July) and Moerdijk (18 July) during the July flood (15–20 July 2021), and riverbank plastic density…



| **Plastic transport along the Dutch Meuse river measured at during including the extreme flood event on 13–20 July 2021. a–d,** River …arge and plastic transport at Maastricht (291 km from the river mouth) Ravenstein (131 km from the river mouth) from January to December 202… at Ravenstein during the July flood (**d**). Note that we refer to the mean plas… in the text.

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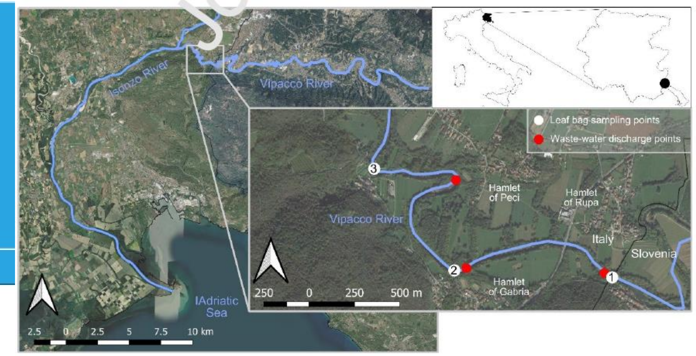
Microplastic patterns in riverine waters and leaf litter: Leaf bag technique to investigate the microplastic accumulation trends in lotic ecosystems

Marco Bertoli, Davide Lesa, Paolo Pastorino, Antonella Mele, Serena Anselmi, Damià Barceló, Marino Prearo, Monia Renzi, Elisabetta Pizzul

Contaminant Hydrology



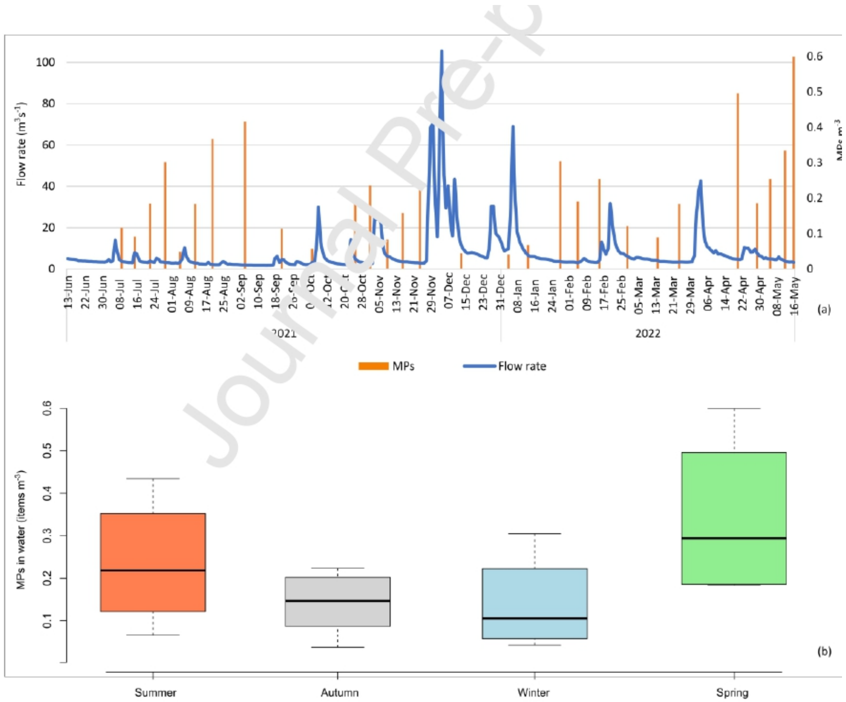


Figure 3. MP concentrations in the Vipacco River waters (items m^{-3}) in relation to the flow rate (a) and sea: variations observed during the study period (b).

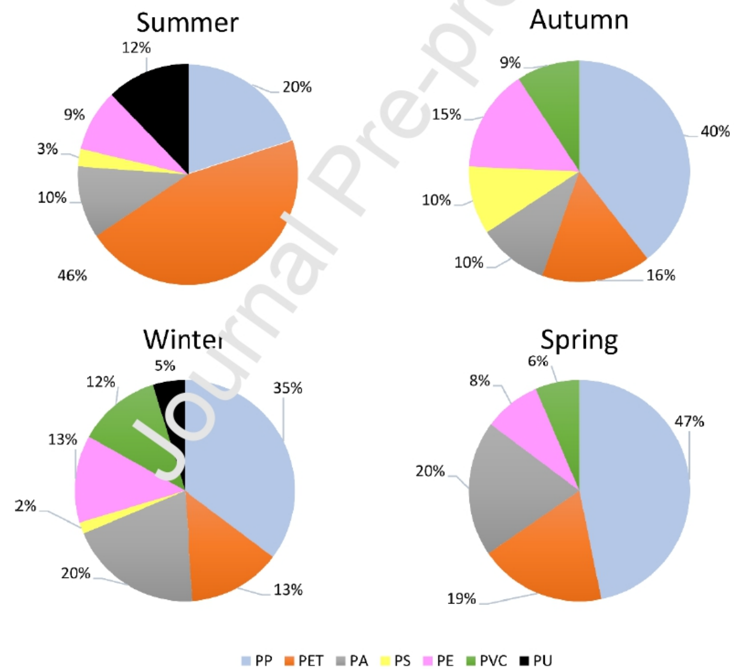


Figure 2. Microplastic chemical composition observed in Vipacco water samples (PP = polypropylene; PU = polyurethane; PET = polyethylene terephthalate; PVC = Polyvinyl chloride; PE = polyethylene, PA = polyamide; PS = polystyrene).

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Microplastics, their abundance, and distribution in water and sediments in North Chennai, India: An assessment of pollution risk and human health impacts

Vignesh K.S.[a], V.N. Prapanchan[b,**], V.N. Indhiya Selvan[c], Natchimuthu Karmegam[d], Woong Kim[e], Damia Barcelo[f,h], Muthusamy Govarthanan[e,g,*]

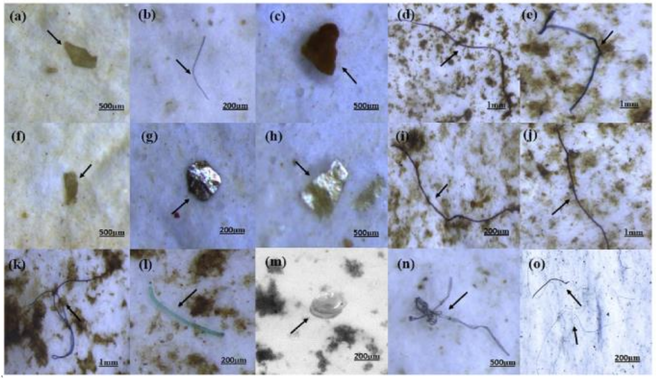


Fig. 6. Visual representation of surface and groundwater microplastics: Fibers (b, d, e, i, j, k, l, n, o), films (g, h), pellets (m), and fragments (a, c, f).

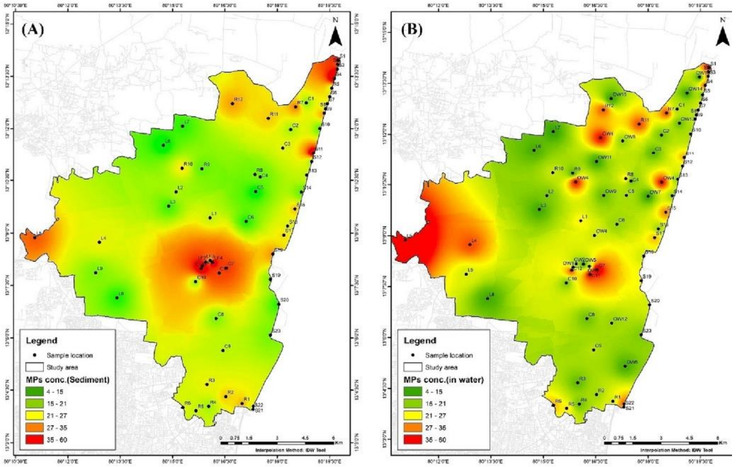
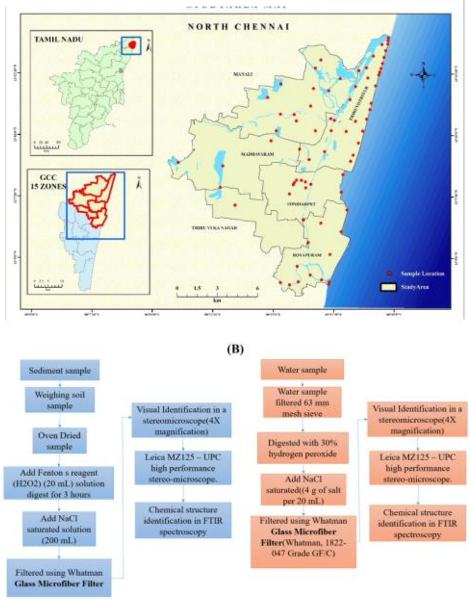
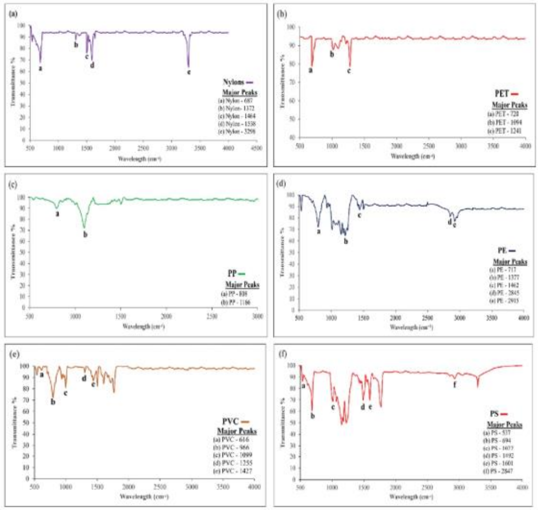


Fig. 2. Spatial variation map of microplastics in (A) sediment and (B) water.



. (A) Map showing the sampling stations in North Chennai region; (B) Approach for retrieving and characterizing microplastics in sediment and water s



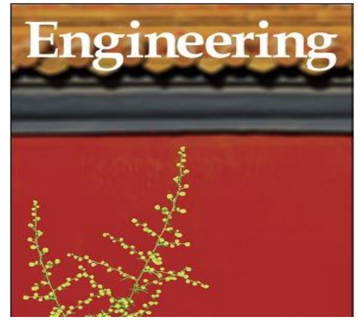
'. Fourier transform infrared (FTIR) spectra obtained for the chosen microplastics present in the water: (a) nylon, (b) PET, (c) PP, (d) PE, (e) PVC and (f) PS.

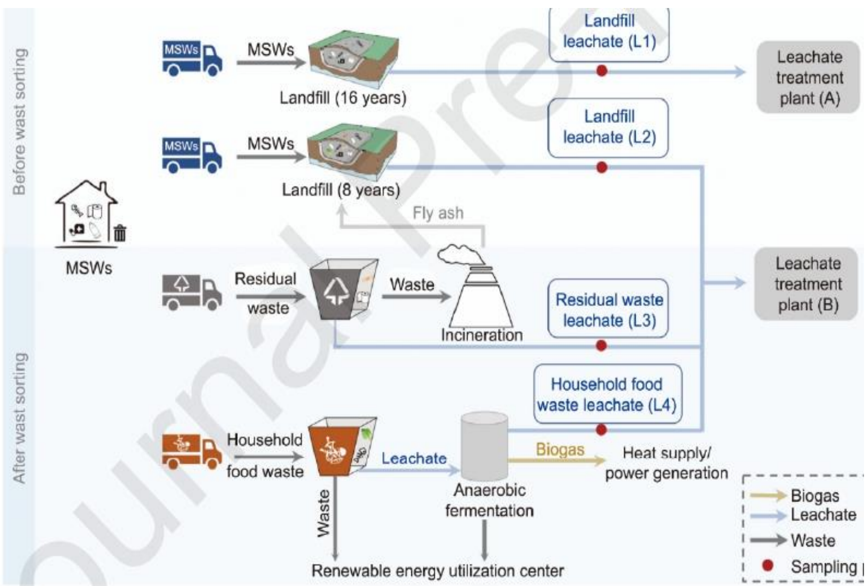
Journal Pre-proofs

Article

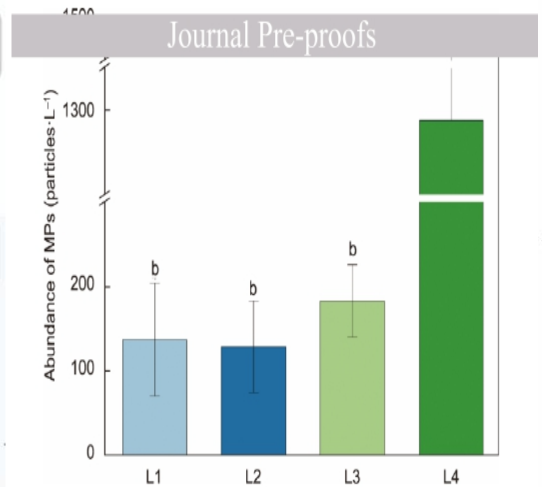
New Insights into Microplastic Contamination in Different Types of Leachates: Abundances, Characteristics, and Potential Sources

Lei Zhang, Wentao Zhao, Liang Zhang, Zhenxiao Cai, Ruiqi Yan, Xia Yu, Damià Barceló, Qian Sui

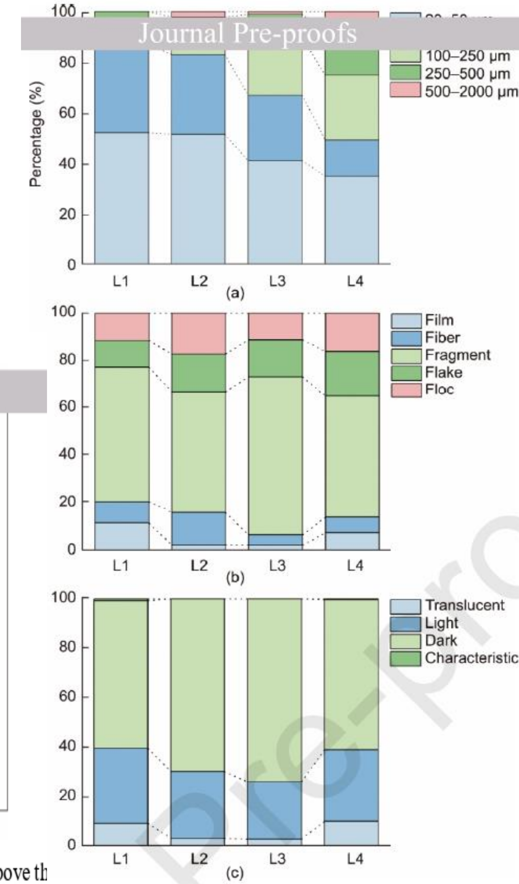




sal methods for MSWs before and after waste sorting and sampling points for leachates



leachates (L1–L4) collected in all sampling events. The letters above th



:, and (c) color of MPs in different leachates.

Water Research 255 (2024) 121443

Contents lists available at ScienceDirect

Water Research

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

Microplastics in different municipal solid waste treatment and disposal systems: Do they pose environmental risks?

Lei Zhang [a], Wentao Zhao [b,c], Ruiqi Yan [a], Xia Yu [a], Damià Barceló [d], Qian Sui [a,c,*]

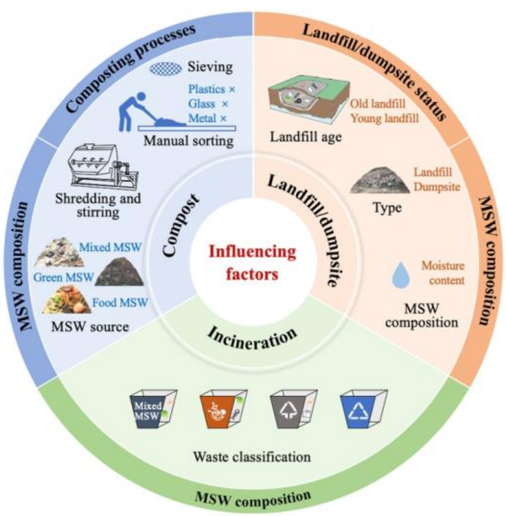
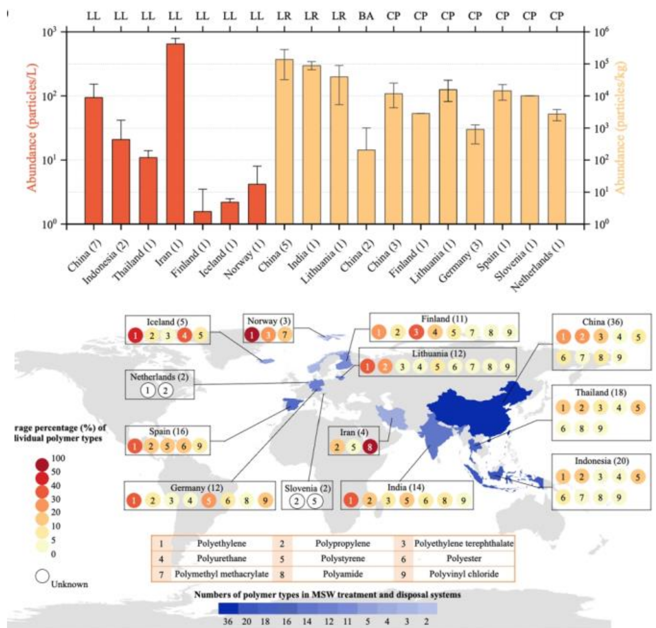
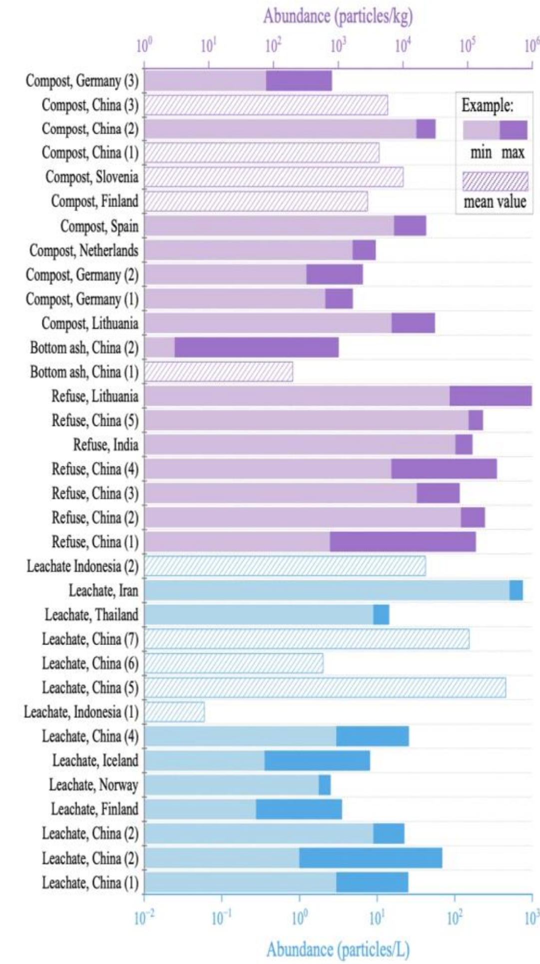


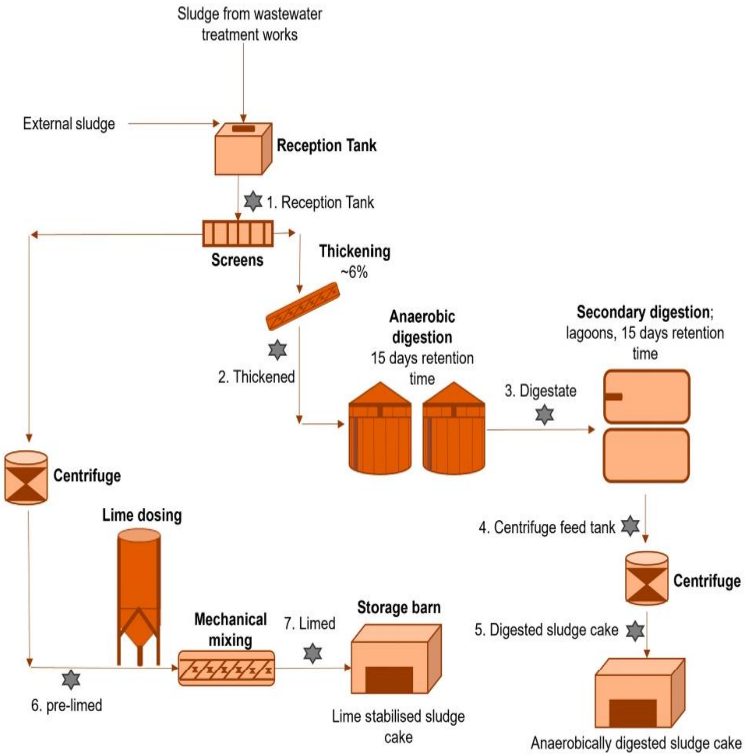
Fig. 4. Factors influencing the occurrence of MPs in different treatment and disposal systems.



rage abundances of MPs (A) and nine polymer types that were detected frequently across studies (detected in more than five publications) (B) in M



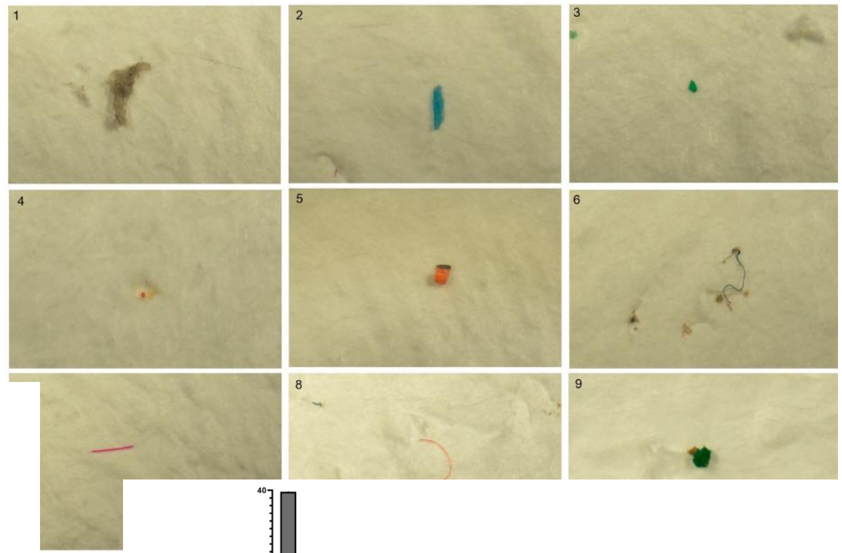
f MPs in MSW treatment and disposal systems in different studies. The colorless filled columns represent mean val



Science of the Total Environment 823 (2022) 153735
Contents lists available at ScienceDirect
Science of the Total Environment
journal homepage: www.elsevier.com/locate/scitotenv

Investigation and analysis of microplastics in sewage sludge and biosolids: A case study from one wastewater treatment works in the UK

Daisy Harley-Nyang [a,*], Fayyaz Ali Memon [a], Nina Jones [b], Tamara Galloway [b]
[a] College of Engineering, Mathematics and Physical Sciences, Harrison Building, University of Exeter, North Park Road, Exeter, Devon EX4 4QF, UK



d microplastics
pre-limed), 3.

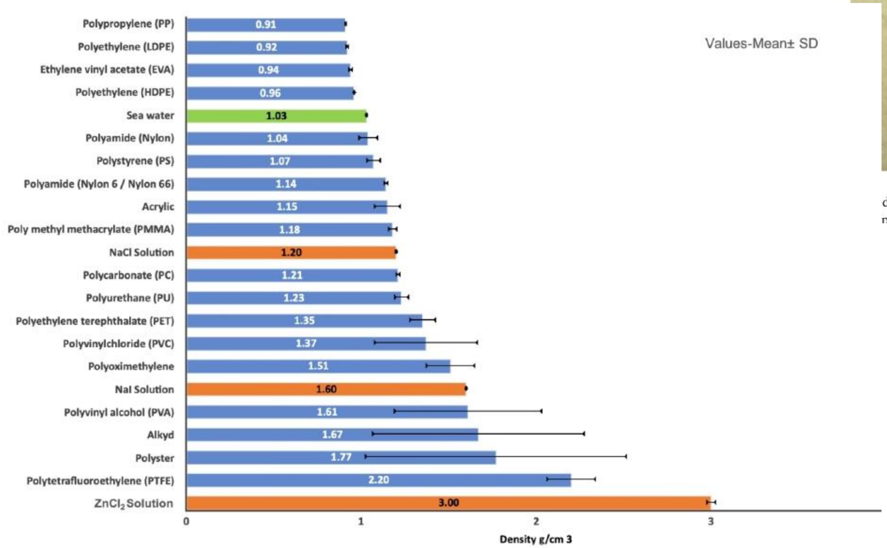


Figure 5. Polymer densities and corresponding solutions (modified after Uddin *et al.*[92]). Blue bars represent the polymer densities orange bars are for the respective solutions used for density separation, and the green bar shows the density of seawater.

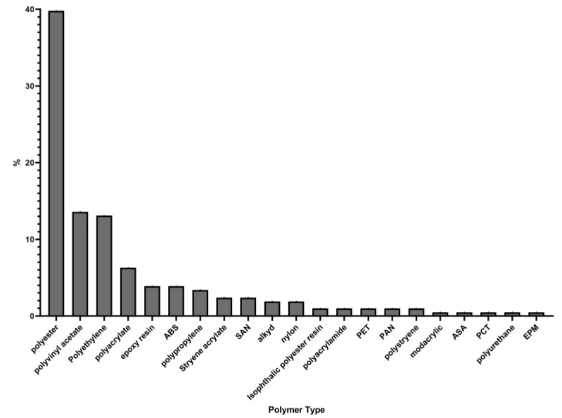


Fig. 5. Polymer type as a percentage of total confirmed microplastics. ABS = acrylonitrile butadiene styrene, SAN = styrene-acrylonitrile resin, PAN = poly
ASA = acrylonitrile styrene acrylate, PCT = polycyclohexylenedimethylene terephthalate, EPM = ethylene propylene rubber.

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Universidade Federal doMaranhao, Sao Luis, MA, BRASIL

Environmental Science & Technology

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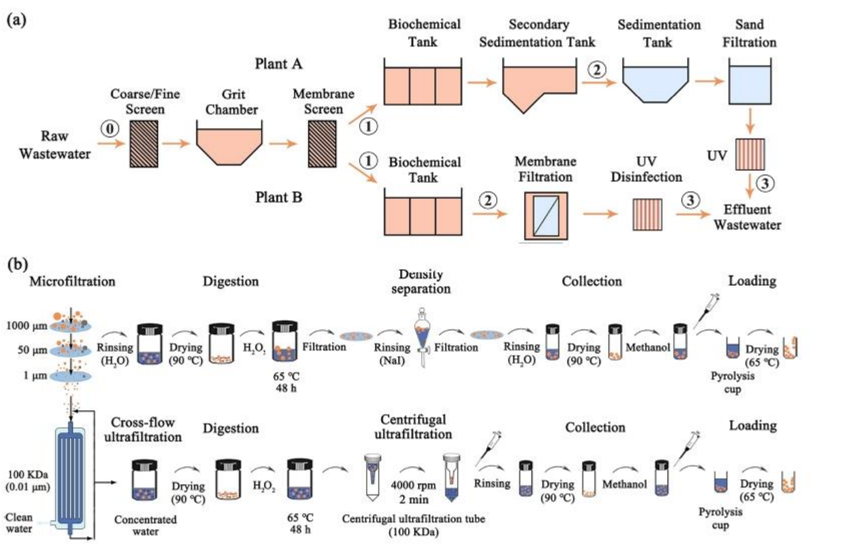
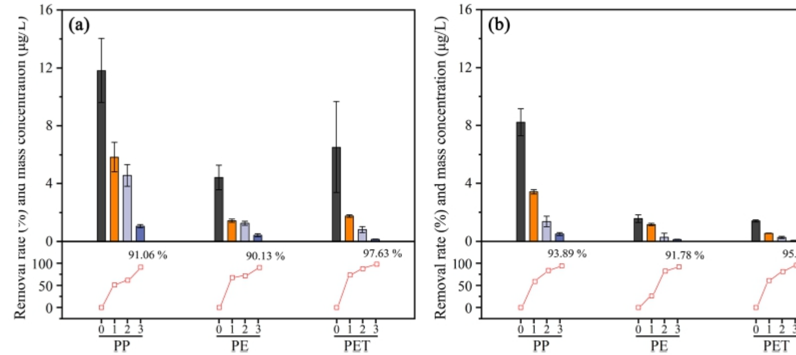
Article

Assessing the Mass Concentration of Microplastics and Nanoplastics in Wastewater Treatment Plants by Pyrolysis Gas Chromatography−Mass Spectrometry

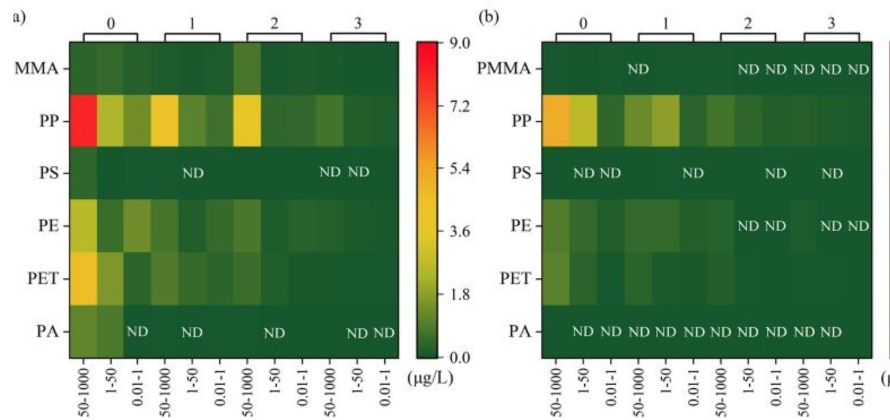
Yanghui Xu, Qin Ou, Xintu Wang, Feng Hou, Peng Li, Jan Peter van der Hoek, and Gang Liu*



1. Flow chart of treatment processes and sampling sites in two WWTPs (a) and pretreatment procedures of wastewater samples fo ection (b). Sampling sites 0, 1, 2, and 3 mean raw wastewater and treated water after the primary, secondary, and tertiary



ss concentration and removal efficiency of the main MPs and NPs (PP, PE, and PET) over the wastewater treatme



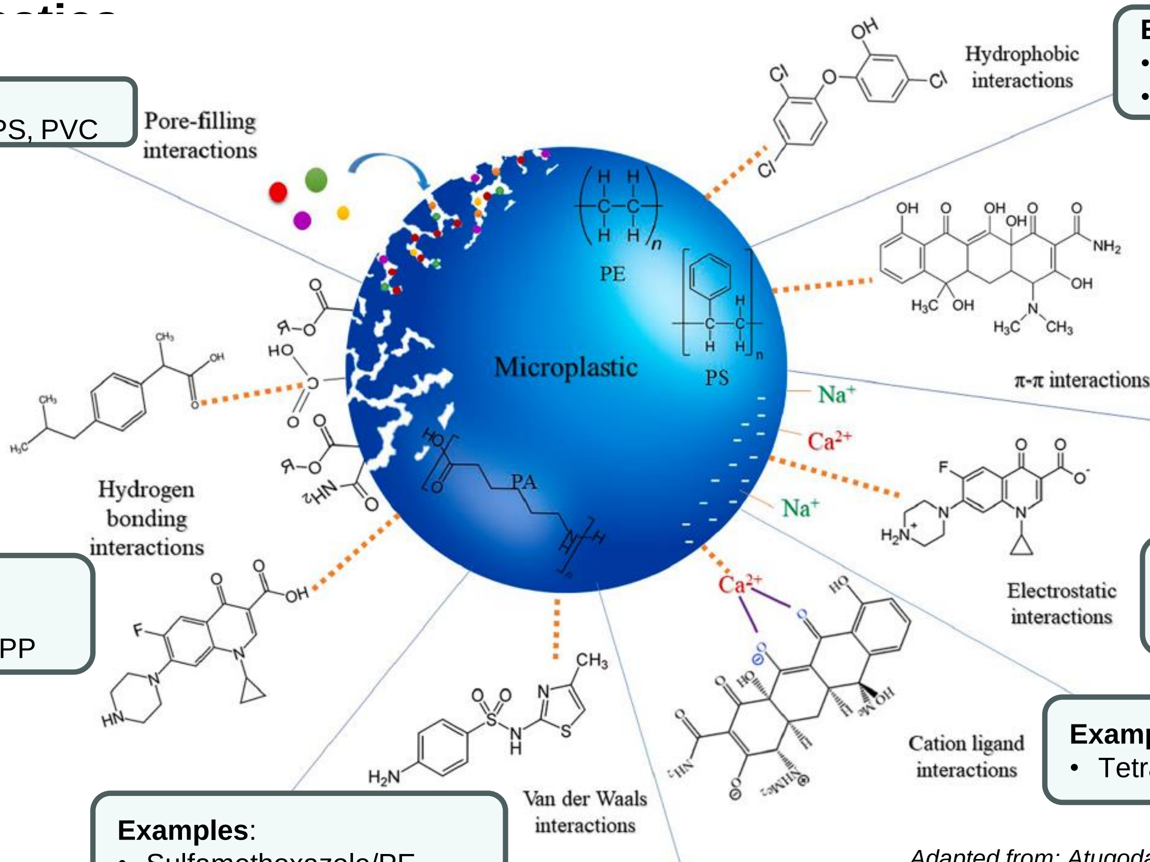
ıaps representing the average concentration of different types with different size ranges at the whole treatment p

Interaction of microplastics(SORPTION) with pharmaceuticals

- **Main mechanisms of interaction between pharmaceuticals and micropla**

Examples:
- Ciprofloxacin/PS, PVC

Examples:
- Ciprofloxacin/PE
- Diclofenac/PS, PE, PP



Examples:
- Tetracycline/PS
- Ibuprofen, diclofenac, naproxen/PS

Examples:
- Ciprofloxacin/PA
- Diclofenac/PS, PE, PP

Examples:
- Ciprofloxacin/PE
- Sertraline/PE

Examples:
- Tetracycline/PE, PS, PVC

Examples:
- Sulfamethoxazole/PE

Adapted from: Atugoda et al., Environ Int. 149 (2021) 106367; Upadhyay et al., Environ. Monit. Assess 194 (2022) 803

PE is the main Carrier of MPs/hydrophobic contaminants (musks, Uvs,PAHs, PCBs,PBDEs)

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Science of the Total Environment

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

Hydrophobic organic contaminants affiliated with polymer-specific microplastics in urban river tributaries and estuaries

Hui He [a], Hui-Ping Wen [a], Ji-Peng Liu [a], Chen-Chou Wu [a], Lei Mai [a,*], Eddy Y. Zeng [a,b]

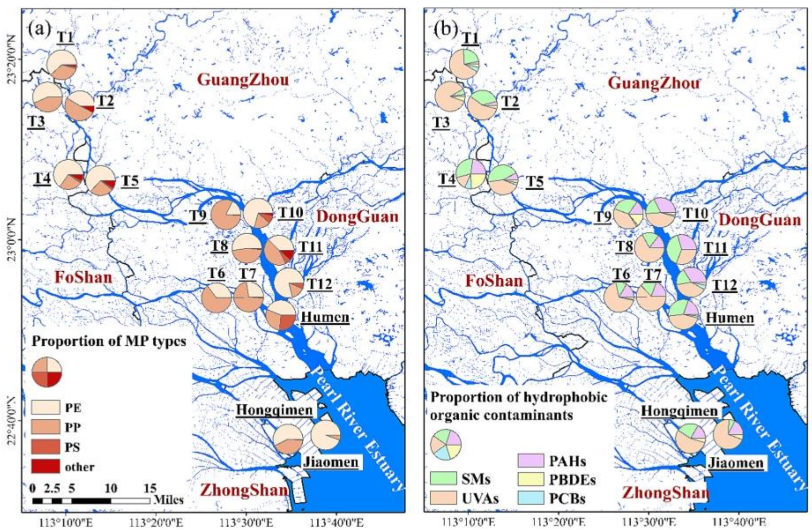
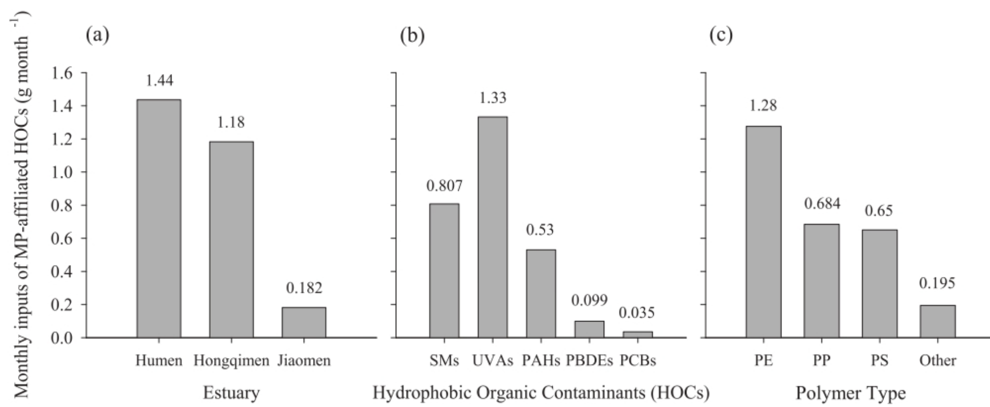


Fig. 2. Proportions of (a) four polymer types of microplastics and (b) five groups of hydrophobic organic contaminants affiliated with microplastics collected fr urban river tributaries and estuaries in the Pearl River Delta, South China. PE: polyethylene; PP: polypropylene; PS: polystyrene; other MPs: other types



6. Monthly inputs of hydrophobic organic contaminants affiliated with microplastics differentiate among (a) three estuaries, (b) five types of hydrop

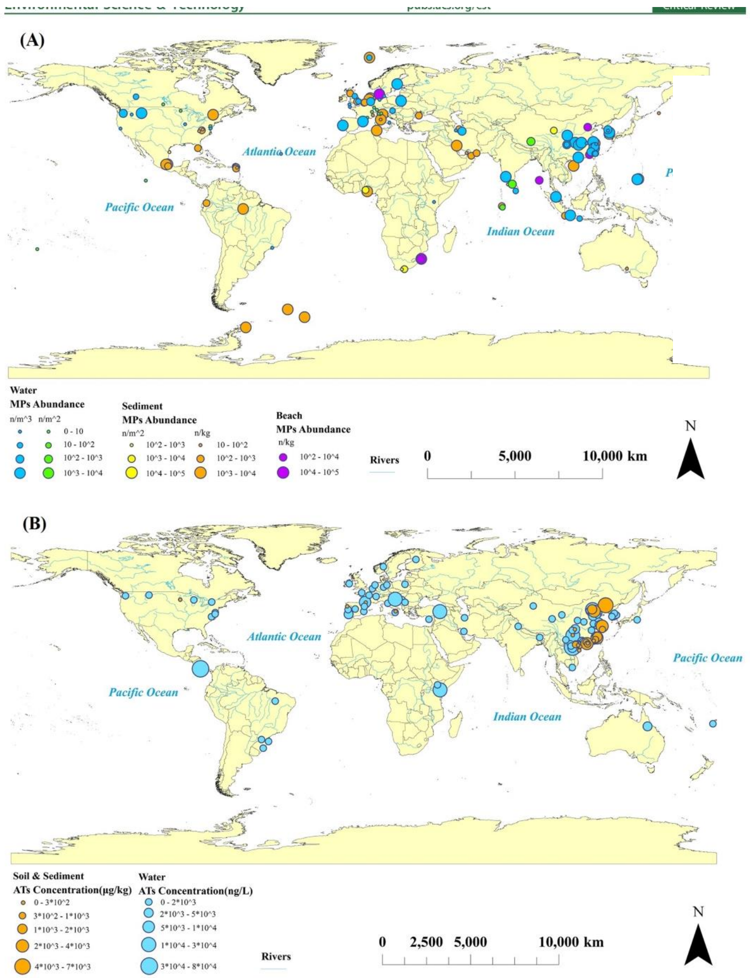


Figure 2. continued

Science & Technology

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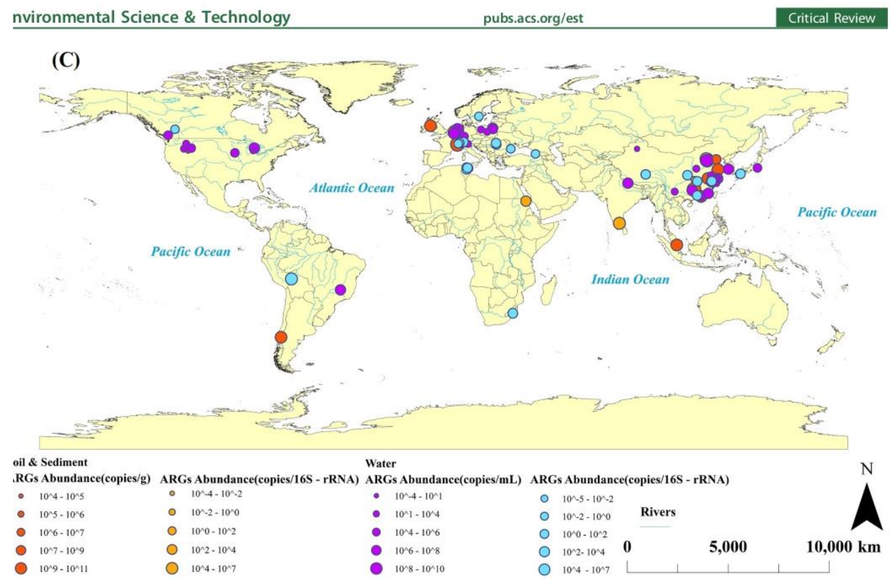
Critical Review

Interaction of Microplastics with Antibiotics in Aquatic Environment: Distribution, Adsorption, and Toxicity

Yanhua Wang, Yanni Yang, Xia Liu, Jian Zhao,* Ruihan Liu, and Baoshan Xing*



igure 2. Spatial distribution of MPs, ATs and ARGs in the environment. (A) MPs abundance in water bodies, sediments, and beaches. (B) ATs oundance in water bodies, soils and sediments. (C) ARGs abundance in water bodies, soils and sediments. The data are collected from the eratures listed in SI Tables S1−S4. It is noted that unmarked areas in the figure do not mean that there is no or little pollution, but there are no

Science of the Total Environment 948 (2024) 175000

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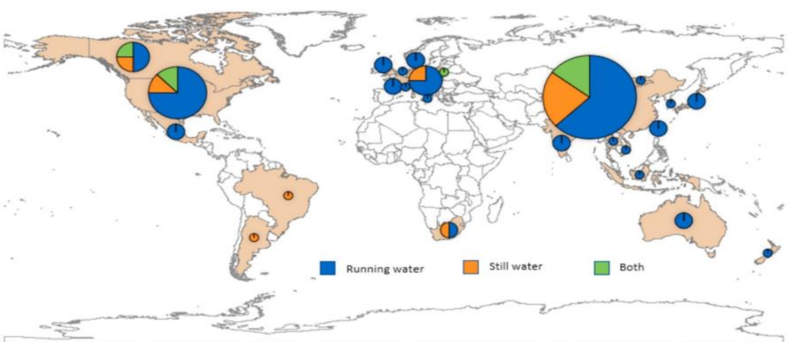
Review

Interaction of microplastics with perfluoroalkyl and polyfluoroalkyl substances in water: A review of the fate, mechanisms and toxicity

Fan Yu [a], Jiaping Wu [a], Huangyingzi Wang [a], Yinzhou Bao [a], Haoyu Xing [a], Wenpei Ye [a], Xuhua Li [a], Manhong Huang [a,b,c,*]

[a] Key Laboratory of Science & Technology of Eco-Textile, Ministry of Education, College of Environmental Science and Engineering, Donghua University, Shanghai



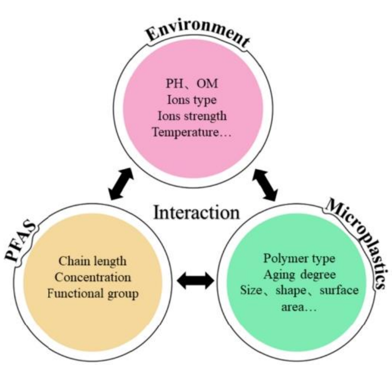


Fig. 5. Factors affecting the interaction of PFAS and microplastics.

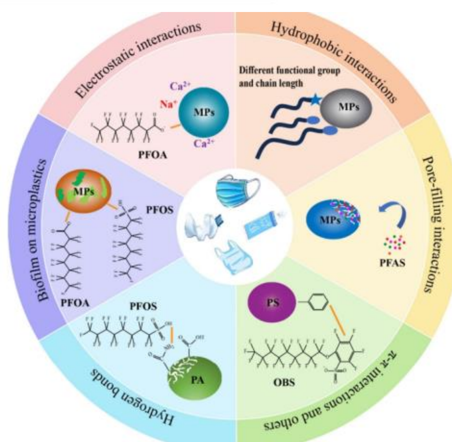
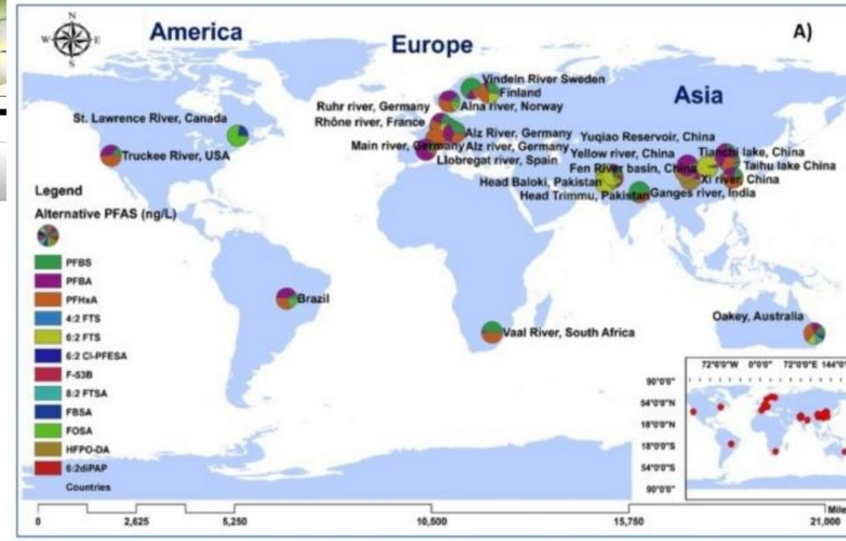
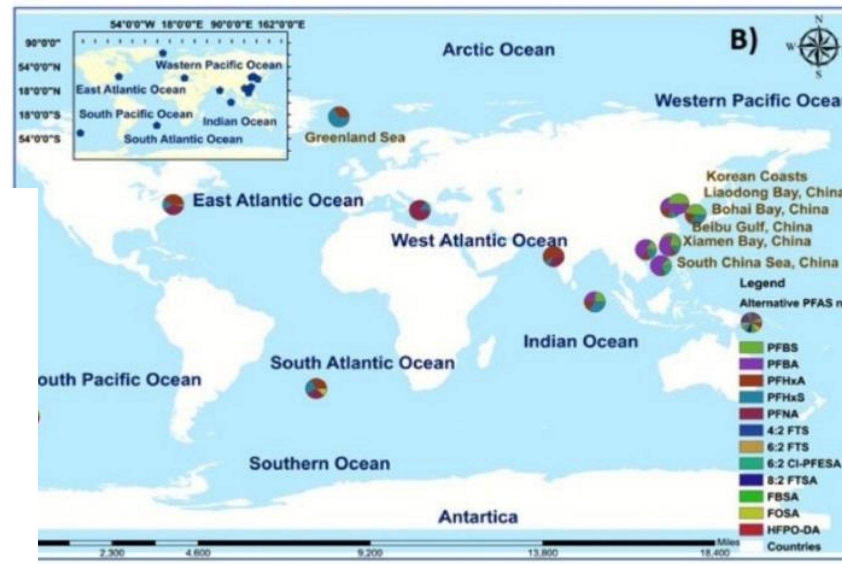


Fig. 4. Probable mechanisms of adsorption of PFAS by the MPs.





istribution of the alternative PFAS detected in freshwater (A) and marine water (B) worldwide (Hami

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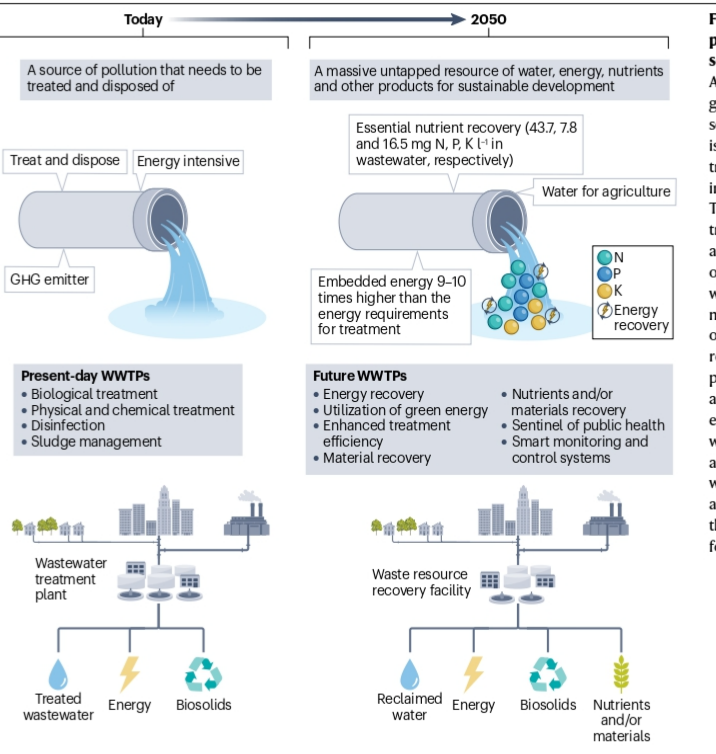

Fig. 5 | Emerging technologies that have the potential to transform the wastewater treat[…] sector into a circular economy framework. A comparison of current and future perceptio[…] goals and outcomes for the wastewater treatm[…] sector. Often, current perception is that wastev[…] is a source of pollution that needs energy-inter[…] treatment and then disposal, in a process that involves serious greenhouse gas (GHG) emissi[…] The goals and outcomes are limited only to treatment, disinfection, sludge management and disposal. New technologies are capable of retrofitting and upgrading all the functions[…] wastewater treatment plants (WWTPs) toward[…] more circular model, transforming perception of wastewater to see it as an untapped resource[…] reclaimed water, energy, nutrient and other products for sustainable development. The go[…] and outcomes of future WWTPs will be to beco[…] energy-neutral and carbon-neutral facilities, w[…]

nature reviews earth & environment

https://doi.org/10.1038/s43017-024-00[…]

Review article

Check for u[…]

Sustainable wastewater reuse for agriculture

Anastasis Christou[1,2], Vasiliki G. Beretsou[2,3], Iakovos C. Iakovides[2,3], Popi Karaolia[2,3], Costas Michael[2], Tarik Benmarhnia[4,5], Benny Chefetz[6], Erica Donner[7,8], Bernd Manfred Gawlik[9], Yunho Lee[10], Teik Thye Lim[11], Lian Lundy[12], Roberta Maffettone[9], Luigi Rizzo[13], Edward Topp[14,15] & Despo Fatta-Kassinos[2,3]

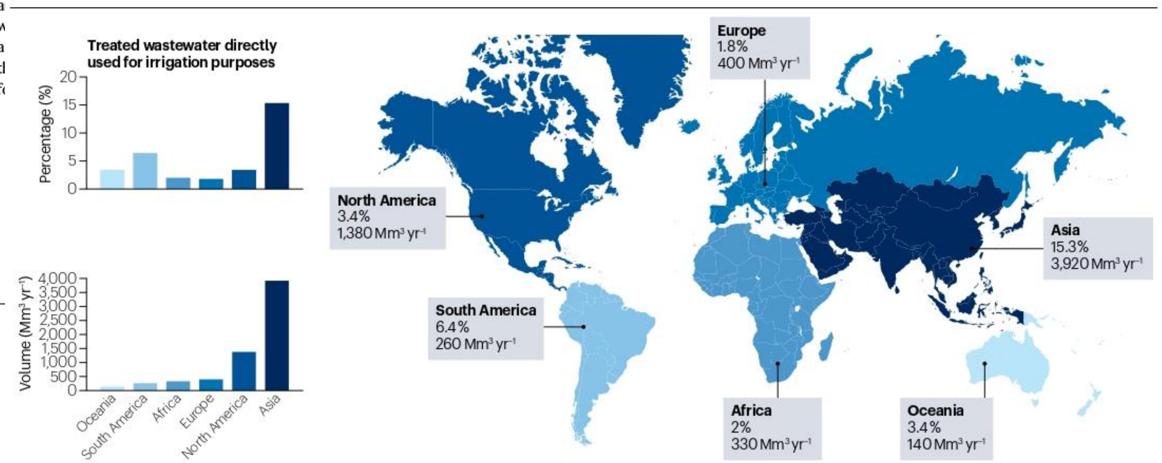

Fig. 1 | Annual volume and percentage of TW reused directly for irrigation. Global direct reuse of TW (with no or little dilution with freshwater) for irrigation varies among continents. Direct application for irrigation is highest in Asia on a continental level, and on regional levels, it is a prevalent practice in countries in Middle East and North Africa, Australia, the Mediterranean region, Mexico, China and the USA. The direct reuse of TW for irrigation is influenced by local water scarcity, availability of treatment infrastructure, presence and enforcement of regulatory measures, and economic motivations. Data for the figure are from refs. 44,46.

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2023 Winner الفائز
King Hamad Prize for Agricultural Development
جائزة الملك حمد للتنمية الزراعية

A reconnaissance study of pharmaceuticals, pesticides, perfluoroalkyl substances and organophosphorus flame retardants in the aquatic environment, wild plants and vegetables of two Saudi Arabia urban areas: Environmental and human health risk assessment

Yolanda Picó [a,*], Julian Campo [a], Ahmed H. Alfarhan [b], Mohamed A. El-Sheikh [b], Damià Barceló [b,c]

- Of 131 emerging contaminants, 87 belonging to all kinds tested were in the samples.
- Content of PPCPs>Pesticides>OPFRs>PFASs except for wild vegetation in Al-Jubail
- Significant differences in pesticide content between Riyadh and Al-Jubail samples
- Caffeine, bisphenol A, diazinon and abamectin showed the highest ecological risk.
- Level of contamination in food does not indicate serious threat to population health

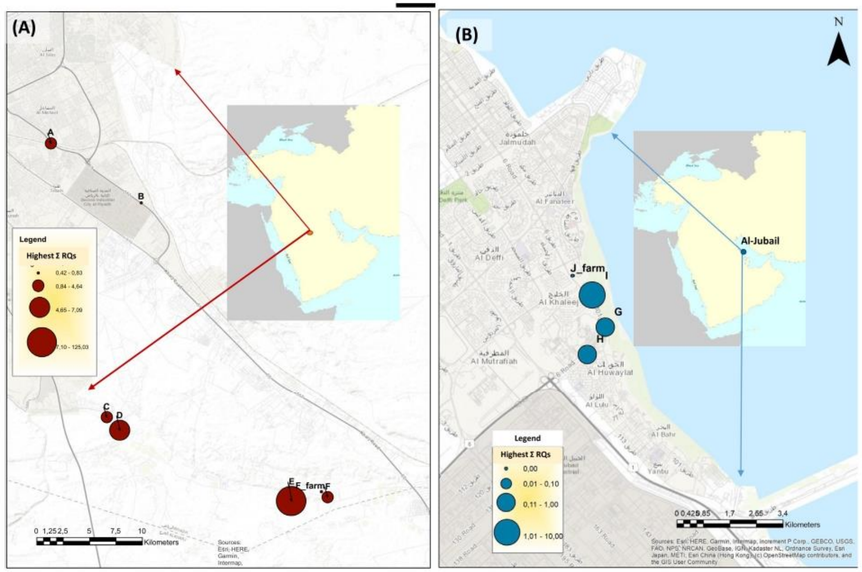
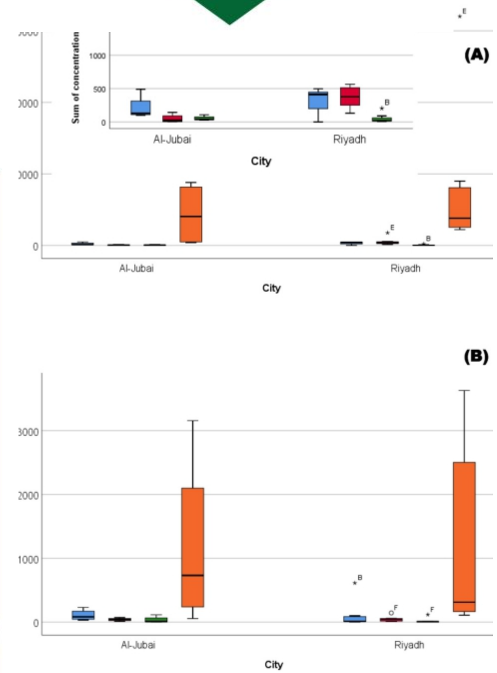


Fig. 4. ΣRQs at each sampling point showing the differences between the different sampling points in (A) Riyadh and (B) Al-Jubail (both maps are not in the same scale).



2. Comparison of the sum of concentrations of each type of contaminants found ... h and Al-Jubail in (A) water and (B) sediments. A smaller scale on the insert of ... (A) to visualize ∑OPFRs, pesticides and PFASs in water. Box colours indicate ... of contaminants ∑OPFRs, ∑Pesticides, ∑PFASs and ∑PPCPs. * indica... ers and the letter the sampling point (see Fig. 1).

Riyadh River

Journal of Hazardous Materials 416 (2021) 125747

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

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First evidence of microplastics occurrence in mixed surface and treated wastewater from two major Saudi Arabian cities and assessment of their ecological risk

Yolanda Picó [a,*], Vasiliki Soursou [a], Ahmed H. Alfarhan [b], Mohamed A. El-Sheikh [b], Damià Barceló [b,c,d]

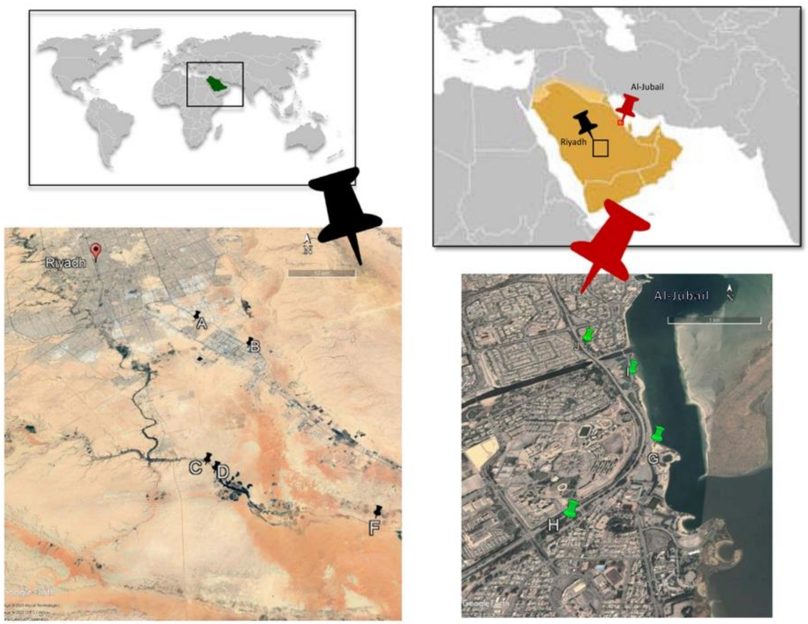


Fig. 1. Maps of the study areas showing the sampling points in Riyadh South (from A to F) and Al-Jubail (from G to J).

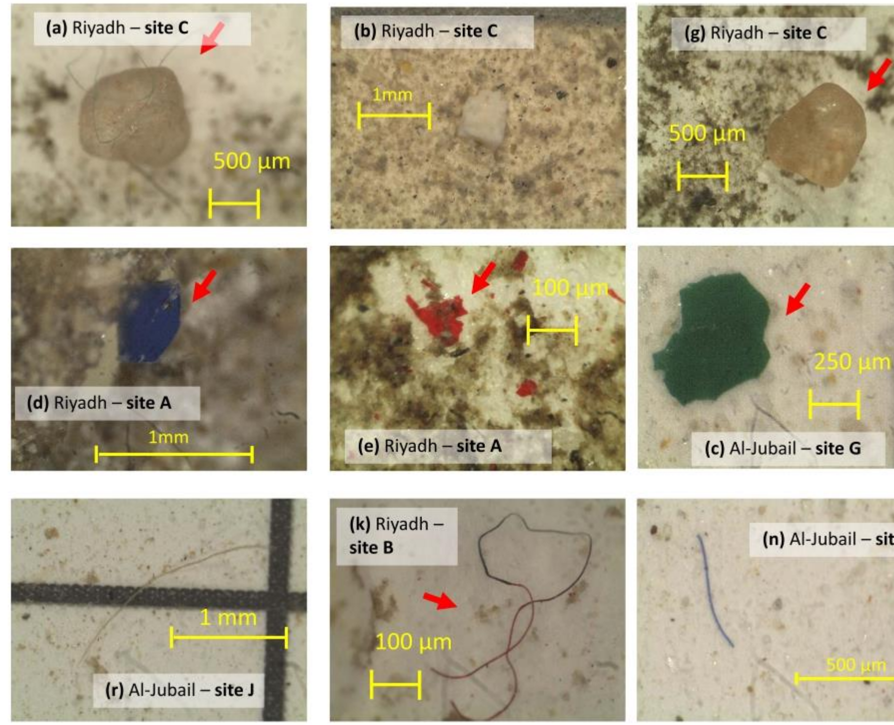


Fig. 3. Photographs of microplastics under the stereomicroscope, sferules (a-c), fragments (d-f) and fibers (g-i).

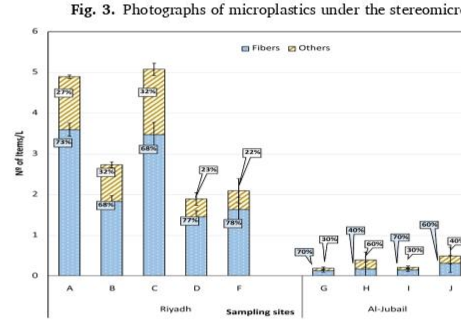
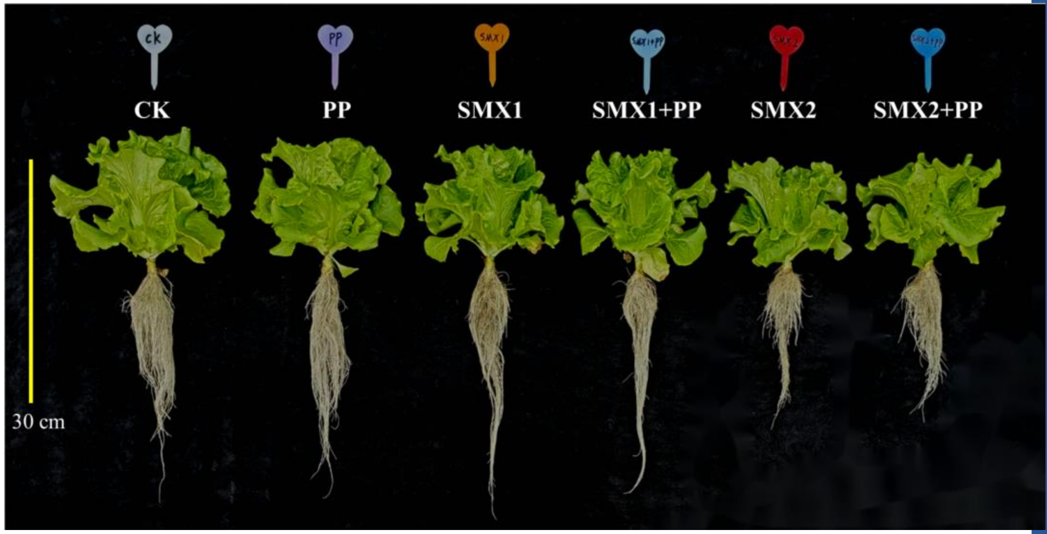


Fig. 2. MPs distribution in Riyadh and Al-Jubail.

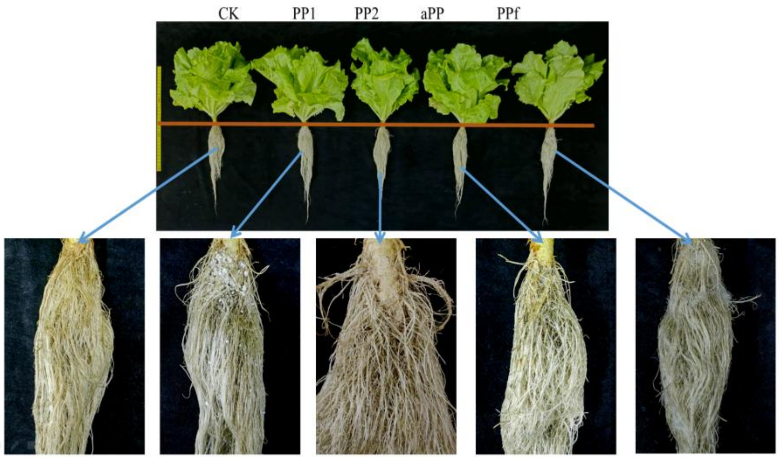
Impact of MPs and Sulfamethoxazole Co-exposure on Lettuce

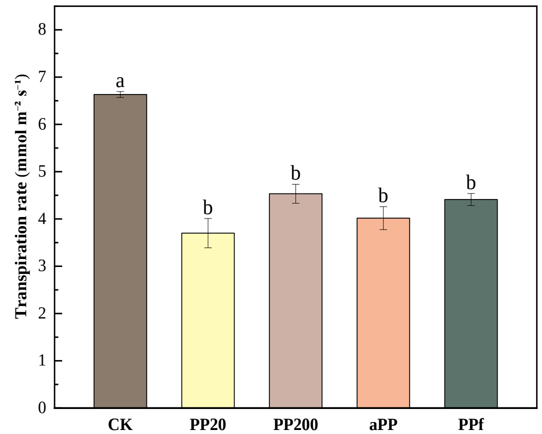
Experiment Design

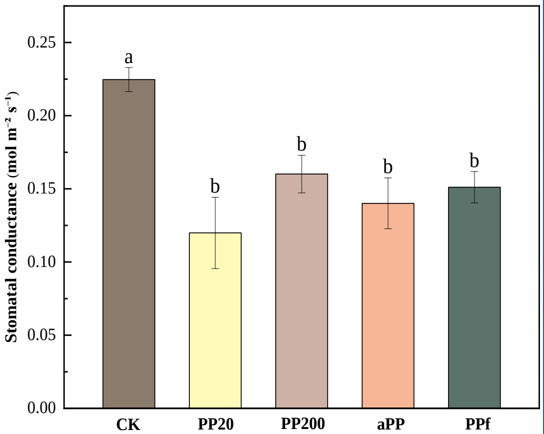
Treatments	Set up
CK	Hoagland nutrient solution without PP MPs and Sulfamethoxazole (SMX)
PP	1 g/L PP MPs (200 μm)
SMX1	0.5 mg/L SMX
SMX1+PP	1 g/L PP MPs+ 0.5 mg/L SMX (Co-exposure)
SMX2	2.5 mg/L SMX
SMX2+PP	1 g/L PP MPs+ 2.5 mg/L SMX (Co-exposure)

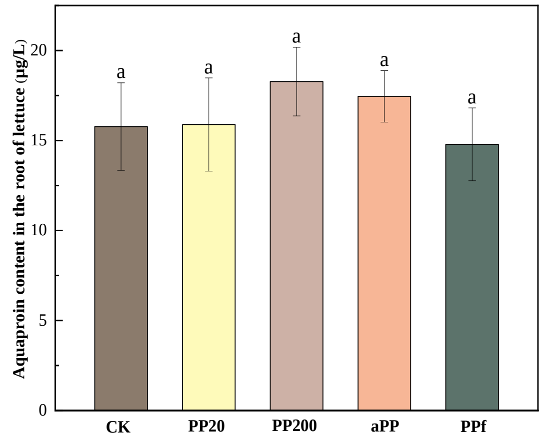


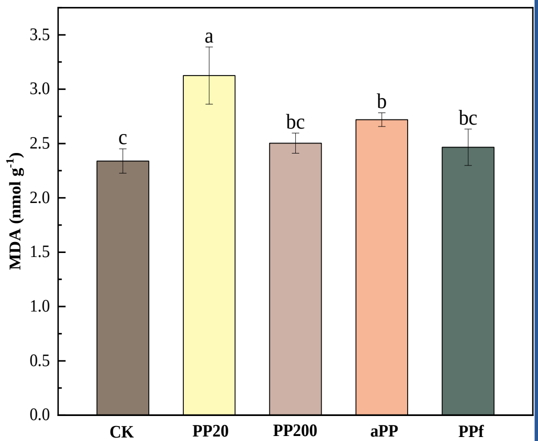
MPs Interferes SMX Uptake of the Lettuce by Transpiration Inhibition











Treatments

PP20: PP MPs with size of 20 μm
PP200: PP MPs with size of 200 μm
aPP: Aged PP MPs with size of 200 μm
PPf: PP fiber with size of 3 mm

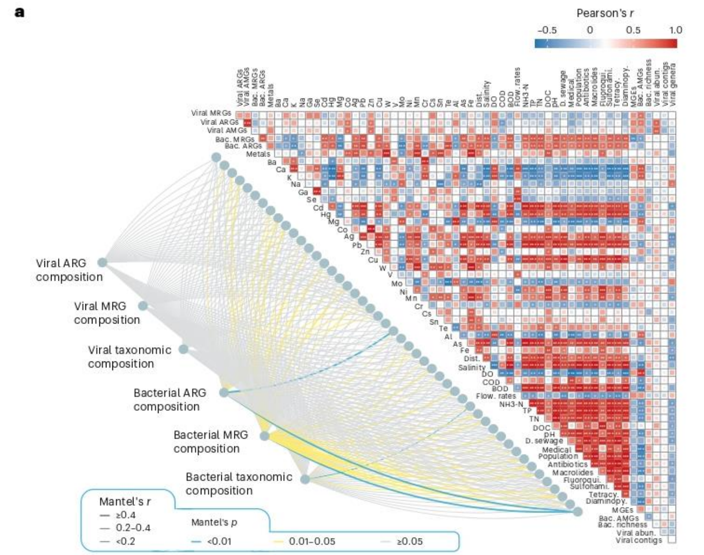
nature water

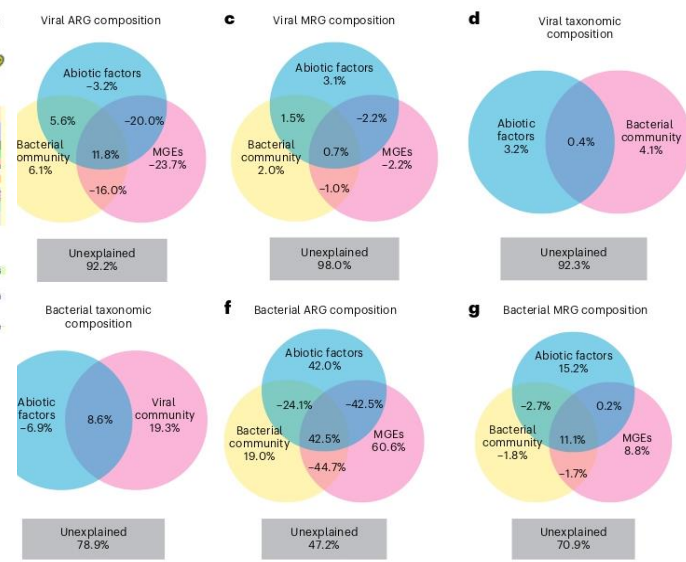
Article https://doi.org/10.1038/s44221-024-0024

Viral metagenome reveals microbial hosts and the associated antibiotic resistome on microplastics

Received: 24 June 2023

Ruilong Li[1,2,6], Xin-Li An[1,6], Yijin Wang[2], Zhugen Yang[3], Jian-Qiang Su[1], Jonathan Cooper[4] & Yong-Guan Zhu[1,5]





| MRG and taxonomic dynamics of bacterial and viral communities. ...rwise comparisons of the biotic and abiotic variables. The colour ... proportion of abiotic and biotic factors on the va... composition (f) and bacterial MRG composition ...

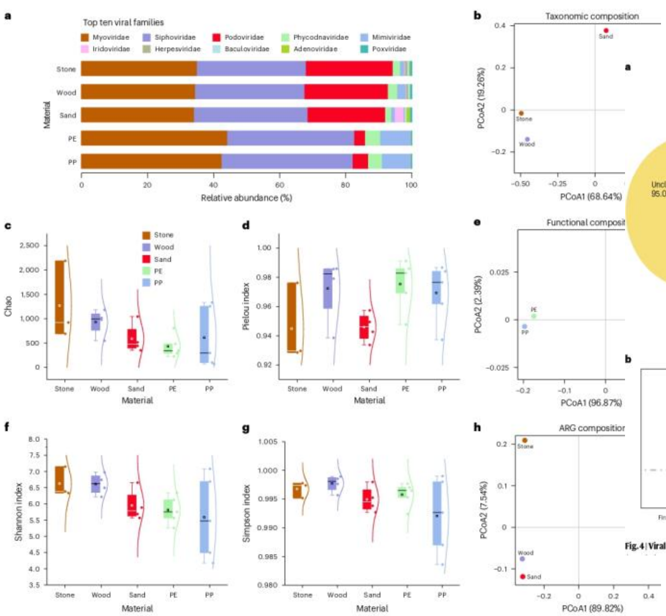


Fig. 5 | Comparisons of viral community composition, richness and evenness in natural particles and microplastics. a,c,d,f,g, Comparisons of viral community composition (**a**), richness (**c**) and evenness (**d**,**f**,**g**) in natural particles ... particles and MPs: 6.37 ± 0.15 and 5.70 ± 0.29, Pielou for nature particles and MP: 0.96 ± 0.01 and 0.97 ± 0.01, Chao1 for nature particles and MPs: 898.27 ± 153.95 and 520.00 ± 111.71, Simpson for nature particles and MPs: 1.00 ± 0.00 and ...

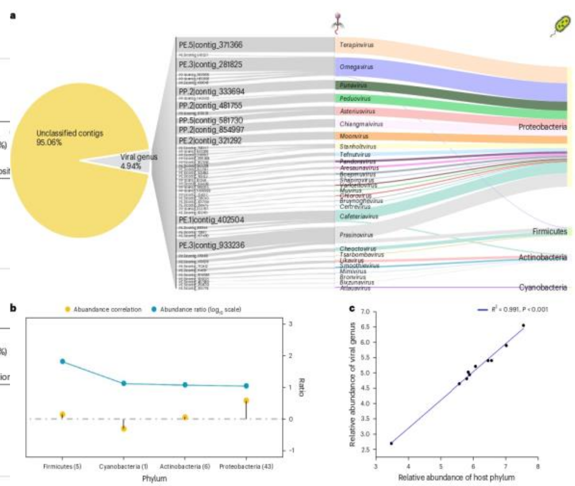


Fig. 4 | Viral–host interaction structure. a, Matched virus–host association. ... RPKM) correlations and abundance ratios. Solid circles indicate positive ...

Co-contamination of MP/NPs in treated Wastewater/irrigated edible plants

- MPs and co-contaminants exist in treated wastewater and joint toxicity can be due to combined exposure, and that be transferred to **soil/plants/crops *via* irrigation with** to **hormetic adaptive** responses that can enhance the plant capacity to defend against massive stress.
- The presence of **MPs/NPs can decrease or increase a negative effect of a co- contaminant or** in some cases can have a neutral effect. The generated effect is a matter of dose of each contaminant and the ratios of the concentration of the contaminants within a mixture
  Agathokleous, E., Iavicoli, I., Barceló, D., Calabrese, E.J., 2021b. Micro/nanoplastics effects on organisms: a review focusing on 'dose'. J. Hazard. Mater. 417, 0–2. https://doi.org/10. 1016/j.jhazmat.2021.126084.
- **PP reduced significantly SMX uptake and translocations in lettuce by inhibiting Transpiration inhibition** J Hazard Materials (submitted 2024)

Advanced treatments for Microplastics in Water

ELSEVIER

Green Analytical Chemistry

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

Removal of microplastics in water: Technology progress and green strategies

Wei Gao[a,b], Yalin Zhang[a], Aoyun Mo[a], Jie Jiang[a,b], Yuqing Liang[a], Xiaomu Cao[a,b], Defu He[a,b,c,d,*]

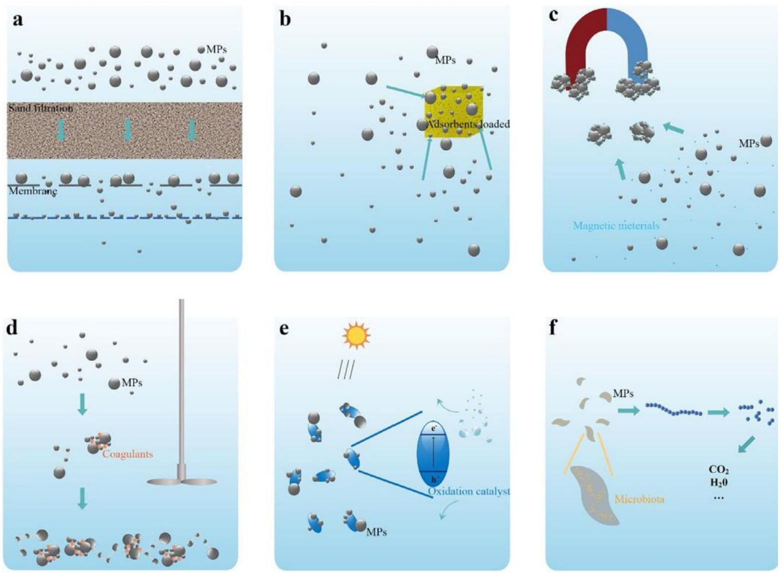


Fig. 2. Schematic diagrams of main technologies for removing MPs in water. Filtration technology (a), adsorption removal (b), magnetic removal (c), coagulati treatment (d), photocatalysis (e), and biodegradation treatment (f).

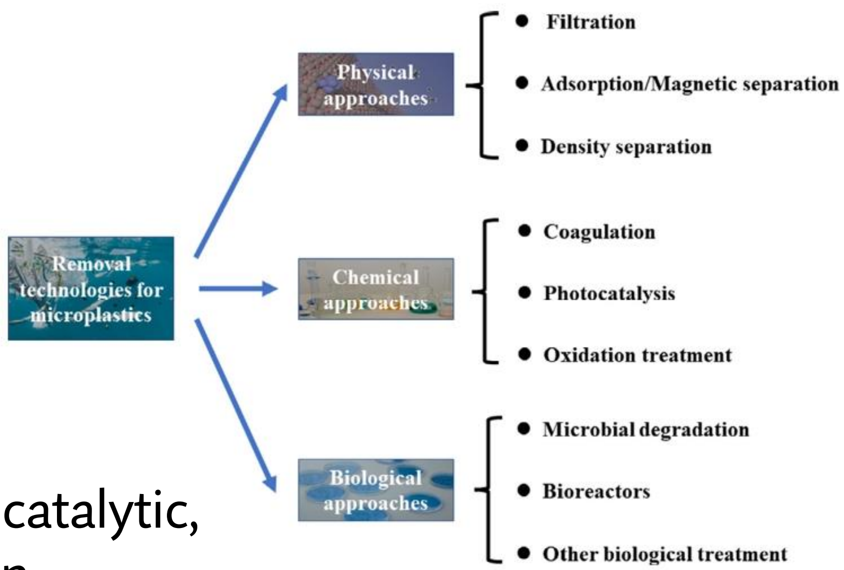


Fig. 1. Ov
MPs in wat

Microplastics removal: MBR+UV, Photocatalytic, Microbial Technologies. Ferro-sonication, Electrocoagulation, Applied **WWTP,Landfills**

Water Research 260 (2024) 121895

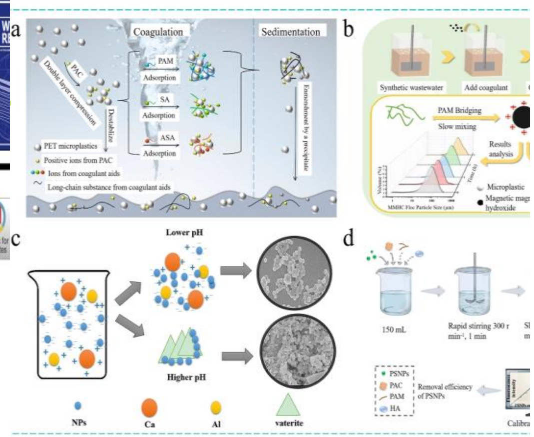
Contents lists available at ScienceDirect

Water Research

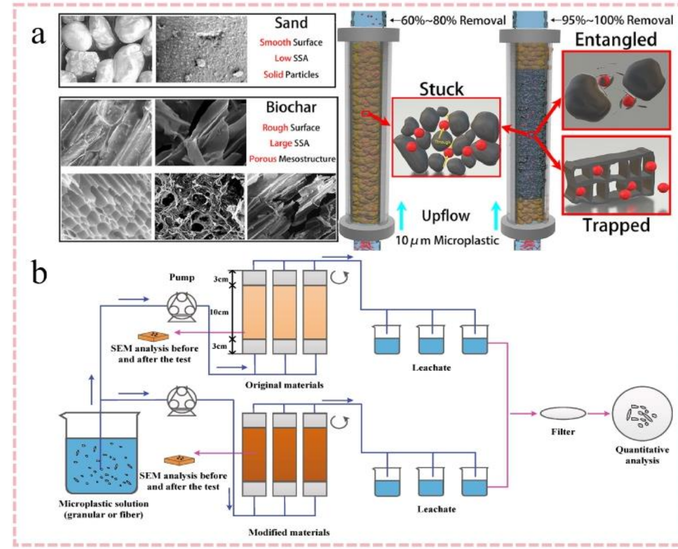
journal homepage: www.elsevier.com/locate/watres

Differences of microplastics and nanoplastics in urban waters: Environmental behaviors, hazards, and removal

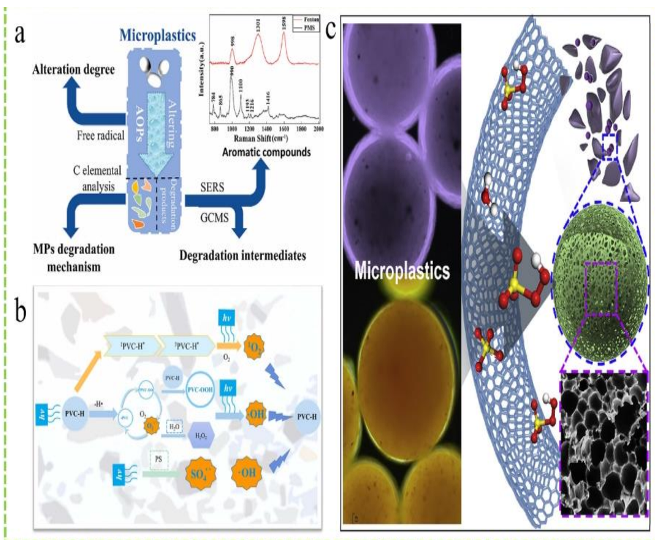
Shuan Liu[a], Qiqing Chen[b], Haojie Ding[c], Yunqian Song[d], Qixin Pan[a], Huiping Deng[a,*], Eddy Y. Zeng[e,*]



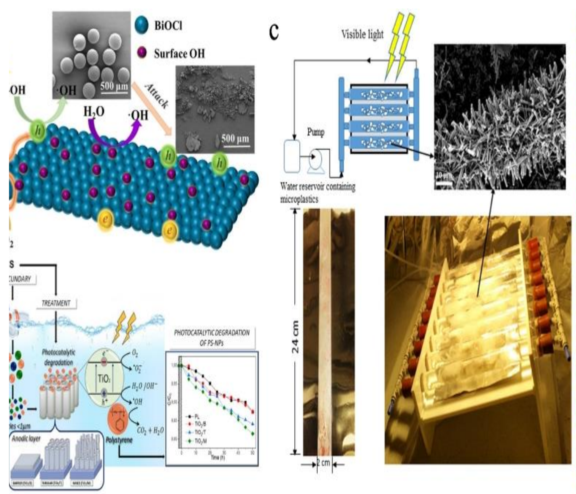
a) The three coagulation aids promoting coagulation to remove PET-MPs. (200 mg L^{-1} PAC, 100 mg L^{-1} SA, 100 r
021a). With permission from Elsevier. Copyright 2021.
emoval process of PE-MPs by $Mg(OH)_2$ coagulant. (200 mg L^{-1} $Mg(OH)_2$, 120 mg L^{-1} Fe_3O_4, and 4 mg L^{-1} PAM). F
mission from Elsevier. Copyright 2021.
emoval process of PS-NPs by composite Ca–Al coagulant. (10 mg L^{-1} PS-NPs, 2 mmol L^{-1} Ca^{2+}, and 1 mmol L
With permission from Elsevier. Copyright 2020.



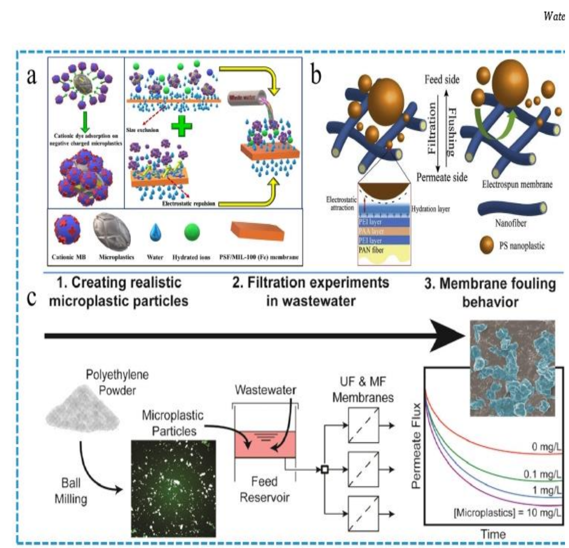
removal process of PE-MPs by biochar/sand filter. (70 mm length biochar samples; flow rate 180 mL h^{-1}; pH=7.56). Figure is taken f
permission from Elsevier. Copyright 2020.



) The degradation process of PS-MPs by Fe^{2+}/oxidants system. (3 mM Fe^{2+}, 0.046 g L^{-1} PMS, 150 rpm, 5 h). Figure is taken from Liu et al. (2022a). W
n from Elsevier. Copyright 2022.



ocess of PS-MPs by hydroxy-rich BiOCl. (250 W Xe lamp, 1 g L^{-1} MPs, 0.5 g L^{-1} of the photocatalyst, 5 h). Figure is taken f
021). With permission from Elsevier. Copyright 2021.
degradation process of PS-NPs by TiO_2. (1 cm^2 photocatalyst area, 0.021 mW cm^{-2} UV lamp, 30 °C, 50 h, 300 rpm). Figure is taken from Domíngu
021). With permission from Elsevier. Copyright 2021.



l process of PVC and PE-NPs by the nanofibrous membranes. (ΔP_0 = 300 kPa, water flux = 72 L m^{-2} h^{-1}). Figure is
mission from Elsevier. Copyright 2021.
ss of PS-NPs by electrospun membranes. (ΔP_0 = 41.4 kPa, water flux = 861 L m^{-2} h^{-1}). Figure is taken from
er. Copyright 2020.

Science of the Total Environment 806 (2022) 150603

Contents lists available at ScienceDirect

Science of the Total Environment

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

Photocatalytic and biological technologies for elimination of microplastics in water: Current status

Parisa Ebrahimbabaie [a], Kimiya Yousefi [b], John Pichtel [a,*]

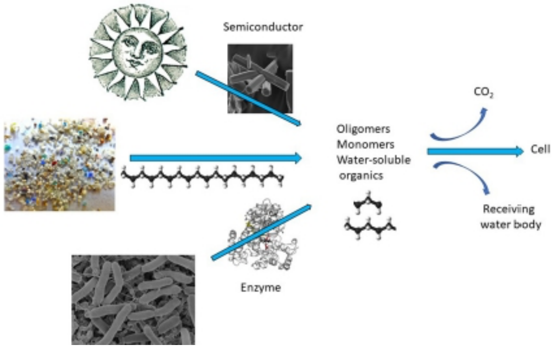
[a] Environment, Geology and Natural Resources, Ball State University, Muncie, IN 47306, USA
[b] Department of Chemical Engineering, Faculty of Engineering, Shahid Bahonar University, Kerman, Iran

HIGHLIGHTS

- Tens of millions of tons of microplastics occur in freshwater and oceans.
- Microplastics can be captured, but few technologies are available for destruction.
- Photocatalytic and microbial technologies show promise for microplastics elimination.
- The use of combined technologies for MP elimination should be considered.

GRAPHICAL ABSTRACT

Photocatalytic and biological technologies for degradation of microplastics in water.



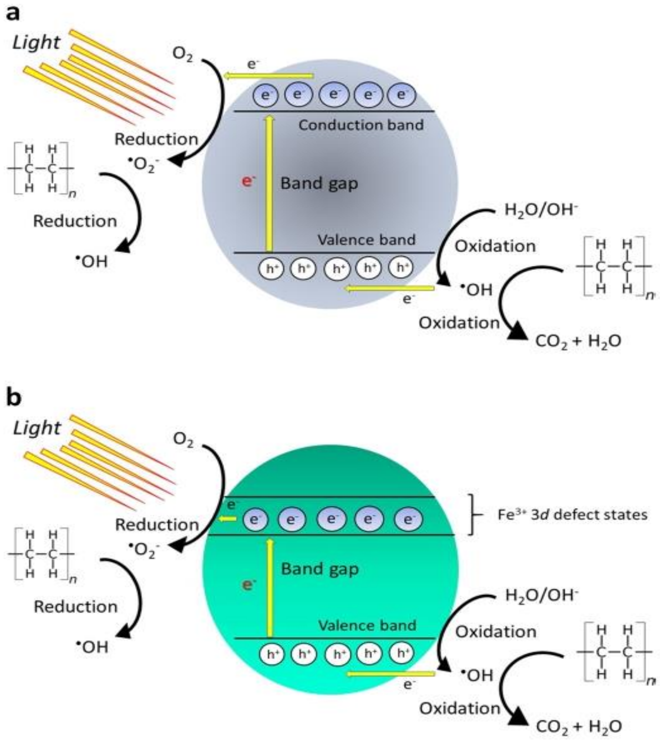


Fig. 2. Mode of action of a photocatalyst for decomposition of PE chain: (a) single catalyst such as ZnO; and (b) Fe-ZnO photocatalyst (Adapted from Lam et al., 2021).


Chemical Engineering Journal

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

Review

Effects of microplastics on wastewater and sewage sludge treatment and their removal: A review

Zhiqi Zhang[a], Yinguang Chen[a,b,*]

[a] State Key Laboratory of Pollution Control and Resource Reuse, School of Environmental Science and Engineering, Tongji University, 1239 Siping Road, Shanghai 200092,

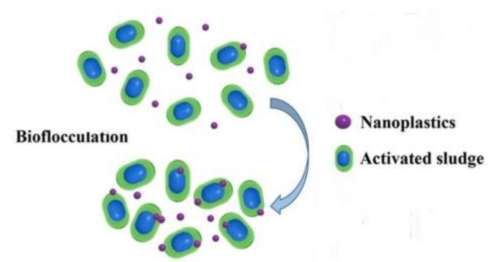
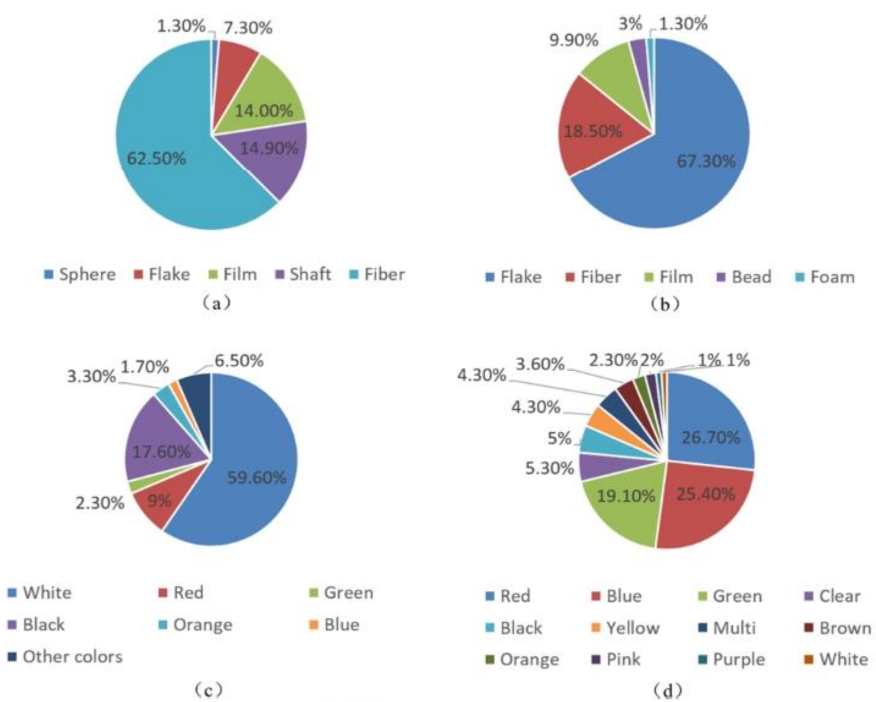
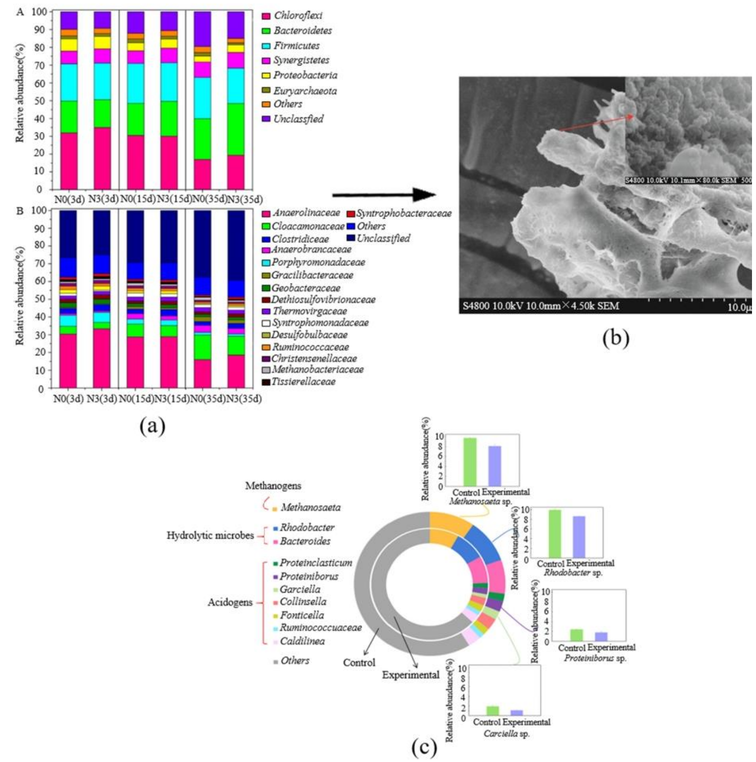


Fig. 3. Interaction between microplastics and activated sludge [61].





e chart of microplastics form distribution in sludge [70,72]. (b) Pie chart of microplastics form distribution in sewage color distribution in sludge [70,72]. (d) Pie chart of microplastics color distribution in sewage [70,72].

. (a) Changes in the abundance of microbial communities under N0 and N3 conditions (phylogenetic markers and < 1% of the total sequence in classified as others; N0: no microplastics; N3: microplastics concentration is 0.2 g/L; A: phylum levels; B: family levels) [75]. (b) SEM images of Ac genigenes exposed to nanoplastics [75]. (c) Distribution of genus microbial populations in anaerobic digestion systems after addition of micropla

TREATMENT SOLUTIONS AND FUTIURE PERSPECTIVES

- MPs reduce the efficiency of the WWT processes
  - Affect **effluent quality** –composed by Polyester and PE
  - Inhibit sludge hydrolysis,acidification and methanopgenesis,
  - Reduce diversity of microbial communities and enzyme activity-destroy cell membranes
- Adsorption, MBRs, Biological Degradation(microbial inoculant, composting) **and AOPs-reduce** 95-99%MPs
  - AOPs-peroxide oxidation (UV/H_2O_2) ,Photo Fenton, Ozone-based processes (O_3) and Photocatalytic degradation (UV Catalysis)
- Studies Needed on the effects and size of MPs on WWT
  - wastewater effluent quality still scarce-mechanism still not clear
  - MPs investigated > 1 µm- **Almost no studies of MPs<1µm**
- Solutions: source control, removing plastic beads from PCP, reduce garbage bags, eliminating excise packaging and promote **green packagin**g with biodegradable materials

Environmental Pollution 344 (2024) 123369

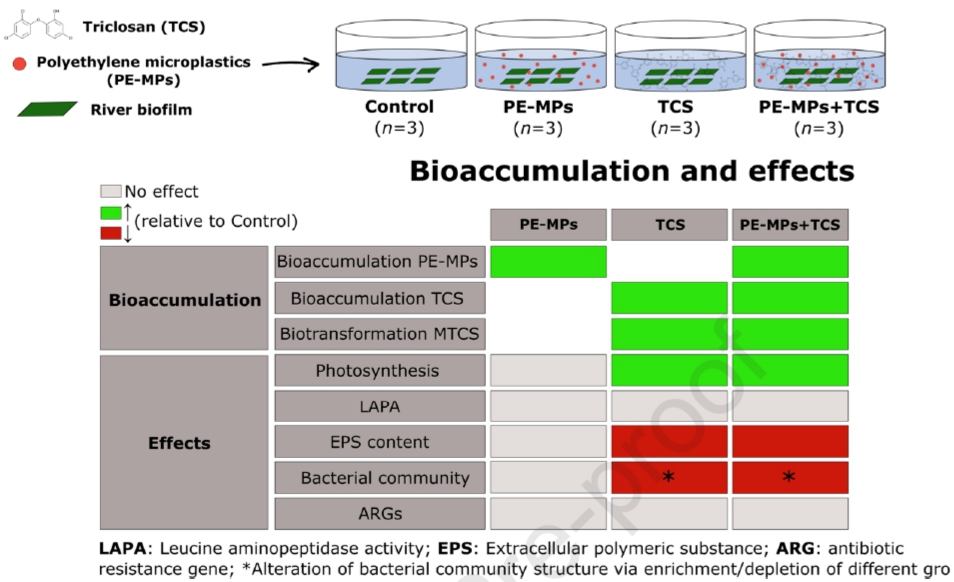
Contents lists available at ScienceDirect

Environmental Pollution

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

Accumulation of polyethylene microplastics in river biofilms and effect on the uptake, biotransformation and toxicity of the antimicrobial triclosan☆

J.M. Castaño-Ortiz [a,b], F. Romero [a,b,c], L. Cojoc [a,b], D. Barceló [a,b,d], J.L. Balcázar [a,b], S. Rodríguez-Mozaz [a,b], L.H.M.L.M. Santos [a,b,*]



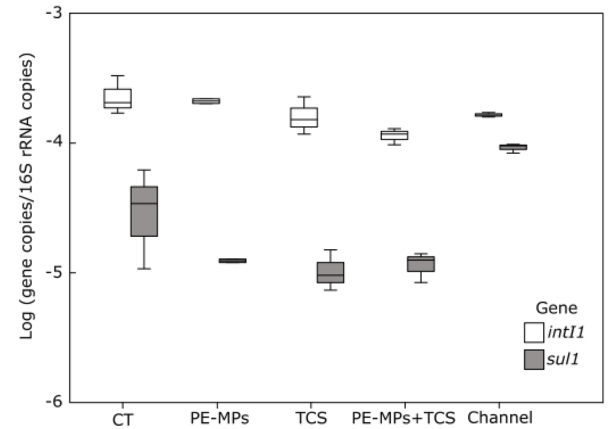
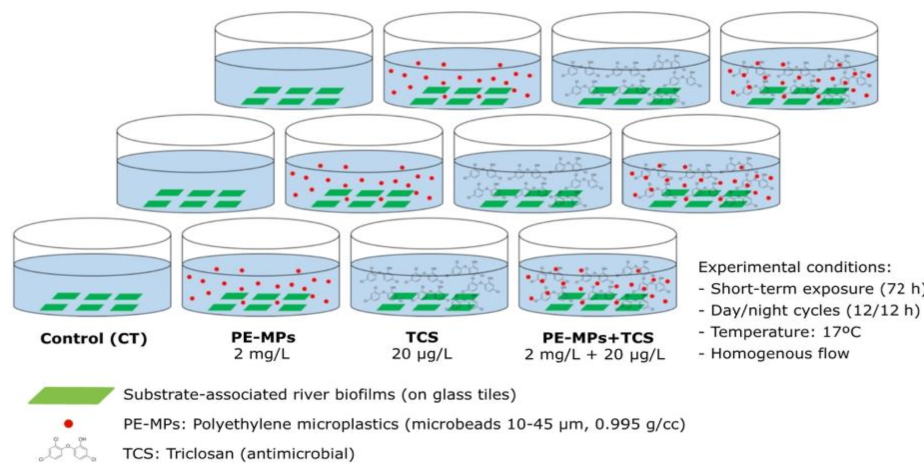


Fig. 6. Abundance of class 1 integron-integrase gene (*intI1*) and the antibiotic resistance gene *sul1* normalized to the 16S rRNA gene copies in the different exposure conditions. CT = Control; PE-MPs = polyethylene microplastics with a particle size of 10–45 µm (2 mg/L); TCS = triclosan (20 µg/L); PE-MPs + TCS = PE-MPs (2 mg/L) and TCS (20 µg/L).



Journal of Hazardous Materials 432 (2022) 128691

Contents lists available at ScienceDirect

Journal of Hazardous Materials

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

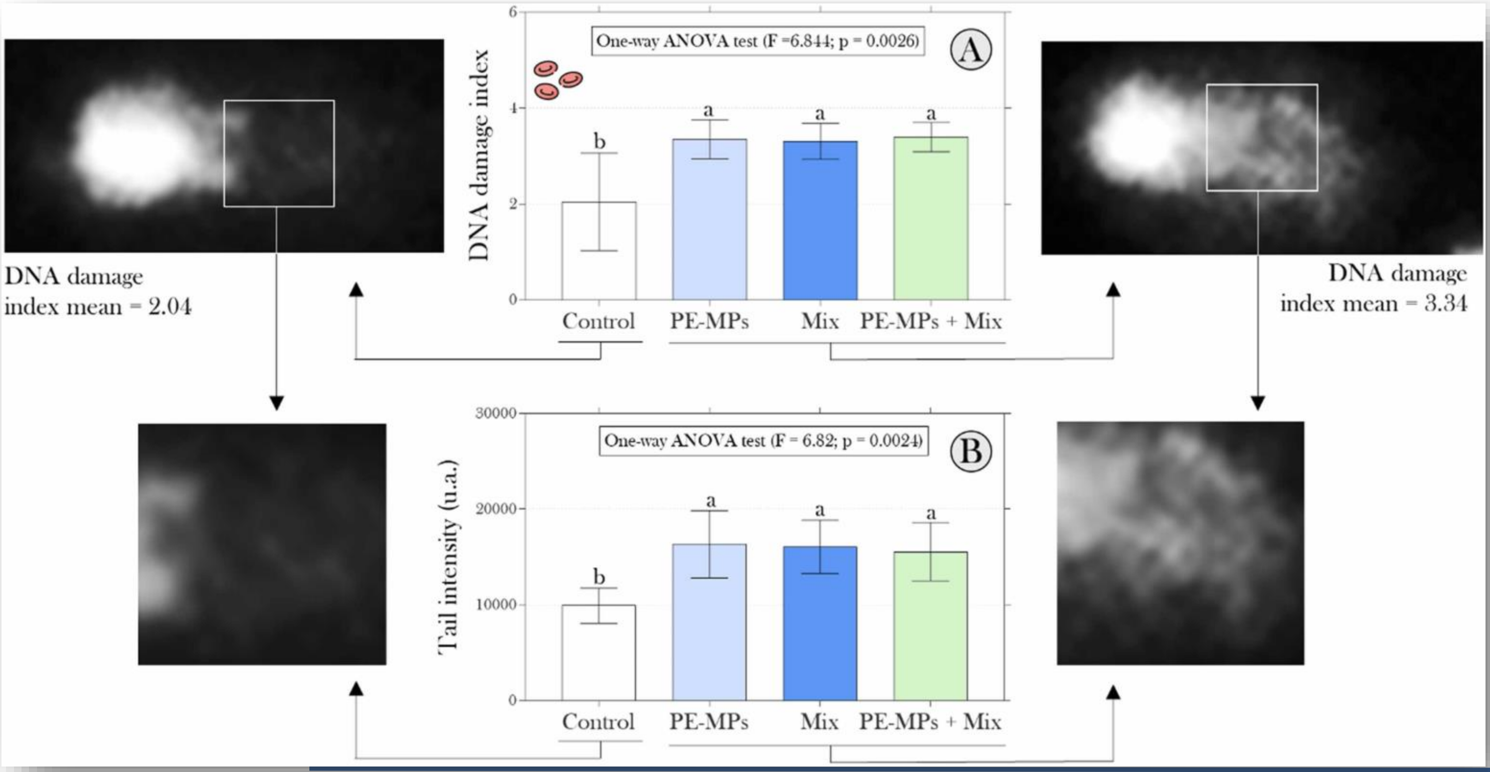
ELSEVIER

Research Paper

Toxicity evaluation of the combination of emerging pollutants with polyethylene microplastics in zebrafish: Perspective study of genotoxicity, mutagenicity, and redox unbalance

Amanda Pereira da Costa Araújo [a], Thiarlen Marinho da Luz [b], Thiago Lopes Rocha [c], Mohamed Ahmed Ibrahim Ahmed [d], Daniela de Melo e Silva [a,e], Md Mostafizur Rahman [f,g], Guilherme Malafaia [b,h,i,j,*]

✓ ***Genotoxic effect is similar in zebrafish exposed to PE-MPs and to mix of pollutant***



Ecological Indicators 150 (2023) 110215

Contents lists available at ScienceDirect

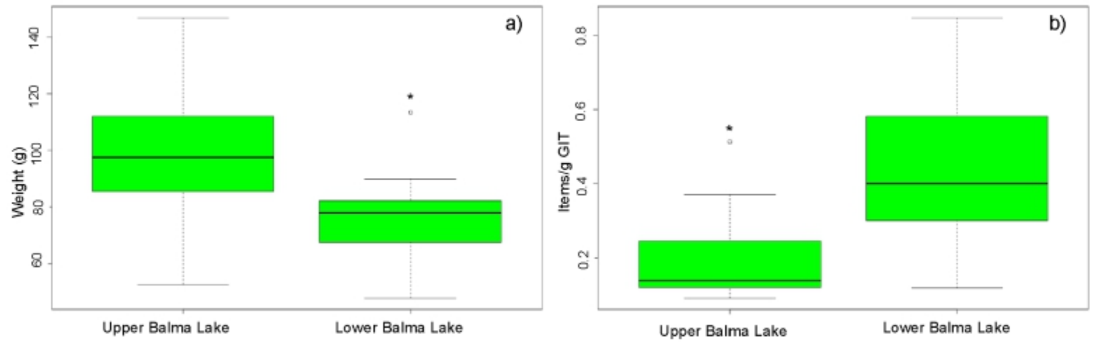
Ecological Indicators

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

ELSEVIER

Microplastics in biotic and abiotic compartments of high-mountain lakes from Alps

Paolo Pastorino[a,*], Serena Anselmi[b], Giuseppe Esposito[a], Marco Bertoli[c], Elisabetta Pizzul[c], Damià Barceló[d,e], Antonia Concetta Elia[f], Alessandro Dondo[a], Marino Prearo[a], Monia Renzi[c]



›oxplots of weight of *Salvelinus fontinalis* in both Upper (n = 11) and Lower (n = 9) Balma Lake in which microplastics items were reco

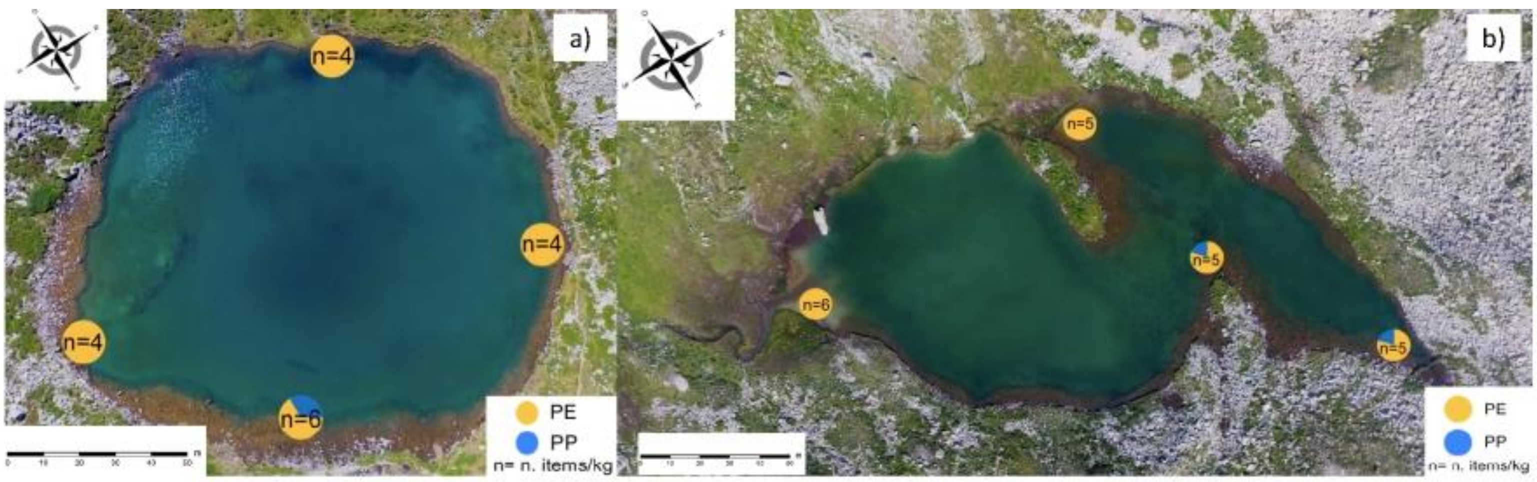


Fig. 2. Location of sampling sites for sediment samples in Lower (a) and Upper (b) Balma Lake. Colors (yellow and light blue) represent a different chemical t microplastics (PE = polyethylene; pp = polypropylene). It is also reported the number of items (n) recorded at each site. (For interpretation of the references tc

Microplastics in Mediterranean seafood (Tunisian coast)

Species	Mean ±SD particles/g
Mullus barbatus	9.04E+04 ±5.09E+04
Sardina pilchardus	8.86 E+04 ±4.05E+04
Mytilus galloprovincialis	8.83E+04 ±4.16E+04
Solea solea	9.38E+04 ±2.85E+04
Sparus aurata – wild	9.50E+04 ±6.64E+04
Sparus aurata – farmed	8.66E+04 ±2.43E+04

- The highest EDIs are for ingestion of farmed *S. aurata*
- MPs <3 µm were detected (method: SEM-EDX) in edible muscle of five species from Mediterranean Sea
- The smallest and biggest MPs (1.8 and 2.5 µm) were found in mullus and sole, respectively.
- The highest level of MPs was found in *M. surmuletus* being a neritic species.
- The presence of MPs in species used for human consumption is a fact today. However, information on the MPs occurrence are again incomplete, the EDIs for seafood are largely unknown.

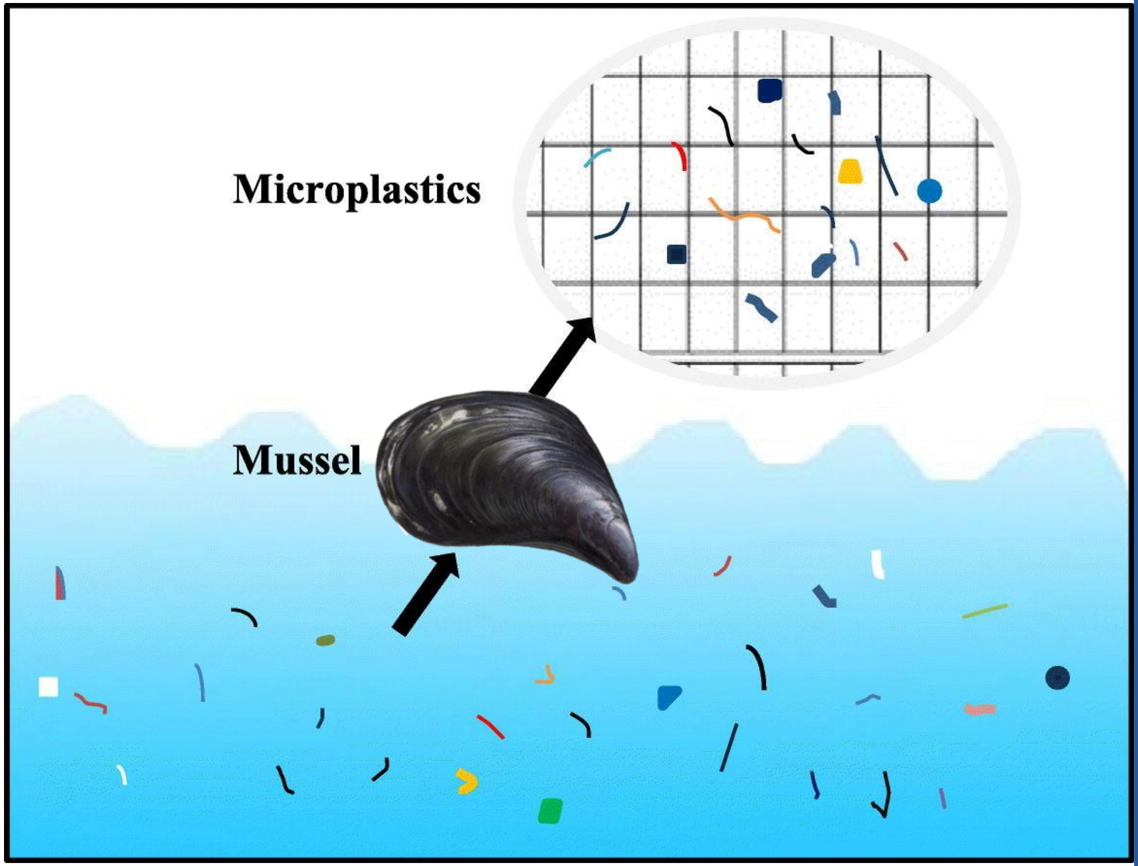
Ferrante et al., 2021
Environ. Res.

MYTILUS GALLOPROVINCIALIS AS BIOINDICATOR OF MICROPLASTIC POLLUTION

For marine environments, bivalves as *Mytilus galloprovincialis* have been found to be the most suitable organisms for biomonitoring, becoming good bioindicators for their natural habitat (Li et al., 2019).

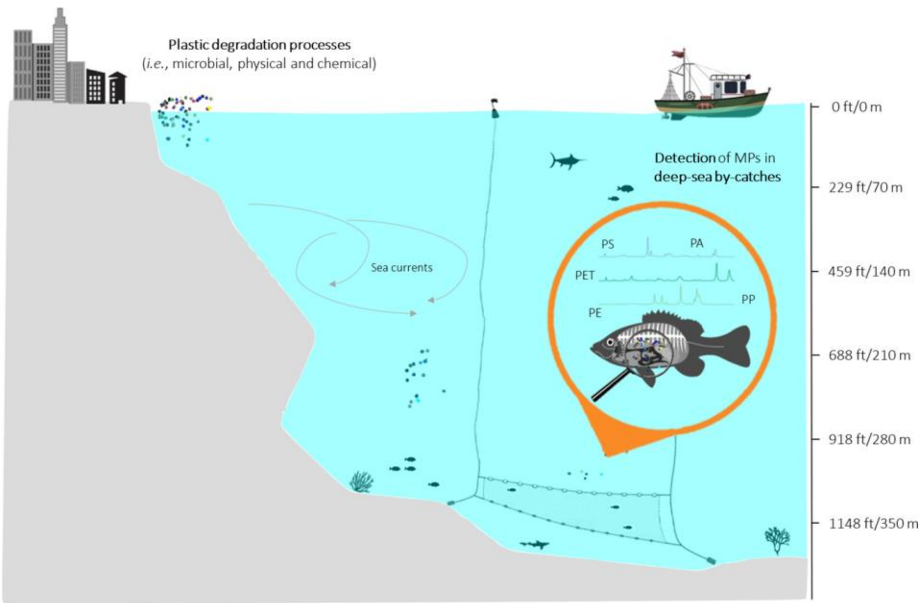
- *M. galloprovincialis* has a high ecological and commercial relevance in the Mediterranean Sea, where MPs contamination is also of particular concern (Lusher, 2015).

- *M. galloprovincialis* has been proposed by the International Council for the Exploration of the Sea to monitor MP pollution in the marine environment (Bråte et al., 2018).



Occurrence of microplastics in the gastrointestinal tract of benthic by–catches from an eastern Mediterranean deep–sea environment

- Deep-sea fish species were collected in Sardinia (Italy) using a bottom gillnet at depths between -250 and -350 m
- At least one microplastic item was found in 48% of the samples
- The most frequent was polyethylene (PE)
- Filament was the most frequent shape recorded



Esposito et al., 2022
Mar. Pollut. Bull.

Journal of Hazardous Materials 460 (2023) 132359

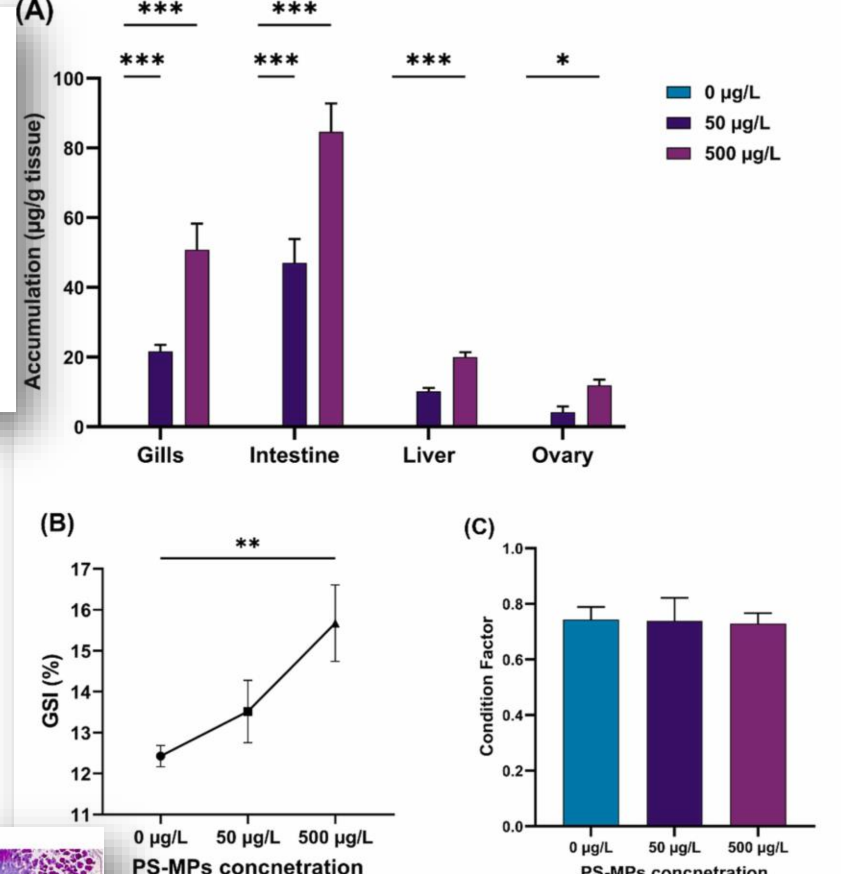
Contents lists available at ScienceDirect

Journal of Hazardous Materials

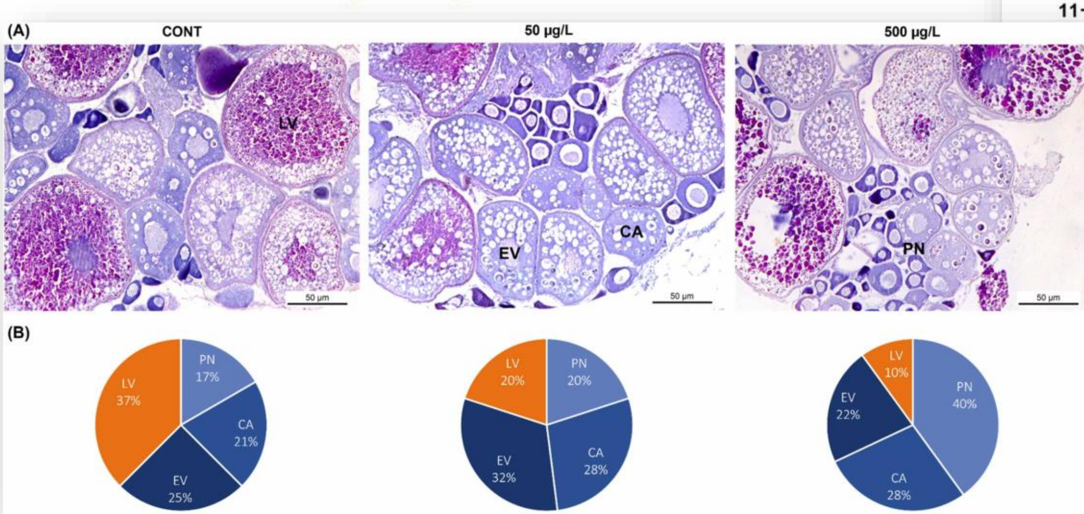
journal homepage: www.elsevier.com/locate/jhazmat

Polystyrene microplastics disrupt female reproductive health and fertility via sirt1 modulation in zebrafish (*Danio rerio*)

Priya Gupta [a,1], Archisman Mahapatra [a,1], Anjali Suman [a], Shubhendu Shekhar Ray [a], Guilherme Malafaia [b,c,d,e,*], Rahul Kumar Singh [a,**]



- ✓ ***PS-MP exposure altered GSI and fecundity rate in female zebrafish***



- ✓ ***PS-MPs affected ovarian maturity and oocyte development***

Combined HFD and PE-MP exposure increased lipid accumulation, total cholesterol, and triglycerides

Science of the Total Environment 902 (2023) 165988

ELSEVIER

Contents lists available at ScienceDirect

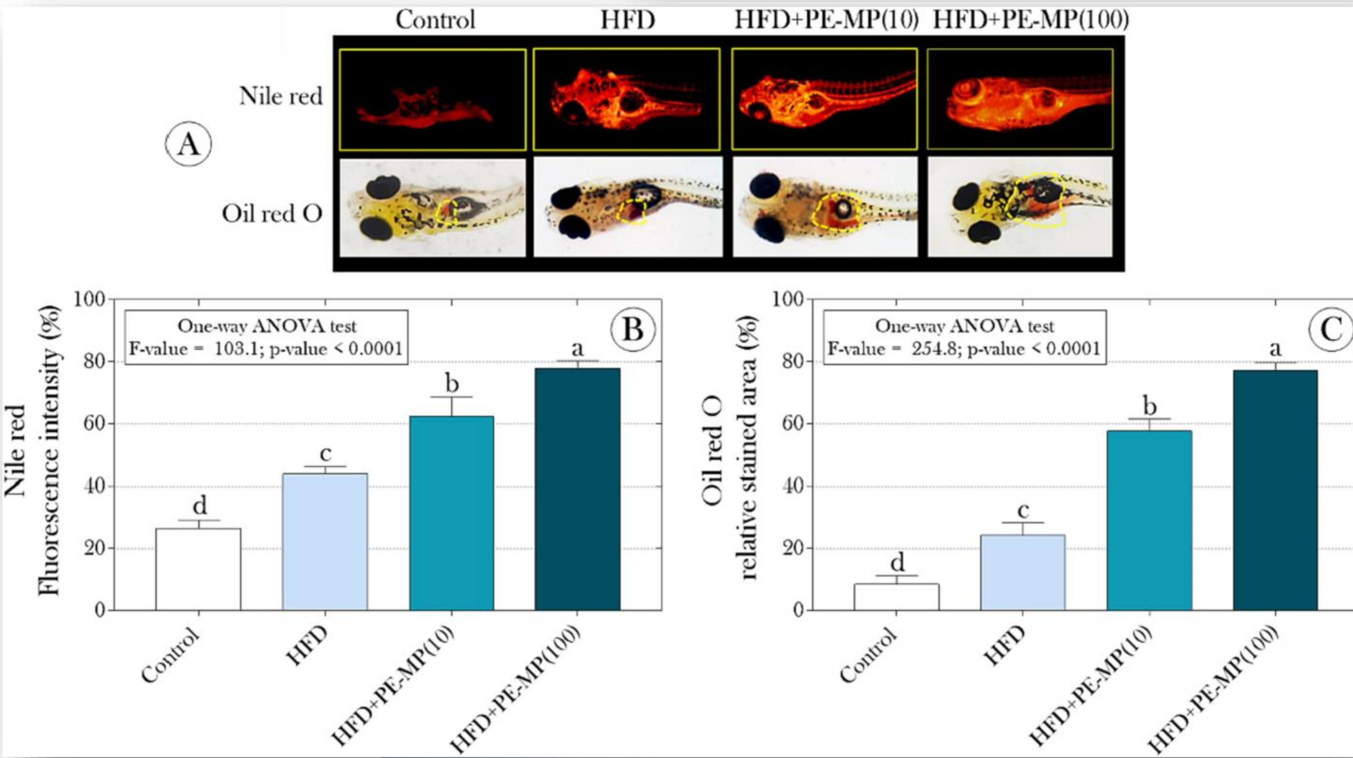
Science of the Total Environment

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

Check for updates

Combined effects of a high-fat diet and polyethylene microplastic exposure induce impaired lipid metabolism and locomotor behavior in larvae and adult zebrafish

Seenivasan Boopathi [a], B. Haridevamuthu [a], Edrea Mendonca [a], Akash Gandhi [a], P. Snega Priya [a], Saad Alkahtani [b], Norah S. AL-Johani [b], Selvaraj Arokiyaraj [c], Ajay Guru [d,*], Jesu Arockiaraj [a,**], Guilherme Malafaia [e,f,g,***]



Contents lists available at ScienceDirect

Science of the Total Environment

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

Green toxicology approach involving polylactic acid biomicroplastics and neotropical tadpoles: (Eco)toxicological safety or environmental hazard?

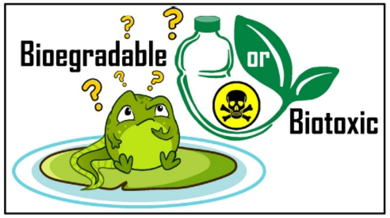
Guilherme Malafaia [a,b,c,d,*], Ítalo Freitas Nascimento [a], Fernanda Neves Estrela [a,c], Abraão Tiago Batista Guimarães [a,c], Fabianne Ribeiro [e], Thiarlem Marinho da Luz [a], Aline Sueli de Lima Rodrigues [b,c]

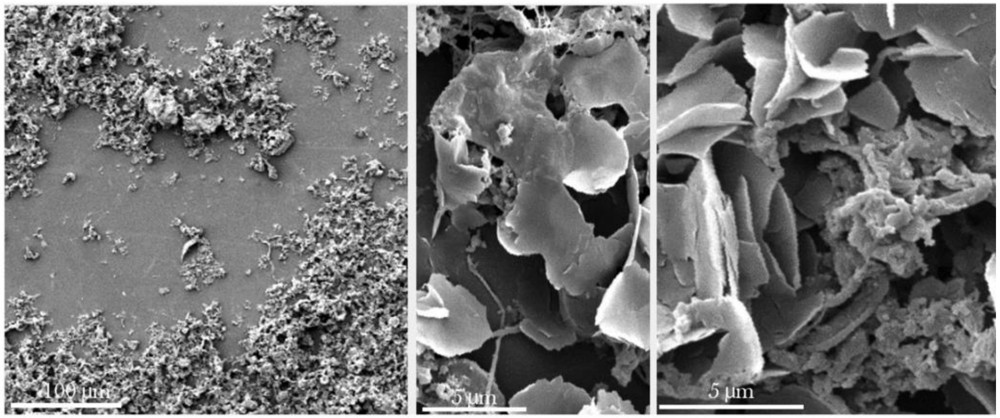
[a] *Biological Research Laboratory, Goiano Federal Institute, Urutaí, GO, Brazil*
[b] *Post-Graduate Program in Conservation of Cerrado Natural Resources, Goiano Federal Institute, Urutaí, GO, Brazil*
[c] *Post-Graduate Program in Biodiversity and Biotechnology, Federal University of Goiás, Goiânia, Brazil*
[d] *Post-Graduate Program in Ecology and Conservation of Natural Resources, Federal University of Uberlândia, MG, Brazil*
[e] *Department of Biology & CESAM - Center for Environmental and Marine Studies, University of Aveiro, Portugal*

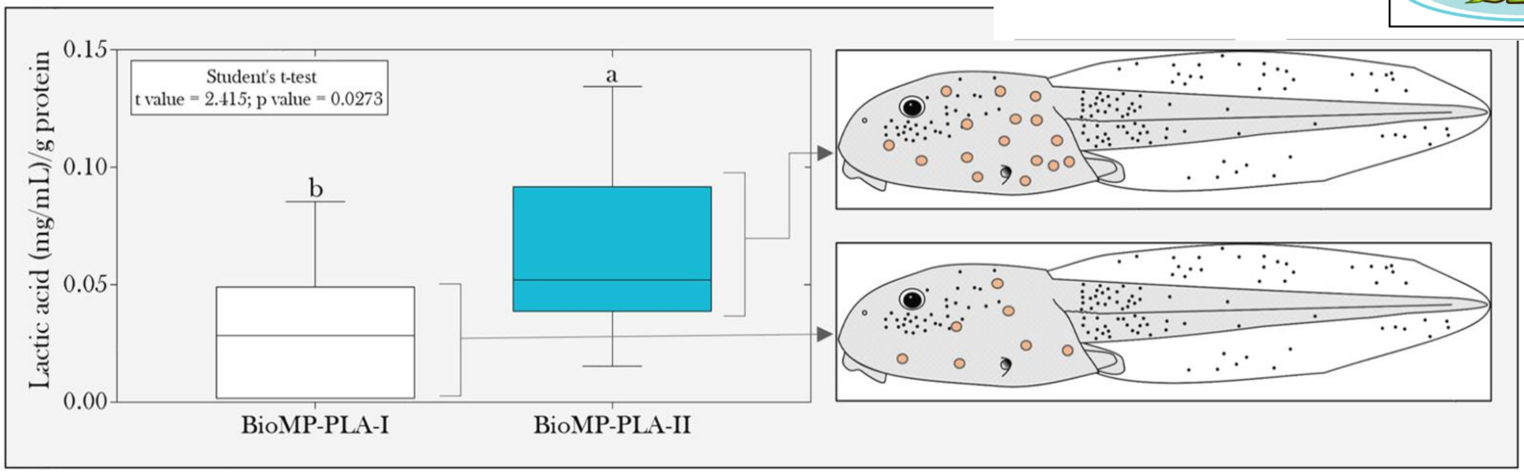
HIGHLIGHTS

- Polylaic acid biomicroplastic (PLA BioMP) affects growth and development of *Physalaemus cuvieri* tadpoles.
- *P. cuvieri* tadpoles exposed to PLA BioMPs show a reduction in lipid reserves.
- PLA BioMPs induce cholinesterase effect (increased AChE and BChE) in *P. cuvieri* tadpoles.
- Increased oxidative stress is observed in *P. cuvieri* tadpoles exposed to PLA BioMPs.

GRAPHICAL ABSTRACT







✓ **Accumulation of Polylactic acid biomicroplastic (PLA BioMP) in *P. cuvieri***

Journal of Hazardous Materials 472 (2024) 134574

Contents lists available at ScienceDirect

Journal of Hazardous Materials

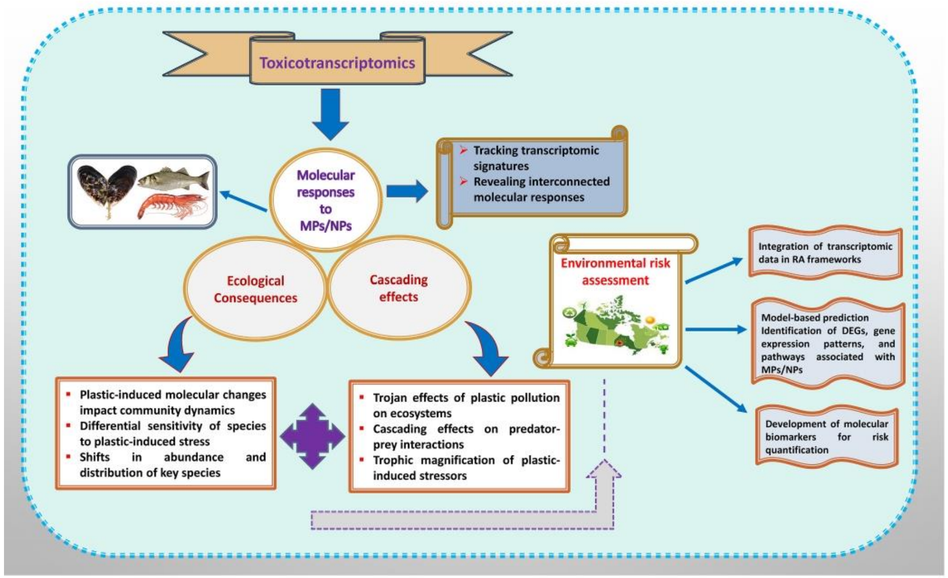
journal homepage: www.elsevier.com/locate/jhazmat

Review

Decoding the molecular concerto: Toxicotranscriptomic evaluation of microplastic and nanoplastic impacts on aquatic organisms

Syed Shabi Ul Hassan Kazmi [a,b], Muhammad Tayyab [c], Paolo Pastorino [d], Damià Barcelò [e], Zaher Mundher Yaseen [f,g], Hans-Peter Grossart [h,i], Zulqarnain Haider Khan [a,b], Gang Li [a,b,*]

[a] Key Laboratory of Urban Environment and Health, Ningbo Urban Environment Observation and Research Station, Institute of Urban Environment, Chinese Academy of



7. Schematic overview illustrates interconnected relationships between transcriptomic analyses, ecological consequences, cascading effects, and environmental assessment in the context of plastic-induced molecular changes in aquatic organisms. **Note:** MPs/NPs= Microplastics, nanoplastics; DEGs= differentially

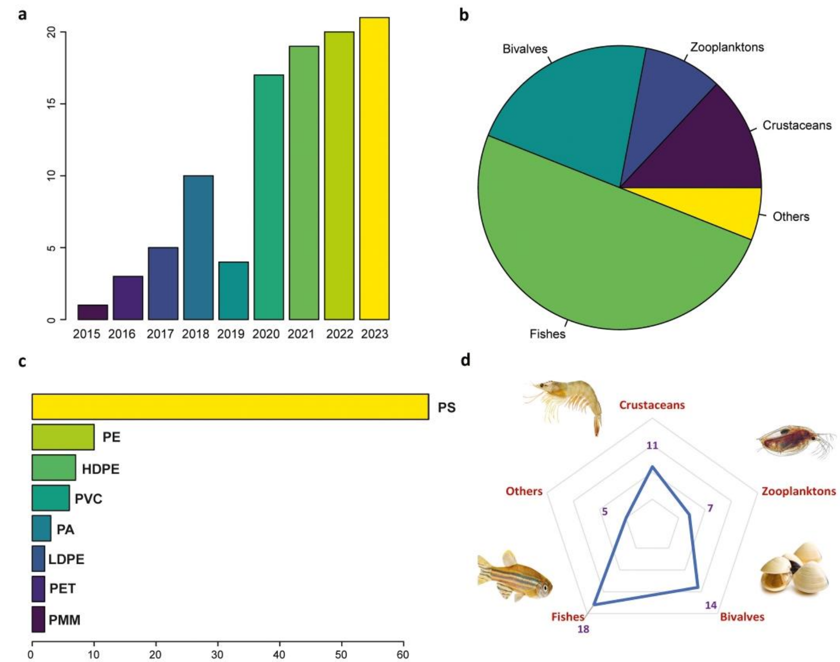
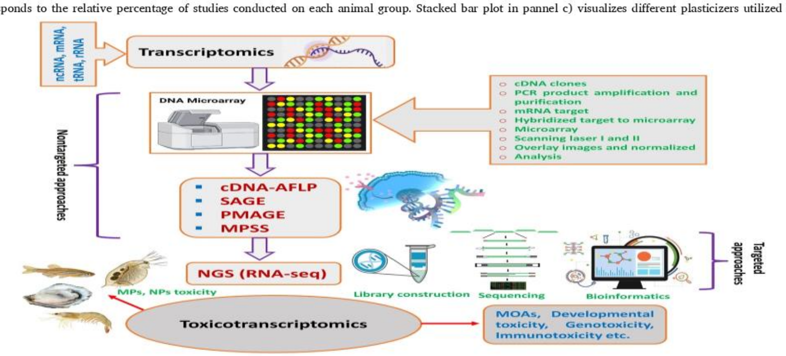


Fig. 4. Bar plot a) illustrates the temporal distribution of studies conducted between 2015 and 2023 focusing on the evaluation of MPs and NPs impacts on aquatic organisms using transcriptomic approaches. Each bar represents a specific year, showcasing the cumulative number of studies summarized. Pannel b) pie chart depicting the distribution of studies on different aquatic organisms, including bivalves, zooplanktons, crustaceans, fishes, and other taxa. The size of each pie slice corresponds to the relative percentage of studies conducted on each animal group. Stacked bar plot in pannel c) visualizes different plasticizers utilized in the



g. 3. Two distinct approaches exist for conducting transcript or gene expression analysis. Targeted methods involve quantifying transcripts based on previ owledge of relevant gene sequences, employing methods based on reporter systems or PCR. Transcriptomics plays a pivotal role in target selection, while targ proaches facilitate the validation of transcriptome data, particularly concerning transcript regulation in response to pollutant (e.g., MPs and NPs) concentrat d time, necessitating the analysis of numerous samples for optimal resolution. Note: ncRNA= non-coding RNA; mRNA= protein-coding messenger R

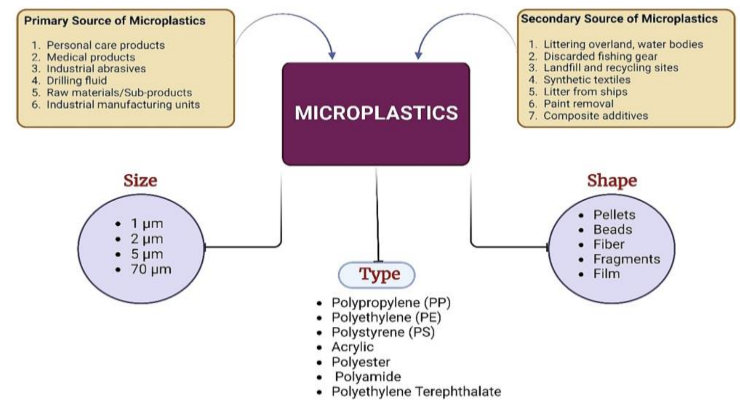


Fig. 1. Sources and Characteristics of Microplastics.

Contents lists available at ScienceDirect

Ecological Indicators

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

Vulnerability of microplastics on marine environment: A review

Chinnathambi Pothiraj [a], Tamilselvan Amutha Gokul [b], Kamatchi Ramesh Kumar [b], Arumugam Ramasubramanian [c], Ayyappan Palanichamy [a], Karthikeyan Venkatachalam [d], Paolo Pastorino [e], Damia Barcelò [f], Paulraj Balaji [g,*], Caterina Faggio [h,*]

Table 1
Adverse Effects of the Polymers and their Additives on Aquatic Organisms.

Polymers / Additives	Effects
Polystyrene	Intestinal injury, oxidative stress, Growth, food uptake
Polyamide, Polyethylene, Polypropylene, Poly Vinyl Chloride	Damage in Intestinal, Liver, kidney and reproductive tract
Polyethylene Terephthalate	Feed habit, body weight
UV Stabilizers/absorbers	Mutagenic, toxic, bioaccumulated and show estrogenic activity
Antioxidants	Estrogenic effects
Plasticizers	Renal, reproductive, cardio, and neuro-toxicity
Flame retardants	Endocrine disruptors
Pigments	Duplication of food resulting gut blockage
Surfactants	Destroy mucus layer, damage gills

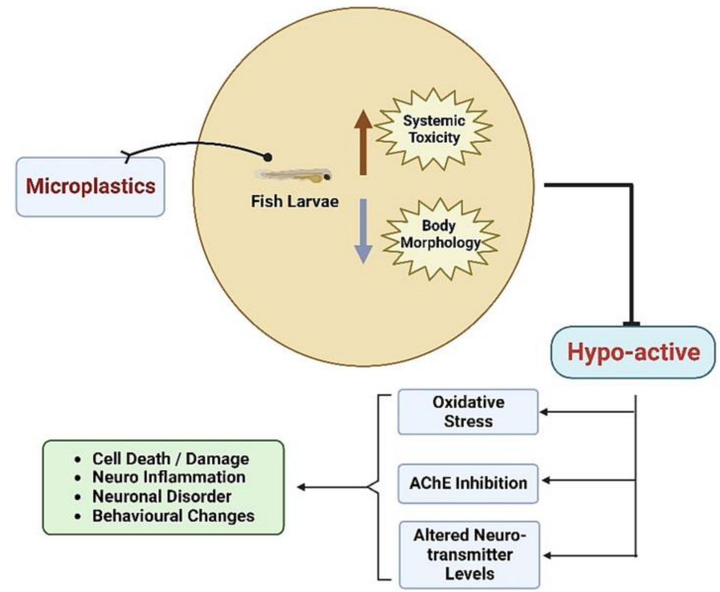


Fig. 2. Mechanism of action of microplastics on AChE.

MPs/NPs and co-contaminants: toxicity and general bioaccumulation of MPs/NPs

- **Aquatic organisms**, such as river biofilms and mussels, were able to **accumulate pharmaceuticals** and the presence of PE-MPs delay the bioaccumulation of citalopram (mussels)
- More studies on MPs particle sizes and polymer types are needed. PS and PE among the most tested polymers, as well as antibiotics (Pharmaceuticals)
- **Laboratory controlled real-world environmental concentrations are needed**, using **aged microplastics** and **long-term exposure** to assess chronic effects
- **MPs accumulation in fish and small crustaceans**
- **AchE inhibiton in zebrafish due to MP altering neirobalsts in larvae**
- **Bioacumulation and Biomagnification and Green Ecotoxicological Prtocols**
- **Toxicotranscriptomics: additional information of molecular responses of aquatic organisms to MPs/NPs**
- **In summary: MP (PE) are present everywhere, high-mountain lakes, in the gastrointestinal tract of benthic by–catches from an eastern Mediterranean, »Mussel Watch», deep sea-environment MPs (< 3 μm)in seafood-** *Sardina, Solea, Mytillus*

Occurrence, Analysis , Fate and Risk of MPs General recommendations

1) Analytical protocols, including sampling and detection methods. Methods X recent paper A standardized method ASTM D8332 pumping 1500 liters of water in 45 minutes to collect particles as small as 45µm, New method using NMR. What about Nanoplastics?

2) Harmonization through inter-laboratory studies and reference material will need to be undertaken at local and global scale

3)Green Ecotoxicological studies using environmental relevant concentrations and representative species at global scale needed

4)Establish an international database to collect occurrence data of long-term monitoring programs

5)How is MPs pollution as compared to other threats like Climate Change a threat to biota, ecosystem and biodiversity? Major or Minor?

6)At present there is no evidence that MPs are a threat to human health, but this can change- fibers in the air at Megacities > 10 Million ? More data on occurrence of MPs in biological fluids?

GLOBAL INTERLABORATORY STUDY ON MICROPLASTICS-34 laboratories

Science of the Total Environment 772 (2021) 145071

ELSEVIER

Contents lists available at ScienceDirect

Science of the Total Environment

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

Results of WEPAL-QUASIMEME/NORMANs first global interlaboratory study on microplastics reveal urgent need for harmonization

Check for updates

L.M. van Mourik [a,*], S. Crum [b], E. Martinez-Frances [c], B. van Bavel [c], H.A. Leslie [a], J. de Boer [a], W.P. Cofino [b]

[a] Department of Environment and Health (E&H), Faculty of Sciences, Vrije Universiteit, De Boelelaan 1085, 1081 HV Amsterdam, the Netherlands
[b] WEPAL-QUASIMEME Laboratory Performance Studies, Wageningen University and Research Centre, PO Box 8005, NL-6700 EC Wageningen, the Netherlands
[c] Norwegian Institute for Water Research (NIVA) Section Environmental Chemistry and Technology,

HIGHLIGHTS

- Thirty-four laboratories participated in a microplastics interlaboratory study.
- Dissolvable tablets were developed to be used as test materials.
- Correct type of polymer was often reported indicating satisfactory performance.
- The large variation in reported particle numbers shows the need for harmonization.

GRAPHICAL ABSTR

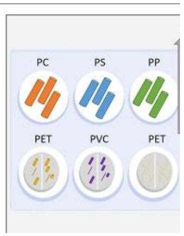


Table 3
Identification method performance for samples 1–6.

Identification method	Method applied (n)	Percentage that identified correct polymer					
		Sample 1 PC	Sample 2 PS	Sample 3 PP	Sample 4 PET	Sample 5 LDPE	Sample 6 PS
μFTIR	6	83%	67%	83%	83%	83%	100%
ATR-FTIR	15	100%	100%	100%	87%	53%	100%
Raman	3	100%	100%	100%	67%	67%	100%
μRaman	1	100%	100%	100%	100%	100%	100%
Py-GC-MS	2	50%	50%	100%	100%	50%	100%

PC, Polycarbonate; PS, Polystyrene; PP, Polypropylene; PET, Polyethylene terephthalate; LDPE, Low-density polyethylene.

RECOMENDATIONS for HARMONIZATION AND LIMITATIONS

- Concentrations of MPs should be reported using more consistent units such as particles/m3 for water and particles/g for sediments.
- The from of MPs should be standarized to harmonise inter-study comparisons: fibre, fragments ,granule, film and foam
- Studies should provide size information about MPs including smallest size collected and detected-we need to understand the size distribution of MPs. We need to consider as well LOD of the analytical instruments
- Analysis of polymer composition should be performed using one of the appropriate techniques, like micro-FTIR, Raman Spectroscopy and/or Pyrolisis GC-MS
- Detailed information about the method used and QA/QC protocols are required.

Table 4

A specific example – Limitations relevant to the study of microplastics in the environment that merit discussion.

1. What size range are you reporting on, and how does this compare to the literature and indeed the probable natural size range?
2. Have you included positive and negative controls, and published your LOD/LOQ methodology?
3. How do your analytical methods compare to those used by other scientists?
4. If you used a microscopic system which required the operator to select targets, could operator bias have influenced your results?
5. What software and library did you use? Different software libraries accept greater or lesser matching of spectra with those of standards.

Contents lists available at ScienceDirect

MethodsX

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

High throughput application of ASTM D8332: Detailed prototype design and operating conditions for microplastic sampling of riverine systems

Jeremiah Bryksa*, Patric McGlashan, Nadia Stelck, Jon Wong, Andrew Anderson-Serson, Matthew Hart, Trace Malcom, Bob Battle, Paolo Mussone

Northern Alberta Institute of Technology, 10210 Princess Elizabeth Ave, Edmonton Alberta, T5G 0Y2 Canada

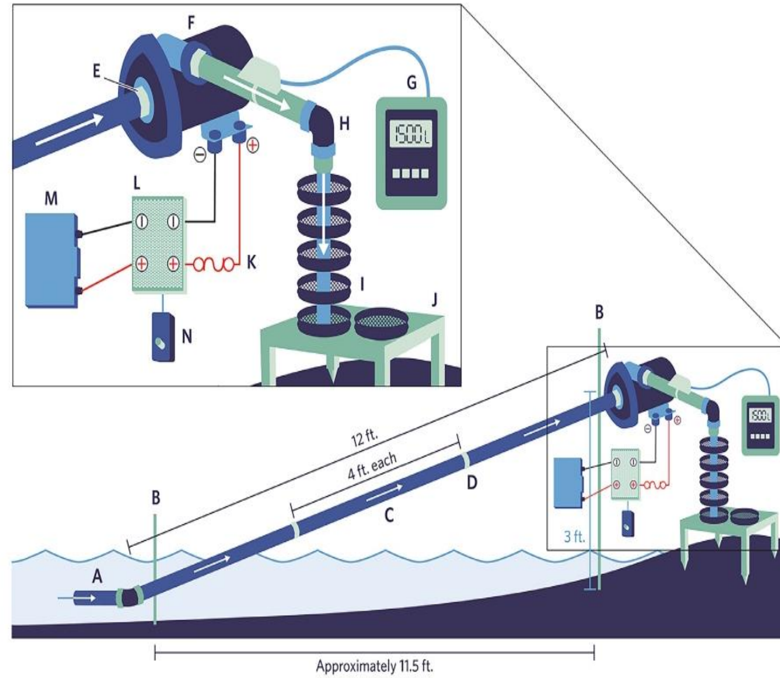


Fig. 1. Freshwater pumping system designed and fabricated in this work. **A** = river inlet $\frac{3}{4}$-inch stainless steel tube; **B** = metal clamps with stands; **C** = 4-foot $\frac{3}{4}$-inch stainless steel tubing sections; **D** = compression fittings; **E** = $\frac{3}{4}$-inch national pipe thread (NPT) fittings; **F** = centrifugal pump; **G** = clamp-on doppler flow sensor (optional); **H** = sample outlet (90° bend) $\frac{3}{4}$-inch stainless steel tubing; **I** = cascade sieve stack with field blank; **J** = aluminum sieve table with mounting spikes; **K** = 10 A fuse; **L** = variable speed controller; **M** = 12 V DC battery; and **N** = speed controller knob.

Fig. 2. High throughput microplastic sampling system components: centrifugal pump with electronics housed in a protective case (left), lithium iron phosphate battery housed in a protective case (center), cascading sieve stacks for samples and blanks with aluminum tables (right).

Fig. 3. Pumping river water in the field through a cascade sieve stack using 2 high throughput microplastic sampling system.

Fig. 4. Duplicate set-up of NAIT high throughput microplastic sampling system on the North Saskatchewan River.

RASIL

Contents lists available at ScienceDirect

Environment International

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

Full length article

Micro(nano)plastics from synthetic oligomers persisting in Mediterranean seawater: Comprehensive NMR analysis, concerns and origins

Alessia Giannattasio [a,1], Veronica Iuliano [a,1], Giuseppina Oliva [b], Domenico Giaquinto [b], Carmine Capacchione [a], Maria Teresa Cuomo [c], Shadi W. Hasan [d], Kwang-Ho Choo [e], Gregory V. Korshin [f], Damià Barceló [g], Vincenzo Belgiorno [b], Alfonso Grassi [a], Vincenzo Naddeo [b,*], Antonio Buonerba [a,b,*]

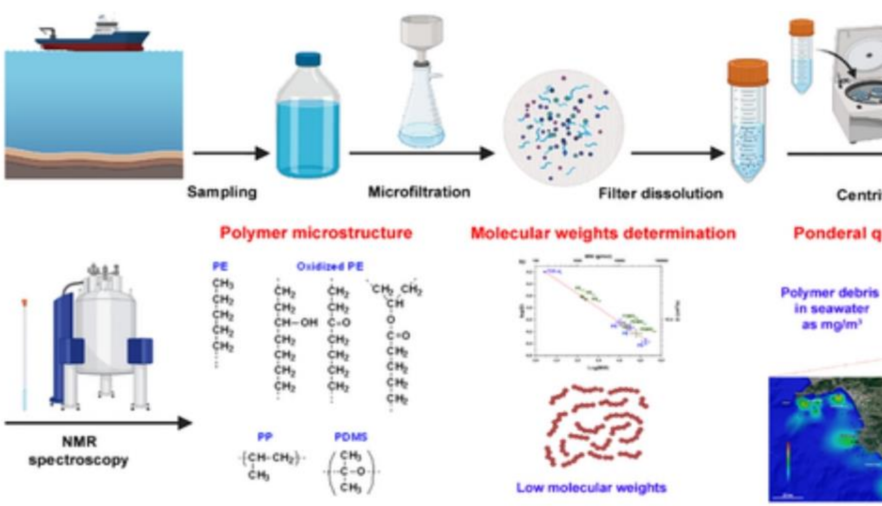


Fig. 2. Synoptical view for the analysis of seawater synthetic polymer debris.

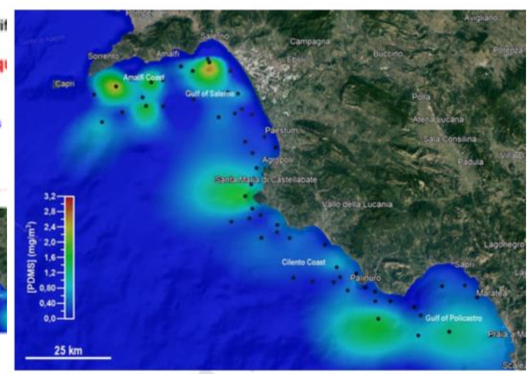


Fig. 8. PDMS concentrations. Coastal PDMS concentrations in Amalfi Coast-Gulf of Salerno (sampling period: 14/06/2021—23/06/2021) and Cilento Coa...

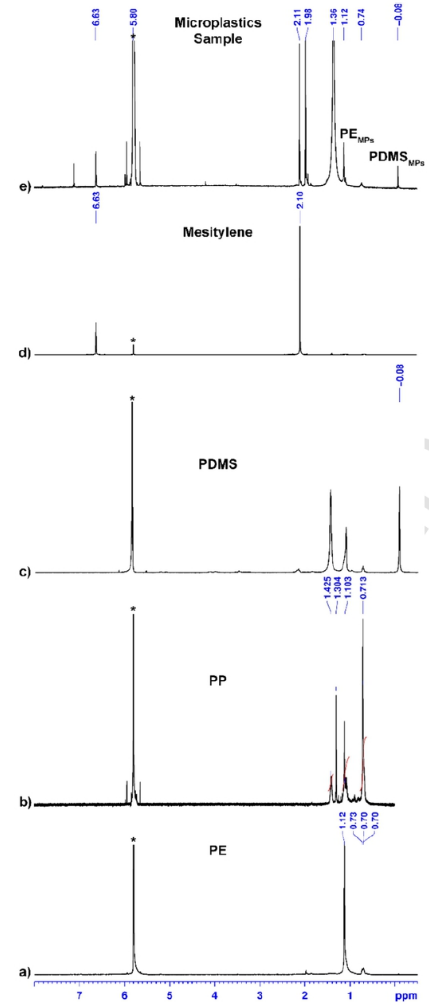


Fig. 5. NMR analysis. ¹H NMR spectra (600 MHz, TCE-d2, 80 °C) of LDPE (a), PP (b), PDMS (c), mesitylene (d) and representative SPD isolated from seawater (e).

Water Research 254 (2024) 121397

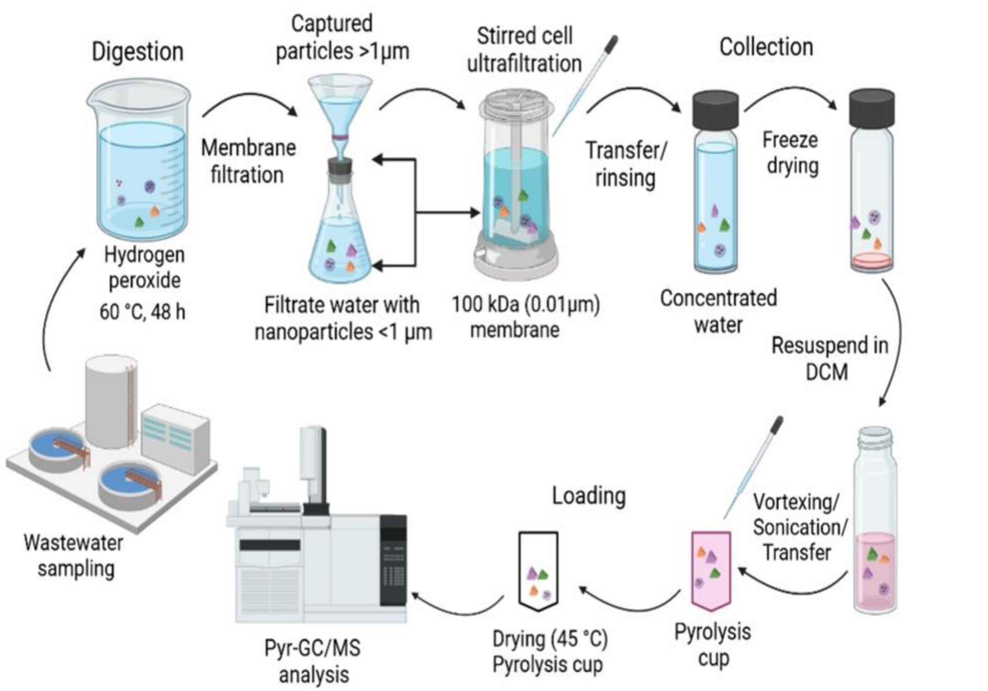
Contents lists available at ScienceDirect

Water Research

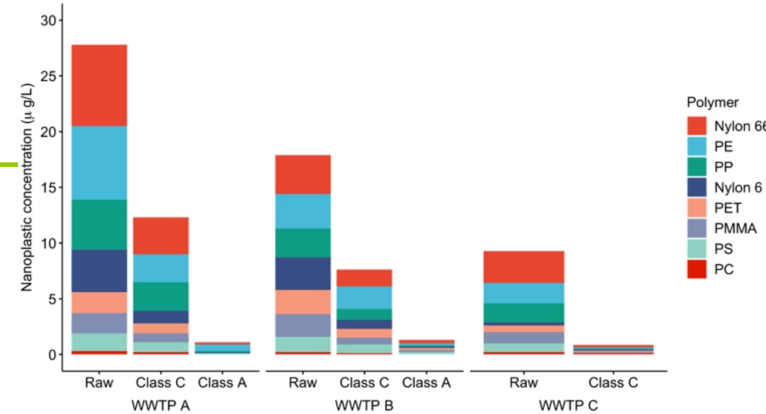
journal homepage: www.elsevier.com/locate/watres

Mass quantification of nanoplastics at wastewater treatment plants by pyrolysis–gas chromatography–mass spectrometry

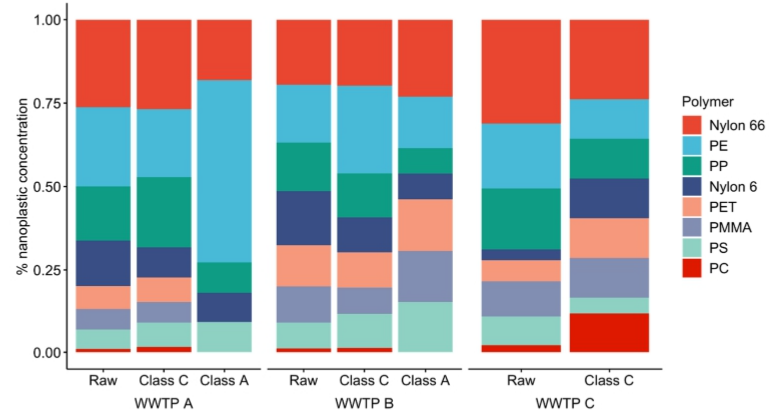
Elvis D. Okoffo *, Kevin V. Thomas



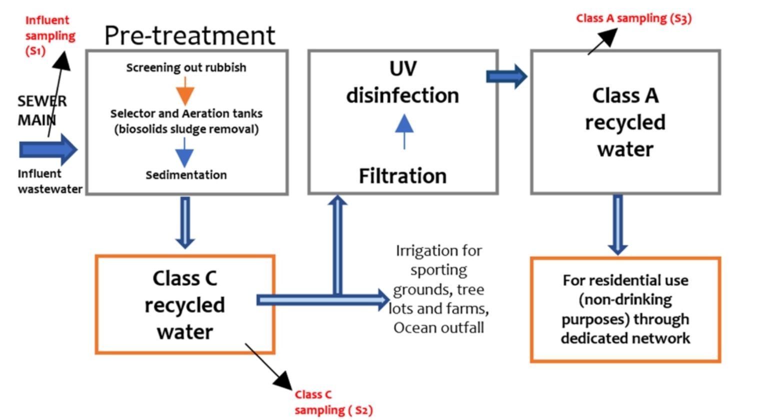
Pre-treatment processes of wastewater samples for nanoplastic detection by Pyr-GC/MS. Reproduced from (Okoffo and Thomas, 2024) with permission from



ig. 3. Mass concentrations (µg/L) of nanoplastics measured in the wastewater samples from WWTPs A, B and C.



ig. 4. Percentage of nanoplastic concentration by polymer type in the wastewater samples from WWTPs A, B and C



hematic of the treatment processes in the studied WWTPs and sampling sites. Class C is treated wastewater after combined primary and se

Airborne MPs in megacities:Paris, Shanghai,London, Beijing,Surabaya

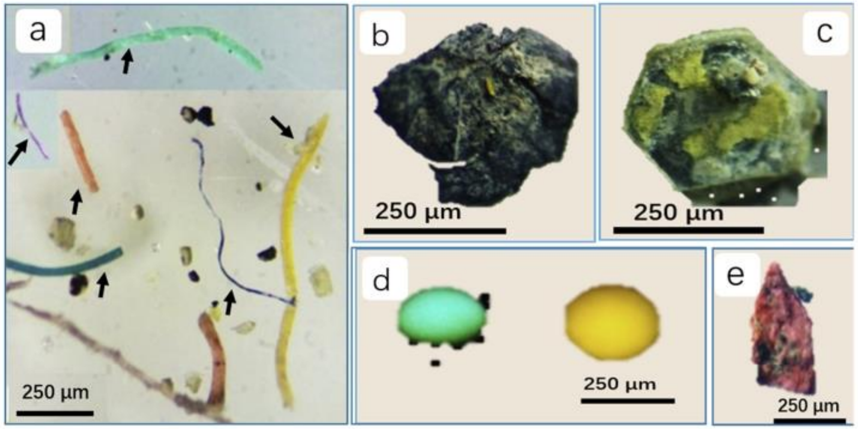


Fig. 5. Optical microscope images of different types of MPs. (a) Fibrous MPs, (b) film MPs, (c) film MPs, (d) spherical MPs, (e) fragmented M
et al. (2019), with permission from Elsevier (License number: 5223490330353).

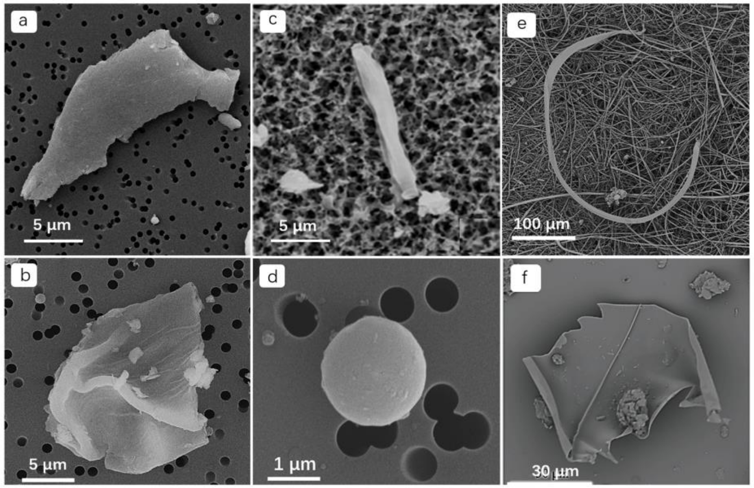


Fig. 4. SEM images of MPs. (a) Fragments MPs, (b) film MPs, (c), fibrous MPs and (d) Spherical MPs, (e) fibrous MPs and (f) film MPs. (a), (b) and (d) were colle in Beijing, China; (c) was collected in Beijing, China by Li et al. (2020), with permission from Elsevier (License number: 5223390347409); (e) and (f) were colle in Hangzhou, China.

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Journal of Cleaner Production

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

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Airborne microplastics: A review of current perspectives and environmental implications

Longyi Shao [a,b,*], Yaowei Li [a,b,c,**], Tim Jones [d], M. Santosh [e,f], Pengju Liu [a,b], Mengyuan Zhang [a,b], Liang Xu [g], Weijun Li [g], Jing Lu [a,b], Cheng-Xue Yang [e], Daizhou Zhang [h], Xiaolei Feng [a,b], Kelly BéruBé [i]

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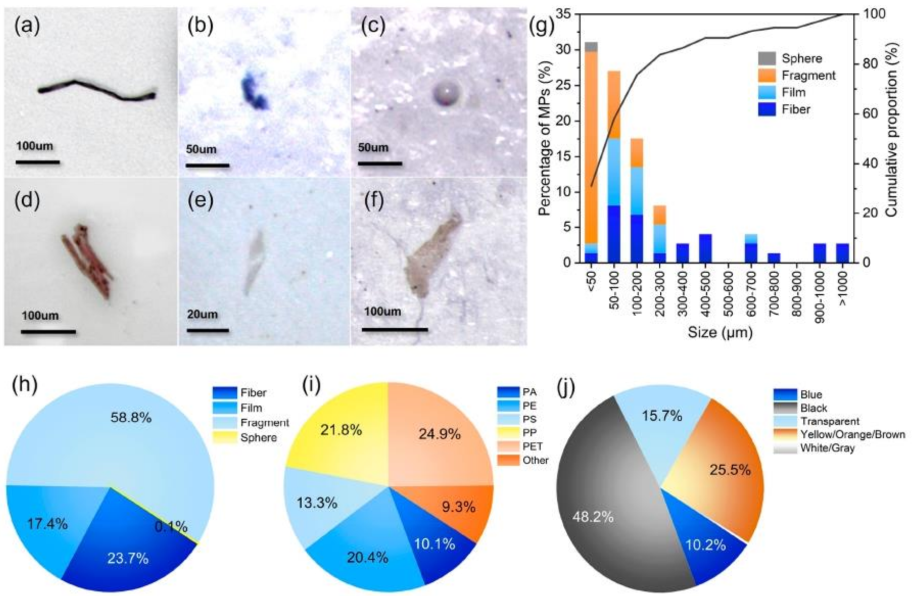
Environmental Science & Technology LETTERS

pubs.acs.org/journal/estlcu

Characterization of Microplastics in Clouds over Eastern China

Xinmiao Xu,[⊥] Tao Li,[⊥] Jiebo Zhen, Yuqian Jiang, Xiaoling Nie, Yan Wang,* Xian-Zheng Yuan, Huiting Mao, Xinfeng Wang, Likun Xue, and Jianmin Chen



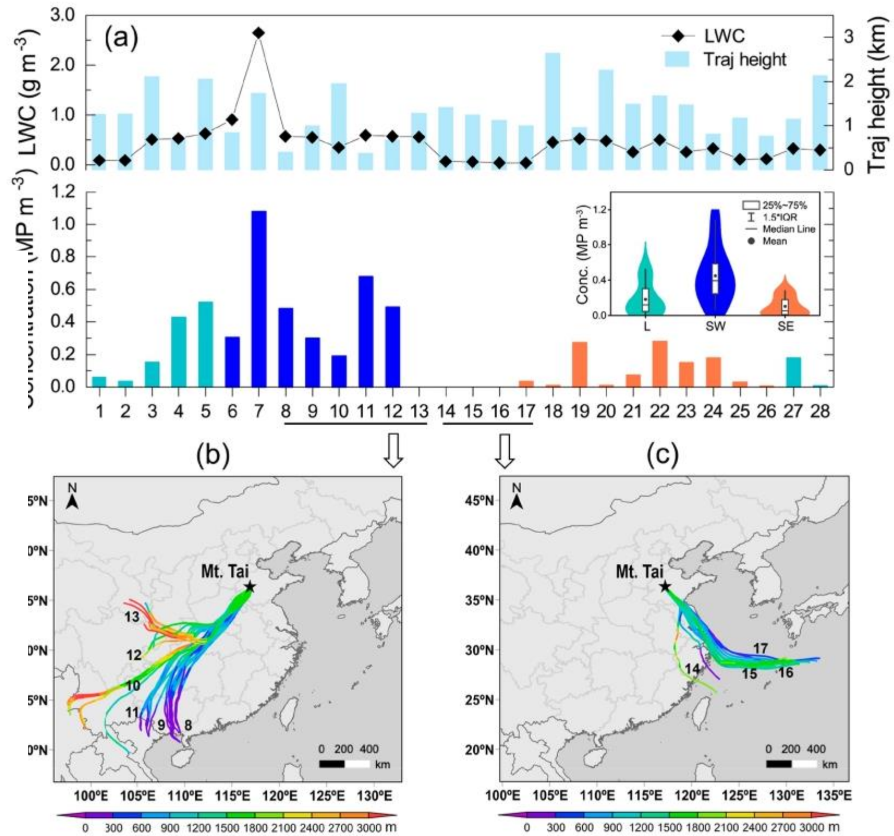


Figure 2. Characterization of MPs observed in cloudwater samples at Mt. Tai. Microscope images of typical MPs: (a, b) fibers, (c) sphere, (fragments, and (f) film. (g) Size distribution of MPs grouped by shape. Composition of MPs was based on (h) shapes, (i) polymers, and (j) cc

concentration and liquid water content (LWC) in cloudwater samples (IDs 1−28) in chronological sequer) 72-h backward trajectories for two continuous cloud events originating from the southwest continent (samples cean (samples 14−17) with trajectory height above sea level denoted by color scale. In panel (a), the average heig

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Environmental Toxicology and Pharmacology

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

Microplastics: Detection in human samples, cell line studies, and health impacts

Damià Barceló[a,b], Yolanda Picó[c,*], Ahmed H. Alfarhan[b]

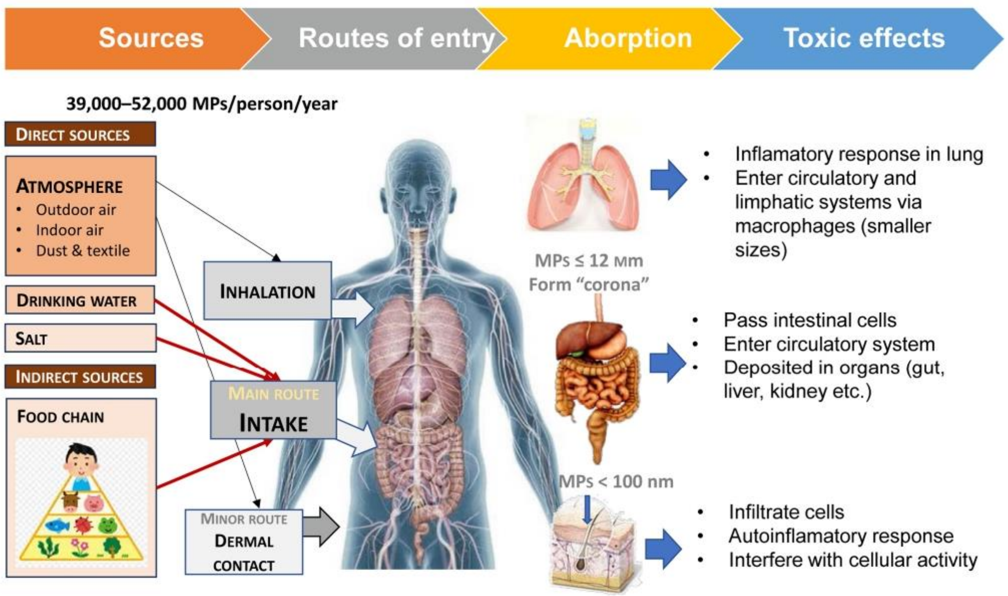
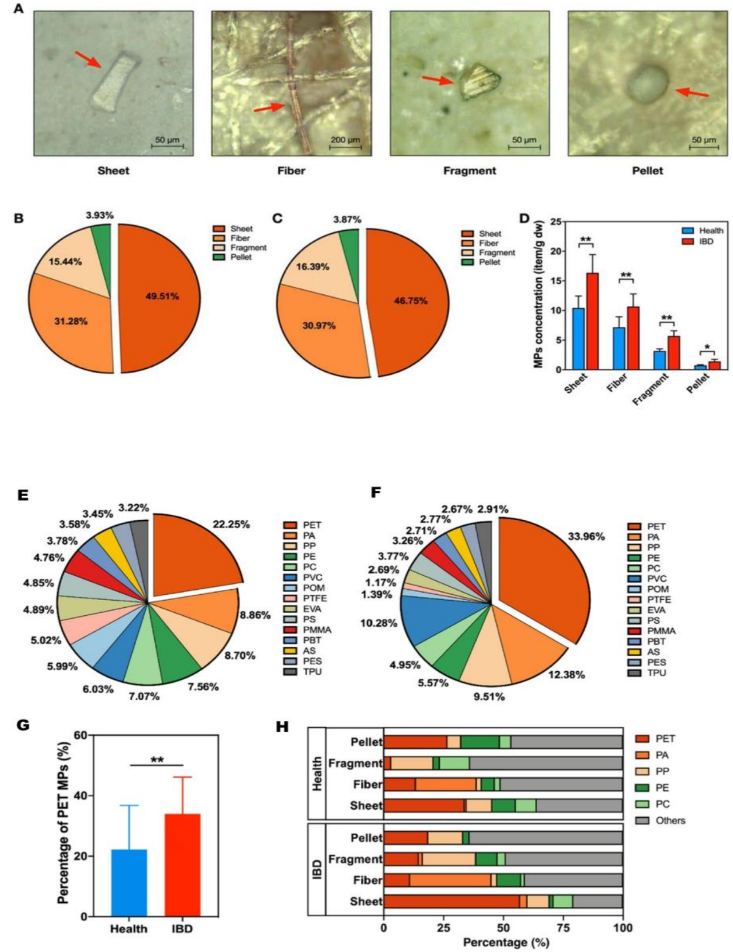


Fig. 1. Potential pathways and routes of exposure to MPs/NPs and potential toxic effects on humans.



. 4. Different shapes of MPs detected in feces from the participants (A) Percentage of different shapes of MPs in the feces from the healthy (B) and IBI
ticipants and the concentrations of different shapes of MPs (D). *p < 0.05; * *p < 0.01; and * **p < 0.001 as well as Relative abundance of different pol
es of MPs in feces from healthy (E) and IBD (F) participants. Comparison of the relative abundance of PET MPs in feces from healthy and IBD participants
ymer distribution of each MP shape detected in the feces (H). * *p < 0.01. Reprinted from (Yan et al., 2022) with permission. Copyrights (2022) Ame

Towards Eliminating Plastic Pollution by 2040, OECD, November 2023. Policy recommendations

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Global Ambition will require new challenges and strong international co-operation

1) ***Curb Production and Demand, implementation of Reuse systems***
2) ***Enhance Waste Collection, treatment specially in developing countries***
3) ***Encourage improvements in recycling***
4) ***Enhance Municipal Litter Management***
5) ***Encourage Research targeting microplastic leakage***
6) ***Ensure strong international co-operation and support***
7) ***Ensure adequate financing of waste treatment***
8) ***Align Financial Flows legally binding to cope with Plastic Pollution***

Sub-Saharan Africa, and the Middle East and North Africa are projected to represent an increasing share of global mismanaged waste over time due to their fast growth of plastics combined with weak waste management systems