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Microplastics and Health: A new challenge for regulators and scientists

Particles and Health 2021

Dr Stephanie Wright | Environmental Research Group & MRC Centre for Environment and Health
School of Public Health | Imperial College London

MRC Centre for Environment and Health

MRC Toxicology Unit

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Plastic to microplastic

- 4.9 Bt of plastic waste released to landfill or the environment (Geyer et al., 2017);
- 4.8 mil – 12.7 Mt entered marine environment 2010 (Jambeck et al., 2015);

'…solid synthetic polymeric particles of no more than 5 mm in their longest dimension and which may contain additives or other substances.' (European Commission, 2019);


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The ins…

Source	Concentration (in numbers)	Size (in µm)	Estimated exposure (EE)	Reference
Seaweed (Baini et al., 2017)	22.57/sample	<500–5000	113/Nori wrap	
	1.6 µg/g PAE	30% 1000–2500	1.9/OA pill	
			0.4 PAE mg/Nori wrap	
			0.007 mg PAE/OA pill	
Salt (Yang et al., 2015)	**7–681/kg**	**55% <200**	**4/day**	
		50–4300		
Salt (Iñiguez et al., 2017)	**128/kg**	**30–350**	**1/day**	
Salt (Kosuth et al., 2018)	**212/kg**	**10–5000**	**2/day**	
Sugar (G. Liebezeit & Liebezeit, 2013)	**249/kg**		**23/22 tsp**	
Honey (G. Liebezeit & Liebezeit, 2013; G. L. Liebezeit, E, 2015)	**175/kg**	**10–3100**	**3.7/tbsp.**	
Indoor air (Dris et al., 2017)	**5.4/m^3**	**50–3250**	**81/day**	
Indoor air (Gasperi et al., 2015)		**50–80% 100–500**		
Outdoor air (Dris et al., 2017)	**0.9/m^3**	**50–1650**	**14/day**	
Tap water (Kosuth et al., 2018)	**9.24/L**	**960 average**	**28/day**	
Bottled water (Kosuth et al., 2018)	**3.57/L**	**970 average**	**4/day**	
Beer (Kosuth et al., 2018)	**4.05/L**	**990 average**	**2/day**	
Tea (Hernandez et al., 2019)	**12 × 10^9/cup**	**8.6–29.3 average**	**11.6 × 10^9/day**	
	3.5 × 10^9/cup	**(and 22–156 nm)**	**3.5 × 10^9/day**	
Soil (with compost) (Blasing & Amelung, 2018)	2.38–180/kg	>1–5000	**<0.036/day**	
	1200 mg/kg		**<0.24/day**	
Total (fibers per day)		**Diet dependent**	**>50-to-billions**	

Source	Reference
Bottled water	ssman et al., 18
Shellfish	slie et al., 2017
Salt	eni and askovic, 2018
Air	anello et al., 19
Deposition	atarino et al., 18
Total	

*Bottled water intake (worst
**Shellfish and salt intake b
***Inhalation intake based on an adult average minute ventilation of 6L/min

Zarus et al., 2021

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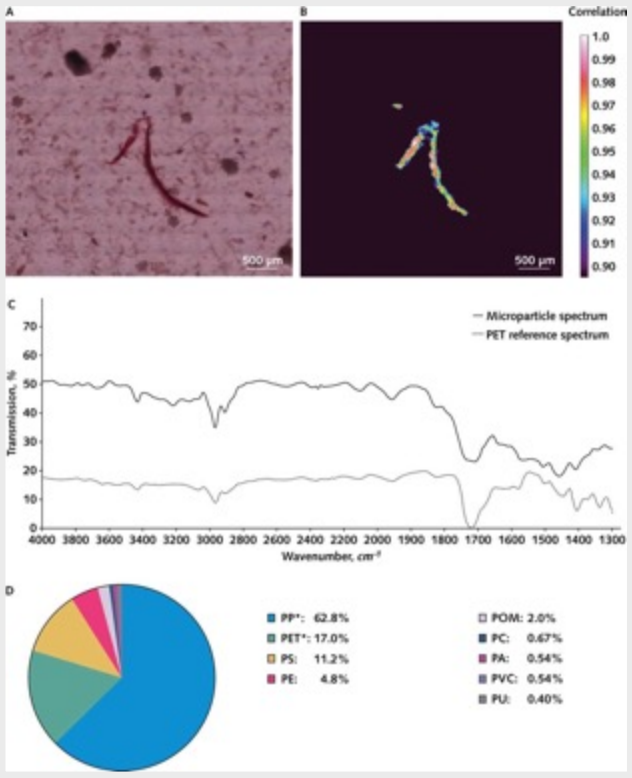
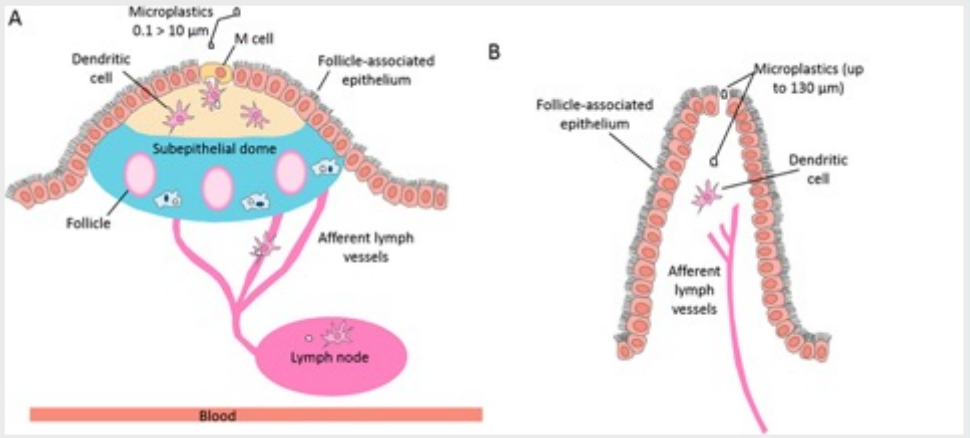
…and outs



- Some particles may pass through.
- 8 to 416 (median 20) microplastic 50-500 µm per 10 g stool (100 g avg).
- Does the size distribution accurately reflect exposure?



Schwabl et al., 2019; Wright & Kelly, 2017

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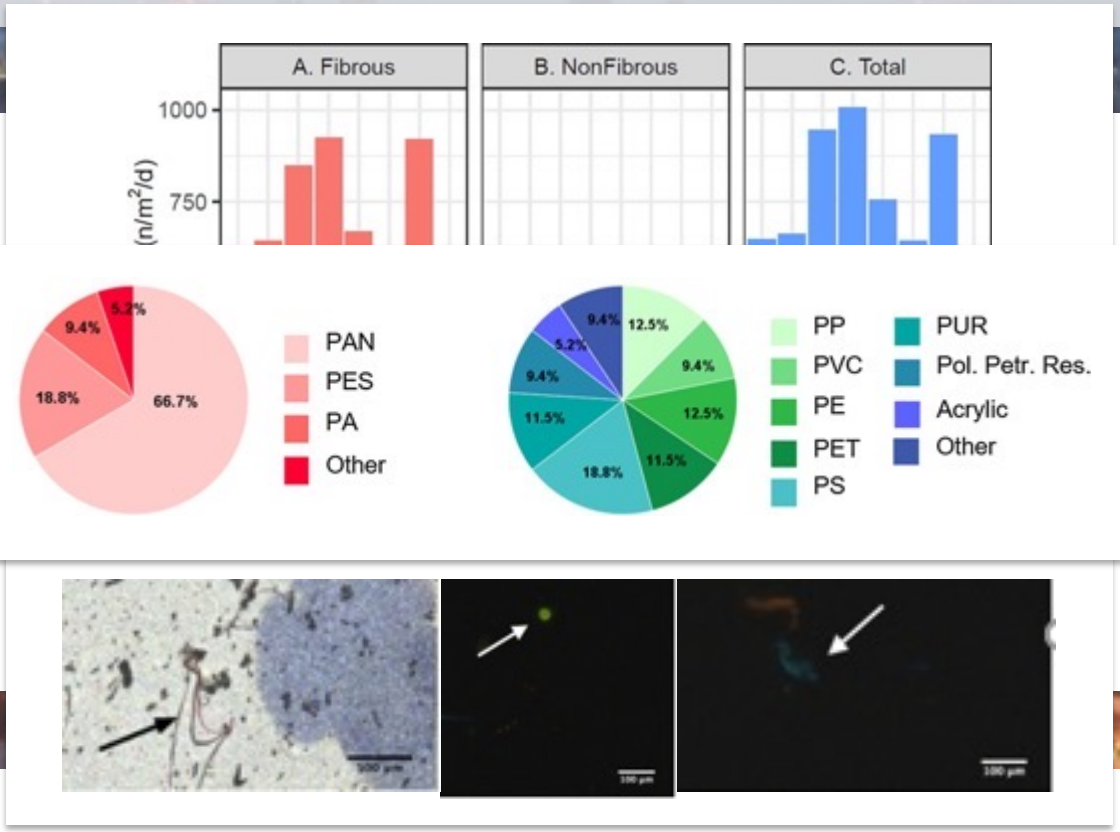
Microplastic in the atmosphere



Wright et al. Environ Int. 2020.

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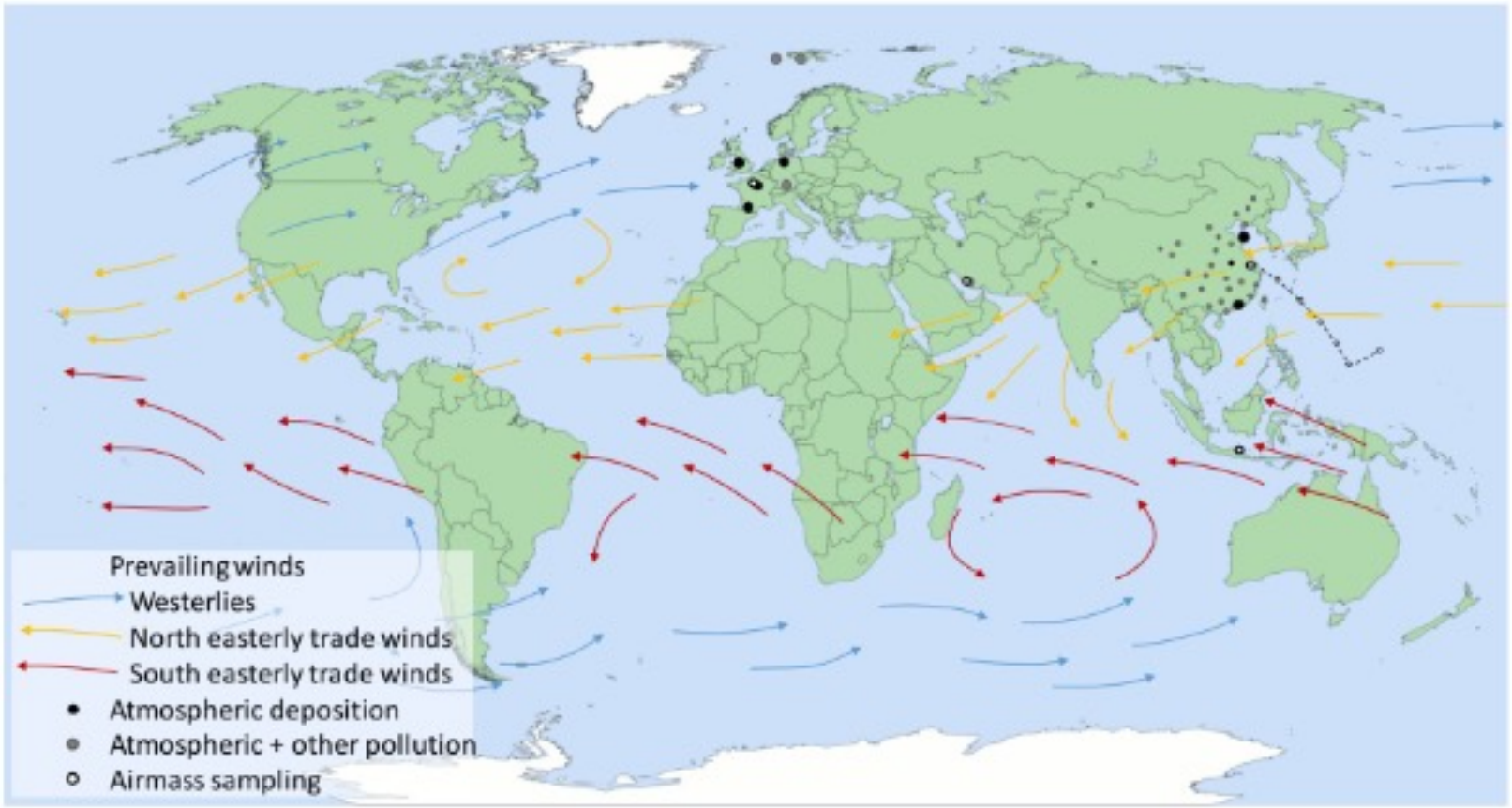
Microplastic contaminates air around the world



Zhang et al., 2020

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Common characteristics and trends

- **Fragments or fibres** dominate shape: sample type, geographical location, environment, analytical method.
- **PET, PE, PS, PP, PA**: depends on shape, sample type, geographical location, environment, analytical method.
- Mainly **secondary** microplastic particles, but evidence of some primary.
- Elevated levels in **urban** and **indoor** environments.

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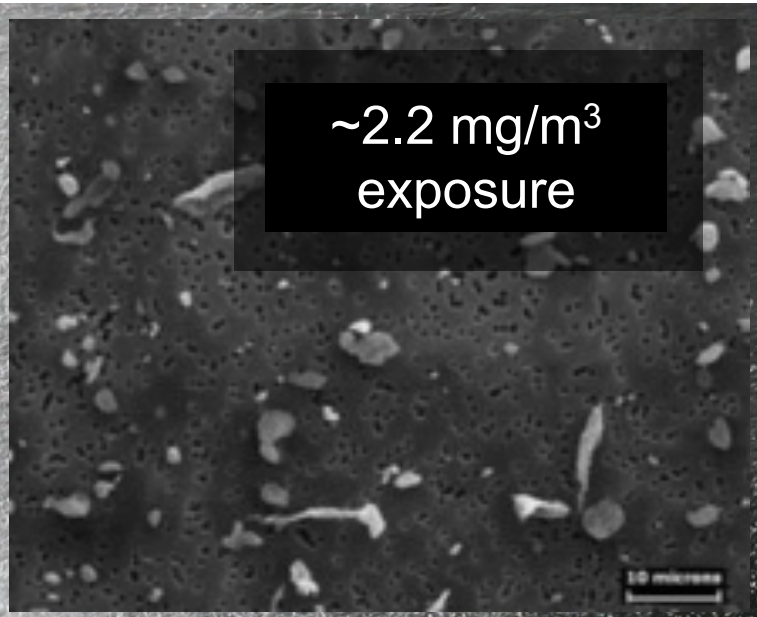
Occupational exposure to high levels of respirable plastic dust can cause lung disease.

Interstitial lung disease

IR all interstitial lung disease = 48 (95% CI 23-88)

IR IPF = 258 (95% CI 104-530)



PE (Spain), PP (Turkey), Rayon (USA)

Inflammation | Granulomas | Fibrosis

- K… 07; Burkhart et al., 1999.

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Microplastic toxicity observed *in vivo*

Plastic	Size	Toxic?	Reference
Polyvinylchloride	1-250 µm	~ Limited, reversible to no observed effects	Agarwal et al., 1978, Pigott et al., 1979
[illegible]	[illegible]	[illegible]	[illegible] 1992
Nylon (flock)	<14 µm (l), <3 µm (w)	~ toxic to no observed effects	Pimental et al., 1975; Porter et al., 1999; Warheit et al., 2003
Polypropylene	30 µm (l), 1.6 µm (w)	✓, reversible at lower doses	Hesterberg et al., 1992

But…very few studies, uncertain interspecies translation, 1 in last 10 years

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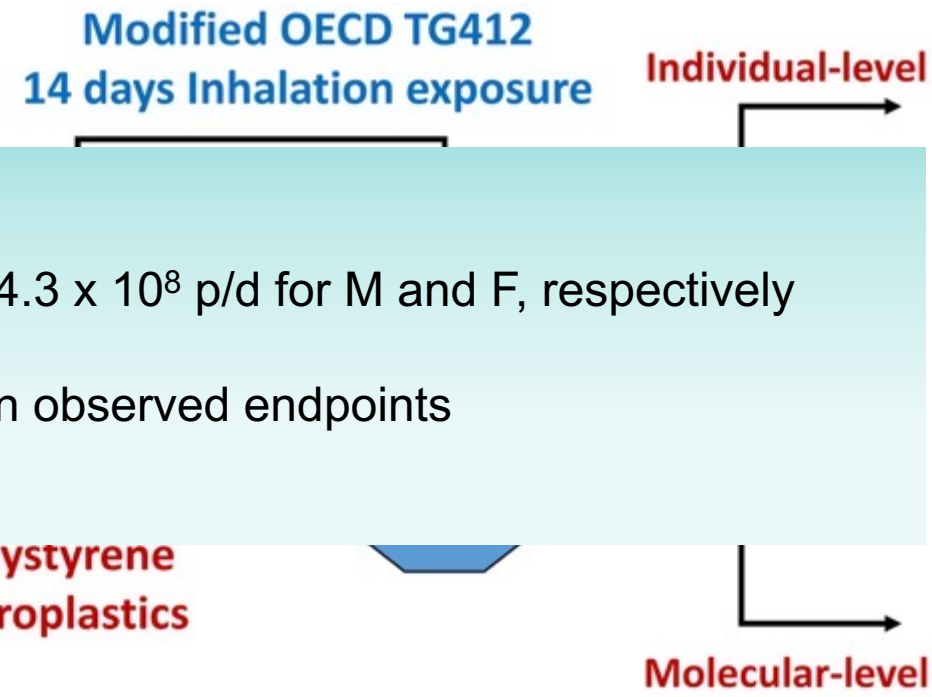
Inhaled polystyrene nanobeads exert minimal effects in healthy animals

Dongyoung Lim [a, 1], Jaeseong Jeong [a, 1], Kyung Seuk Song [b], Jae Hyuck Sung [b], Seung Min Oh [c], Jinhee Choi [a]

- Subacute inhalation toxicity study



- Exposure equivalent to 6.2 and 4.3 x 10^8 p/d for M and F, respectively
  - =1.6 and 1.1 x 10^5 cm^{-2}
- No quantitative dose-response in observed endpoints

pg/day and 20.6 pg/day, respectively

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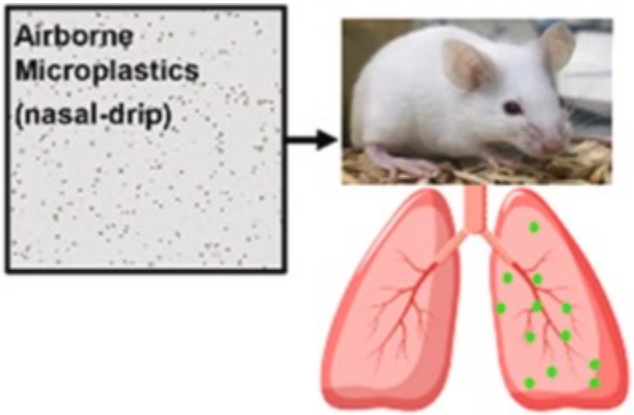
Even more recent findings…

- Amino formaldehyde: 1-5 μm - 1.03 × 10^7 particles MP in 20 μL saline every 3 d
  - Normal: ↑ infl cell; mac aggregation; ↑ TNF-a (BALF); ↑ IgG1
  - Asthmatic (HDM): exacerbated symptoms; ↑ infl cell; mac aggregation
    - (Lu et al., 2021)
- Reprotoxic effects



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If microplastics impact health, why don’t we know about it already?

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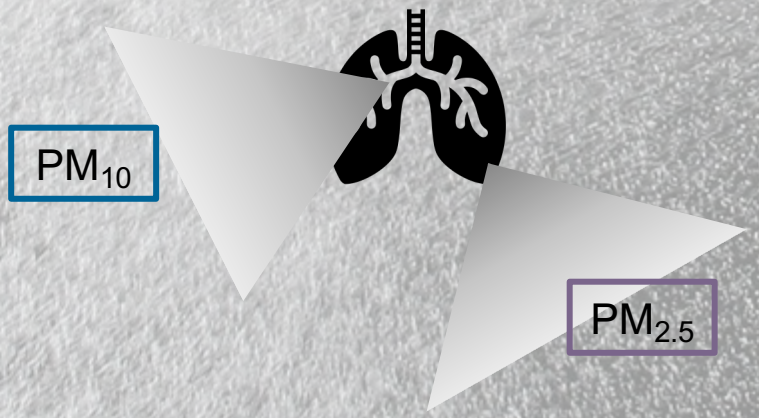
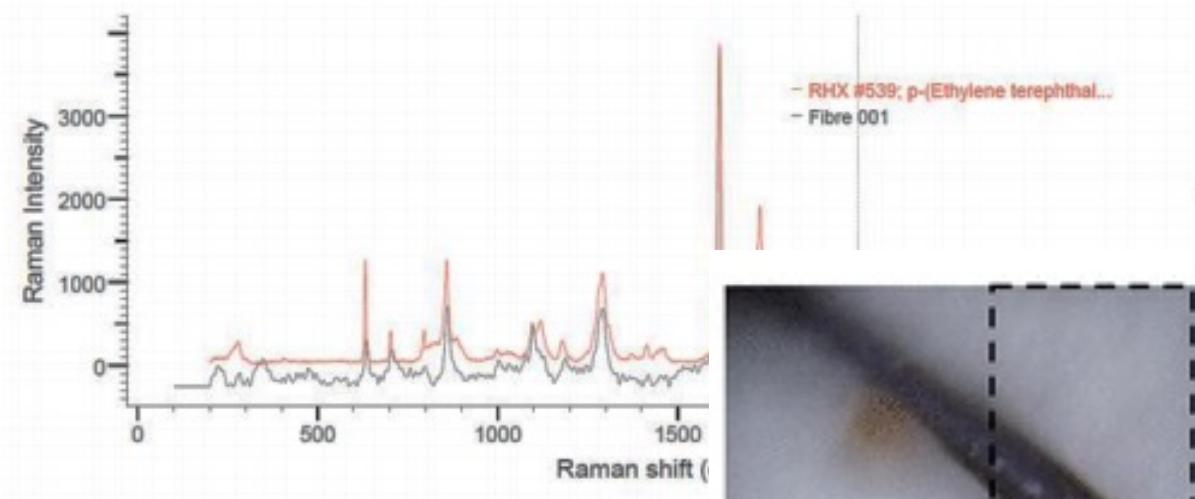
The size data gap

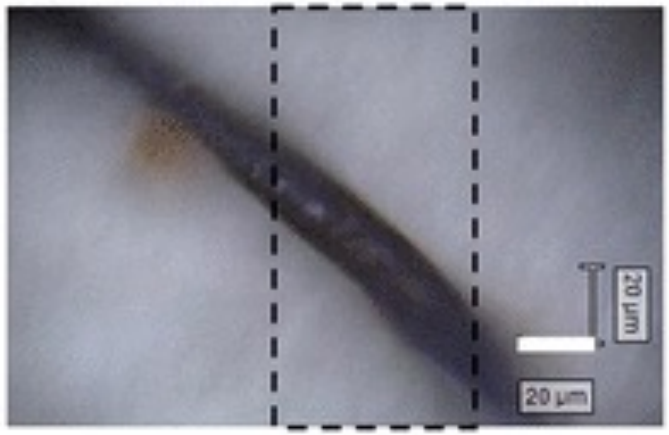
- Up to June 2020:
  - 9 studies – air (100% LOD 11 um)
  - 9 studies – bulk deposition (100% LOD 10 um)
  - 6 studies – dust (100% LOD 50 um)

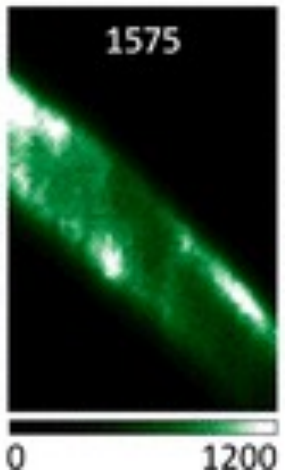


Wright et al., 2021. Microplastics & Nanoplastics.

How can we detect PM10 microplastics?







Wright et al. Environ Sci Technol. 2019.

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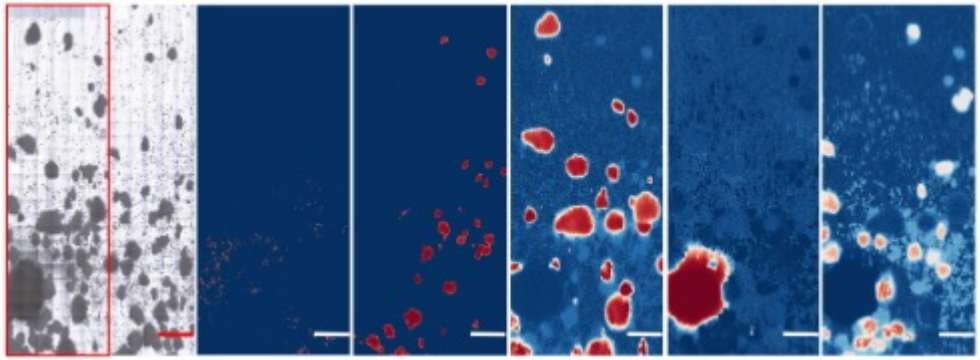
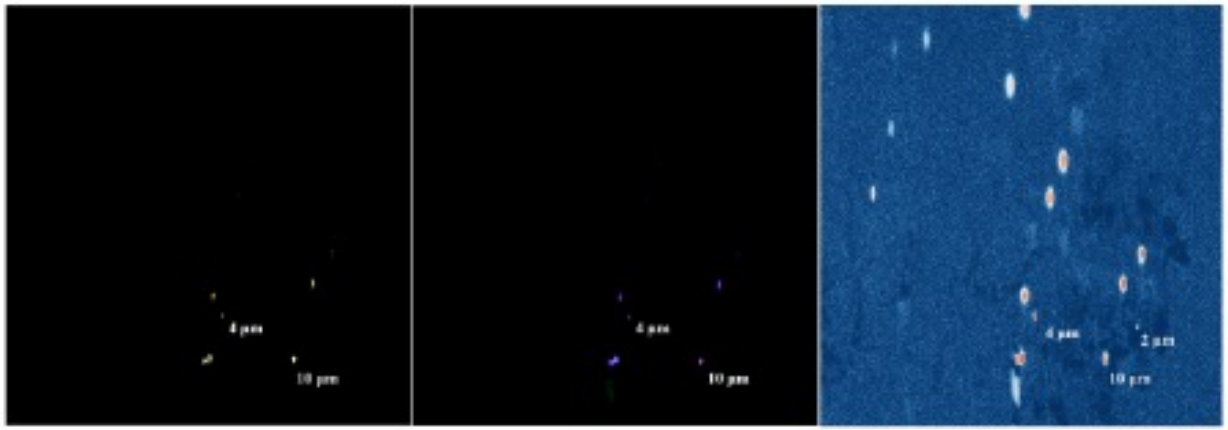
How can we detect <PM_{10} microplastic?

Environmental reference



2-10 µm



Levermore et al. Analytical Chemistry. 2020.

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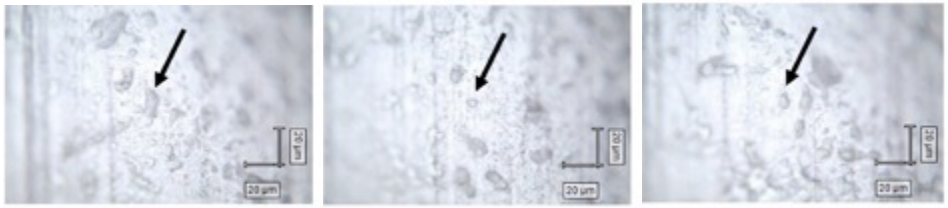
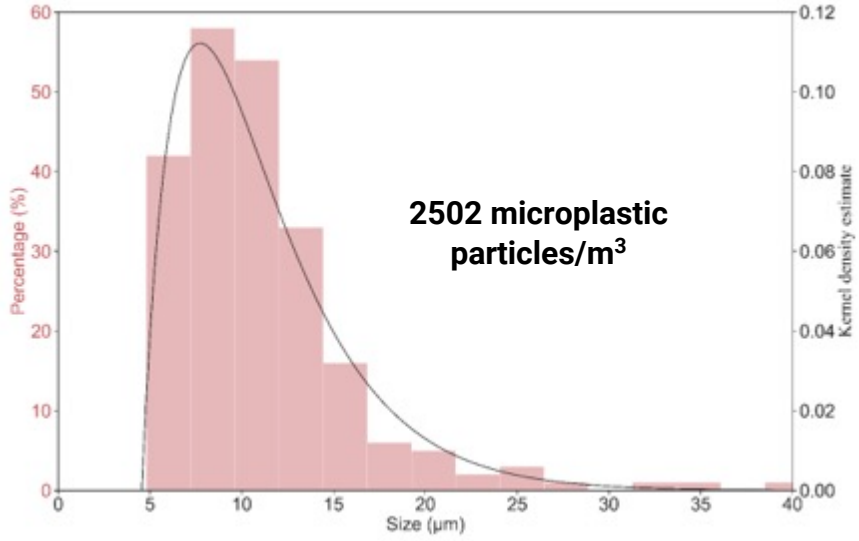
Is microplastic a component of PM_{10}?





- Microplastic (>4.7 um) = ~0.1%

- What's the relative contribution to 'particle' exposure?
- What's the relative potency of (different) microplastic particles?
- Is there a mixture effect?

Wright et al., 2019. ES&T; Levermore et al., 2020. Anal Chem.

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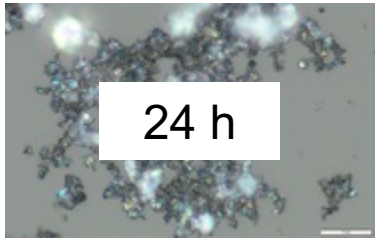

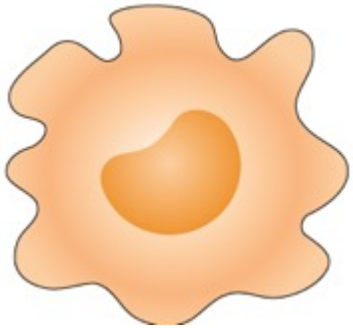

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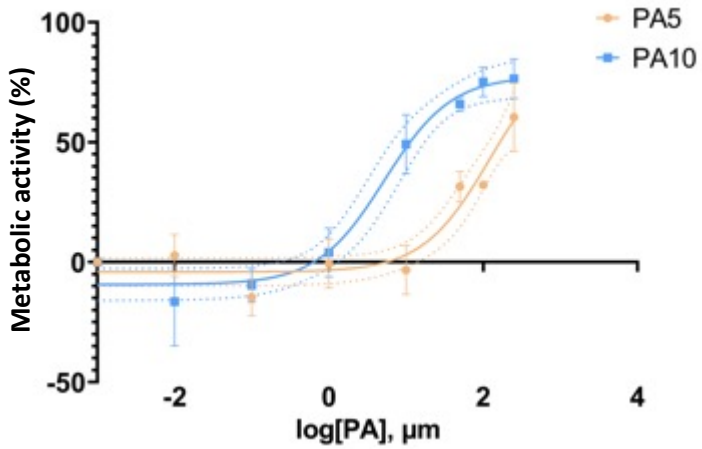

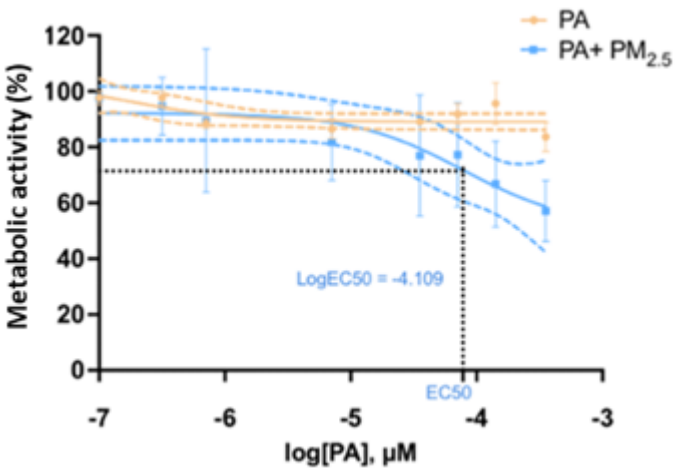

*relative to positive control

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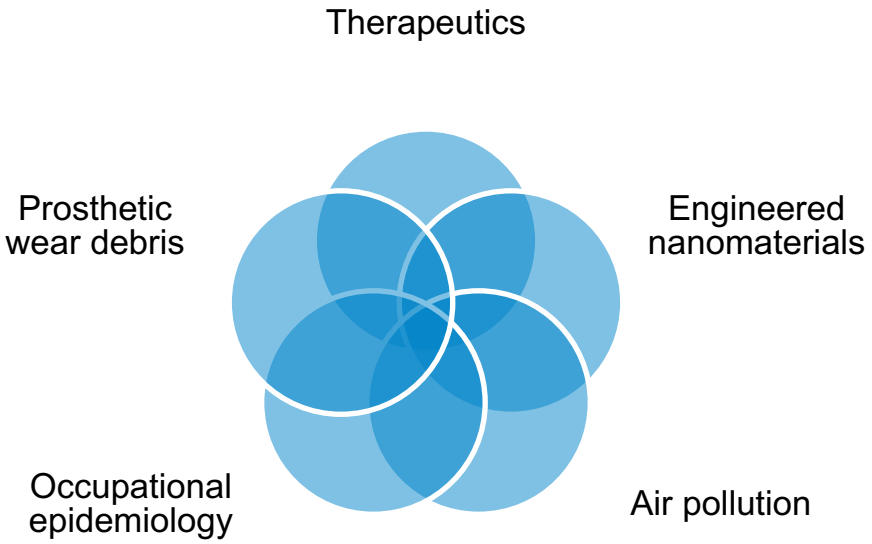
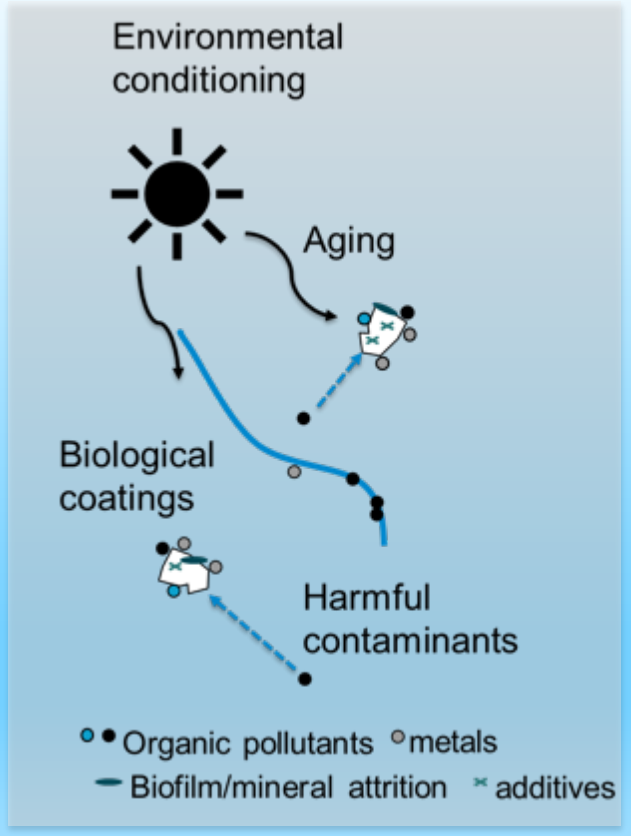
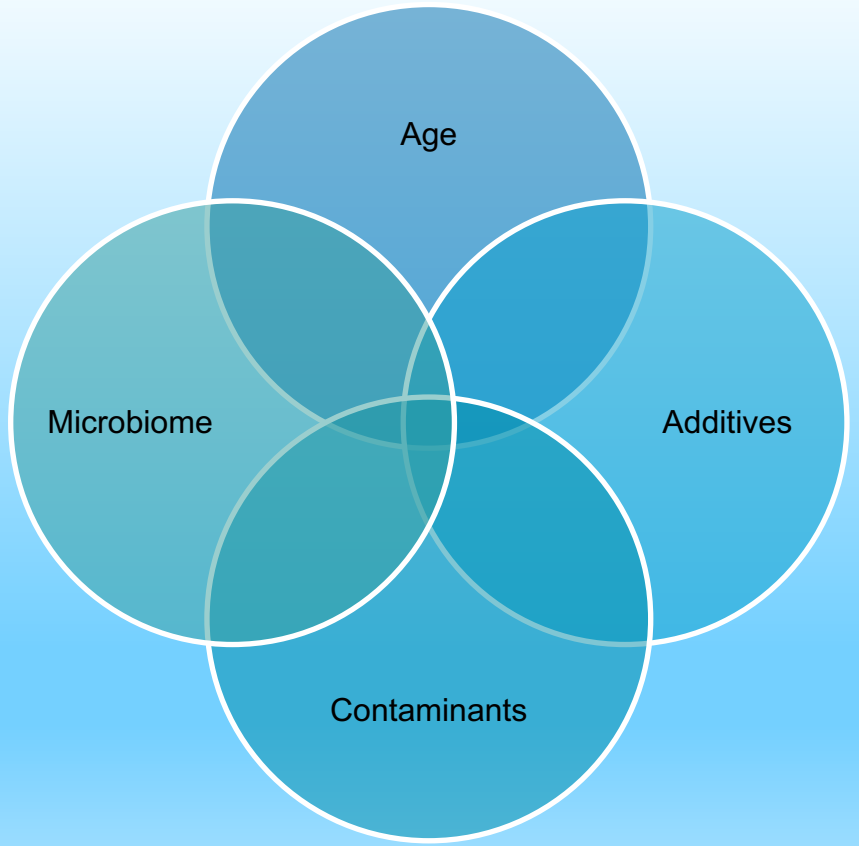
Particle effects



- Size/aspect ratio
- Shape
- Surface chemistry
- Surface charge
- Bulk composition – plastic effect?
- Hydrophobicity
- Crystallinity, porosity?
- Persistence

The microplastic mix





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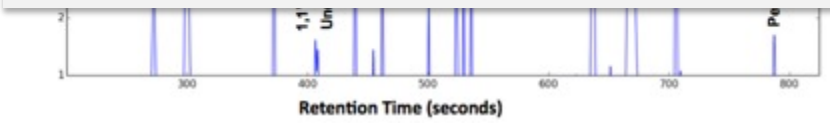
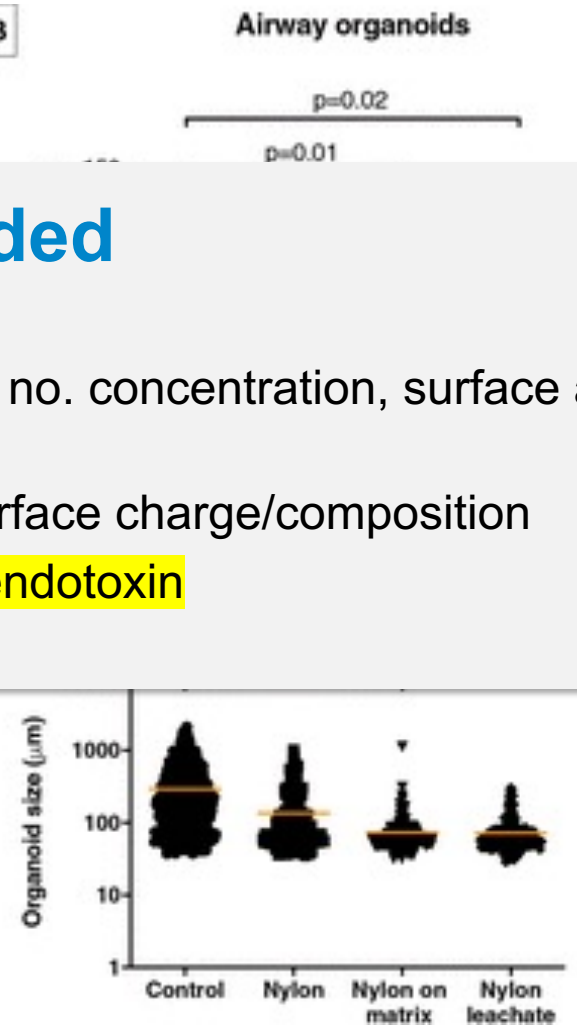
Full characterisation is needed

- Dose metrics: mass concentration, particle no. concentration, surface area, volume
- Physicochemical properties: size/shape/surface charge/composition
- Impurities/artefacts: organics, inorganics, endotoxin





Van Dijk et al., 2021.

Key knowledge gaps/holes

- Exosure – analytical challenge
- Which properties drive observed effects and how they relate to environmental exposures
  - Reference material
- Which biochemical pathways are perturbed and why?
- The contribution of microplastic to particle exposures…
- …and non-communicable disease (epidemiological studies)
- Mixture effects with other ambient contaminants.

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Thank you!

Imperial College London
Prof Frank Kelly
Dr Ian Mudway
Prof Terry Tetley
Mr Joseph Levermore
Dr Ana Oliete
Alexander Mitchener
Dr David Green
Dr Anja Tremper
Dr Thomas Smith (LSE)
Mr Jannis Ulke

King's College London
Dr Andrew Chan

Analysis of Microplastics in Environmental Samples by Pyrolysis/Thermal Desorption-(GC)xGC-TOFMS

Development of screening criteria for microplastic particles in air and atmospheric deposition: critical review and applicability towards assessing human exposure

Stephanie L. Wright[1], Todd Gouin[2*], Albert A. Koelmans[3] and Lisa Scheuermann[4]

Detection of Microplastics in Ambient Particulate Matter Using Raman Spectral Imaging and Chemometric Analysis

Joseph M. Levermore*, Thomas E. L. Smith, Frank J. Kelly, and Stephanie L. Wright

Raman Spectral Imaging for the Detection of Inhalable Microplastics in Ambient Particulate Matter Samples

Stephanie L. Wright,* Joseph M. Levermore, and Frank J. Kelly

Atmospheric microplastic deposition in an urban environment and an evaluation of transport

S.L. Wright[a,b,1,*], J. Ulke[a,1,2], A. Font[a,b], K.L.A. Chan[c], F.J. Kelly[a,b]

Plastic and Human Health: A Micro Issue?

Stephanie L. Wright*[,‡] and Frank J. Kelly[‡]

Contact details/for more information
Dr Stephanie Wright
s.wright19@imperial.ac.uk
https://www.imperial.ac.uk/people/s.wright19

NIHR | Health Protection Research Unit in Environmental Exposures and Health at Imperial College London

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