Microplastics: An Emerging Threat to Global Ecology and Public Health

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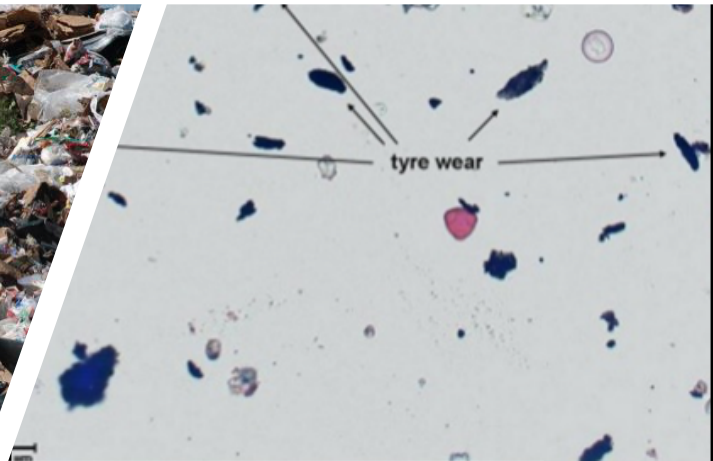
Microplastics in Food

- 1000/person/yr Chinese sea salt (*Yang et al., 2015*)
- 100,000/person/yr Chinese shellfish consumer (*Li et al. 2015*)
- 6292/L bottled mineral water (*Ossman et al., 2018*)
    - 691,491/person/yr based on EU consumption statistics (*Statista*)
- 68,416 MP/person/y household dust (*Catarino et al., 2018*)

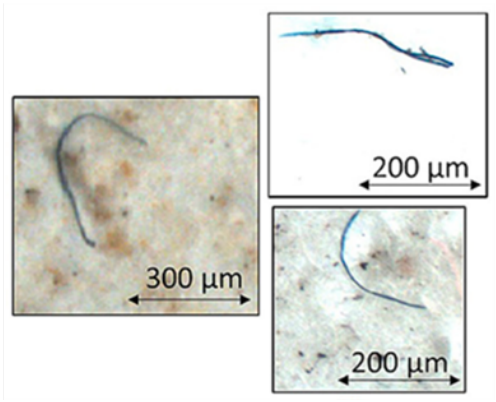
Plastic in **our** environment

Synthetic textiles…clothes, furniture, carpets
Synthetic rubber…tires, shoes
Thermoplastic paints
Construction/buildings

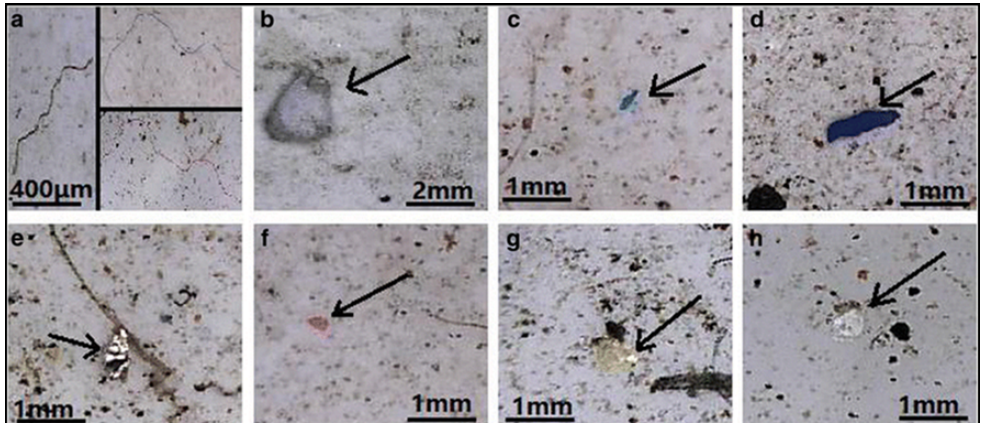
Waste incineration
Landfill
Recycling
Laundry exhausts
Agriculture



Microplastics in Air



Dris et al. 2016.



Cai et al. 2017.

Up to 32,000/m^3 organic carbon-based fibres (*Schneider et al., 1996*)

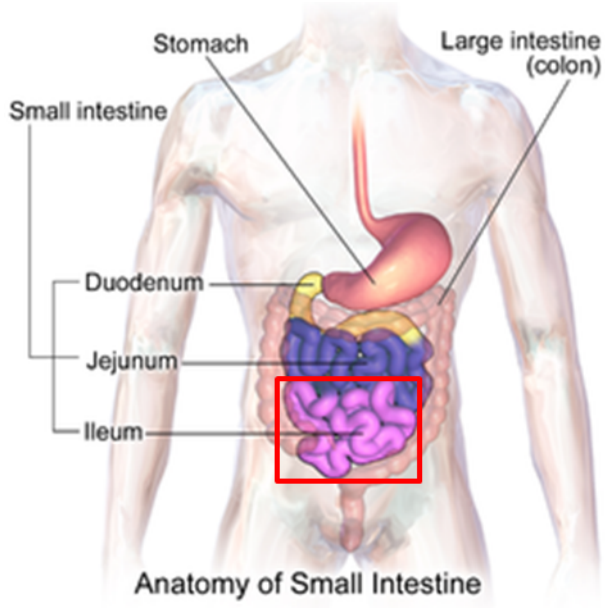
How Does This Compare?

- Diet: est. 10^{12} –10^{14} TiO_2 particles (0.1 – 3 µm)/person/d via typical Western diet (*Lomer et al., 2004*)
- Inhalation: est. median of 11 x 10^9 - ~30 x 10^9 UFP/m^3 for Boston (6 o. of. m greater) (*Simon et al., 2017*)
  - Exponential relationship between particle size and abundance
- Gap in knowledge re. microplastic sizes

Only a few studies, still methodologically challenged

Uptake?

Gut

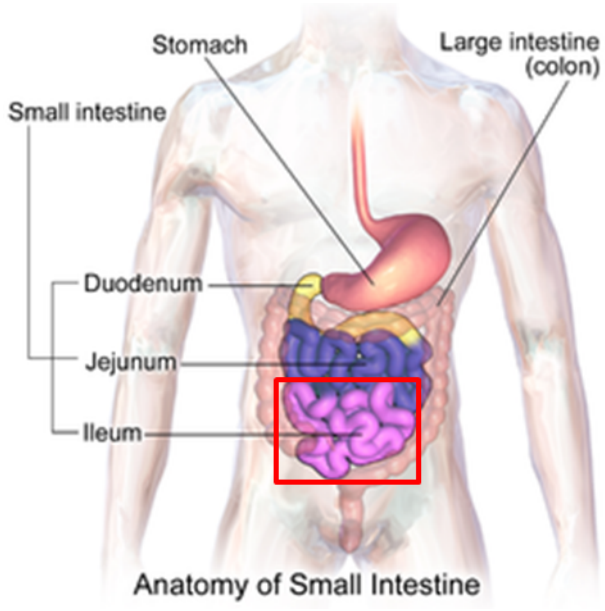


- Small intestine
- Peyer's Patches (PPs): latex up to approximately 5 µm [rats] (*Le Fevre et al., 1989*)
  - Polystyrene^{-} (50 nm): bioavailability (from blood) up to 1.7% [rats] (*Walczak et al., 2015*)
- Persorption: PVC particles up to 150 µm [dogs] (*Volkheimer 1975*), low rate (0.002%)

…0.13 microplastics/L bottled water…14/y

Distribution?

Gut



- Latex (1.2 µm): PPs (mainly) and mesenteric lymph nodes [rats] (*Le Fevre et al., 1989*)
- Polystyrene^{-} (50 nm): kidney, heart, stomach wall and intestinal wall [rats] (*Walczak et al., 2015*)
- PVC particles (up to 150 µm): blood, bile, urine and cerebrospinal fluid [dogs] *(Volkheimer 1975)*

Influenced by surface chemistry and size

Lack of representative NMPs used in experiments

Exposure?

Airway

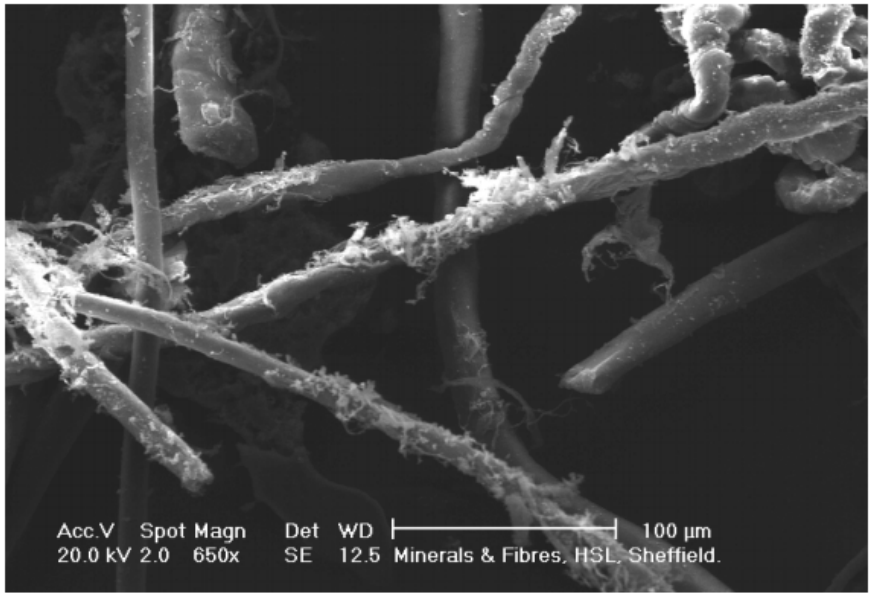
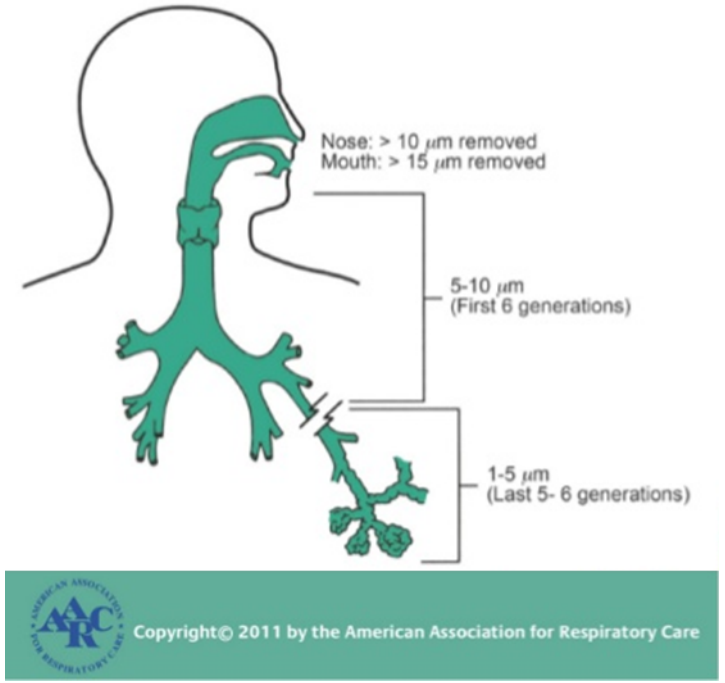


Figure 23: Large polypropylene fibres showing fibrils formed on the fibre surface after testing



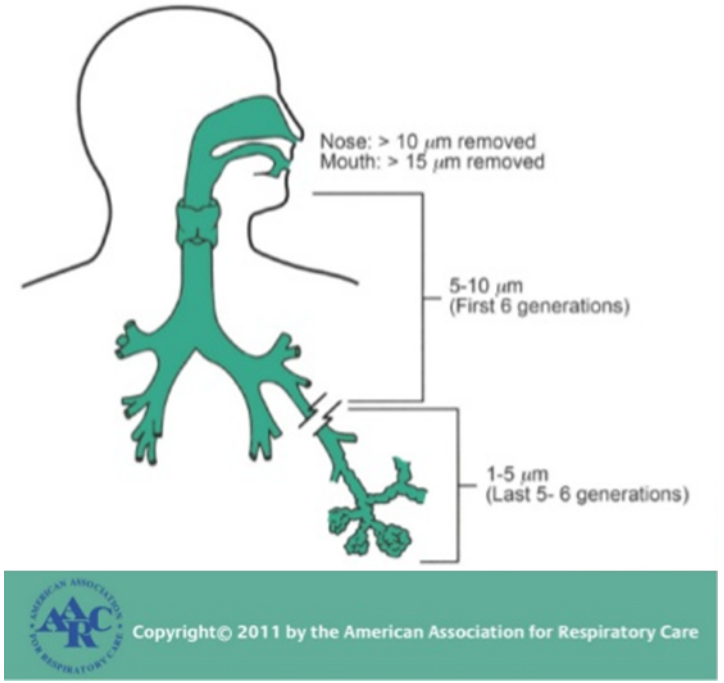
Will vary by shape, size and density of the microplastic

10 µm polystyrene bead = 10 µm aerodynamic diameter

Uptake and Distribution?

Airway

- Particles on alveoli epithelium phagocytosed by macrophages
- Will likely differ depending on shape (fibrous v non-fibrous) as well as size
- Polystyrene^{+} (50, 100 nm) taken up by alveolar epithelial cells (*Thorley et al., 2014*)
- High deposition in lymph nodes (PS, 50-900 nm), accumulation in spleen, 50 nm in blood [mouse] (*Mohammed et al., 2013*)



Influenced by surface chemistry and size

Lack of representative NMPs used in experiments

Impacts

Occupational

Interstitial Lung Disease

- **Flock (nylon) Worker's Lung** (*Kern et al. 1998, 2000, 2003*)
  - Average respirable particulates 2.2 mg/m^3 (*Burkhart et al., 1999*)
  - Cough; chest pain; infection in the airway; tissue inflammation
    - '**Health hazard exists from occupational exposures to flock–associated dust**' (National Institute for Occupational Safety and Health)

- **Other synthetic textiles** (*Pimentel et al., 1975*)
  - Inflammation around acrylic/polyester/nylon dust; respiratory irritation.

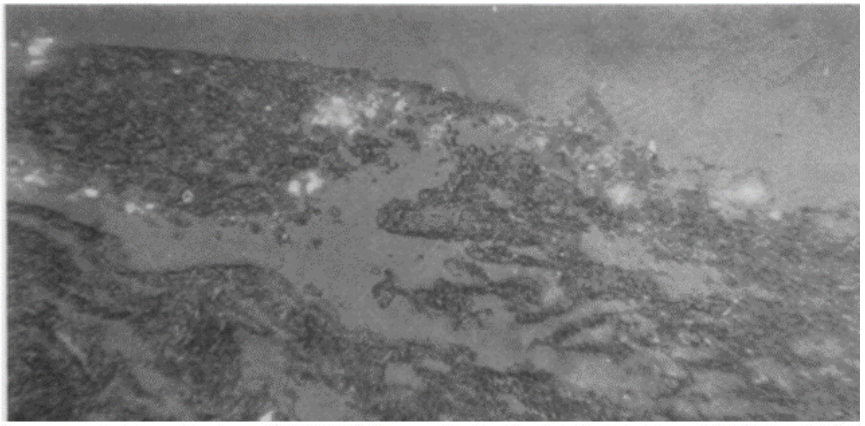


FIG. 10. *Case 5. (a) View of a zone of pulmonary lesions. Birefringent inclusions*
nylon (polarized light) (H and E ×15). (b) Same area as in (a) after addition of m-cres

Plastic Toxicity?

ELSEVIER

Science of The Total Environment

Volume 409, Issue 18, 15 August 2011, Pages 3309-3324

Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition

Delilah Lithner, Åke Larsson, Göran Dave

- Unreacted residual monomers in polymeric material
- Hazard classifications (taken from Annex VI in the EU classification, labelling and packaging (CLP) regulation)
  - Does not include PBT/vPvB or endocrine disrupting characteristics
- Polyurethane, polyacrylonitrile, polyvinylchloride

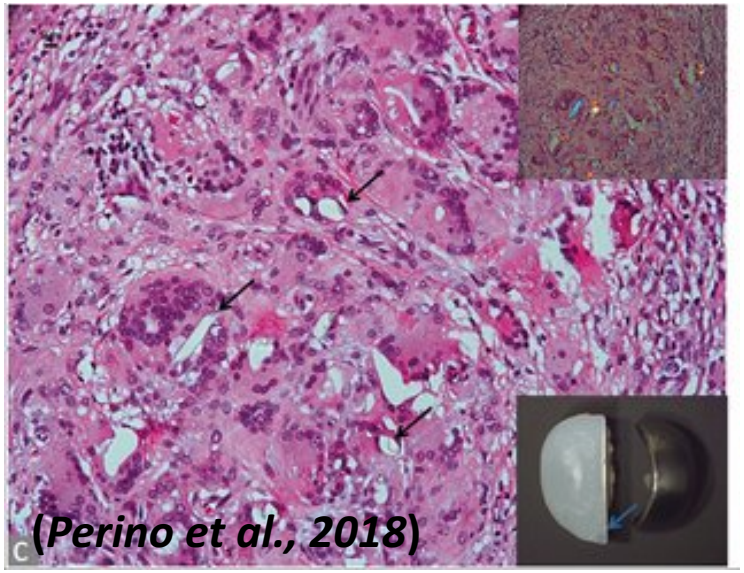
Microplastic Toxicity?

Particle

- Lesions 30 d post exposure to PVC (25 mg, ↑ time) [rats] (*Agarwal et al., 1978*)
- Dose-dependent ↑ pulmonary macs & granulomas post-90 d exposure to inhaled PP fibres (15 – 60 mg/m^3) [rats] (*Hesterberg et al., 1992*)
- PET prosthetic wear debris forms fibrin,

  necroses and scar formation [humans]

  (*Willert et al., 1996*)



(***Perino et al., 2018***)

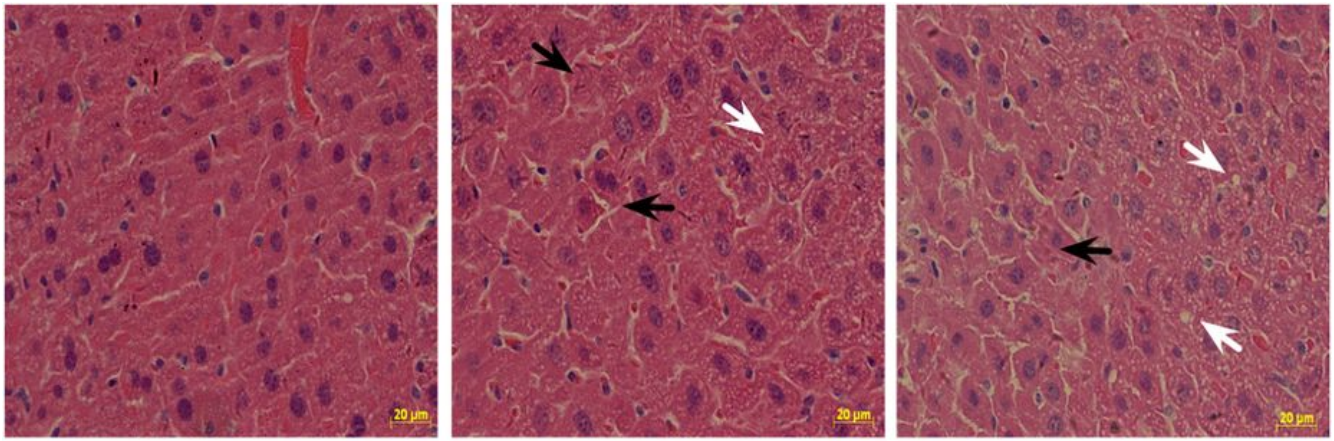
Tissue accumulation of microplastics in mice and biomarker responses suggest widespread health risks of exposure

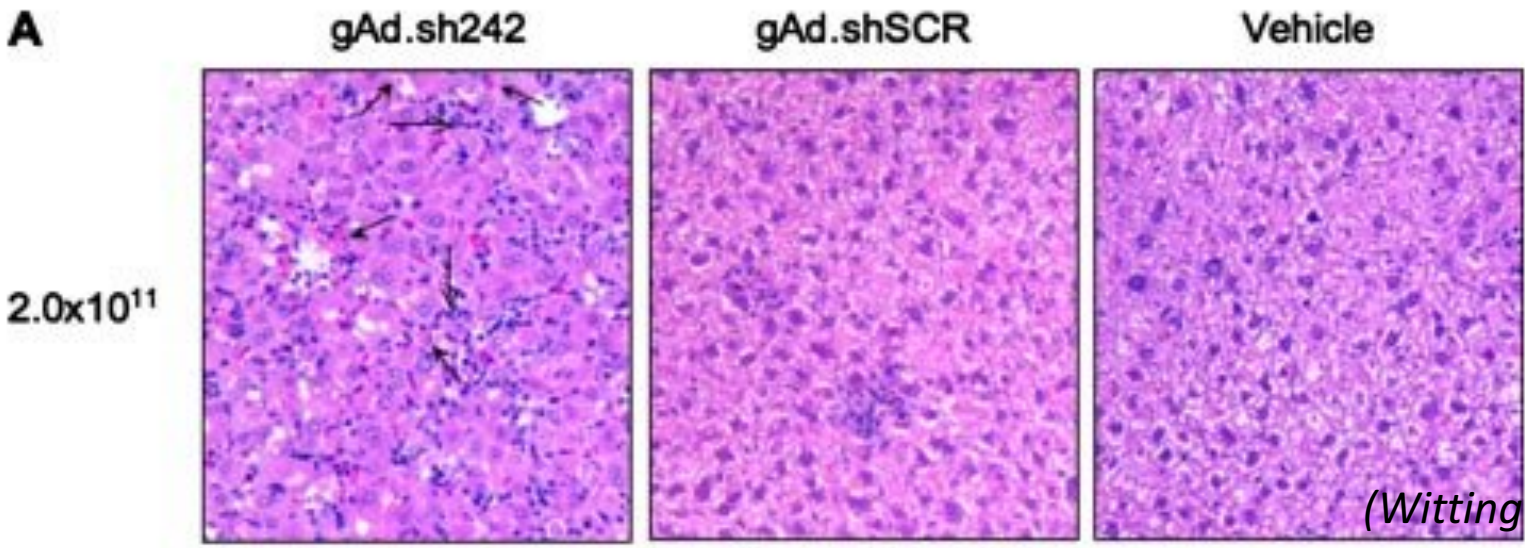
Yongfeng Deng, Yan Zhang, Bernardo Lemos & Hongqiang Ren

Uptake of microplastics and related health effects: a critical discussion of Deng et al., Scientific reports 7:46687, 2017

Authors | Authors and affiliations

Albert Braeuning



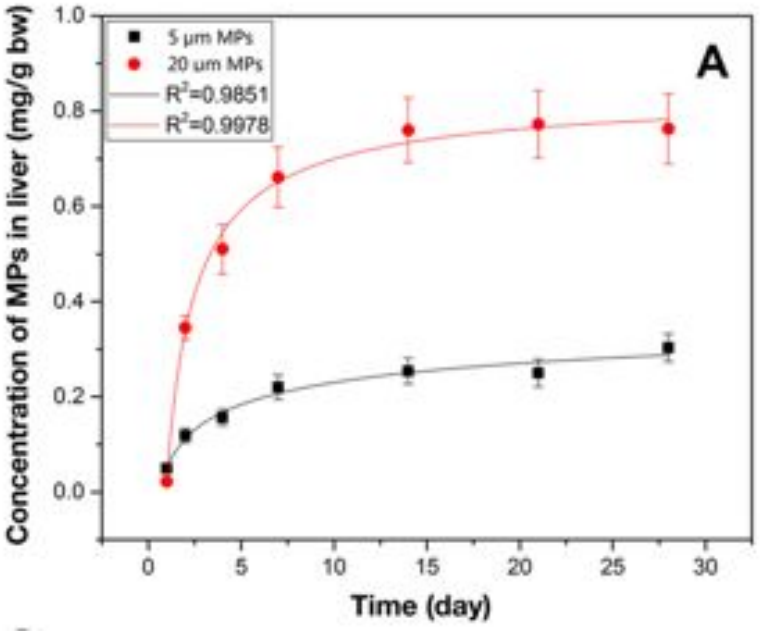


(Witting et al., 2008)

Tissue accumulation of microplastics in mice and biomarker responses suggest widespread health risks of exposure

Yongfeng Deng, Yan Zhang ✉, Bernardo Lemos & Hongqiang Ren

0.1 mg of fluorescent PS (5 µm or 20 µm d) in 0.5 ml of liquid per animal, daily.



0.5 mg/g body or organ weight when exp. 0.4 mg/g.

Extrapolated to organ weight
0.5 mg/g × 1.7 g = 0.85 mg i.e. 200% the received dose!

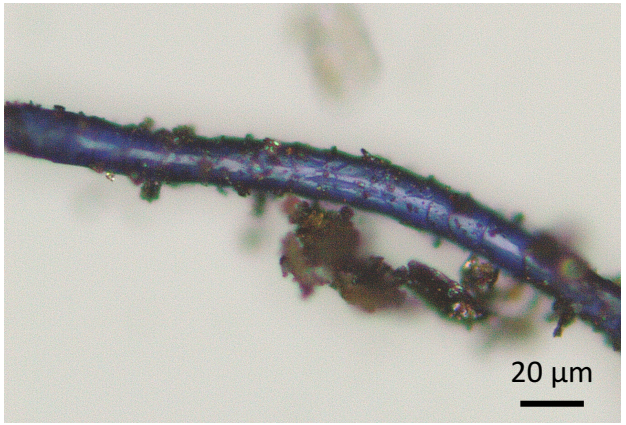
‘Further research is needed to close existing knowledge gaps on microplastic uptake and to allow for a proper assessment of possible health risks to humans.’ Braeuning, 2018

Microplastic Toxicity?

Chemical

- Unreacted monomers, additives, dyes and pigments
  - MPs ingested via mussels contribute est. 3.4 x 10^{-5} g BPA/person/y (Rist et al., 2018) or 2% (EFSA, 2018)
  - ↑ brominated flame retardants in household dust (210 mg g^{-1}) due to abrasion of particles/fibres from treated items (*Rauert et al., 2014*)
    - Est. contribute up to 15% exposure (Li et al., 2014)
    - Thyroid homeostasis/cognition (Howe et al., 2018)

- Sorbed HOCs/metals…particles?
  - Microplastic ingestion via 225 g Chinese mussels – 19 pg PCBs, 170 pg PAHs – 0.006^ and 0.004% increase, respectively (EFSA, 2016)



Summary

- Sparse evidence for dietary and airborne microplastic exposure
- Different modes of particle uptake are plausible, although unstudied for representative microplastics
- Nano-PS distributes beyond portal of entry to secondary tissues
- Exposures (18 months +) to high concentrations cause occupational lung disease
- Plastic wear debris causes inflammation in joint tissues
- Potential for vector effect?

Knowledge ‘Holes’

- Daily intake
- Kinetics and distribution of microplastics and contaminants post-exposure (ADME)
- Studies on representative microplastics
- Paucity in data on occurrence of biologically relevant sizes due to analytical challenges
- Adverse Outcome Pathways (AOP)
- Negative controls
- What might exposure to low concentrations over a lifetime do?

Thank you

KCL
Prof Frank Kelly
Dr Ian Mudway
Mr Joseph Levermore
Dr Ana Oliete

MRC Toxicology Unit
Prof Anne Willis
Prof Marion MacFarlane
Dr John Le Quesne
Leah Officer

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