

Bridging the knowledge gaps in microplastics pollution

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MARLICE
2024

III International Forum
on Marine Litter and
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DSC-TGA
 ICP-MS/ICP-OES
 Py-GC/MS
micro-FTIR
NIR
 evolved gas analysis (EGA-MS)
 FTIR-focal plane array
 surface-enhanced Raman scattering (SERS)
 coherent anti-Stokes Raman scattering (CARS)
 tip-enhanced Raman spectroscopy (TERS)
 thermal desorption-proton transfer reaction-mass spectrometry (TD-PTR/MS)
 thermal extraction desorption-GC/MS (TED-GC/MS)
 scanning near-field optical microscopy (SNOM)
 laser direct infrared (LDIR)
 stimulated Raman scattering (SRS)
 quantitative proton NMR (qNMR)
 scanning near-field microscopy
ATR
MALDI-ToF/MS
micro-RAMAN
 superlensing
 nano-FTIR

Analytical Techniques

Clean surfaces
 Verification of exposure
Source of materials
 Laboratory blanks
 Replication
QA/QC
 Clean rooms
 Chemical purity
 Subsamples
 Blank subtraction (by colour and category)
Harmonization
Standardization
 Interlaboratory comparison studies
Identification of all materials
 Ageing
Positive controls
Reporting transparency
 LOD/LOQ reporting if applicable
Reference materials
 Clean laboratory practices
 Particle size and shape
 Field blanks

Methodological aspects

Relevant (eco)toxicological data require mass concentration

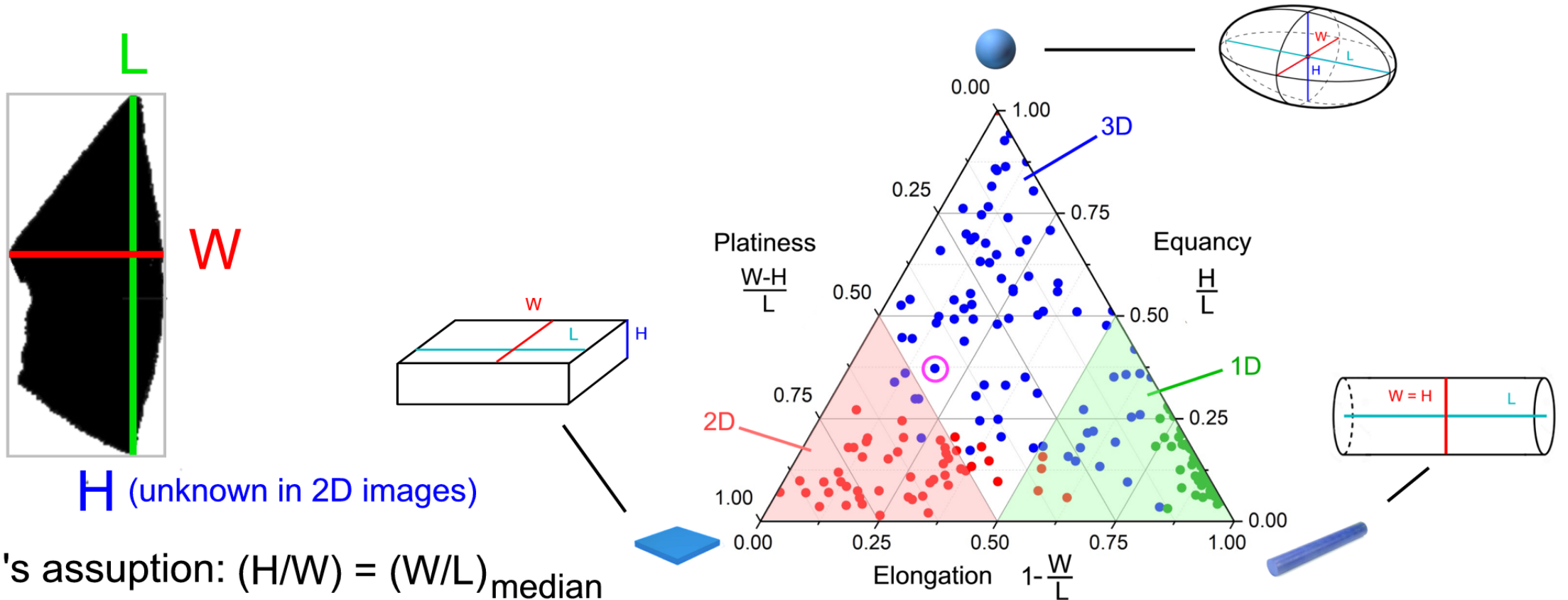
Exposure verification, data reporting for effect thresholds

Projected (2D) images + Shape models = Particle volume

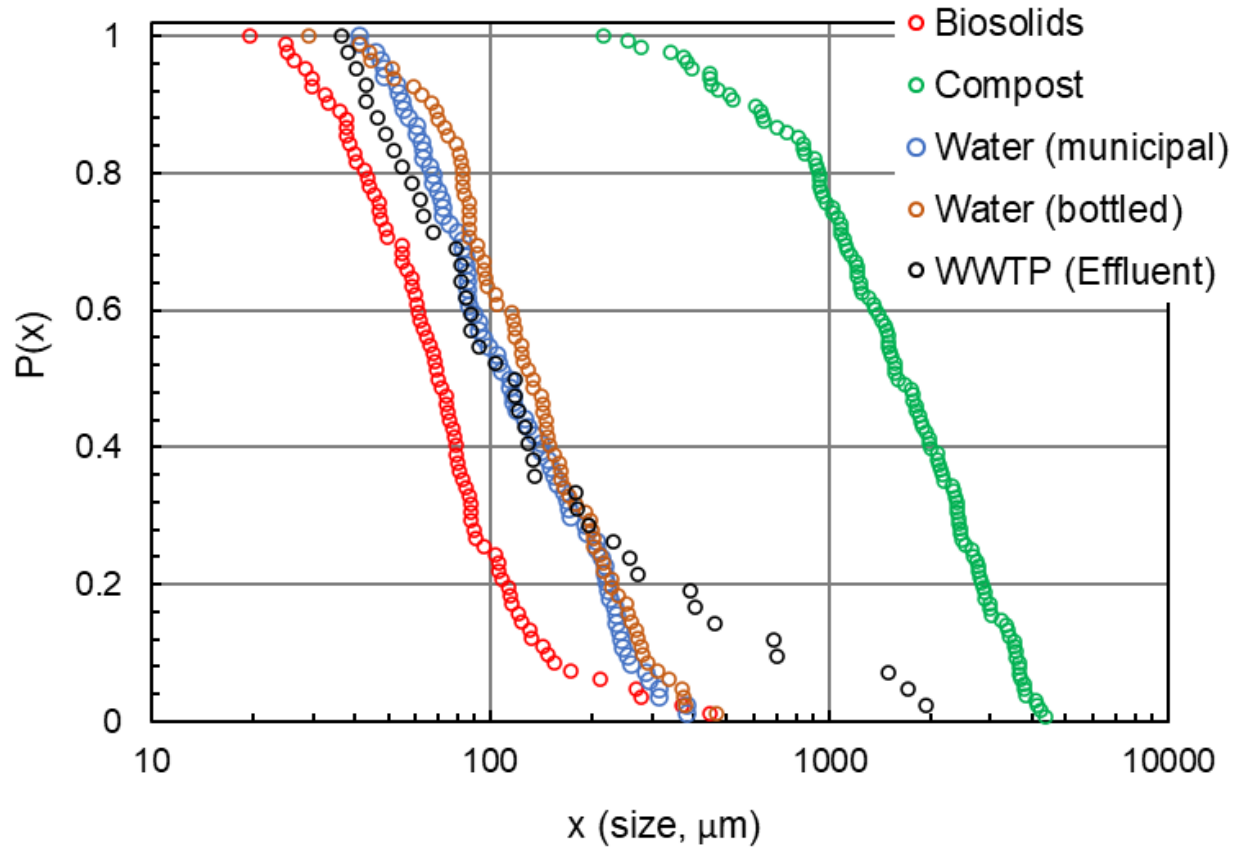
Particle volume + Density + Void fraction (if needed) = Mass of individual particles

Mass of individual particles + Subsample estimations = Total mass in a sample/subsample

Total mass in sample/subsample + Sample volume or mass = **Mass concentration**



Exposure estimation: particle counts versus mass concentration



WWTP Effluent:

A2O WWTP: 10.7 MPs/L = 15 $\mu\text{g/L}$
300 Million MPs/day = 430 g/day

Biosolids:

Dry sludge 183 MPs/g; dry pellets 165 MPs/g
In mass units 165 MPs/g = 135 $\mu\text{g MP/g}$ biosolids
MP input to agricultural lands in Europe:
2-3 Mt x 135 $\mu\text{g MP/g}$ = 270-400 t/year (other estimations 50 000 and 175 000 tonnes/year)

Compost from OFMSW:

5-20 MPs/g (separate collection) ~30 mg MPs/g
OFMSW 100 Mt; dry compost 32 Mt; x 30 mg
MPs/g = 470 000-1 900 000 t/year (EU, only MPs)

Drinking water:

Municipal drinking water: 12.5 (8.3-21.7) MPs/m³, 18 ng/L, EDI: 0.5-2.2 ng kg⁻¹ day⁻¹ (2 L/day)

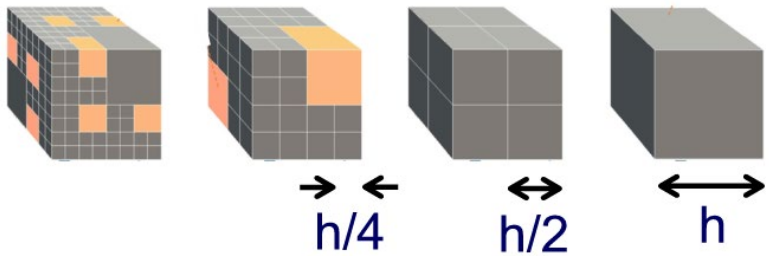
Bottled (PET): 0.73 (0.64-1.58) MPs/L, 1.61 (1.10-2.88) $\mu\text{g/L}$, EDI: 4-18 ng kg⁻¹ day⁻¹

1 g in 10 years (bottled, 65 L/year) and 75 years (municipal 2 L/day)

Exposure estimation for small microplastics and nanoplastics

Fractal fragmentation theories allow rational estimations of mass concentration for sizes too small to be accurately measured.

In fractal theories, fragmentation depends on the probability «p» of crushing with crushing ratio «b». The number of fragments N_i with size x_i is given by:

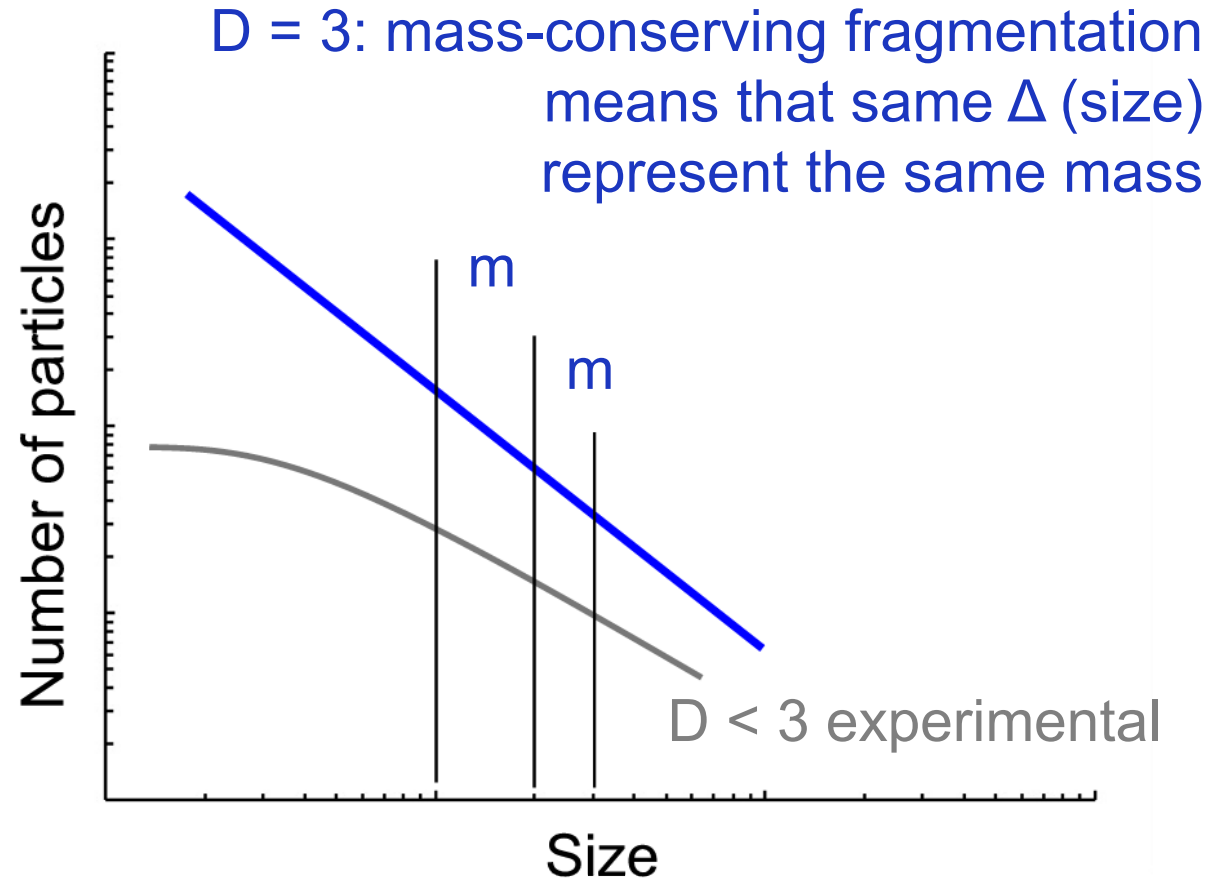


$$N_i = C x_i^{-D} \text{ with } D = 3 + \frac{\ln p}{\ln b}$$

log-log constant slope means scale invariance

D = fractal dimension identified with the dimensionality of the fragmentation process

$$M_i = \int \rho \frac{\pi}{6} x_i^3 (C x_i^{-3}) dx = \rho \frac{\pi}{6} C \Delta x_i$$



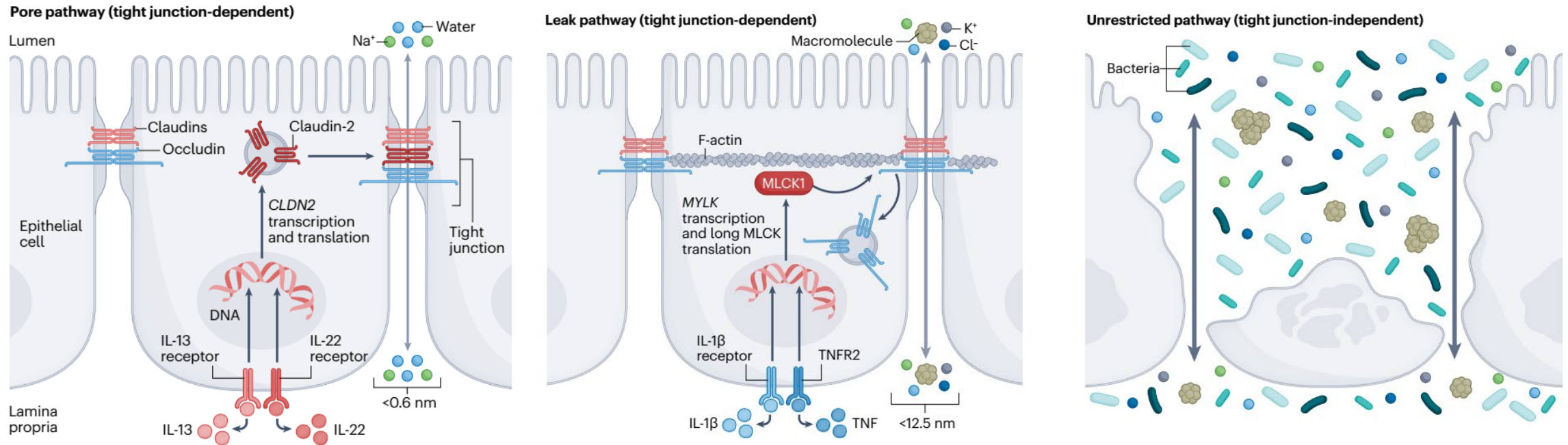
Risk assessment

1

Precise exposure estimation is needed for nanoplastics, additives, NIAS (oligomers), and polymer degradation products (including textiles and bioplastics)

2

Internalization mechanisms should be clarified



3

Accurate **exposure-effect (hazard)** information is required for **modelling risk** meaning broader range of endpoints with attention to sublethal and chronic effects and interactions with other stressors + **other hazard related aspects** are trophic transfer, particularly in agroecosystems and interaction with the biota (ARG, ARG, pathogens)

Key issues - important gaps



1. Accurate exposure estimations needed in mass units
2. Detailed information on internalization mechanisms
3. Exposure-effect information suitable for risk assessment
4. Possible trophic transfer and human exposure through food products
5. Fate of polymer degradation products, especially for new products such as bioplastics
6. Interaction with microorganisms