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Topical Discussion: Understanding Microplastic Fate and (Eco) Toxicity Through Interdisciplinary Collaboration

Monday, May 1, 2023

Session Co-Chairs:

Susanne Brander, Oregon State University, MP interest group co-chair

Amila Abeynayaka, Institute for Global Environmental Strategies - Japan, Steering committee SETAC NA LCA IG & SETAC MP IG

Roland Hischier, EMPA, Head ALCA group, SETAC Europe LCA interest group co-chair

Valentina Pauna, Norwegian Institute for Sustainability Research (NORSUS), Steering committee SETAC MP IG

Expert Panelists:

Denise Mitrano, ETH Zurich

Jim Lazorchak, US EPA

Marisa Passos, European Commission Joint Research Center

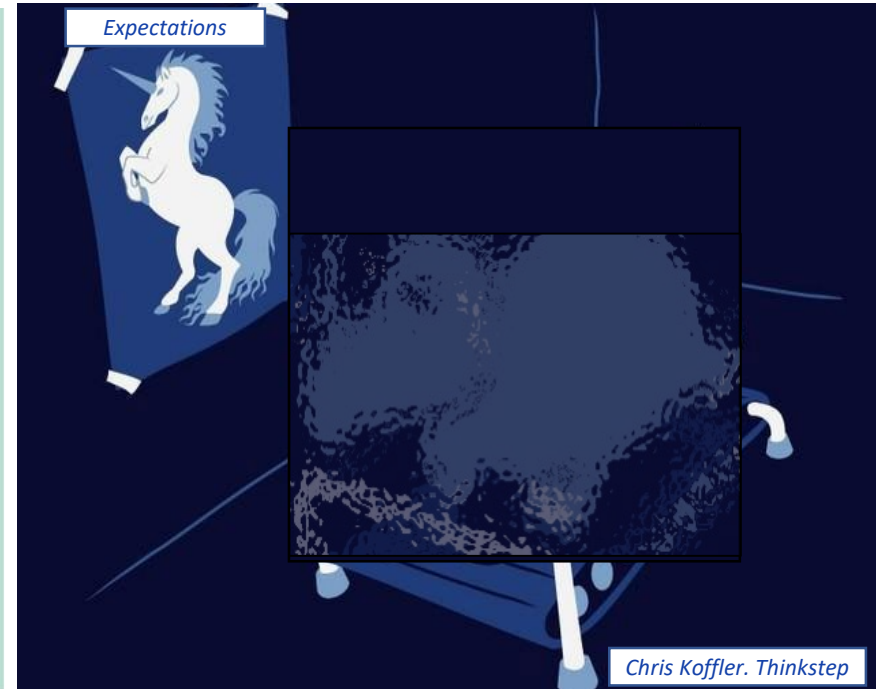
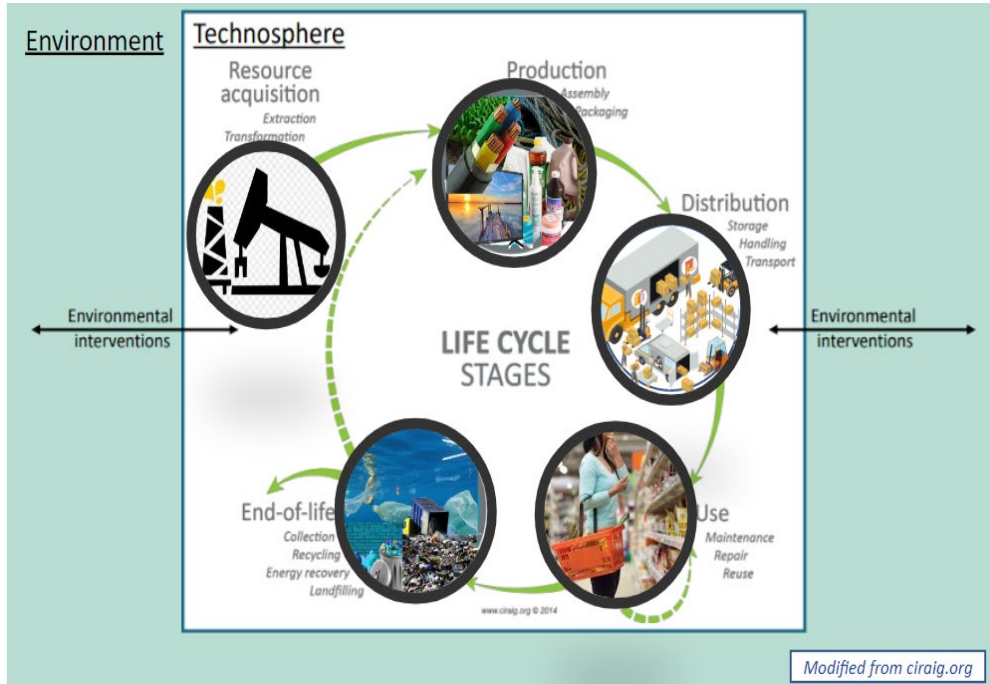


SETAC EUROPE 33RD ANNUAL MEETING
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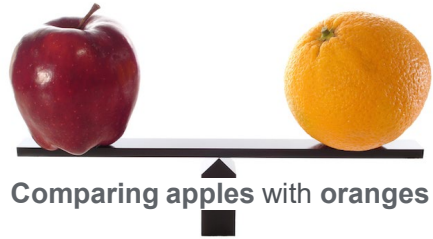


Sustainability of Plastic: Life Cycle Assessment (LCA)

Here it is, the reality of LCA!

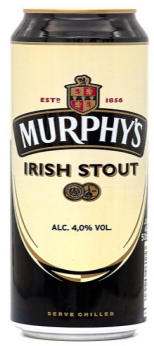


LCA, Life Cycle Inventory (LCI) & Life Cycle Impacts Assessment (LCIA)



Comparing apples with oranges

Functional Unit



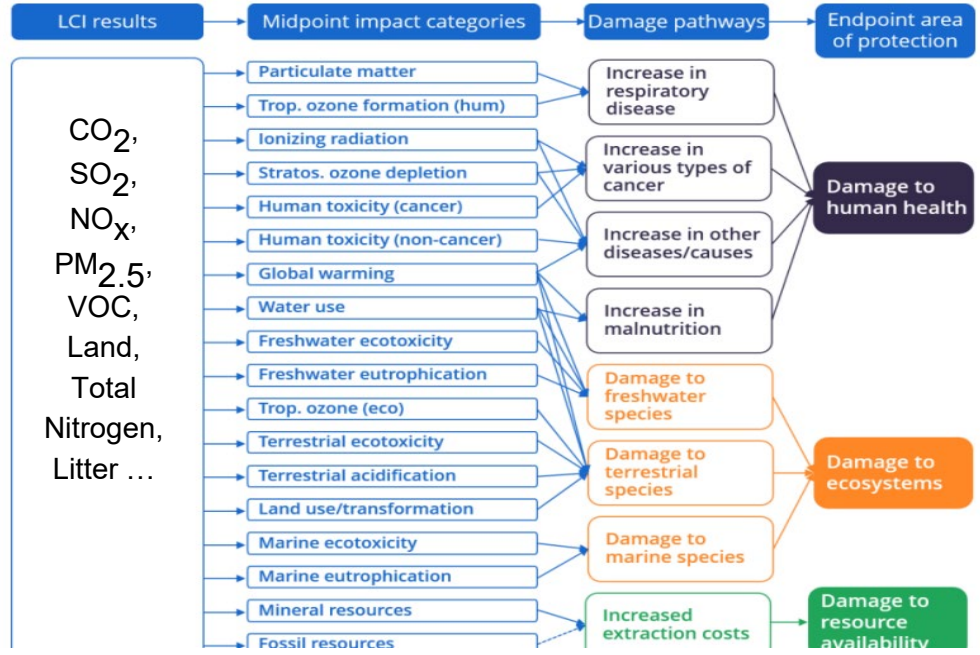
Vs



Idea: Chris Koffler. Thinkstep



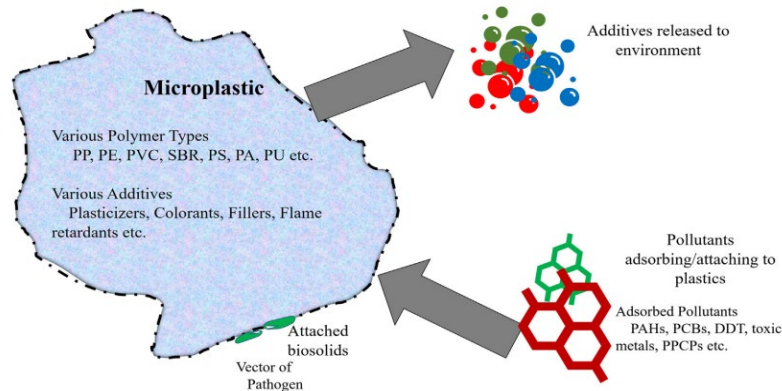
IMPACT World+



LCIA Characterization Factors

A. Diversity of plastic ...

B. Plastics and Chemicals of Concern

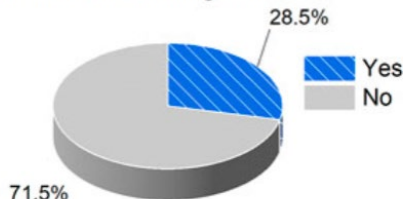


Rochman et al. (2019)

Data Availability?

Findable,
Accessible,
Interoperable,
Reusable

Is there a Data Sharing Statement?



Jenkins et al. (2022)

Indicator of Damage = Characterization Factor × Environmental Intervention

Fate Factor (FF) × Exposure Factor(XF) × Effect Factor (EF) = Characterization Factor (CF)

Distribution/
Longevity/Degradation

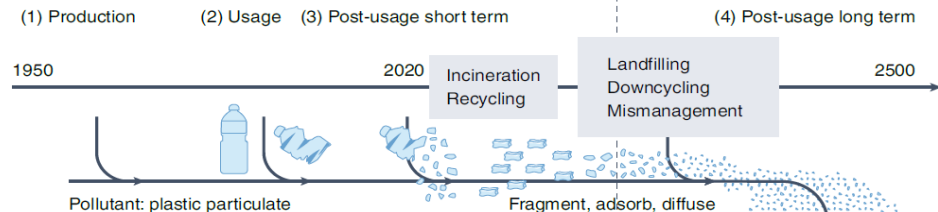
Interaction with
Sensitive Receptors

Consequences

i.e. Plastic Leaked into
Environment

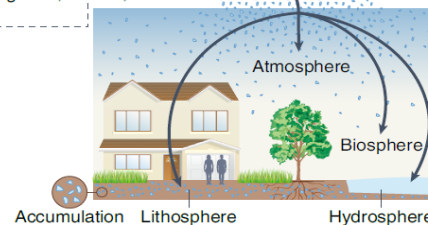
Typical limit of LCA time horizon

Pollutants: SO₂, CO₂, M²A, CFC-11, NO_x, P, Cu, 1,4-DCB, PM_{2.5} and so on



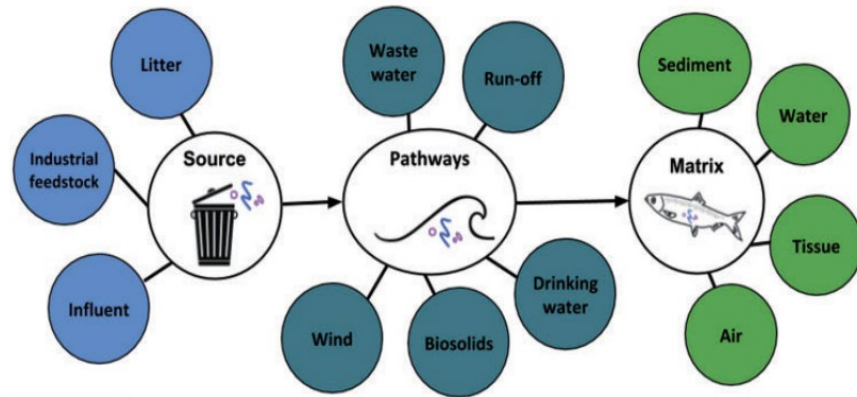
C. Time Horizon & Plastics in Environment

Gontard et al. (2022)

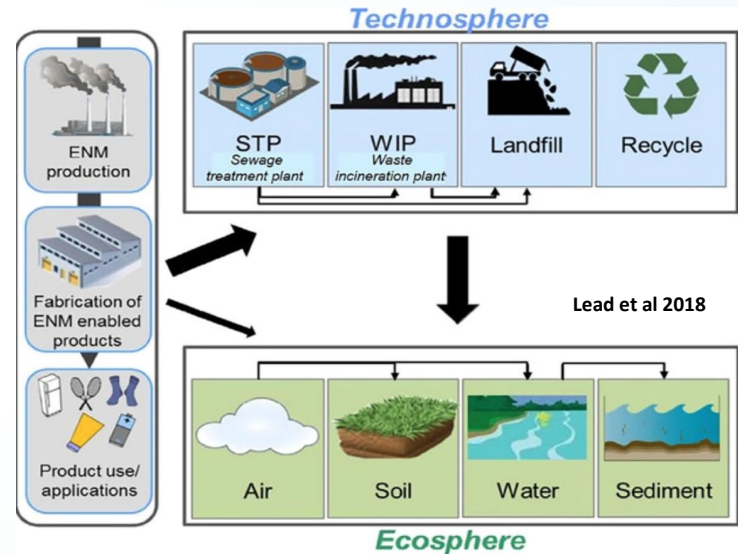


Microplastics and Nanoplastics Research

The fields of microplastics and nanoparticle research share challenges along several common threads. Risk assessment from both needs to be integrated with LCA approaches.



Brander et al 2020



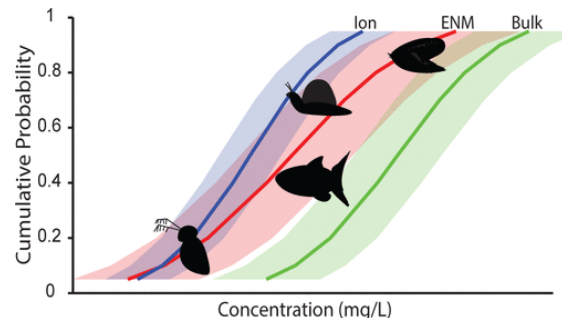
Risk Assessment

New or shared challenges faced by micro and nanoplastics

- Can we address secondary (degradation, breakdown, fragmentation) products?
- Need for dose-response data for environmentally relevant concentrations or exposure scenarios. But what is environmentally relevant, do we really know?
- How can we all get on the same page for reporting the density of plastics so we can compare results?

Lessons learned:

- Need better understanding of mechanisms of action to accurately assess risk
- Better knowledge of smaller size fractions in the environment and their concentrations will improve exposure assessment.



Garner et al 2015, ES&T

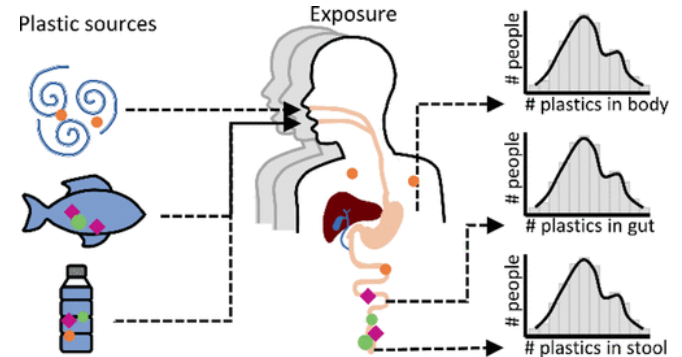
Regulatory concerns

Shared challenges faced by micro and nanoplastics

- Current frameworks e.g. LCA don't account for microplastic persistence, fragmentation, how to avoid regrettable substitutions?
- Human and environmental exposure widely documented, what next?

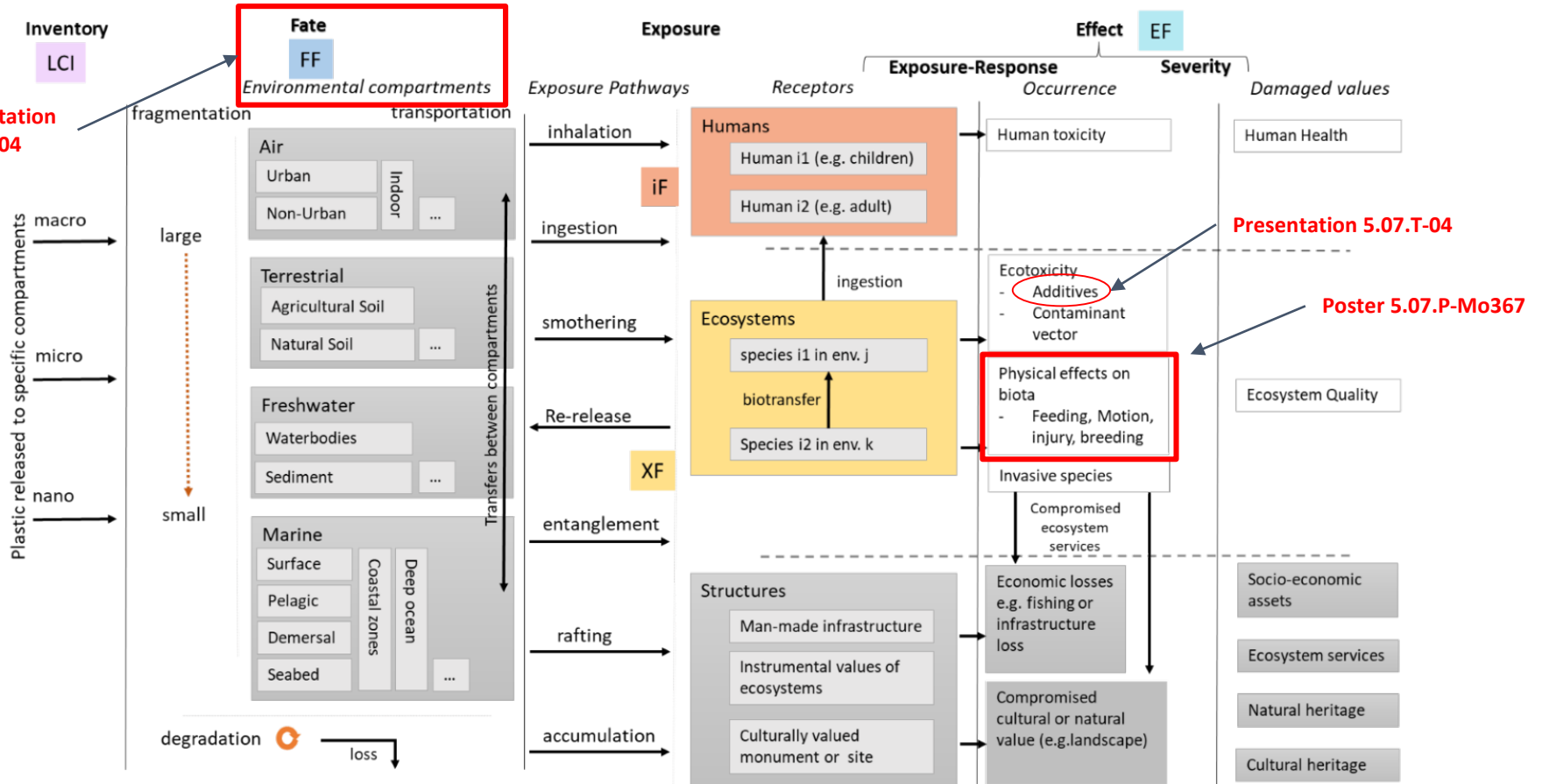
Proposed approaches

- Cap on virgin plastic production recommended by scientists, as well as move to circular economy.
- Is this realistic? How do we use available data on risk combined with LCA to assess different scenarios?



Integration of plastic litter impacts into LCA

Presentation 5.07.T-04

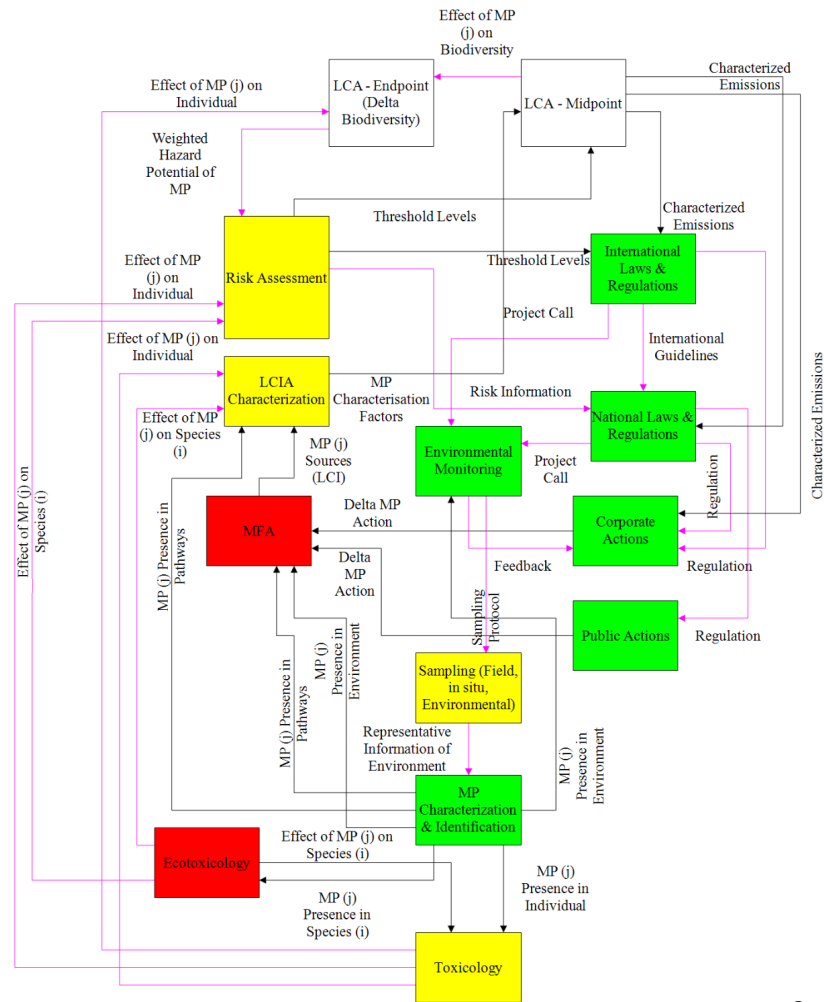


Modified from Woods, J. S., Verones, F., Jolliet, O., Vázquez-Rowe, I. and Boulay, A. M. 2021. A framework for the assessment of marine litter impacts in life cycle impact assessment. *Ecol. Indic.*, 129 (107918).

<https://doi.org/10.1016/j.ecolind.2021.107918>, in Askham et al. 2022.

LCA's (synergistic) interaction with Risk Assessment, Ecotoxicology, Toxicology, Material Flow Analysis, etc., etc., etc...

- LCA inherently relies on data from other fields of study, both directly and indirectly.
- LCIA (and the characterisation of MNPs) inherently relies on metadata from a variety of fields, but particularly:
 - Toxicology
 - Ecotoxicology
 - Materials Science
 - Marine Pollution (environmental sampling/monitoring)
 - Etc. (don't forget about hydrology, sedimentology, oceanography)
- LCA interacts both directly and indirectly with decision-making, regulations should be considered in LCA.



The data we need in LCA and ways to get it - *what are we missing?*

- **Consider:**
 - If you are a data gatherer, what data can you provide, what is feasible?
 - If you are a data user, what data must you have for your assessment?
 - How can data users better communicate with data gatherers and vice versa? (i.e. how to be efficient, how to communicate clearly also across disciplines and sectors)

	Inventory (LCI)	Fate (FF)	Exposure (iF)	Exposure (XF)	Effect (EF)
Field studies					
Metadata					
1) Location of sampling	✓	✓	✓	✓	✓
2) Date & time of sampling	✓	✓			
3) Depth of sampling	✓	✓	✓	✓	✓
4) Sampling device	✓	✓			
5) Conditions of sampling environment	✓	✓		✓	
6) Effluent sampling	✓	✓			
7) other chemicals or additives found in samples	✓	✓	✓	✓	✓
Data Types					
1) Qualitative					
a) Polymeric composition	✓	✓	✓	✓	✓
b) evidence of fragmentation		✓			
c) morphology		✓	✓	✓	✓
d) colour of particles	✓	✓		✓	✓
e) biofouling		✓		✓	✓
f) additives in particles	✓	✓	✓	✓	✓
2) Quantitative					
a) total mass of particles	✓	✓	✓	✓	✓
b) dimensions		✓	✓	✓	✓
c) mass of particles per size range	✓	✓	✓	✓	✓
d) aspect ratio		✓	✓	✓	✓
e) mass of individual particles		✓	✓	✓	✓
f) % monomers within polymers observed	✓	✓	✓	✓	✓

Way Forward / Discussion

- Which fields of study do you think LCA of plastic is reliant on, how could this change?
- Where do we stand on Fate modeling (diversity of plastics and compartments)?
- How can an interdisciplinary outlook benefit micro and nanoplastic research in the project planning stages?
- Is the quality, quantity, and diversity of data available on MNP hazard and risk to the environment and human health sufficient to improve LCA models globally?
- How do we best validate LCA models, given this is an excellent opportunity for synergistic improvements across relevant disciplines?



Join at www.setac.com/group/IGplastic !!

- ▶ Twitter (@SETAC_plastics)
- ▶ Website: microplastics.setac.org



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- ❑ Add your recent work to the site, and see others' recent work
- ❑ Find organizations, labs and researchers working on plastic pollution
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