Towards the development and application of an ERA framework for microplastic particles

Todd Gouin
Acknowledgements

SYMPOSIUM PROGRAMME

Towards the Development and Application of an Environmental Risk Assessment Framework for Microplastic

3 November 2018
Sheraton Grand Hotel, Sacramento, California

Organised by
Motivations

- Increasing pressure on assessing the environmental risks, associated with particulates, such as NMs and microplastic
  - Scientific
  - Regulatory

- Challenges towards effective and efficient governance and regulation.
  - Technical/scientific “problems”:
    - (standard) test methods are missing or not applicable;
    - test methods are not always relevant
  - Infrastructure for data management not adequate
    - doubts about quality of data; no facilities for checking or curation
## EU Legislation & Policies – SAPEA Report

- **Product Legislation**
  - REACH
- **Waste Legislation & Emissions**
  - Waste Framework Directive
  - Packaging & Waste
  - Landfill Framework Directive
- **Environmental Legislation**
  - Water Framework Directive
- **Non-binding strategies**
  - Plastics Strategy
  - Circular Economy

### Table 4.1: Overview of EU Legislation and Policies on Microplastics

<table>
<thead>
<tr>
<th>Legislation</th>
<th>Date</th>
<th>Status &amp; Milestones</th>
<th>Concerned environmental compartment</th>
<th>MEP explicit targeted?</th>
</tr>
</thead>
<tbody>
<tr>
<td>REACH Directive 1907/2006</td>
<td></td>
<td>Implementation in discussion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 degradable plastics and intentionally added microplastics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECMA will propose a restriction on market introduction or use of microplastics per January 2019, when it is the most appropriate limit. These measures are targeted at effects or exposures that cause the risk identified, in a period of time and not proportional and being practical and feasible.</td>
<td></td>
<td>Soli/Water</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Single-Use Plastics 1907/2006 and Fishing gear</td>
<td>May 2018</td>
<td>Legislative process ongoing</td>
<td>Water (Marine)</td>
<td>Yes</td>
</tr>
<tr>
<td>Packaging and Packaging Waste 64/50/EC</td>
<td>May 2018</td>
<td>Revised version to transpose</td>
<td>Soli/Water</td>
<td>No</td>
</tr>
</tbody>
</table>

### Environmental legislation, quality of receiving environment

<table>
<thead>
<tr>
<th>Legislation</th>
<th>Date</th>
<th>Status</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>European action plan for the Circular Economy. Closing the loop (COM 2016/674)</td>
<td>Dec 2015</td>
<td>/</td>
<td>Soli/Water/No</td>
</tr>
</tbody>
</table>
Problem formulation

- Different instruments appear to address varying aspects related to concerns associated with microplastic
  - Clarity of problem trying to address?

Reduce risk?
Reduce harm?
Reduce release of plastic?
On the question of risk...

“Concentrations detected are orders of magnitude lower than those reported to affect endpoints such as biochemistry, feeding, reproduction, growth, tissue inflammation and mortality in organisms. The evidence for microplastics acting as a vector for hydrophobic organic compounds to accumulate in organisms is also weak. The available data therefore suggest that these materials are not causing harm to the environment.”

Where risk is assessed based on estimating the ratio of PEC/PNEC
Risk assessment framework

- Exposure and fate pathways
  - Degradation
  - Aggregation
  - Agglomeration
  - Sedimentation
  - Long-range transport
  - Bioaccumulation
  - Sorption of chemical contaminants
  - Source characterization and apportionment

- Characterization of physicochemical properties
  - Size
  - Shape
  - Chemical composition
  - Surface properties
  - Density
  - Porosity

- Microplastic particles

- Effects
  - Development and standardization of effect studies
    - Relevant endpoints
    - Sensitive species
    - Adverse outcome pathway
    - Mechanism of action
      - External physical effect
      - Internal cellular effect

- Modelling
  - Predicted environmental concentration

- Monitoring
  - Compartment and species of concern

- Dose-response

- Risk assessment
  - Mesocosm
  - Field studies
  - Mixture toxicity
  - Species sensitivity distributions

- Higher tier studies

Critical Review

Toward the Development and Application of an Environmental Risk Assessment Framework for Microplastic

Todd Dourson, Richard A. Becker, Anne-Gaelle Collot, John W. Davis, Brett Howard, Kunfumi Inaweska, Mark Lampi, Blanca Serrano Ramon, Jay Shih, and Philip W. Hopp
Risk assessment framework

Toward the Development and Application of an Environmental Risk Assessment Framework for Microplastic

Critical Review

Environmental Toxicology and Chemistry Volume 26, Number 10 - pp. 2591-2593, 2019

Received: 4 April 2019 | Revised: 13 May 2019 | Accepted: 14 June 2019

Development and standardization of effect studies
- Relevant endpoints
- Sensitive species
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External physical effect
- Mechanism of action

Internal cellular effect

Dose-response

Mesocosm
Field studies
Mixture toxicity
Species sensitivity distributions

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Modeling
Monitoring
Predicted environmental concentration

Higher tier studies
Environmental fate – CEFIC LRI ECO 48

**Nano2Plast Models**

- Predicted environmental concentrations (PEC) at the local (river) and global ocean scale
- Fill crucial data & knowledge gaps for microplastic exposure and risk assessment

New model framework for microplastic fate & transport in rivers

Existing models for nanoparticles

Prof. Matthew MacLeod & Dr. Antonia Praetorius
Risk assessment framework
Microplastic Effect Thresholds for Aquatic Species

Hypothesis
That adverse physical effects of MP particles will primarily consist of a decreased nutritional value of ingested particles and/or from physical obstruction, both of which depend on the dose and bioavailability of the complex particle mixture present in nature.

Vera de Ruijter, Paula Redondo Hasselerharm, Bart Koelmans
Risk assessment framework

- Environmental fate & exposure assessment
  - Exposure and fate pathways
    - Degradation
    - Aggregation
    - Agglomeration
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    - Long-range transport
    - Bioaccumulation
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- Microplastic particles
- Characterization of physiochemical properties
  - Size
  - Shape
  - Chemical composition
  - Surface properties
  - Density
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- Effects
  - Development and standardization of effect studies
    - Relevant endpoints
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- Microplastic particles
- Characterization of physiochemical properties
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Critical Review
Toward the Development and Application of an Environmental Risk Assessment Framework for Microplastic
Intrinsic and Extrinsic properties

- polymer particle
- metal particle
- carbon nanotube

Particle

- size
- material
- surface
- shape

hydrophobic coating

surface functional group
- -SH
- -NH2
- -COOH

surface charge

sphere
cube
rod
plate
star
Linking exposure to observed adverse effect

- Intrinsic physical–chemical properties → Exposure
  - Bio-physical interaction → $E_{Pint}$
  - Biological uptake → $E_{IT}$

$OAE = \sum E_{IT} + \sum E_{Pint}$
Standardized testing – Challenges and limitations

Environmental compartment (fresh and marine water, fresh and marine sediment, terrestrial)
Has regulatory action been helpful?

- Actions to date appear to be reactive to public pressure and do not appear to address dominant sources.
  - “Ban the bead”
  - Single-use plastic
    - Plastic Straws
  - Others?

- Do *ad hoc* responses to public pressure help address uncertainties or frustrate advancing scientific and technological solutions to addressing accumulation of plastic in the environment?
  - Precautionary approaches imply that actions can facilitate innovation, but if actions are inappropriate or disproportionate, they may fail to achieve the end-goal?

- Can a more holistic strategy that is supportive of scientific and technological innovation be adopted that enables regulatory decision-making to be science-based, and which can also incorporate informed precautionary measures?
  - EU Plastics Strategy
  - Circular Economy
Bringing stakeholders together
INNOVATION

- Understand
  - Risk assessment
- Improve
  - Release mitigation
- Develop
  - Material science
- Use
  - Socio-economic impact
Bringing stakeholders together
A Global Plastics Contaminants Program

The Northern Contaminants Program (NCP) works to reduce or eliminate contaminants in traditional foods, and to provide information on contaminants to individuals and communities. It is a multidisciplinary initiative, funded by the Government of Canada, addressing health, science, and communications issues related to contaminants in Canada’s Arctic. It was established in 1991 through the Government of Canada’s Green Plan and Arctic Environmental Strategy.

“It’s good to have aspirational goals…”
LRI SECRETARIAT

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Cefic-LRI Programme

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