EMIFACT-MNP: EMIssion FACTors for Micro and NanoPlastics

Cefic-LRI project ECO60

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UK Centre for Ecology & Hydrology

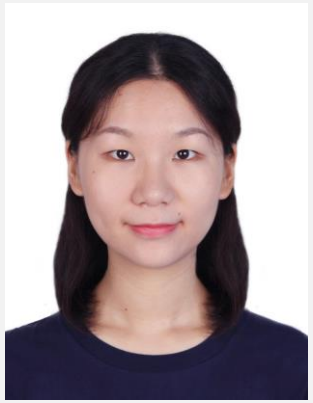
Empa
Materials Science and Technology

Duke

Who we are

Empa
Materials Science and Technology

Bernd Nowack



Danyang Jiang

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Mark Wiesner

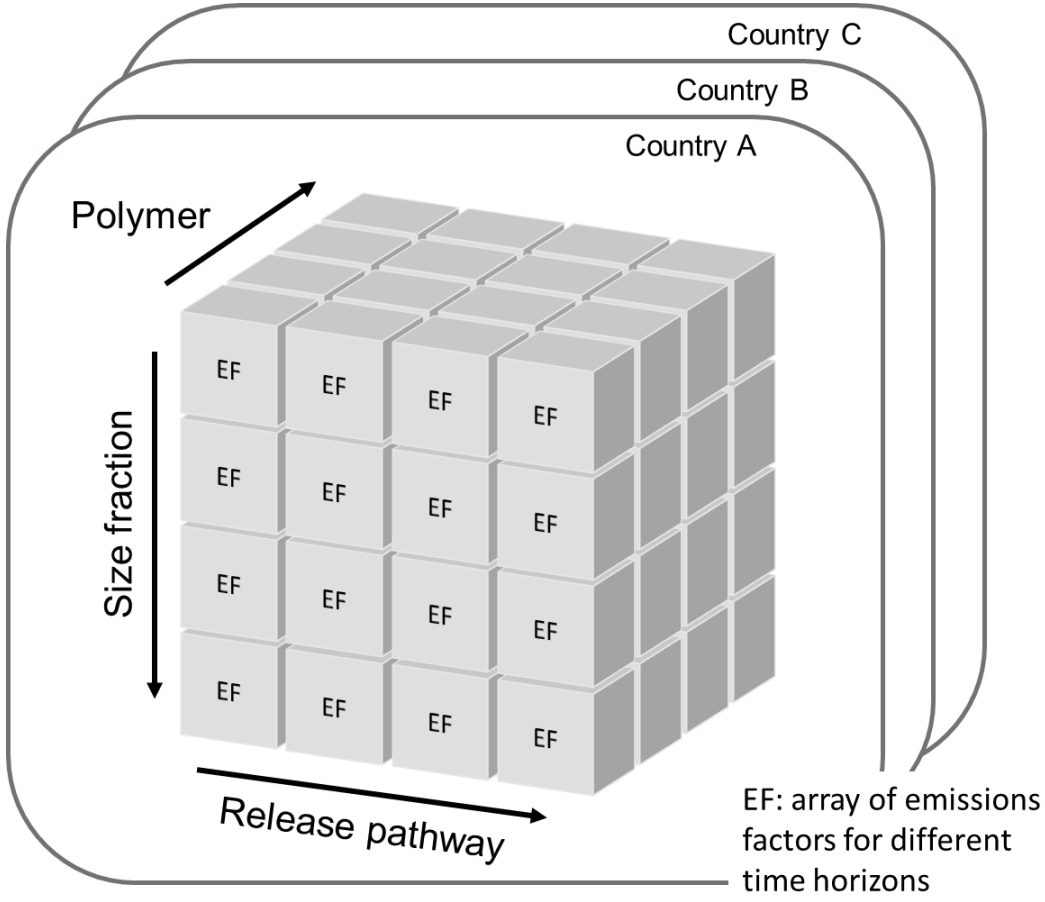
UK Centre for Ecology & Hydrology

Sam Harrison

Claus Svendsen

Project objectives

Aim: To develop a model that predicts environmental emissions factors (EF) for the **full size range** of plastic emissions, spanning the **full range of professional, consumer and industrial scenarios**, covering their **whole lifecycle** and a broad range of **widely used polymers**.



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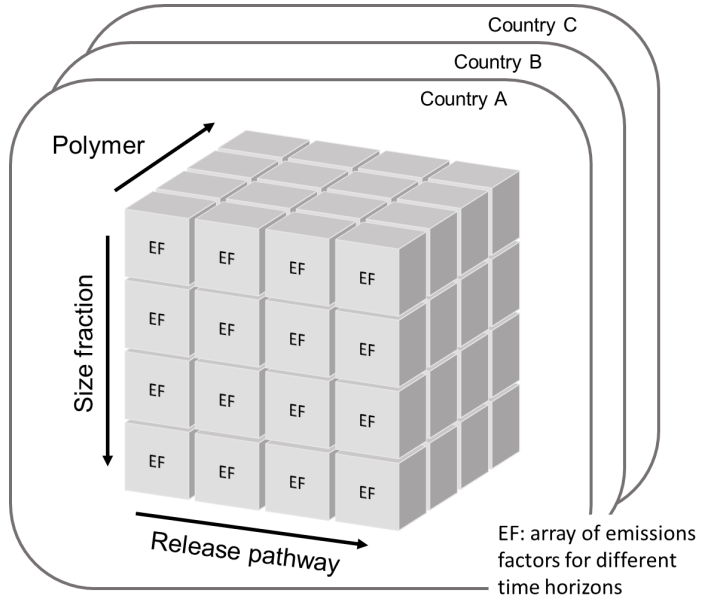
Project objectives

We will advance state-of-the-art by:

- Providing **spatially distributed** EF on a European scale.
- Providing **size distributed** EF over relevant time horizons.
- Considering the full polymer material flow through the technosphere towards environmental release.
- Yielding **probabilistic EF** through use of existing probabilistic material flow analysis developed by Empa.

The end product will be a **framework for generating EF, applied to a broad range of polymers** to produce **SPERC-like EF**.



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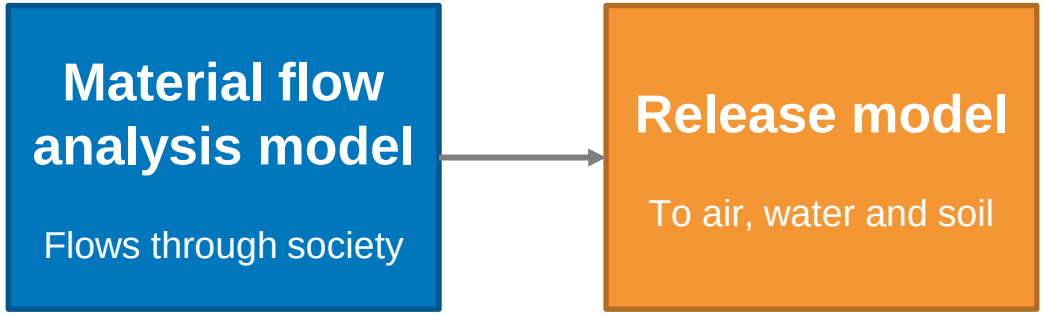
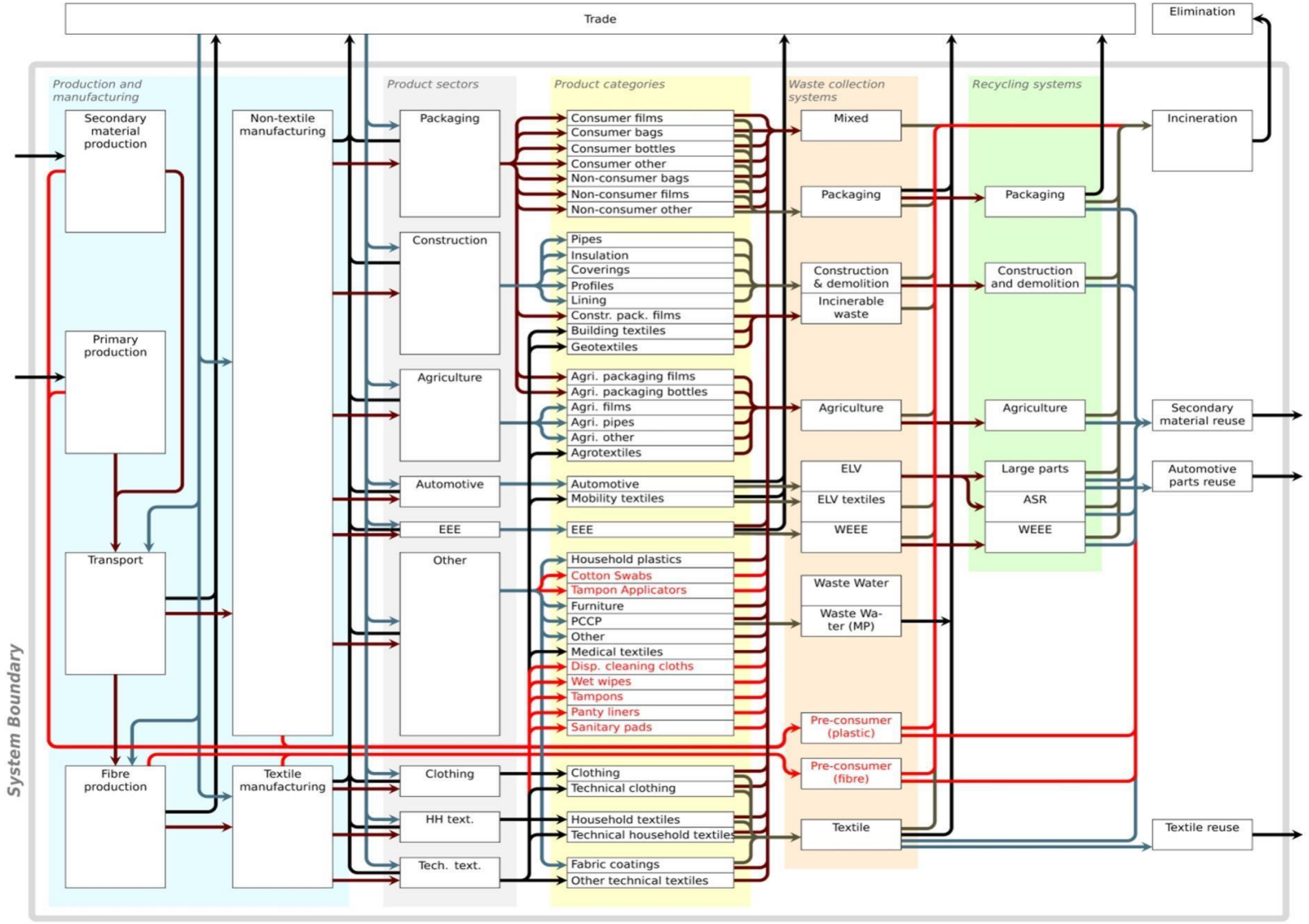
The existing model for Switzerland



- Covers all life-cycle stages and all uses
- Probabilistic to represent uncertainty and variability in all model parameters
- Polymer-specific:
  - LDPE, HDPE, PP, PS, EPS, PVC, PET
  - PUR, ABS, PA, PC, PMMA
  - Rubber used in tyres

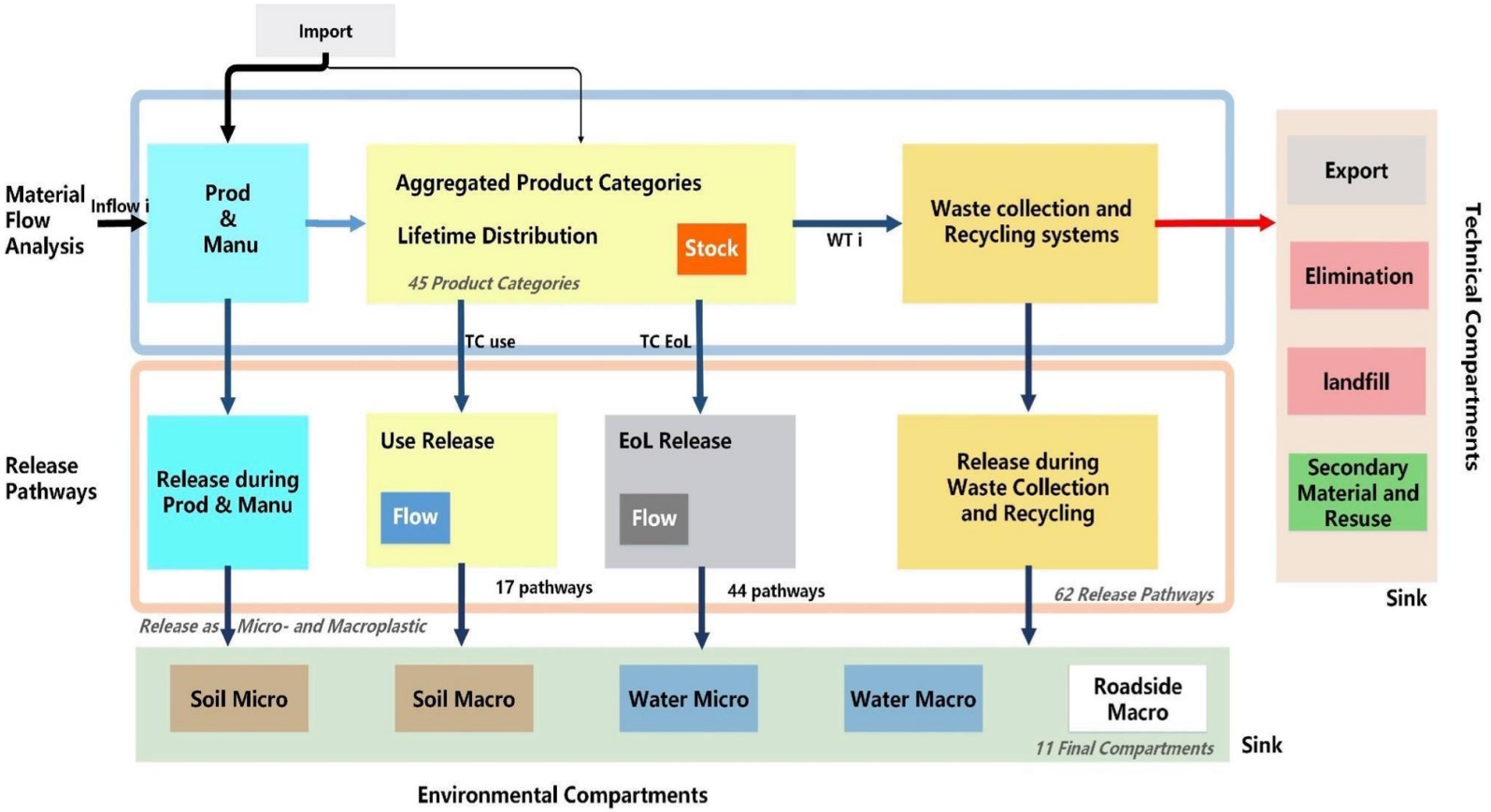
Kawecki and Nowack (2019)
Liu and Nowack (2022)
Sieber and Nowack (2020)

The existing model for Switzerland: MFA



- 9 product sectors
- More than 35 product categories
- 13 waste collection systems
- 6 recycling systems

The existing model for Switzerland: Release model



- Direct releases
- Indirect releases (through a technical compartment, e.g. WWTP)
- Macro- and microplastics
- 40 release pathways covered, each for a specific EF

Extending the model

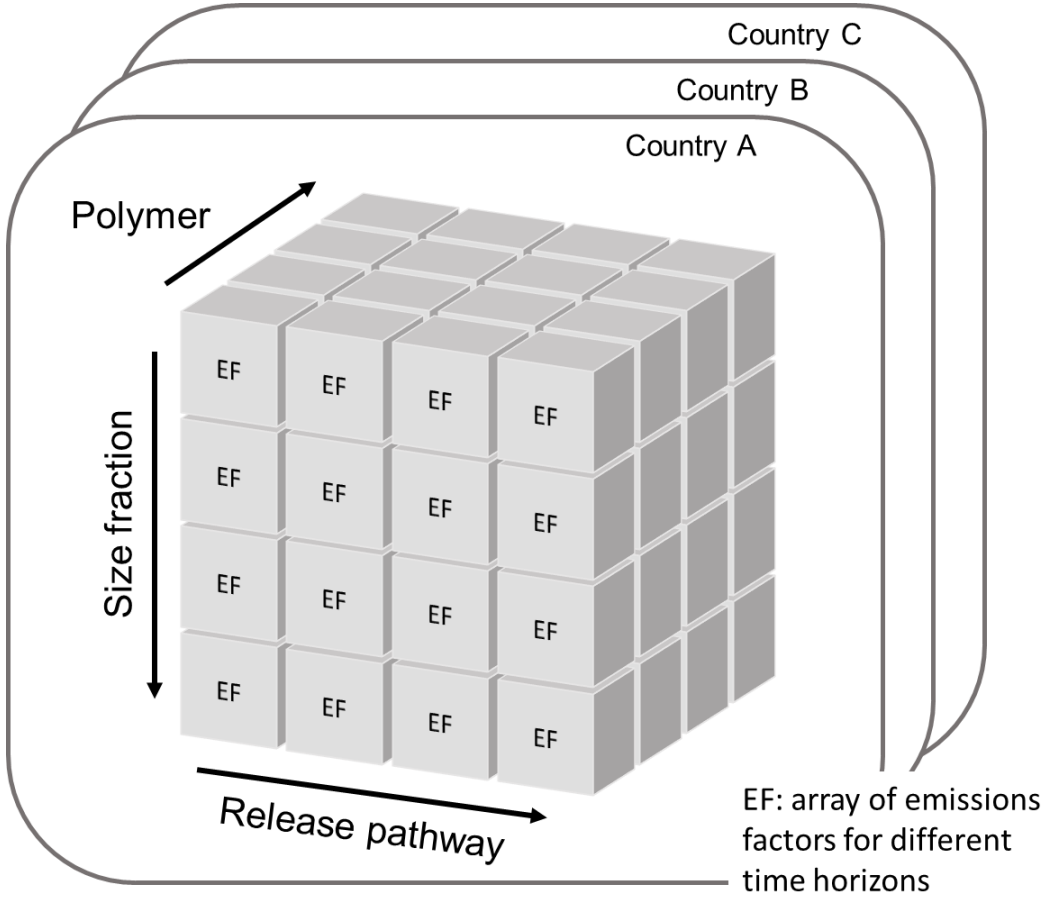
- Extend to the whole of Europe:
  - Modify and add release processes not relevant for Switzerland
  - Waste system adaptation to all European countries
- Add fragmentation to predict size-distributed release
  - Current model is two size classes (macro, micro)
  - We will extend this using the ECO59 project data and model to predict size-distributed releases from nano to macro

Stakeholder consultation

- We are obtaining feedback from industrial sector experts on assumptions made, common practices, and processes that should be considered.
- Based on the following priority sectors:
  - Automotive
  - Agriculture
  - Recycling
  - Construction
  - Fishing
  - Textiles

Summary

- We are developing a model that predicts size-distributed EF across Europe, covering all uses and lifecycle stages and a broad range of polymers.
- Output will be these EF matrices with SPERC-like documentation and open source code and guidance.
- We are currently consulting industry stakeholders to aid this development.



Thank you

Any questions?

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Task 1.3: Stakeholder consultation

•Obtain feedback from industrial sector experts on assumptions made, common practices, and processes that should be considered

•Online and face-to-face meetings to start with

Advisory network based on priority sectors. Key partners:

- **Automotive:** German Automobile Club, ADAC (Germany); European Tyre & Rubber Manufacturers' Association (ETRMA)
- **Agriculture:** National Farmers' Union (UK)
- **Recycling:** Suez Environnement (France)
- **Construction:** EBP (Switzerland)
- **Fishing:** Defra Marine and Fisheries Division (UK)
- **Textiles:** EUROTEX
- **Others:** European Plastic Converters (EuPC); Plastics Europe

Ideas welcome!

Task 2.2: Integration of fragmentation to predict size-distributed microplastic releases

- Basis: the fragmentation model and associated data developed in the ECO59 project
- General methodology will be developed
- Six specific scenarios of high economic and potential environmental impact will be considered
- Tire use
- Construction materials
- Agriculture applications
- Post-consumer processing (e.g. waste handling and recycling)
- Clothing (microplastic fiber release during washing and wearing)
- Pre-consumer processing (e.g. pellet loss).

Task 2.2: Integration of fragmentation to predict size-distributed microplastic releases

- Emission factors will be obtained for five size classes, or “bins”: 10 nm-100 nm, 100 nm-1 µm, 1-10 µm, 10-100 µm, and greater than 100 µm.
- The initial distribution of these bins will be estimated from data curated in WP 1, with extrapolation to the smaller size classes as appropriate.
- The distribution will be applied to the mass flow estimated for a given application to obtain initial EF for materials by size.
- Time-dependency of the size of the EF is considered based on the modelling approach developed in ECO59

ECO59: FRAGMENT-MNP

The initial size distribution of polymer on release to a technical or environmental compartment will be followed by a modification of size distribution over time as plastics degrade and fragment.

We will use the ECO59 modelling approach to obtain **EF by size bin at key time horizons** corresponding to the initial time at a point in the life cycle and subsequent periods of e.g. 1, 10, 100 years as these materials may transit through use and disposal phases of their life-cycle.

FRAGMENT-MNP model will be used to make these predictions based on mechanical stress encountered during the polymer lifecycle.

Task 1.1: Data collation on material flows and emissions

1)Adapt the model parameters used in the Swiss model to on the country-specific modeling of material flows.
2)Generate region-specific Emission Factors (country level) based on different waste management systems.

3)Include new processes not relevant for Switzerland but important on a European scale, e.g. release to the oceans.

4)Update EFs used in the Swiss model focusing on:

-Tire wear

-Construction (including demolition of buildings)

-Agriculture

-Post-consumer processes (e.g. waste handling and recycling)

-Pre-consumer processes (e.g. pellet loss)

-Clothing

5) Determine polymer-specific release estimates based on experimental data.

Task 1.2: Data collation on fragmentation

Review and collate data on size distributions and fragmentation

- Assess the availability of data on the size distribution of polymers released to the environment
- Integrate these distributions (where possible) into the PMFA model to give EFs for specific size fractions
- Collect data on pertinent conditions for plastic wear (magnitudes of chemical and mechanical stresses) for specific stages of plastic life cycle
- Make initial estimates of effective EFs due to fragmentation during life cycle using FRAGMENT-MNP model.