

Identifying regional hot-spots for microplastic immissions into agricultural soils

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A top-down modeling approach
for Germany

The bigger picture

Our institute is involved in two projects funded by the German Ministry for Research and Education. We are studying two river basins in Germany to better understand the sources of MP coming from the land and ending up in the North Sea (via the Weser catchment) and the Baltic Sea (via the Warnow catchment).

As a partner of two large consortia, we are specifically looking at MP pathways associated with agriculture.

In both projects, three models are coupled to estimate the quantities of MP in the different ecosystems:

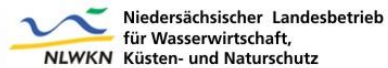
- Using features of the agricultural sector model RAUMIS (<https://www.thuenen.de/en/infrastructure/the-thuenen-modelling-network/models/raumis/>), we estimate the MP amounts from agriculture that are potentially available in soils
- Our results will be used by our partners at the Research Center Jülich for a hydrologic model (mGROWA) that estimates the amounts of MP from all sources emitted into the freshwater system
- Their results will then enter an estuary model at NLWKN / IOW, resulting in MP concentrations in the sea

Specifically, we use MP analytic results from the literature in combination with agricultural datasets to estimate the spatial distribution of diffuse MP contamination in agricultural soils, that can potentially be emitted into the waterways.

The bigger picture



Weser Catchment



Warnow Catchment



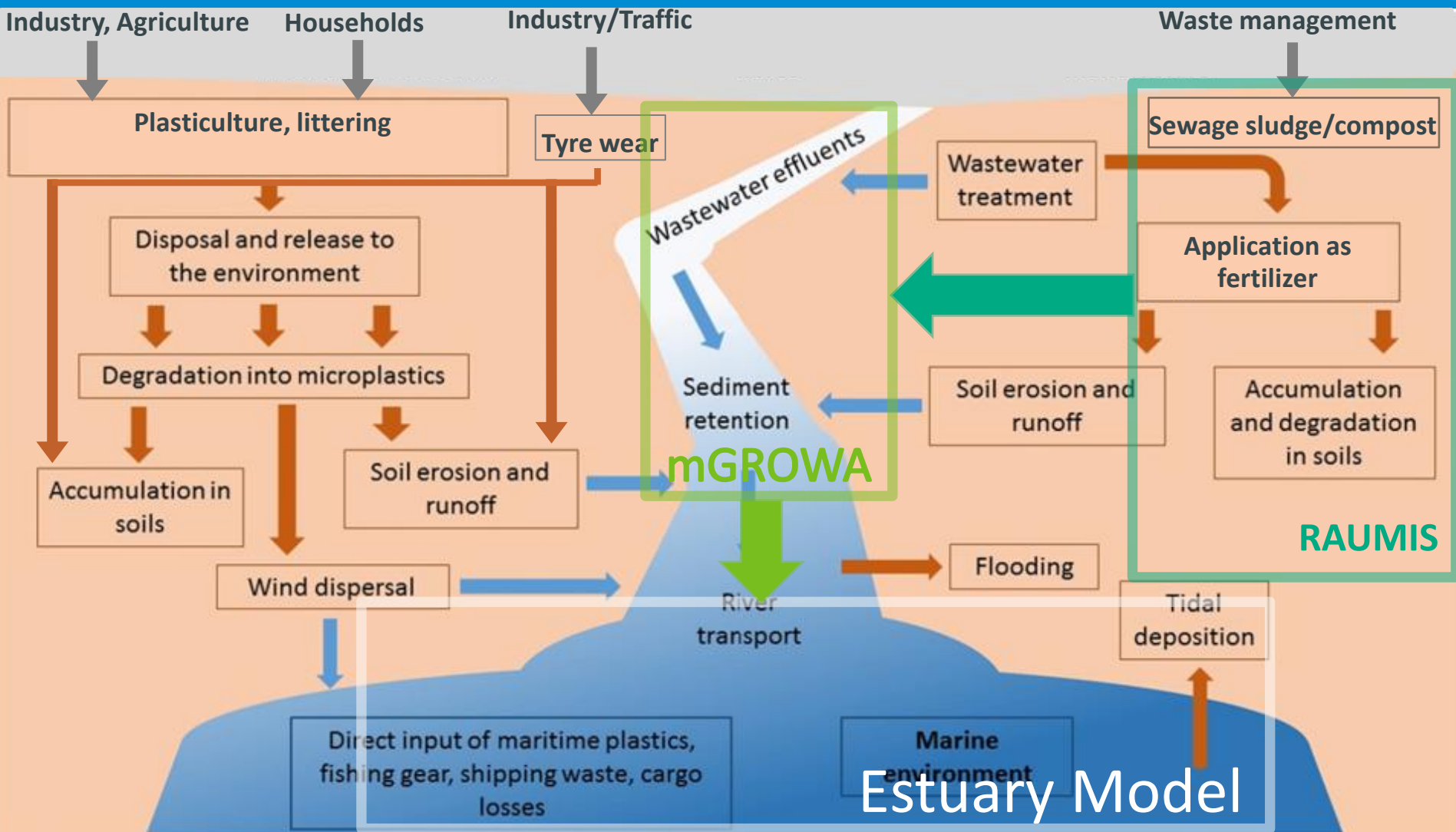
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Quellen • Senken • Lösungsansätze

Sources and pathways of microplastic



Microplastic in agricultural soils

What do we know?

- MP has been found in biosolids used as fertilizer: sewage sludge and compost
- MP has been found in soil (stemming from different, partly unknown sources)

Research questions:

- What are the relevant sources and pathways?
- How much MP accumulates in soils?
- How much of that MP is emitted into freshwater systems?

Which challenges do we encounter?

- Analytic results in soils and biosolids are scarce
- Pathways between systems (erosion, percolation etc.) have not been sufficiently quantified yet
- Therefore, only rough estimates are possible on the MP quantities we can expect in soils from the sources deemed most relevant
- This approach can be adapted and amended by data and parameters once more knowledge becomes available



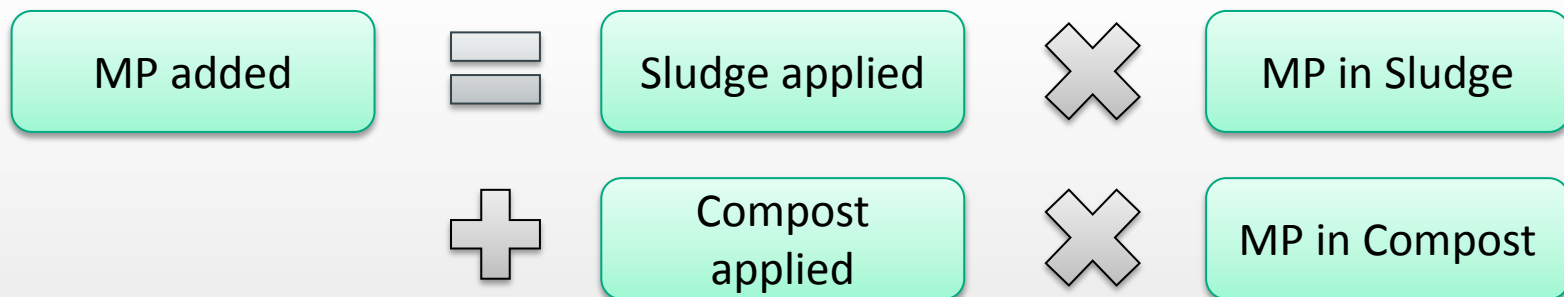
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Methods

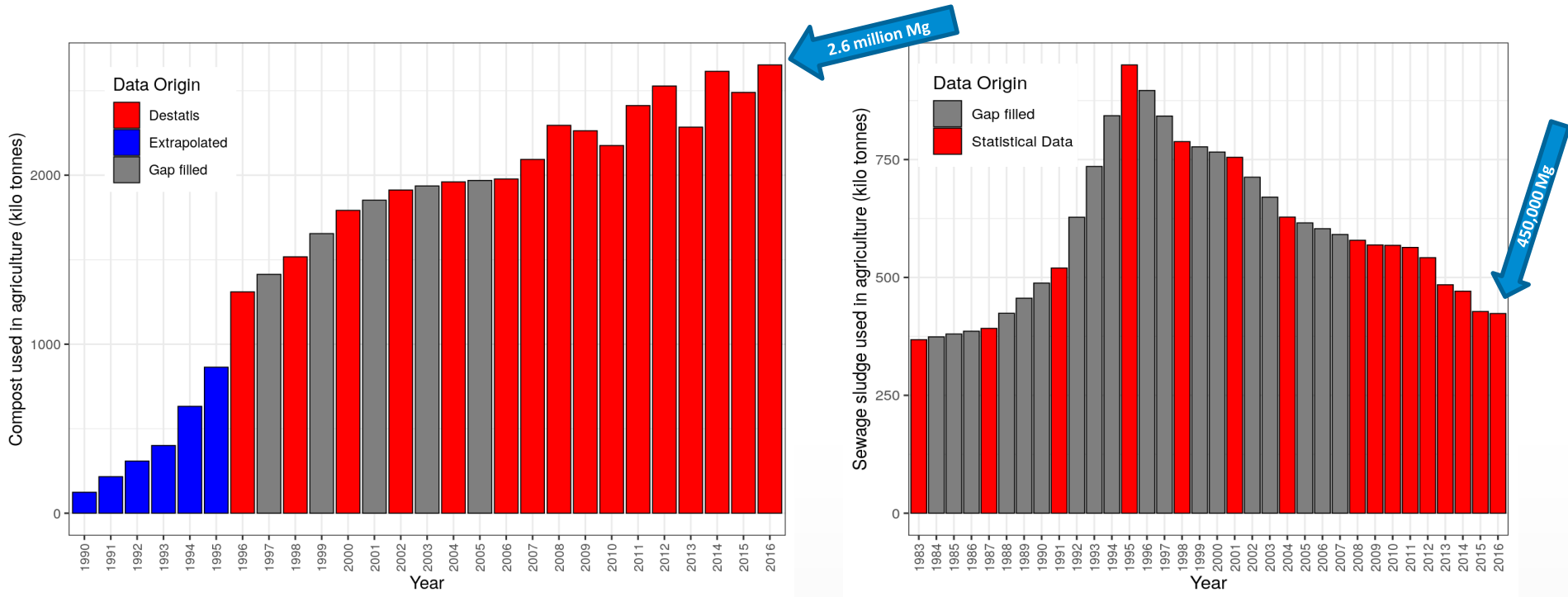
Data:

- Statistical data on biowaste, compost, and sewage sludge production in Germany since 1990 (biowaste, compost) and 1983 (sewage sludge)
- Current (2016) statistical data on biowaste, compost, and sewage sludge production on NUTS 1 and NUTS 3 level
- Current MP amounts in sewage sludge and compost (Literature research)
- Global polyester production (to estimate MP amounts in sewage sludge of past years)

Calculation:



Compost and sewage sludge production for agricultural use in Germany

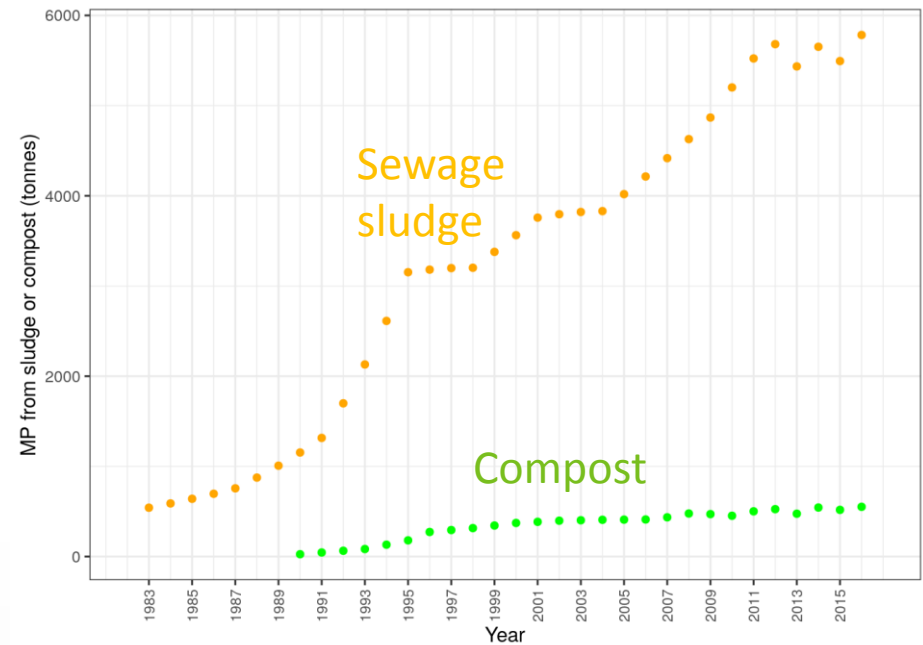


- Historical data on compost and sewage sludge is available only on a national level and fragmentary
- No knowledge exists on the change in MP concentrations in these biosolids over time
- Assumption for compost: MP concentrations are constant between 1990 and 2016
- Assumption for sludge: MP has increased proportionally with global polyester production until current (2016) concentrations

Microplastic from compost and sewage sludge

According to our assumptions, total microplastic from sewage sludge is about 10 times higher than that from compost.

In the following slides, these total amounts are distributed regionally, according to production data of 2016...



Sewage sludge

Summed up 1983 – 2016:

- 110 kilo tonnes in total
- 9.3 kg MP per ha cropland
- 0.0002 wt.% MP in soil (DW)

Compost

Summed up 1990 – 2016:

- 9.5 kilo tonnes in total
- 0.8 kg MP per ha cropland
- 0.00002 wt.% MP in soil (DW)

→ approx. 10 times more MP from sludge than from compost

Spatial distribution: MP from compost

MP-Concentration in compost (1990-2016):



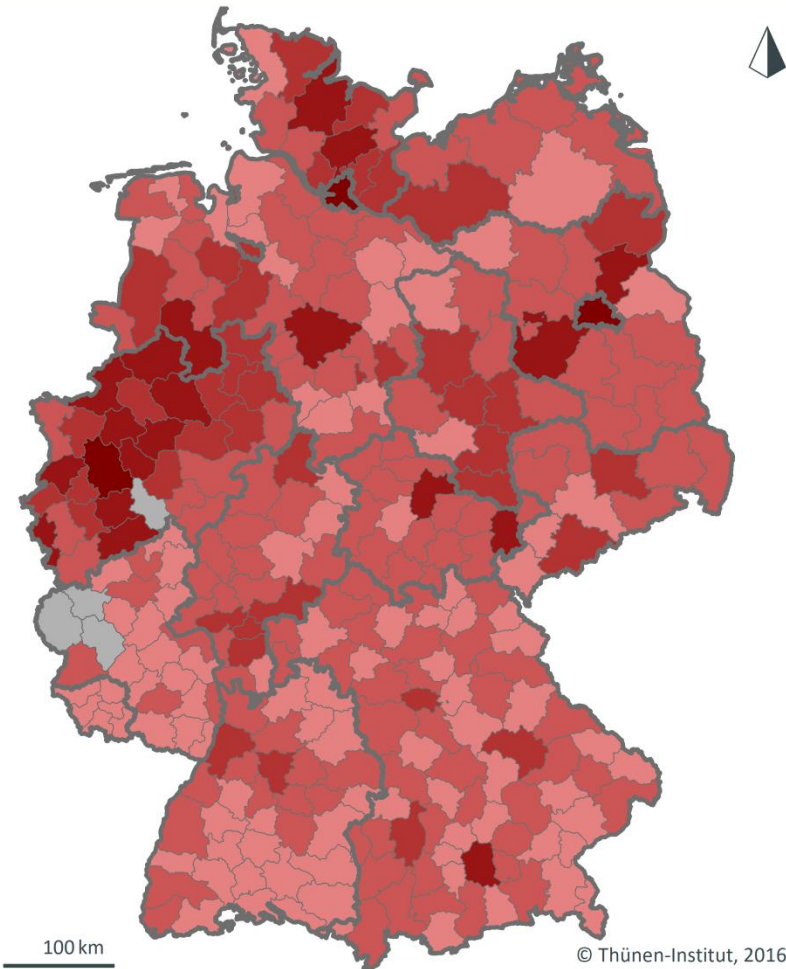
0.039 wt. % DM

**Microplastic from compost
applied to agricultural soils
(accumulated 1990-2016)**

Microplastic (Mg)



Source: Destatis, Regionaldatenbank Deutschland, Bertling et al., 2018, Vollertsen & Hansen, 2017



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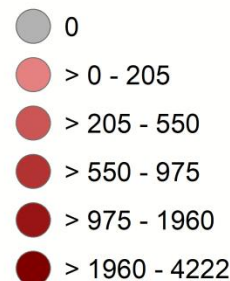
Spatial distribution: MP from sewage sludge

MP-Concentration in sewage sludge:

1.37 wt. % DM

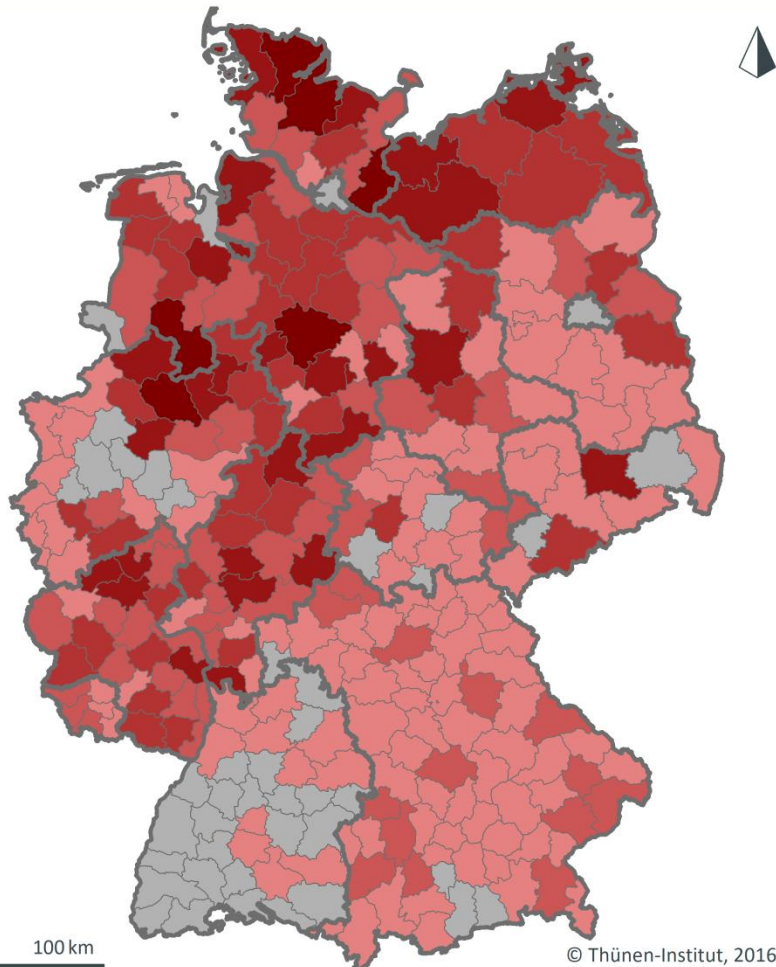
**Microplastic from sewage sludge
applied to agricultural soils
(accumulated 1983-2016)**

Microplastic (Mg)



Scale 10 x
higher!

Source: Destatis, Regionaldatenbank Deutschland, Bertling et al., 2018,
Vollertsen & Hansen, 2017



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Results – Limitations

Due to the limited knowledge in a relatively new research field, these first results are subject to many simplifying assumptions:

- No transfer out of the soils, fragmentation to nano-scale, or metabolisation is accounted for (all Microplastic entering the soil is assumed to stay there)
- Regional sewage sludge and compost amounts are distributed according to production location, transport to the application field is not accounted for
- MP concentrations in sewage sludge and compost are not based on robust data, regional differences are not accounted for (not known)

Why modeling MP distributions, ...

... despite the little knowledge on measured data?

- Models can connect fragmentary measured data
- Models can inform data collection (e.g., where are hotspots expected?)
- Models are developed dynamically and improved by stepwise incorporation of improved data
- Models contribute to a systemic understanding of microplastic entry pathways and processes

Outlook

- Using improved data:
 - Sludge application data for the river basins (high resolution and hard to obtain due to privacy concerns)
 - Adding analytic results for sludge and compost (once available), for improved knowledge on the possible range of concentrations
- Adding another entry pathway: estimating the impact of plasticulture
- Understanding and incorporating export processes:
 - Vertical transport (soil profile)
 - Erosion: Export coefficient of microplastic
 - These parameters are needed for the interface with hydrologic models

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