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The RSVP Tool – Representative Sample Volume Predictions for Monitoring Microplastics

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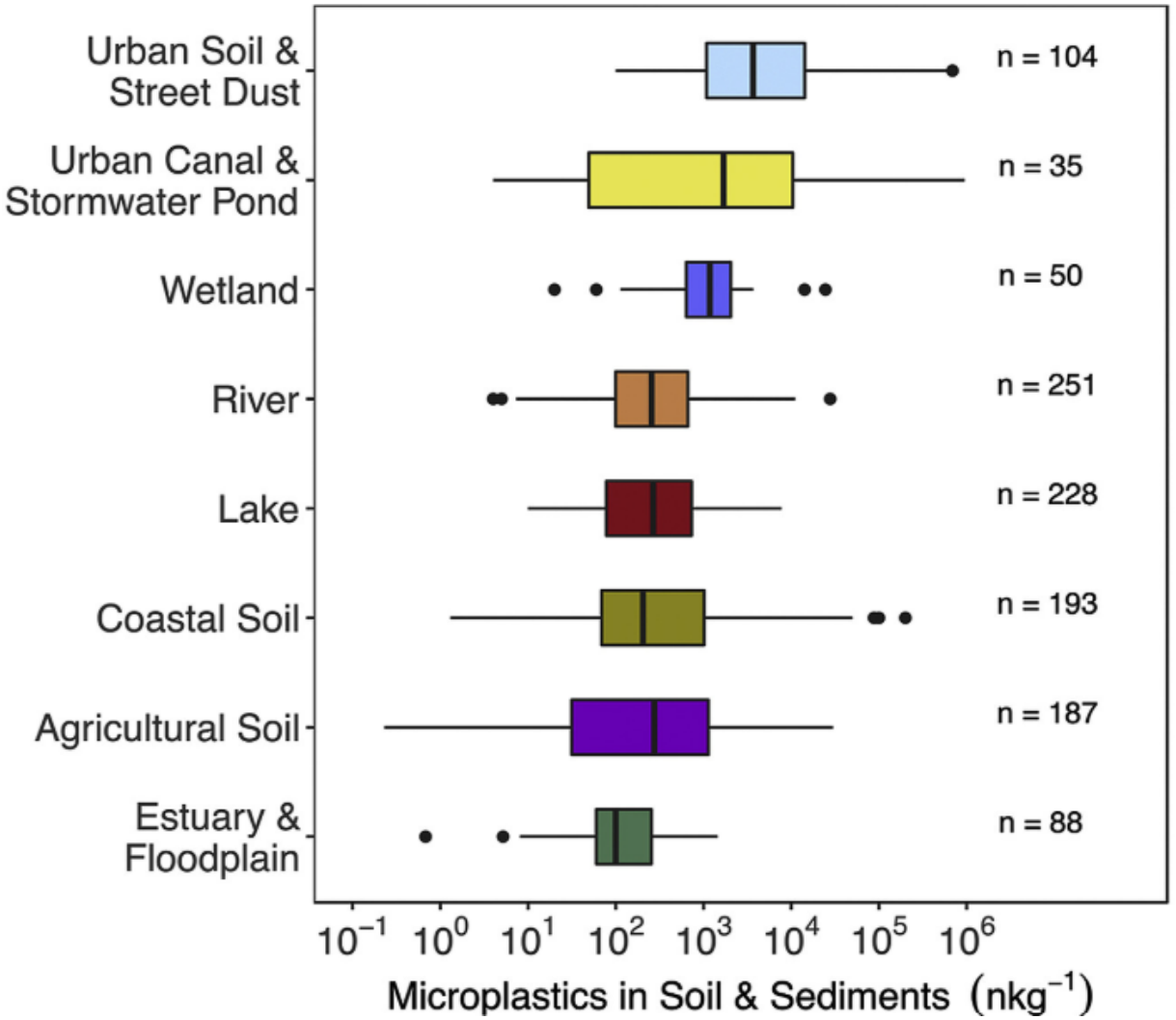
Introduction

Reported MP concentrations range up to 8 orders of magnitude across soils and freshwaters[1].

Without robust methods (including sampling) - how do we design & execute **relevant and representative** monitoring programs **with utility for risk assessment**?



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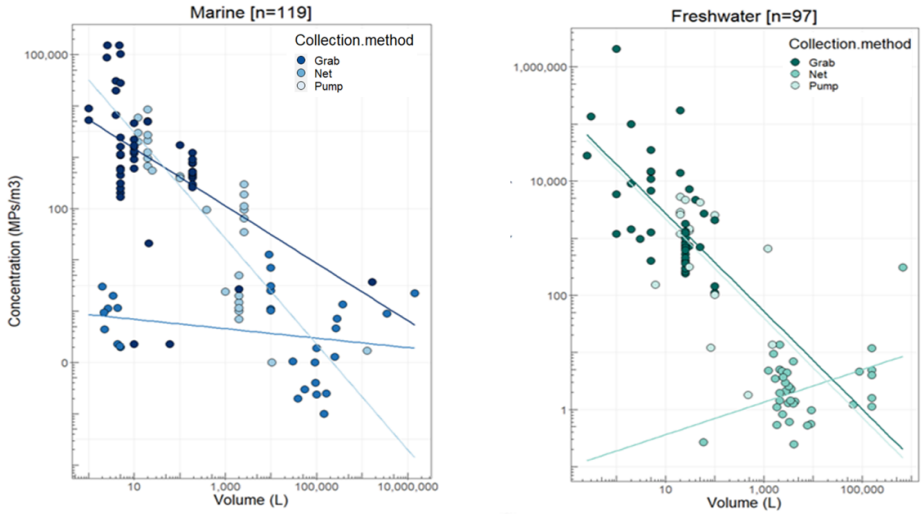
[1] **Koutnik *et al.* (2021)** Distribution of microplastics in soil and freshwater environments: Global analysis and framework for transport modeling. *Environmental Pollution*

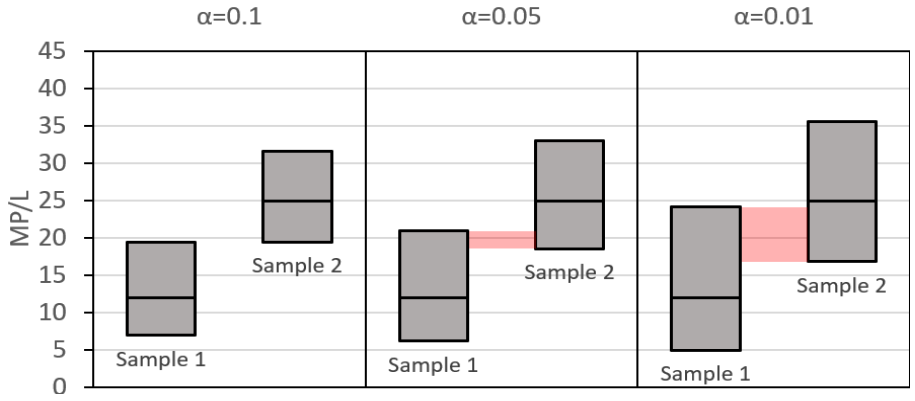
Overview

1. Why do we see such differences?



2. Sample Volume– A Critical Design Parameter

3. RSVP Tool – Putting it into practice



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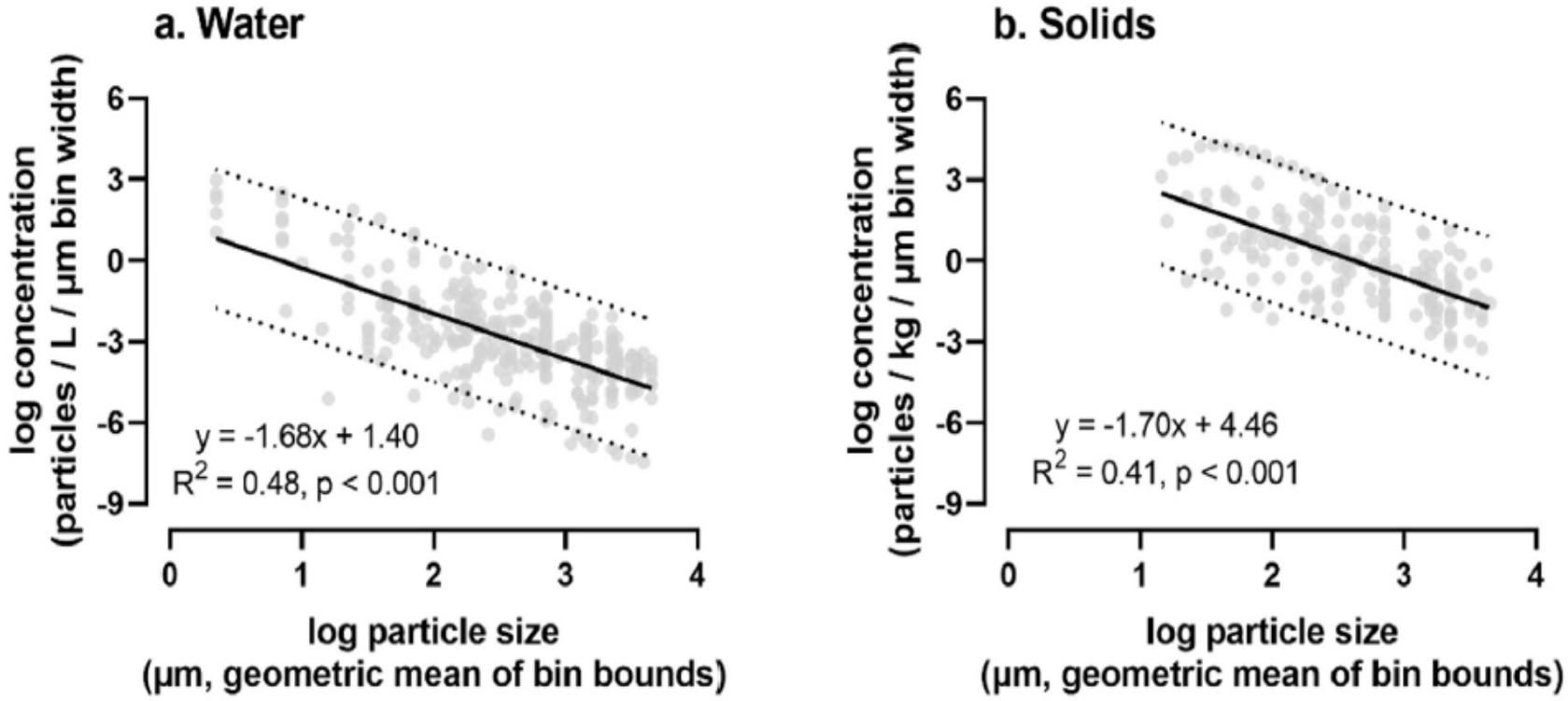
Why do we see such differences?

Analytical size limits may be having a big effect

Common across environments[2]

Harmonisation needed!



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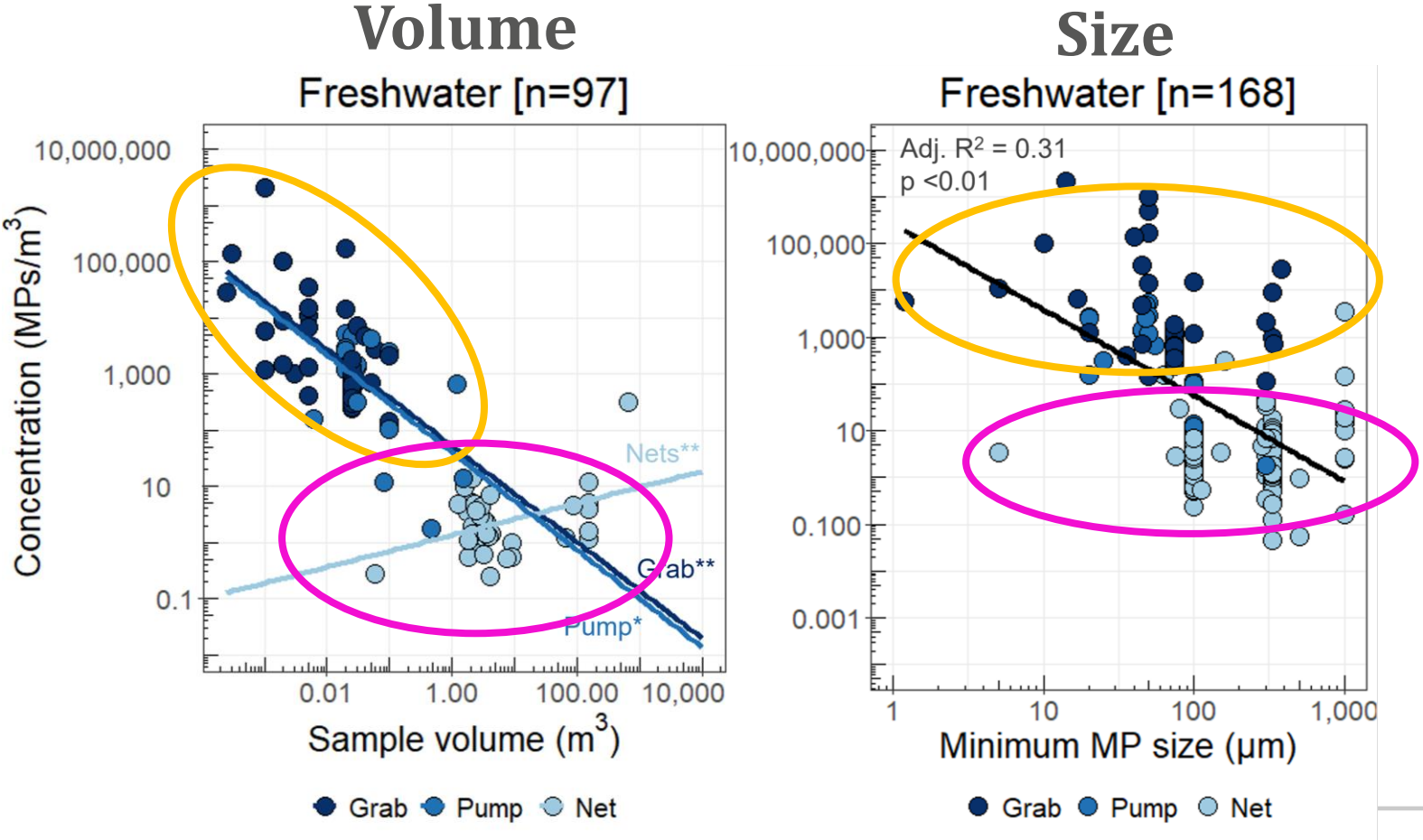
[2] **Leusch *et al.* (2023)** Analysis of the literature shows a remarkably consistent relationship between size and abundance of microplastics across different environmental matrices. *Environmental Pollution*

Size isn't (always) everything…



Grab samples: concentration *scales strongly with volume* collected but not MP size?

Net samples: a common size range → harmonised concentrations reported?

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Cross *et al. 2025* Ensuring Representative Sample Volume predictions in microplastic monitoring. *Microplastics and Nanoplastics*

Are there artefacts in extrapolating from laboratory → environmentally-relevant scales?

“How can we be sure we have collected enough sample?”

$$P(k) = \frac{\lambda^k e^{-\lambda}}{k!}$$

The ***Poisson distribution*** expresses the probability, P(k) of:

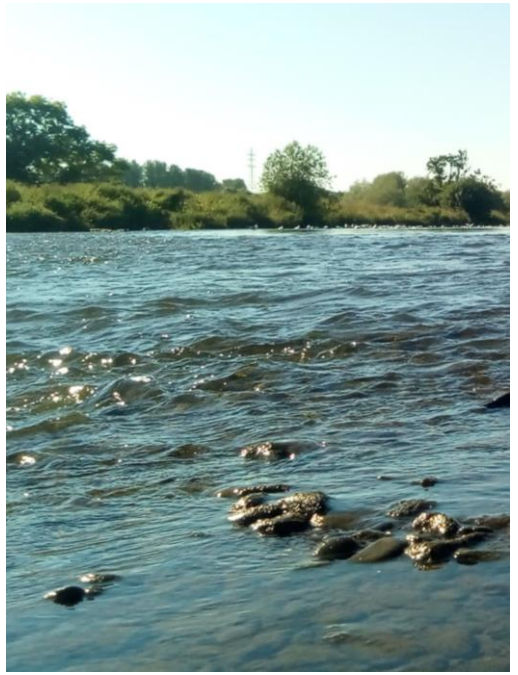
1) a given number of events, K (e.g. capturing a given number of microplastics)
2) occurring in a fixed interval (e.g. a fixed volume of water or area of a field)
3) with the expectation of λ events in that given interval (e.g. the ***expected*** concentration of microplastics in that environment)

"Did I sample enough to detect *any* particles?"

We can predict the volume ***v*** needed to capture one microplastic particle in a water body with:

- an expected concentration ***c***
- at a given significance level (**α**)

$$v = -\frac{ln(1-\alpha)}{c}$$



Relevance to risk assessment:

- Confidence in presence/absence assessment
- Sampling design for new studies

Example – Minimum Sample Volume Prediction

CLEAN **0.5 MP/L**

Significance	Probability of finding at least 1 MP	Minimum volume (L)
0.1	90%	4.61
0.05	95%	5.99
0.01	99%	9.21

DIRTY **50 MP/L**

Significance	Probability of finding at least 1 MP	Minimum volume (L)
0.1	90%	0.04
0.05	95%	0.06
0.01	99%	0.09

The lower the expected concentration, the greater the sample volume needed to reliably detect a single particle (at a given value of α)

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Cross *et al.* 2025 Ensuring Representative Sample Volume Predictions in microplastic monitoring. *Microplastics and Nanoplastics*

How many particles *should* I plan to capture?

Depends on your aim!

- **10 particles:** minimum to calculate sampling error with no replication (Tanaka et al., 2023)[4]
- **50 particles:** minimum to ensure sampling error is within +/- 30% of the concentration estimate (Tanaka et al., 2023)
- **96 particles:** to allow for both total concentration **and** polymer identity assessment with 10% error (Cowger et al., 2024)[5]

RSVP allows you to set your own **target**

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[4] Tanaka *et al.,* 2023 An analytical approach to confidence interval estimation of river microplastic sampling. *Environmental Pollution*.

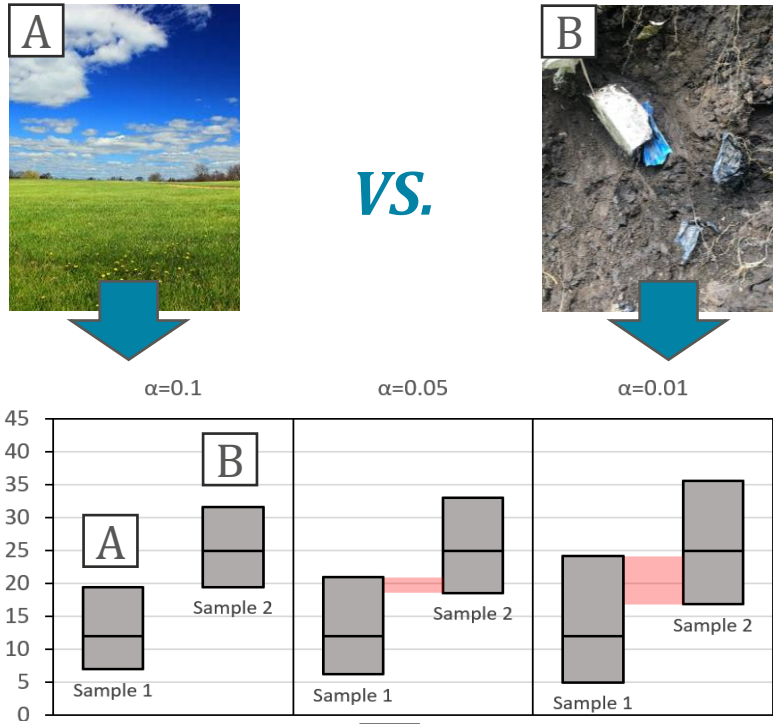
[5] Cowger et al., 2024 How many microplastics do you need to (sub)sample? *Ecotoxicology and Environmental Safety*

"Are my two samples different?"

Poisson point process can estimate confidence intervals for samples without replication (Tanaka *et al*., 2023)[4]

By comparing the overlap, **do samples differ** at given significance levels?

Note, validity demonstrated for mixed waters, lab prep SOPs for other matrices e.g. soils need to mix and randomly distribute microplastics to meet same conditions.



Significance level α	Outcome
0.10	yes
0.05	no
0.01	no
0.001	no
-	-

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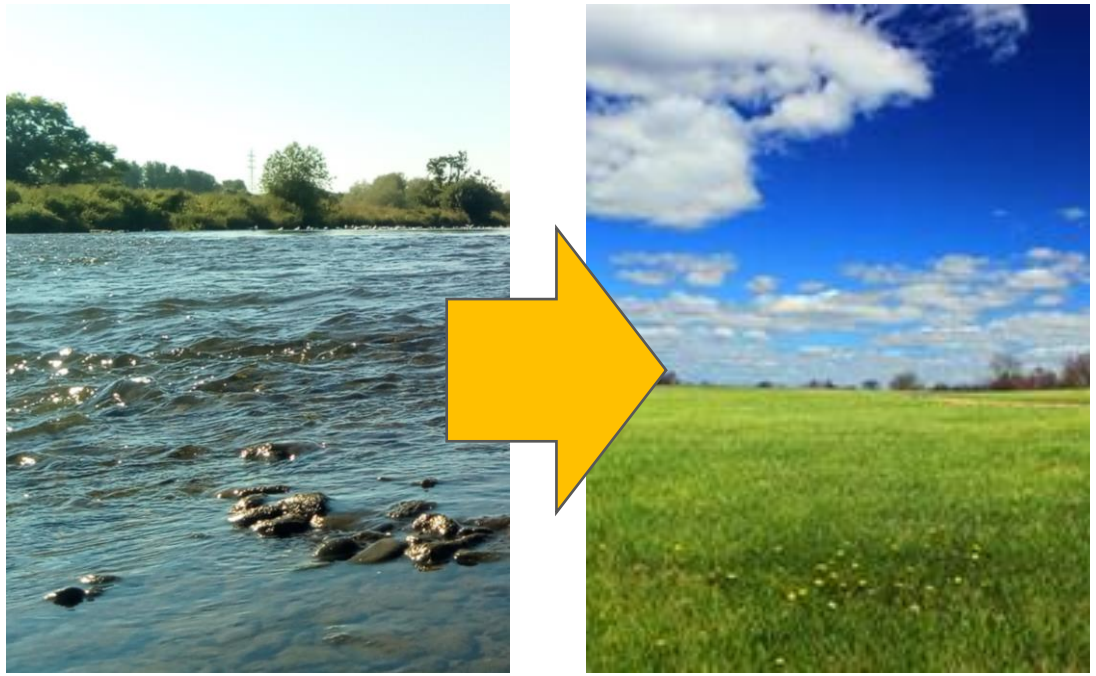
[4] Tanaka *et al.,* 2023 An analytical approach to confidence interval estimation of river microplastic sampling. *Environmental Pollution*.

Putting it into practice

What next for other matrices?

RSVP applicable if assumptions of independence and random distribution of microplastics can be validated in:

- Groundwater
- Landfill leachate
- Recycled agricultural waste streams



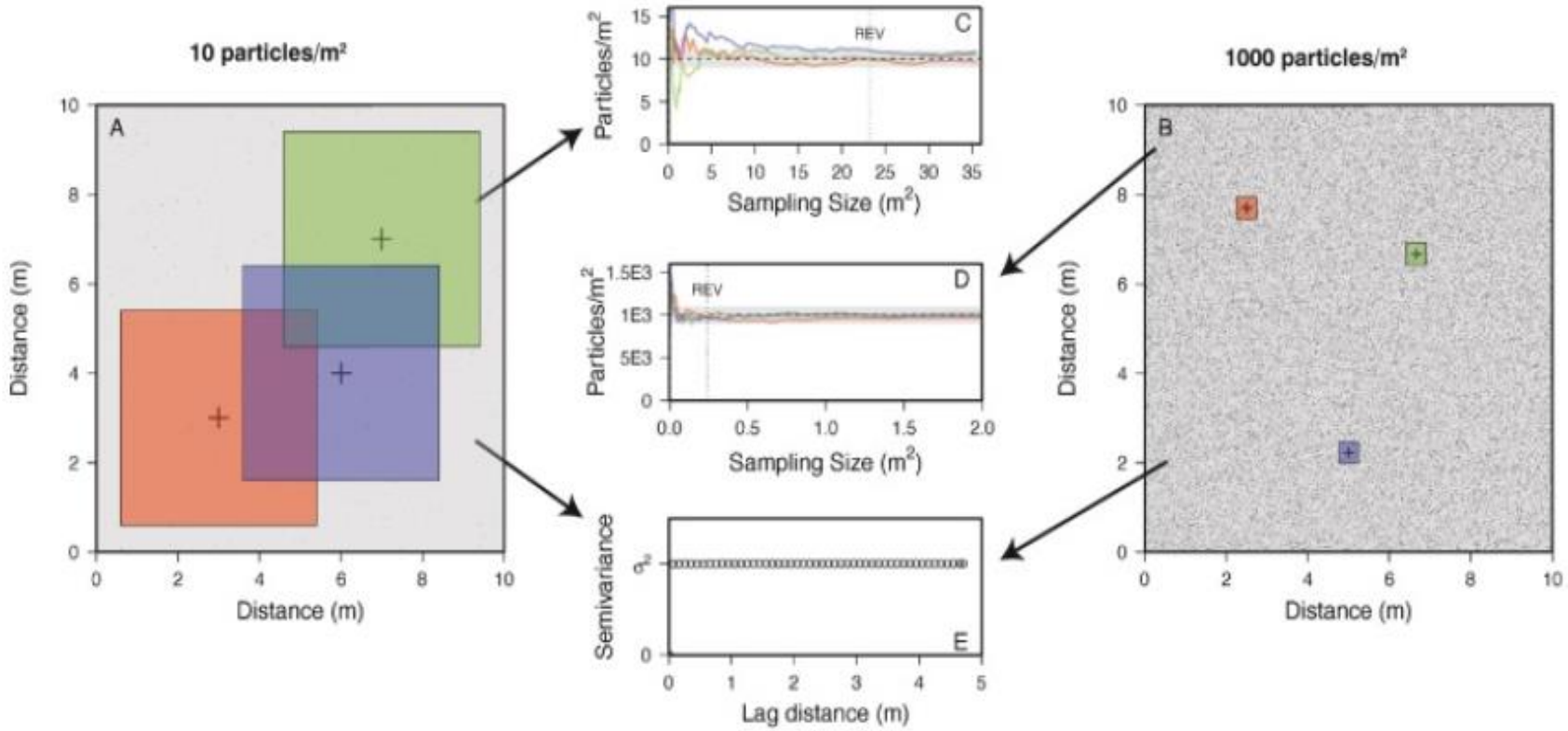
Can this help us harmonise sampling designs and reporting results across studies (e.g. Horizon Europe UPSTREAM)?

An example application – soils?

There is already excellent work!

e.g. guidance on how many samples to take to be representative[6]

But how do you know your subsample unit size is sufficient?



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[6] **Yu *et al.* 2023** How to take representative samples to quantify microplastic particles in soil? *Science of the Total Environment*

Conclusions

Existing data finds **sample volume** to be a **critical** parameter

Poisson distribution has several **assumptions that need to be met** – validation and confirmation needed in new environments!

Can these principles be applied in other matrices? **What data is needed** to do this? **A call for data! Do you have replicate data for sediments, soils, air, whatever? Let's discuss!**

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Thank you to the team!

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https://link.springer.com/article/10.1186/s43591-024-00109-2

RSVP tool paper above link or QR code:

Cross et al., 2025 Ensuring representative sample volume predictions in microplastic monitoring

RSVP tool developed as part of Exxon Mobil Biomedical Services project "Relevance & Reliability of Environmental Sampling Data for Use in Quantitative Risk Assessment – Towards Developing Best Practices & Guidance in Sampling & Reporting"

Further development and application of the tool undertaken as part of project UPSTREAM by the European Union under Grant Agreement no 101112877 and co-funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding guarantee grant numbers 10082527, 10066959, 10089056, 10087702, and 10066963.