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The RSVP Tool – Representative Sample Volume Predictions for Monitoring Microplastics

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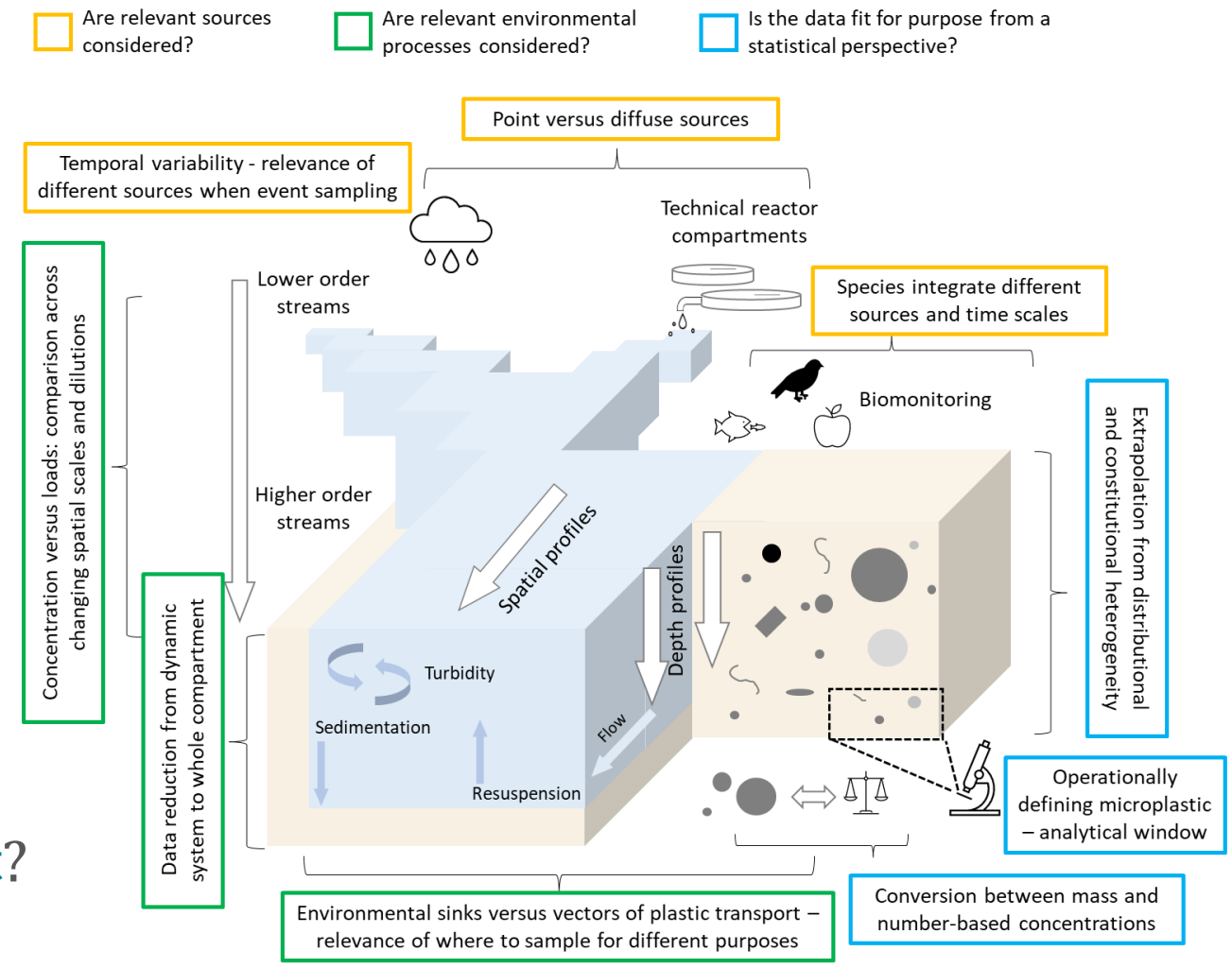
Introduction

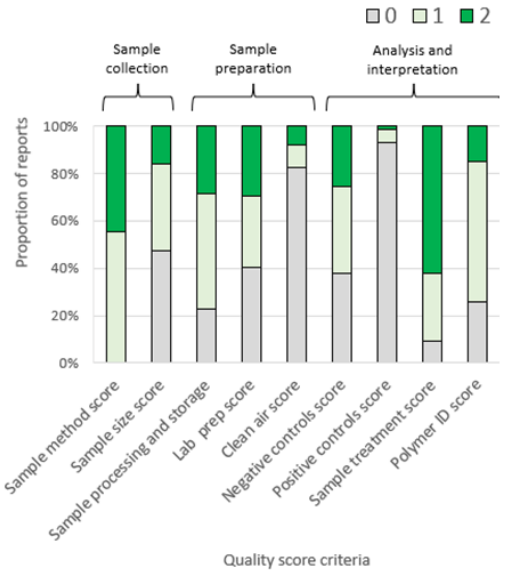
Reported MP concentrations vary ~7 – 8 orders of magnitude (freshwater & marine systems)

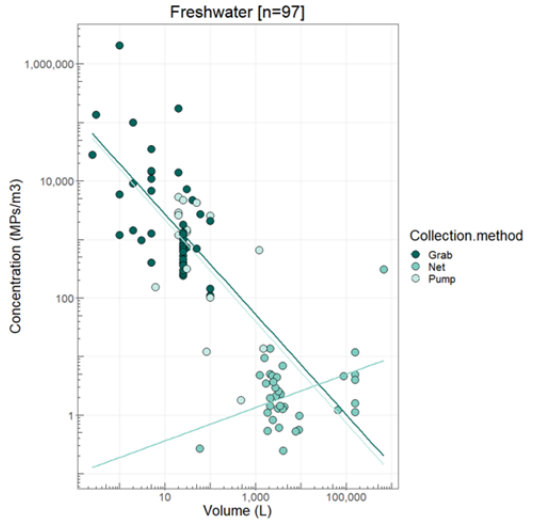
Without robust methods **(including sampling)** - how do we design & execute **relevant and representative** monitoring programs **with utility for risk assessment**?



Overview

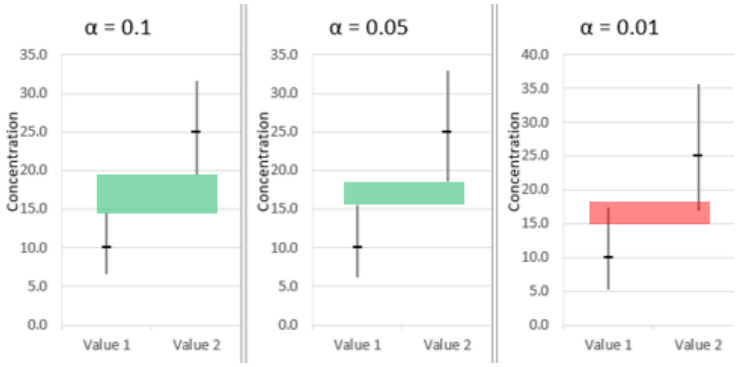
1. Review & QA of Available Data





2. Sample Volume– A Critical Design Parameter

3. RSVP Tool Example Use Cases



Reviewing the available data

Literature reviewed though June 2020 including studies prior to 2004 introduction of the term “microplastic”

marine **166**

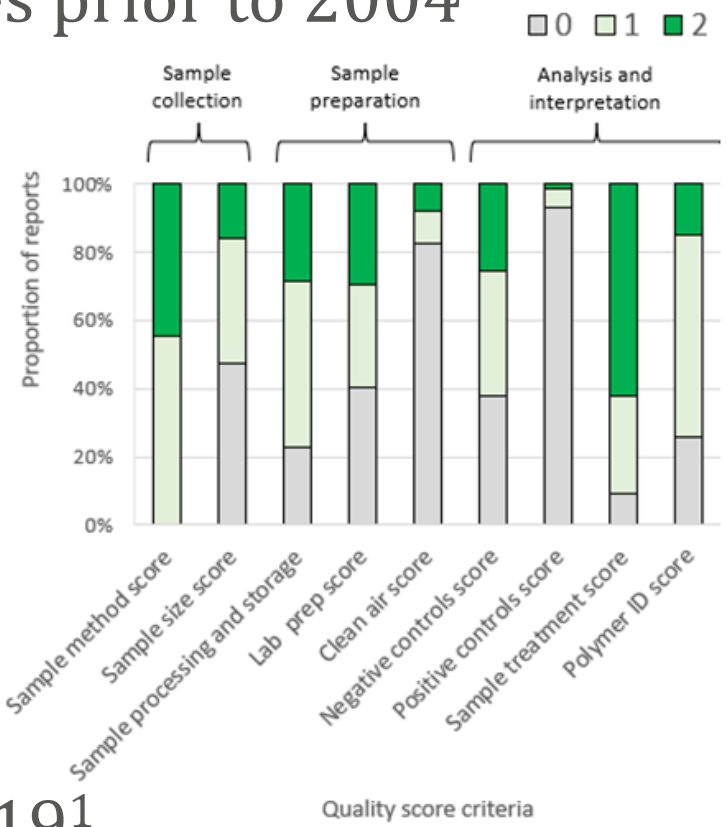
N.D - ~2 x 10^5 MPs/m^3

N.D - ~13 x 10^6 MPs/km^2

Freshwater **74**

N.D - ~4 x 10^6 MPs/m^3

N.D - ~3 x 10^7 MPs/km^2



Studies quality scored according to Koelmans *et al.*, 2019[1]

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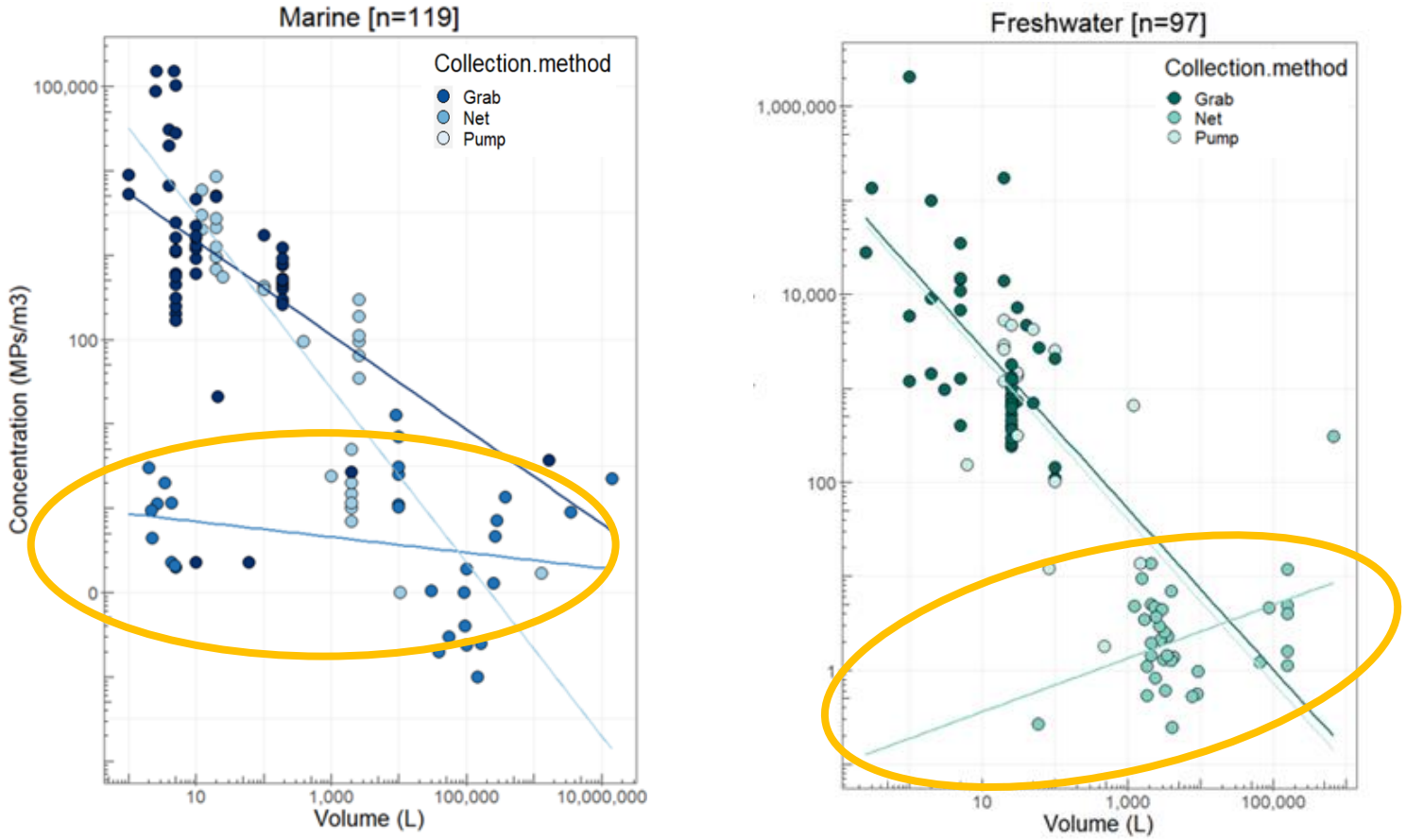
[1] **Koelmans *et al.* (2019)** Microplastics in freshwaters and drinking water: Critical review and assessment of data quality. *Water Research*

Sampling volume – a critical parameter



Pump & grab sample concentration ***scale strongly with volume*** collected

Why is this not the case for nets?

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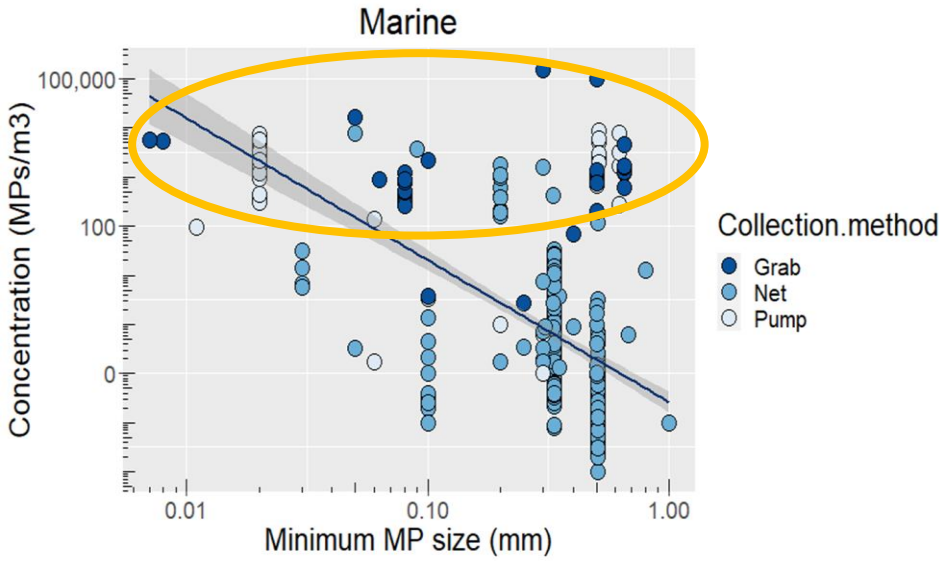
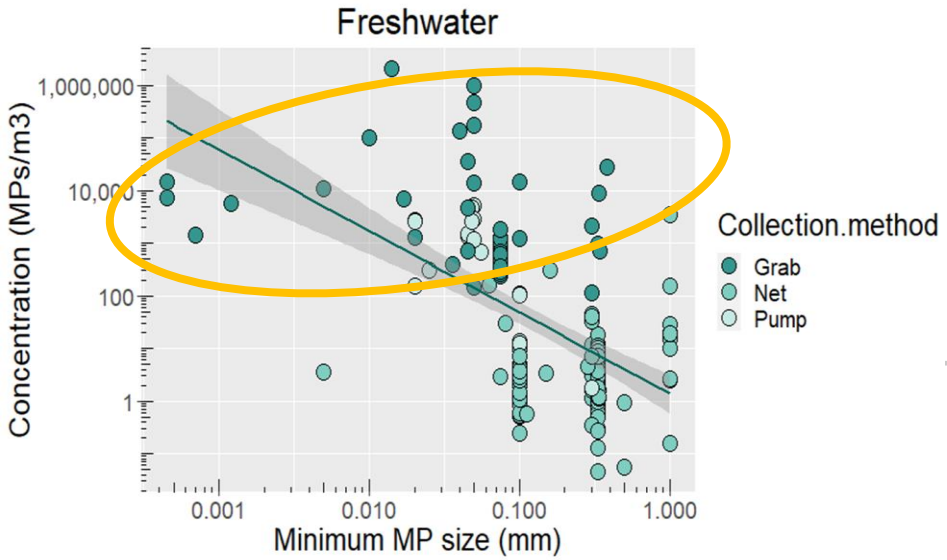
Size can't explain it all…





We might expect particle size to scale with concentration as MPs fragment further

Across all data there is a signal of this, but weak and noisy

For grab samples the relationship seems non-existent

Are there artefacts & limitations in extrapolating from laboratory to 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:

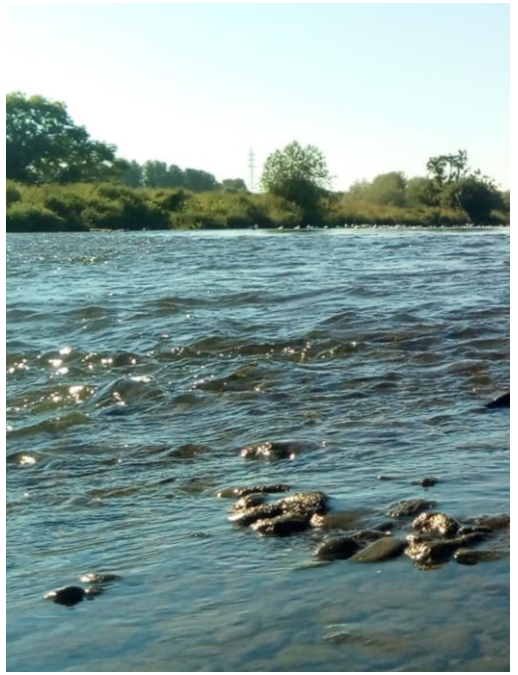
1) a given number of events, K (e.g. capturing a given number of microplastics)
2) occurring in a fixed interval (e.g. a fixed volume of water)
3) with the expectation of λ events in that given interval (e.g. the ***expected*** concentration of microplastics in that environment)

"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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How many particles ***should*** I plan to capture?

Depends on your aim!

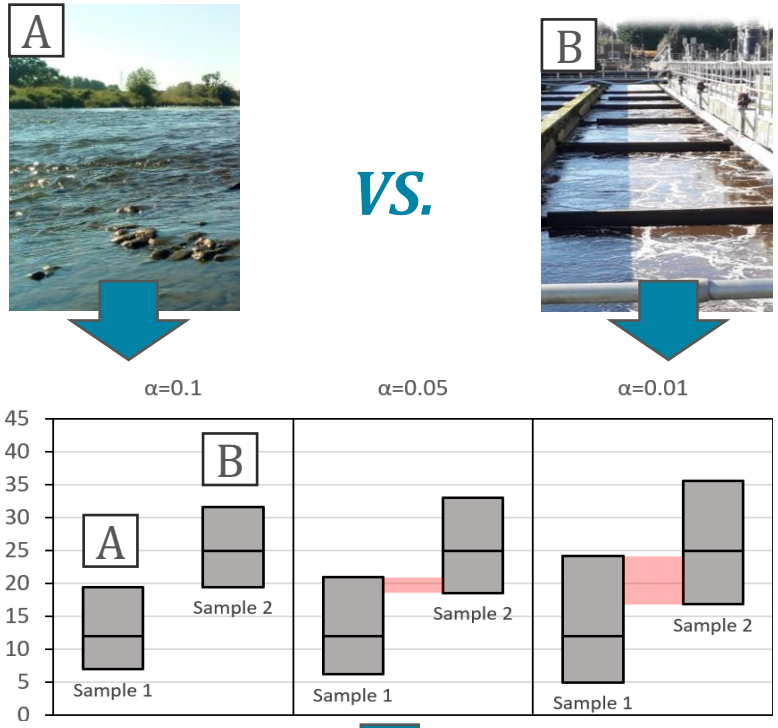
- 10 particles: minimum to calculate sampling error with no replication (Tanaka et al., 2023)
- 50 particles: minimum to ensure sampling error is within +/- 30% of the concentration estimate (Tanaka et al., 2023)
- 96 particles: to allow for both total concentration **and** polymer identity assessment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

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

“Are my two samples different?”

The same Poisson point process can be used to estimate the confidence intervals for samples without replication (Tanaka *et al*., 2023) [2]

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



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

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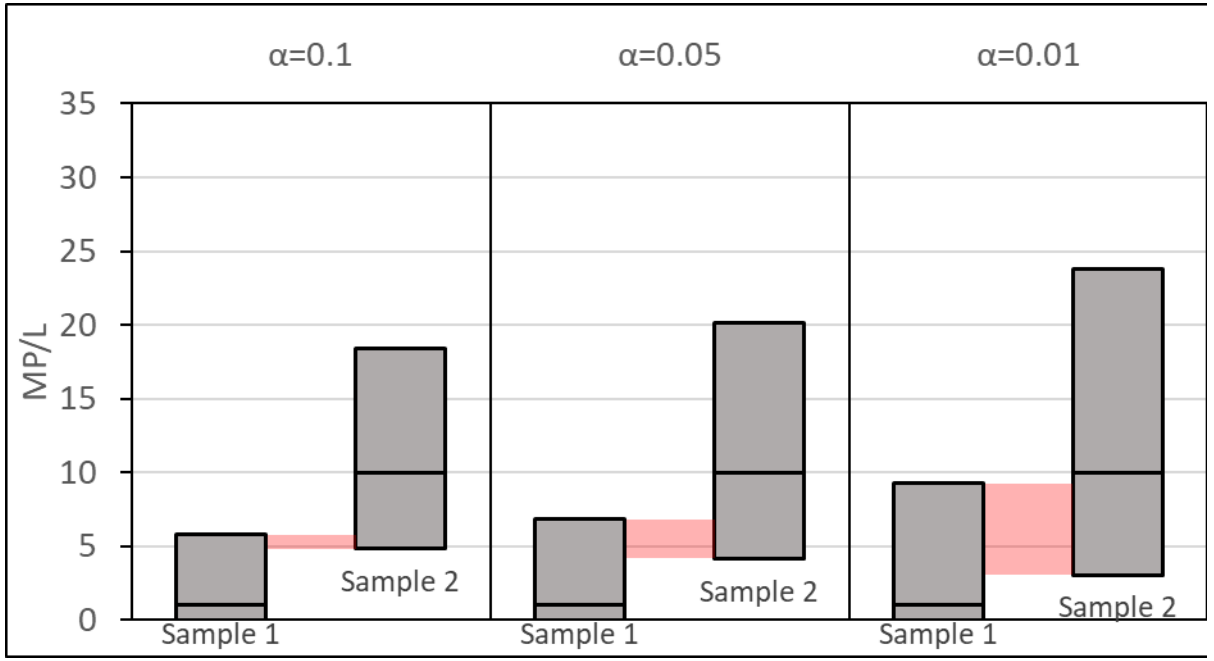
[2] Tanaka *et al.,* 2023 An analytical approach to confidence interval estimation of river microplastic sampling. *Environmental Pollution*.

Example - Power Analysis using RSVP Tool

	Sample 1	Sample 2
Concentration in MP/L	1.00	10.00
Amount sampled in L	0.75	0.75
Total number of microplastics in sample	0.75	7.5
Shape parameter A (lower)	0.75	7.5
Shape parameter A (upper)	1.75	8.5
Rate parameter B	1	1
The lower value is…	Sample 1	



To measure 10x difference, statistically (α = 0.05):

0.75 L → 2.25 L (3x)

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

Conclusions

Existing data finds sample volume(s) as a critical parameter

Confidence in MP concentration data in a mixed body of water can be quantified using Poisson distribution (assuming independent action)

The RSVP tool intends to be a pragmatic tool for researchers and risk assessors to both design new **and** evaluate existing monitoring data for microplastics in waters

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Thank you to the team!

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