Methods used to determine macro-, micro- and nanoplastics in the environment

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Arctic Plastic Symposium,
Reykjavik 22nd November 2023

Defining what we mean:

Developing methods to fit research or monitoring aims is a key step in plastic pollution control and management.

Harmonisation of methods is paramount for monitoring.

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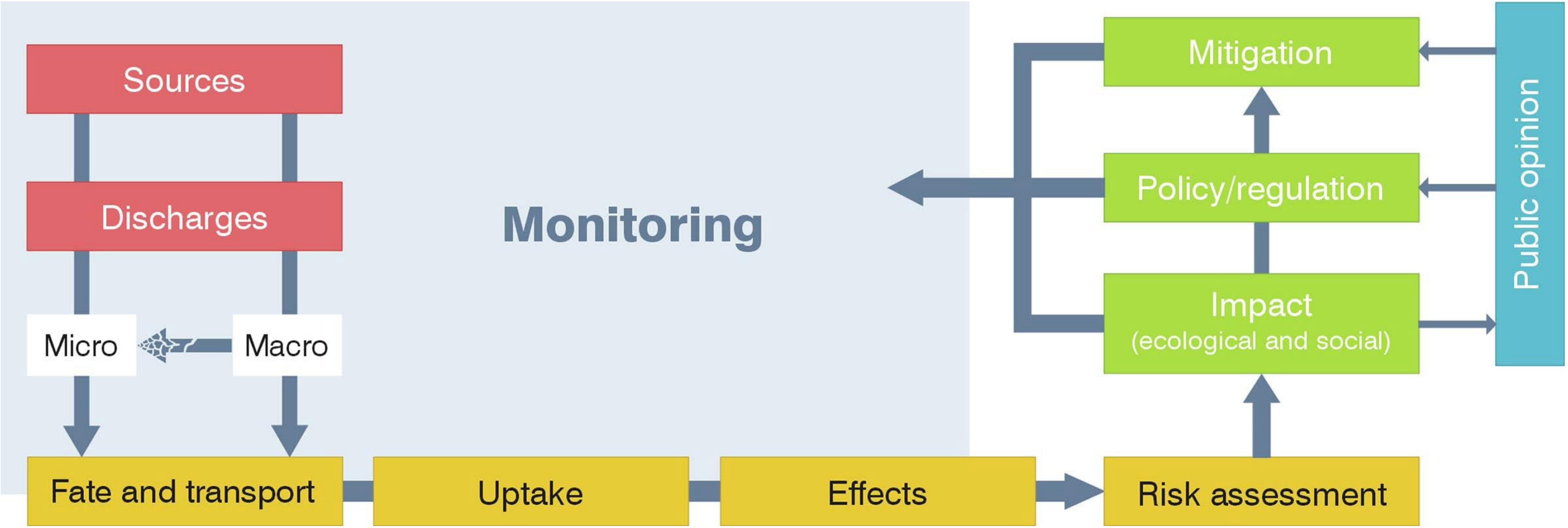
Different research questions, different approaches



Lusher, A.L., et al. 2021 *Moving forward in microplastic research: A Norwegian perspective.* Environment International, 157, p.106794.

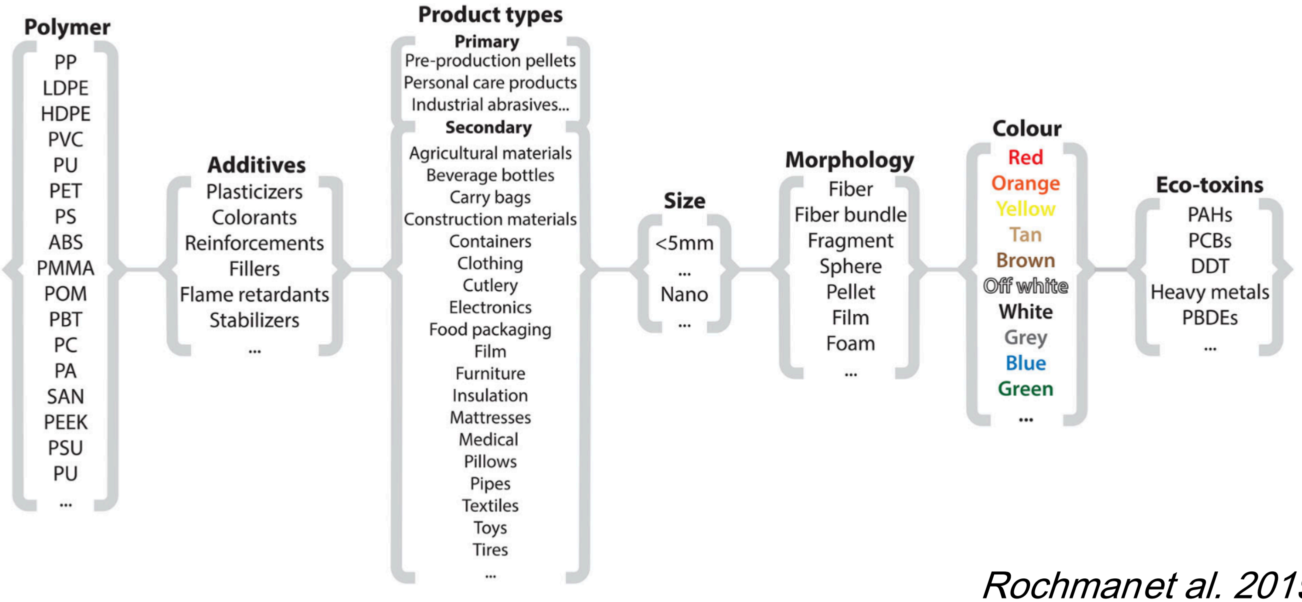
Plastics research is increasing exponentially

- Plastics are a ubiquitous contaminant - different ecosystems, matrices…

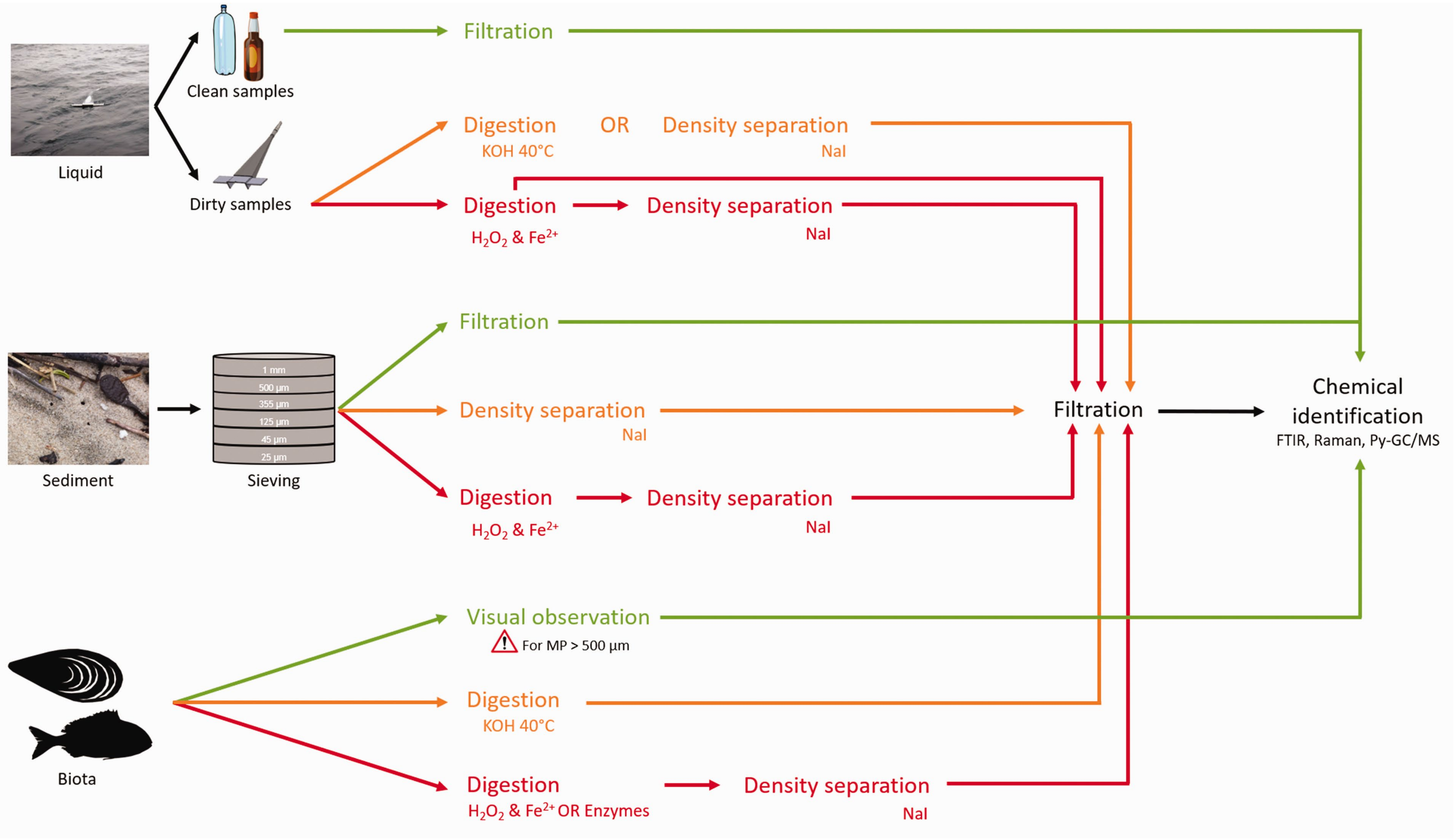
- Highly diverse nature of plastic pollution

- Still an evolving field

➡ various types of sampling and analysis approaches



Rochmanet al. 2019



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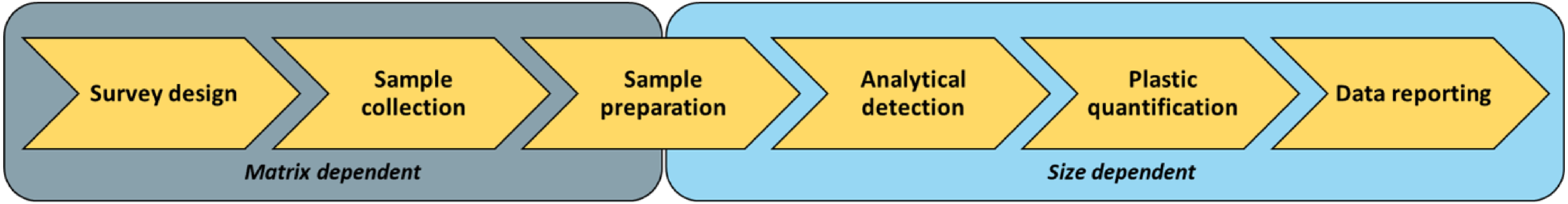
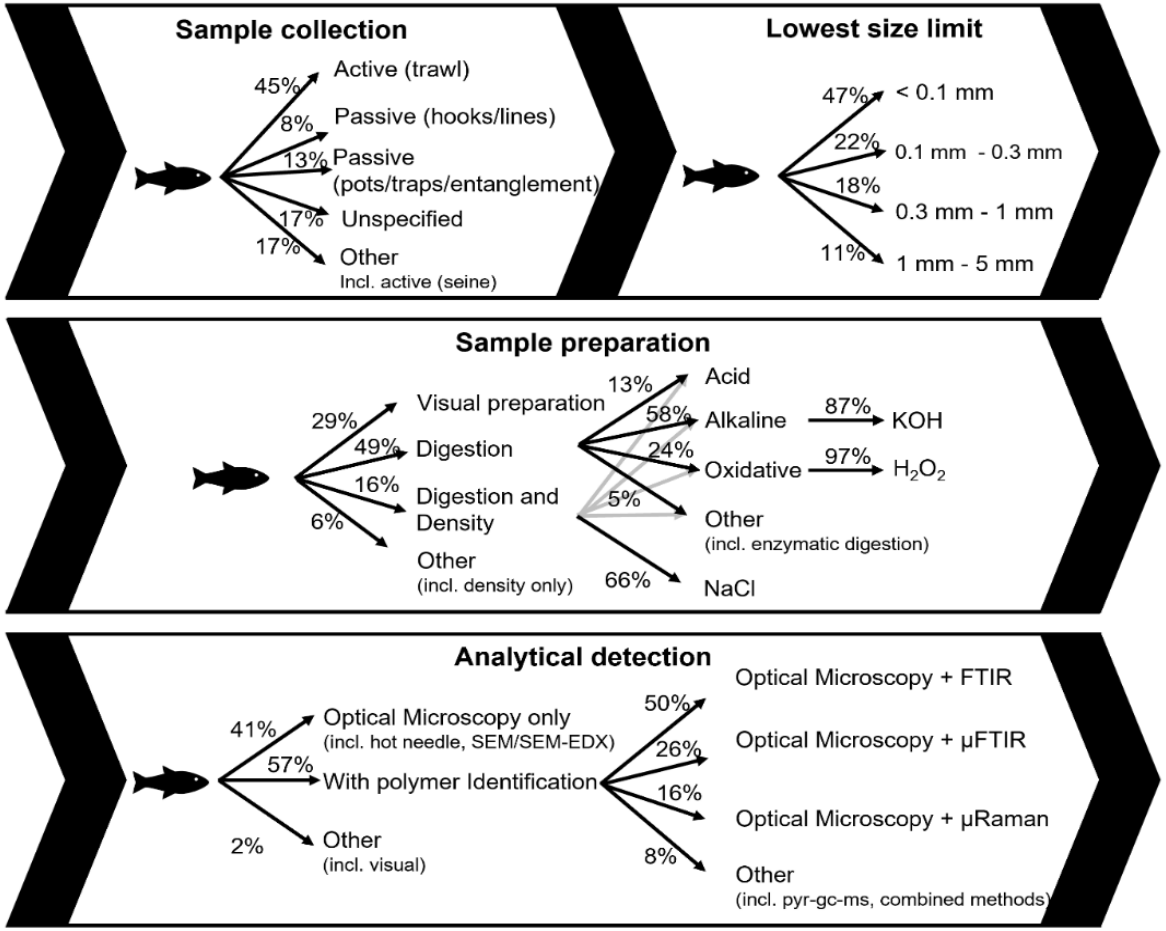
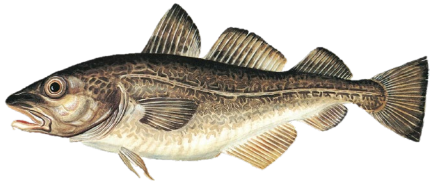
Lusher, A.L., et al., 2020 *Isolation and extraction of microplastics from environmental samples: an evaluation of practical approaches and recommendations for further harmonization*. Applied Spectroscopy, 74(9), pp.1049-1065.

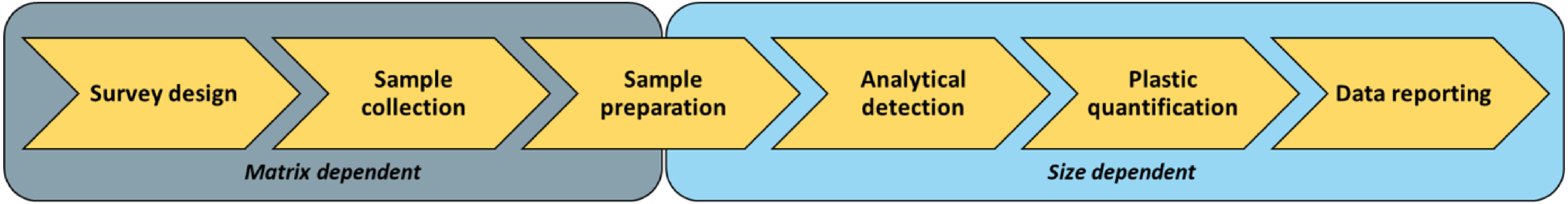


(Aliani et al., 2023)

Using biota as an example:







(Aliani et al., 2023)

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First quantification of semi-crystalline microplastics in industrial wastewaters

Hajo Bitter [1)], Susanne Lackner [1), *]

[1)] Department of Civil and Environmental Engineering Sciences, Institute IWAR, Chair of Wastewater Engineering, Technical University of Darmstadt, Germany

SETAC PRESS

Environmental Toxicology and Chemistry, Vol. 35, No. 7, pp. 1627–1631, 2016

Plastic Debris in the Aquatic Environment

RELEASE OF PRIMARY MICROPLASTICS FROM CONSUMER PRODUCTS TO WASTEWATER IN THE NETHERLANDS

ANNEMARIE VAN WEZEL,*†‡ INEZ CARIS,§ and STEFAN A. E. KOOLS†
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‡Copernicus Institute, Utrecht University, Utrecht, The Netherlands
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ELSEVIER

Full length article

Discovery and quantification of plastic particle pollution in human blood

Heather A. Leslie [a], Martin J.M. van Velzen [a], Sicco H. Brandsma [a], A. Dick Vethaak [a,b], Juan J. Garcia-Vallejo [c], Marja H. Lamoree [a,*]

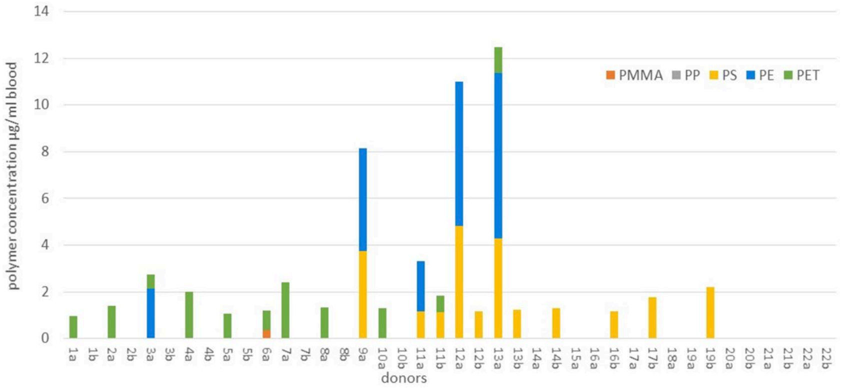

Fig. 1. Concentrations of plastic particles by polymer type in whole blood samples of 22 donors (duplicates a and b, except for No. 6, 9, 15 and 18). All values >LOQ.

0.2-66 µg/l in wastewater effluent

1.6-12.5 µg/ml = 1600-12500 µg/l in human blood (!!!)

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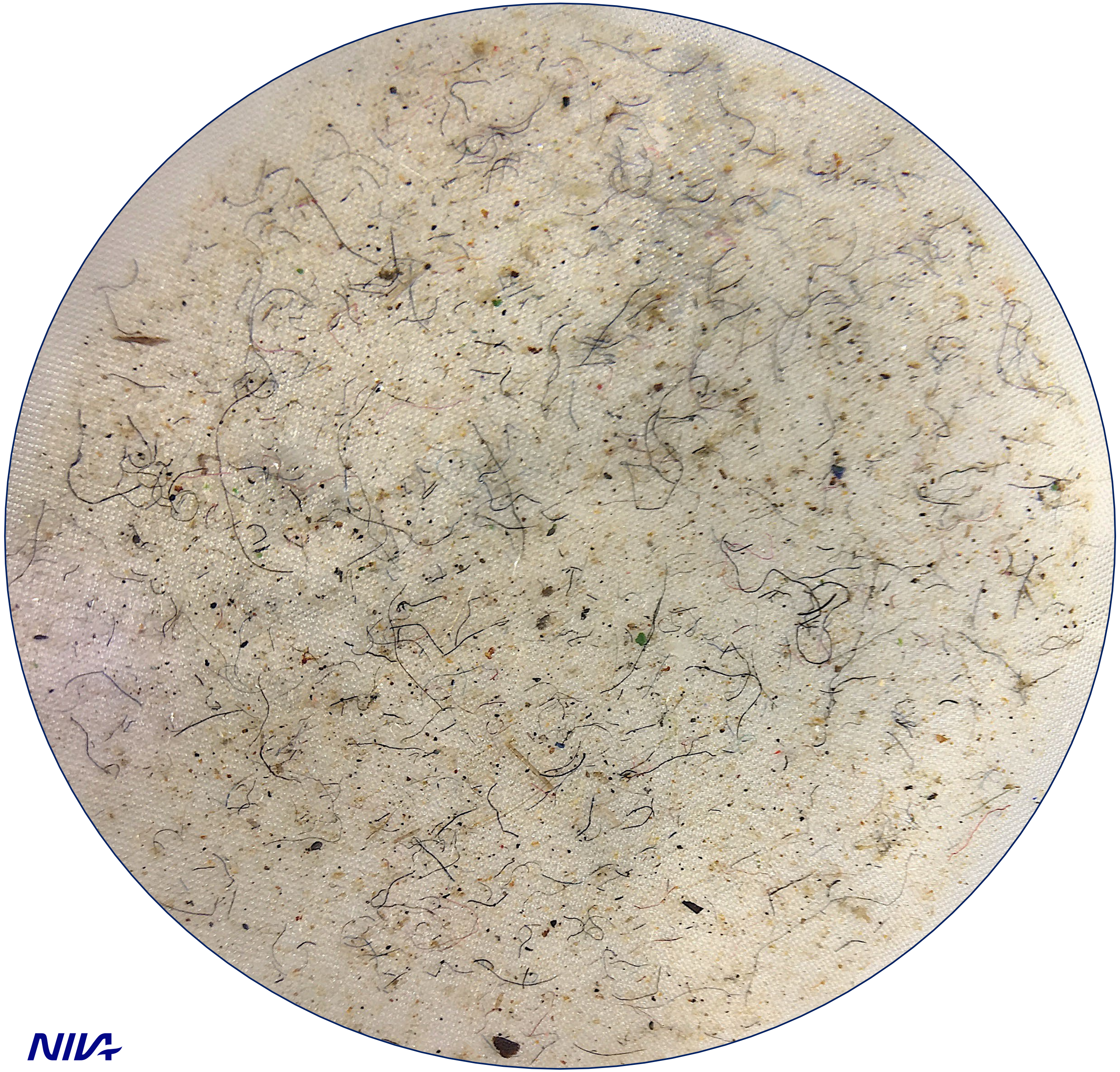

Just one of the many challenges with plastic pollution research……

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CNR ISMAR ISTITUTO DI SCIENZE MARINE

Methods are important for (micro)plastic monitoring

- Require tailored methods for reliable detection and environmental enumeration
- Necessary to choose appropriate tool, or combination of tools
- Many standardised methods are developed south of the Arctic and ill-suited (Melvin et al. 2021)

Methods must be adapted to the ecosystem

Local site conditions

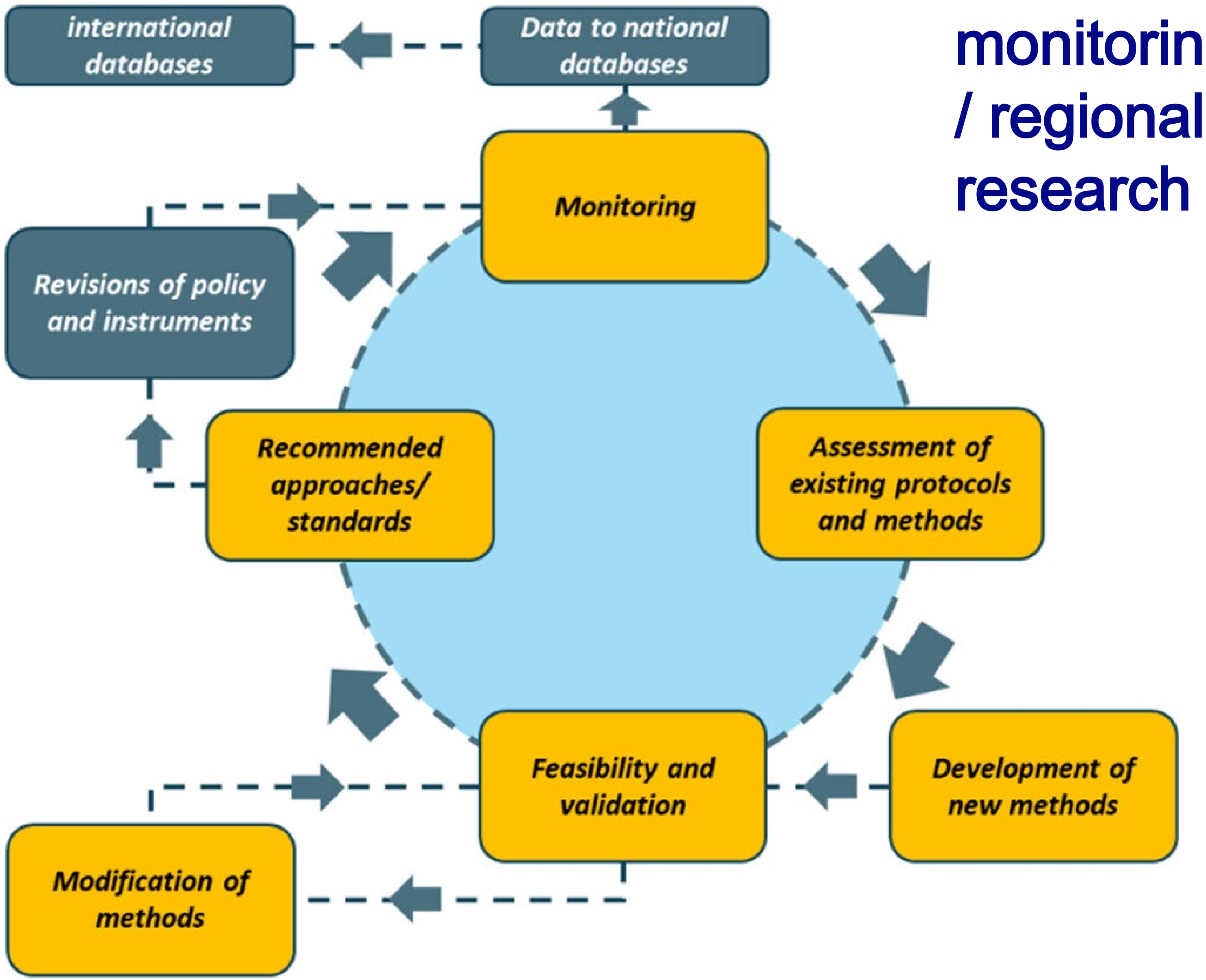
Proximity to anthropogenic activity

J. Falk Anderssen/NIVA

Presence of fauna

Eric Baccega/NPL

Balance between monitoring (nationally / regionally) and research

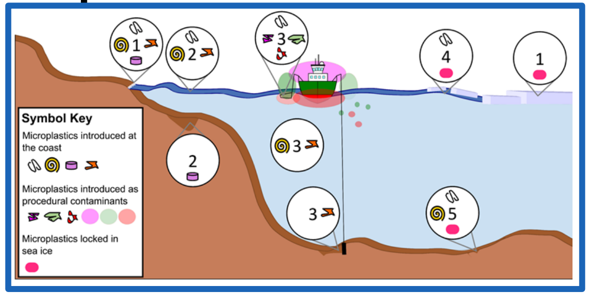


Lusher, A.L. and Primpke, S., 2023. *Finding the Balance between Research and Monitoring: When Are Methods Good Enough to Understand Plastic Pollution*?. Environmental Science & Technology, 57(15), 6033-6039.

Value of multi -matrix monitoring

AMAP recommend a joint sediment and water approach is adopted.

- ✔ Can be carried out in same sampling campaign
- ✔ Provide complementary, but not overlapping, information
- ✔ Provide the most complete picture of plastic pollution



Martin et al. 2022, Arctic Science

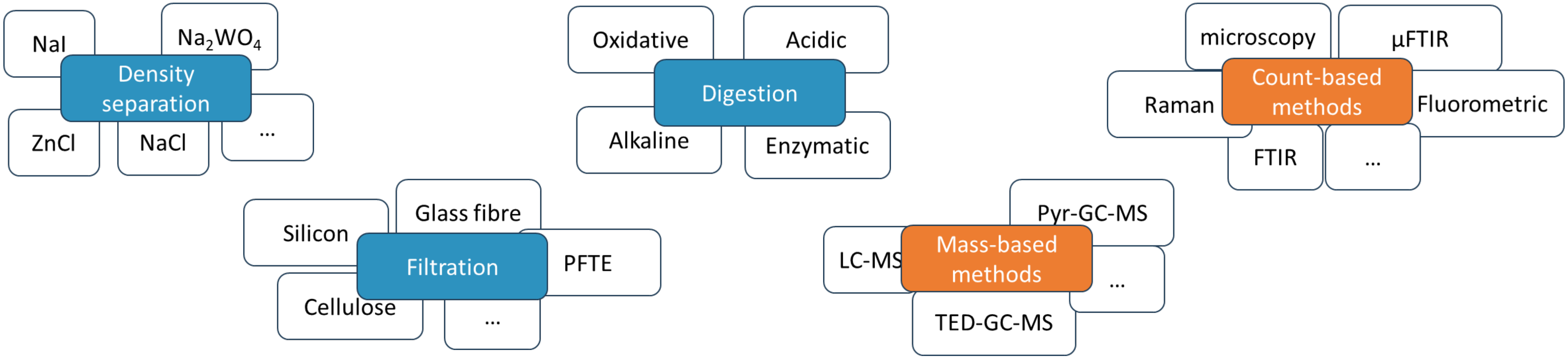
Water
– potential to track rapid fluctuations

Sediment
– spatially and temporally integrated signal

✘ Still biased to marine – integration of freshwater and terrestrial samples is important

Martin, J., et al., 2022. *The power of multi -matrix monitoring in the Pan -Arctic region: plastics in water and sediment*. Arctic Science, 9(1), pp.146-164.

What method should we choose?

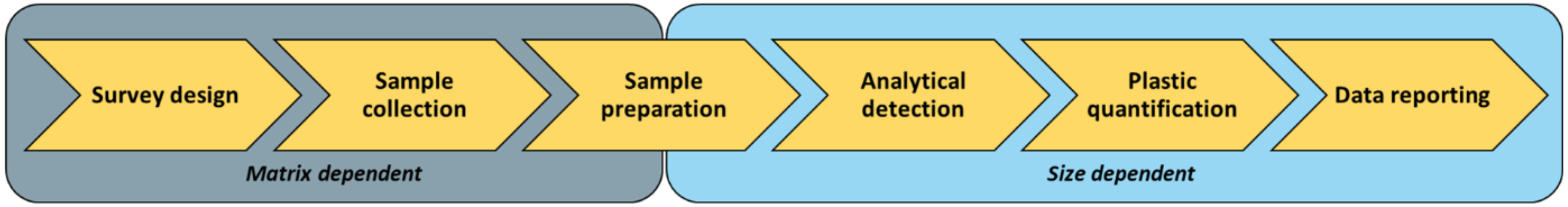


- How do we decide what is best?

→ Decisions for monitoring guidelines need to be informed by sound science, meet a minimum criteria, and allow data comparisons.

Solutions for addressing the useability of methods

(1) Break the analytical elements into useable pieces: steps



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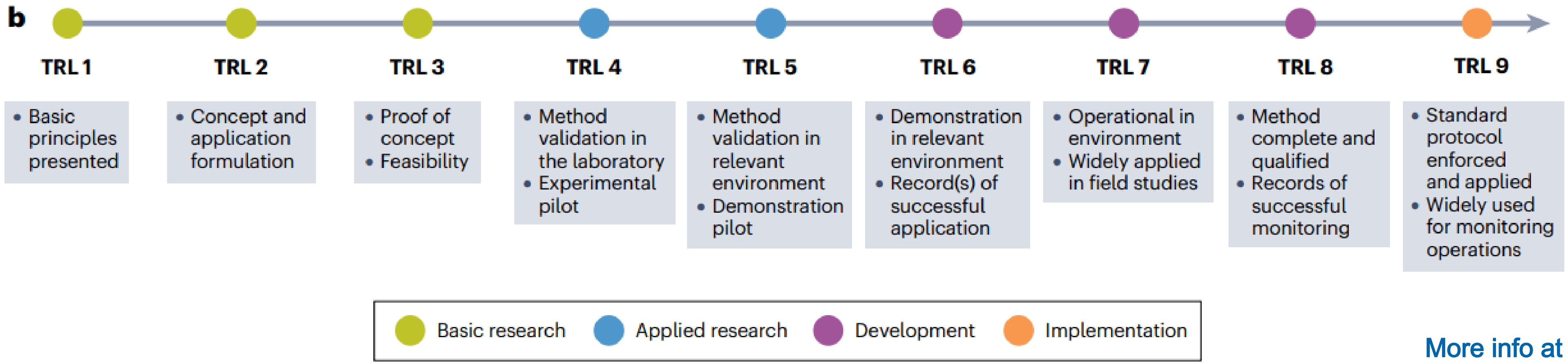
(Aliani et al., 2023)

(2) Assess the reproducibility of each approach and the requirement for further research/development, or recommend for monitoring programmes



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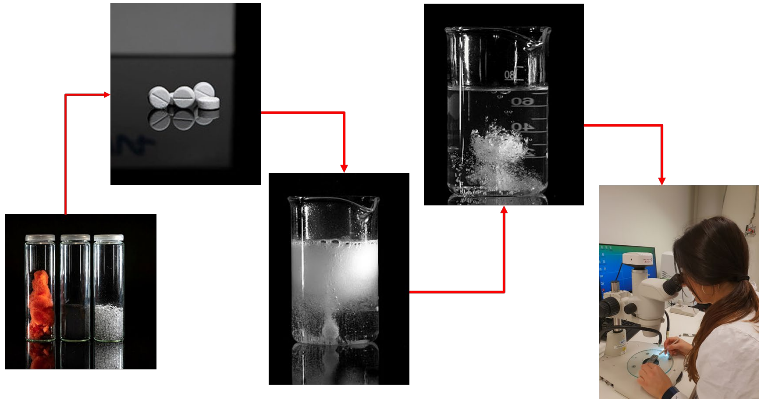
More info at 11:50 (Theme 1)

Tools for validating methods

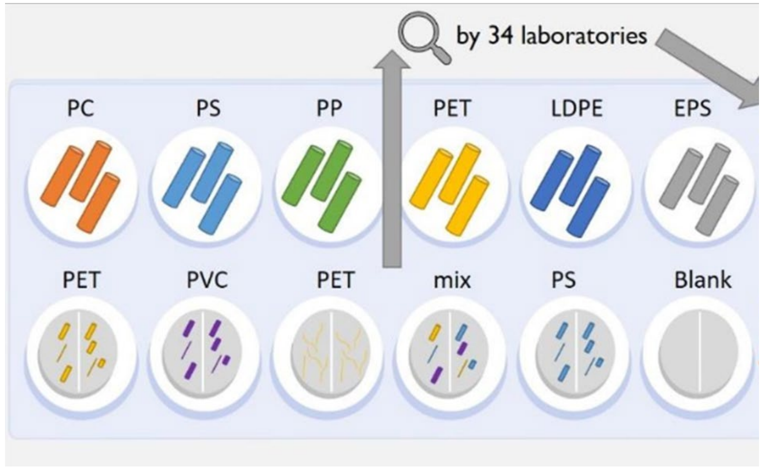
(1) Recovery test / positive controls



- Spiking samples with a known quantity of polymers

- Challenge: generation of relevant reference materials

- Aim of the study, target size, shape, polymer



Martínez-Francés, et al. 2023. *Innovative reference materials for method validation in microplastic analysis including interlaboratory comparison exercises.* Anal Bioanal Chem 415, 2907–2919\

Tools for validating methods

(2) Interlabaotry comparison exercises (ILCs)

- Compare methods through ILCs looking at different aspects of the analytical approach
  - Sampling
  - Processing
  - Analysis

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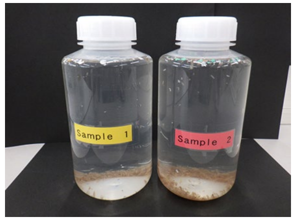
BASEMAN
MICROPLASTICS ANALYSES IN EUROPEAN WATERS

Interreg Mediterranean
PLASTIC BUSTERS MPAs
Tsangaris et al., 2021, MPB, 164:111992



Ministry of the Environment – Government of japan (2017)
Isobe et al., 2019, MPB, 146:831-837

WEPAL QUASIMEME
WEPAL-QUASIMEME/ NORMAN network
Van Mourik et al., 2021, STOTEN, 772: 145071

SCCWRP SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
De Frond et al., 2022, Chemosphere, 298:134282.

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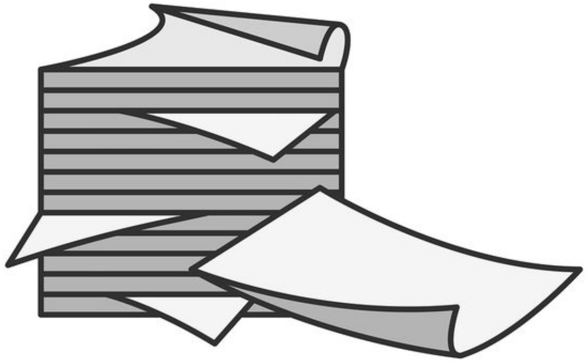
Tools for assessing available methods

(1) Critical reviews



(2) Guidelines for QA/QC steps

Applied Spectroscopy

Special Issue: Microplastics

Applied Spectroscopy
0(0) 1–27

DOI: 10.1177/0003702820945713
journals.sagepub.com/home/asp
SAGE

Sampling and Quality Assurance and Quality Control: A Guide for Scientists Investigating the Occurrence of Microplastics Across Matrices

Susanne M. Brander[1], Violet C. Renick[2], Melissa M. Foley[3], Clare Steele[4], Mary Woo[4], Amy Lusher[5], Steve Carr[6], Paul Helm[7], Carolynn Box[8], Sam Cherniak[9], Robert C. Andrews[9], and Chelsea M. Rochman[10]

Table 2. The quality assurance and control (QA/QC) criteria used to assess the quality of research papers in Table 1.

QA/QC measures
Monitor contamination
1. Account and monitor for plastic used throughout collection, extraction, and identification
2. Procedural blank samples processed alongside collected samples (negative controls)
3. Monitor airborne contamination with a wet filter and/or an open petri dish in the field and laboratory
Prevent contamination
4. Prefilter liquid reagents into clean glassware
5. Use glass and metal instead of plastic whenever possible
6. Muffle glassware, glass filters, and metal (450 °C for minimum 5 hr) prior to use or rigorously clean glassware and equipment (acid wash protocol, multiple rinses with filtered water and ethanol)
7. Rinse glassware prior to use and in-between samples
8. Cover all containers (e.g., aluminum foil) when not in use
9. Wear cotton laboratory coats or non-synthetic clothing when interacting with samples
10. Use positive controls and test and report method recovery
11. Check filters for contamination under microscope and clean prior to use (not necessary if can be muffled)
12. Perform extractions in clean air environment (laminar flow hood, air-controlled space)
13. Identify polymers with chemical characterization method (e.g., FTIR, Raman, Pyrolysis-GC/MS)

Each QA/QC measure was assigned a number. If the study did not mention a particular QA/QC measure, the appropriate number was added to the criticism column in Table 1. The numbers assigned to each measure do not signify priority over the other measures. One hundred thirty studies were reviewed against this QA/QC list.

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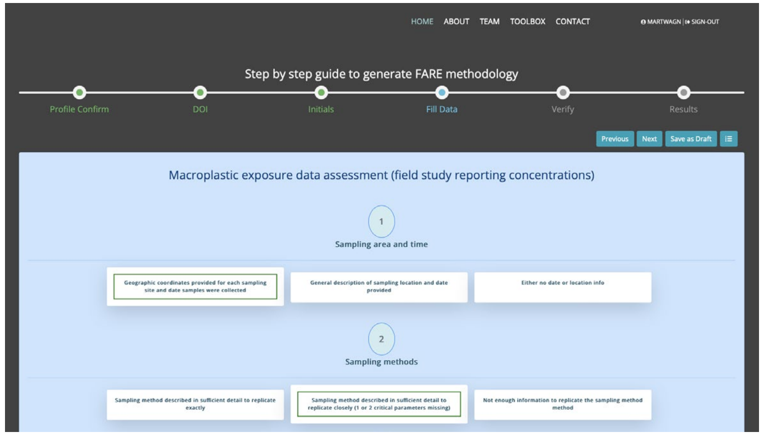
Tools for assessing available data

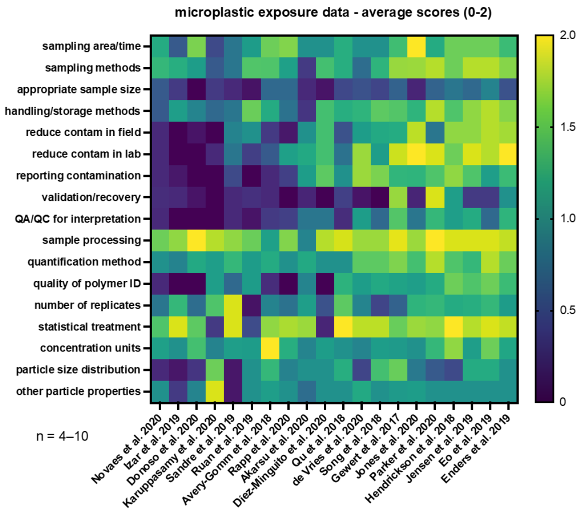
(3) Online platform – crowd sourced

FARE

The FARE project has developed and tested a new toolbox specifically designed to assess the quality of existing macro- and microplastic exposure and effects data.

- Insufficient quantity of exposure and hazard data for macro- and microplastic
- Variable quality of existing macro- and microplastic exposure and hazard data
- Lack of tools for assessing the quality of data





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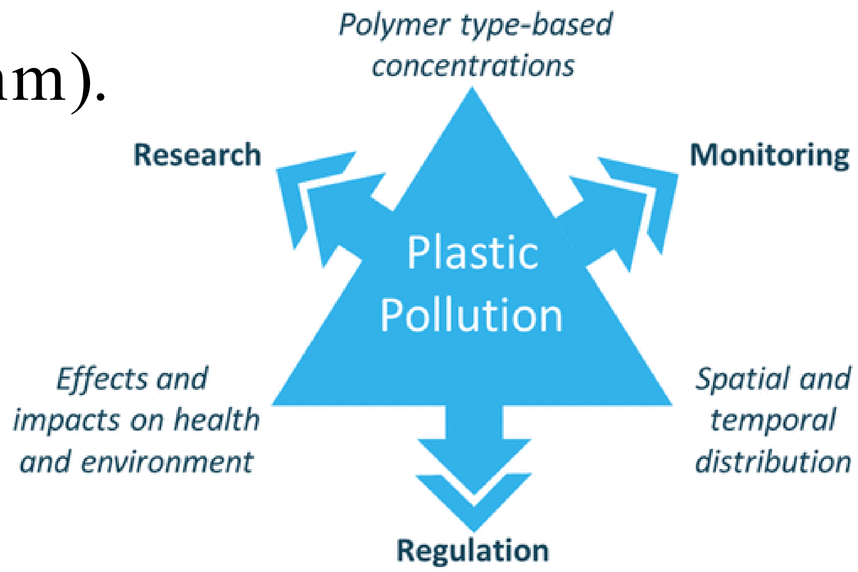
Do we have enough methods yet?

Different research questions require different methods.

Method choices depend on rigorous examination of the science being published.

We already have methods ready for monitoring (>1 mm).

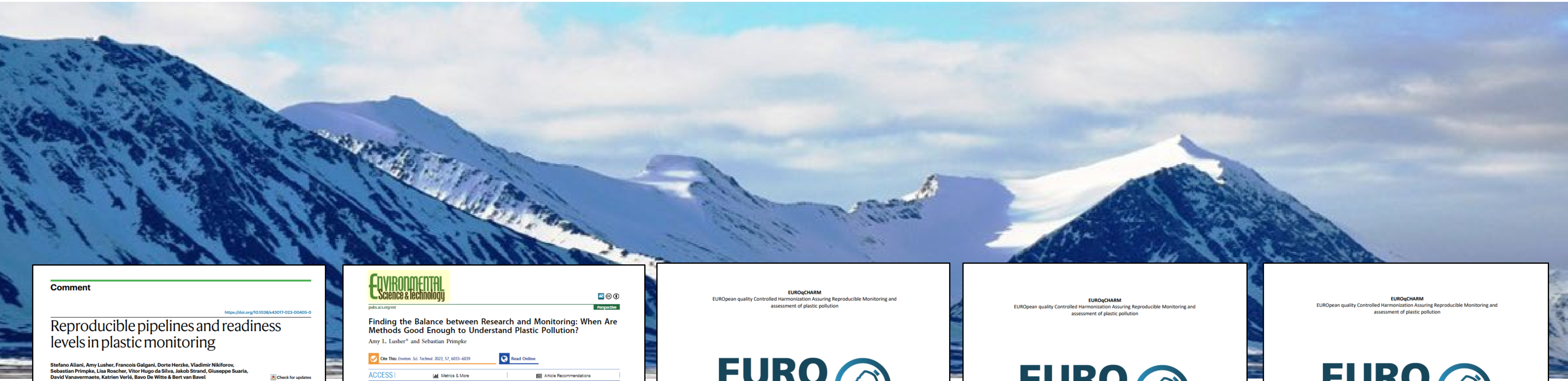


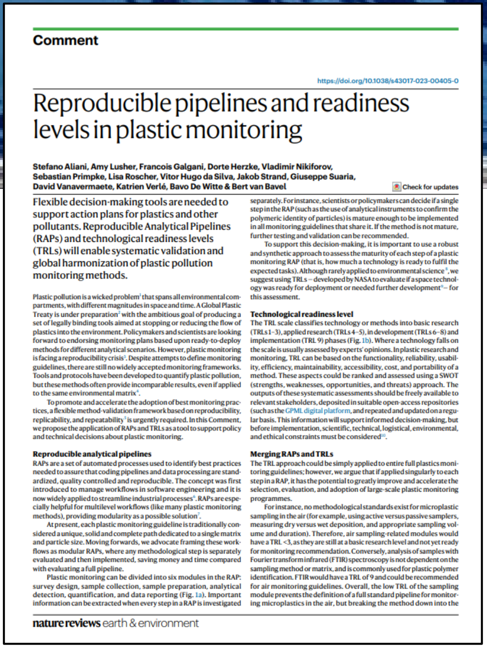
Lusher, A.L. and Primpke, S., 2023. ***Finding the Balance between Research and Monitoring: When Are Methods Good Enough to Understand Plastic Pollution*** ?. Environmental Science & Technology, 57(15), pp.6033-6039.

Provencher, J.F., Covernton, G.A., Moore, R.C., Horn, D.A., Conkle, J.L. and Lusher, A.L., 2020. ***Proceed with caution: the need to raise the publication bar for microplastics research*** . Science of the Total Environment, 748, p.141426.

Thank you for listening

Amy.Lusher@niva.no




Comment

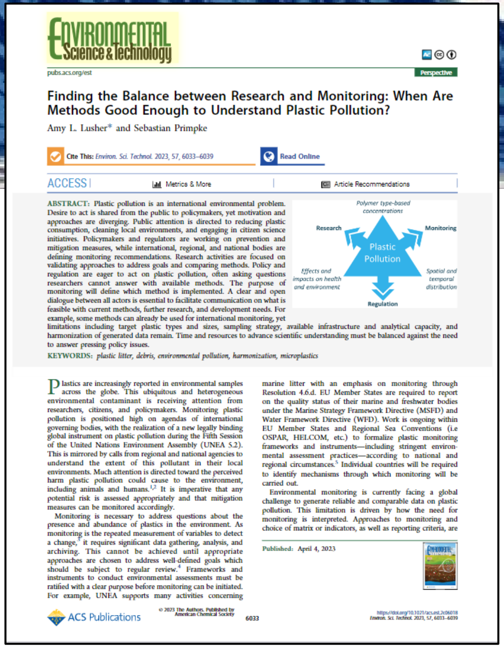
https://doi.org/10.1038/s43017-023-00405-0

Reproducible pipelines and readiness levels in plastic monitoring

Stefano Aliani, Amy Lusher, Francois Galgani, Dorte Herzke, Vladimir Nikiforov, Sebastian Primpke, Lisa Roscher, Vitor Hugo da Silva, Jakob Strand, Giuseppe Suaria, David Vanavermaete, Katrien Verlé, Bavo De Witte & Bert van Bavel

Flexible decision-making tools are needed to support action plans for plastics and other pollutants. Reproducible Analytical Pipelines (RAPs) and technological readiness levels (TRLs) will enable systematic validation and global harmonization of plastic pollution monitoring methods.

nature reviews earth & environment


Environmental Science & Technology

Perspective

Finding the Balance between Research and Monitoring: When Are Methods Good Enough to Understand Plastic Pollution?

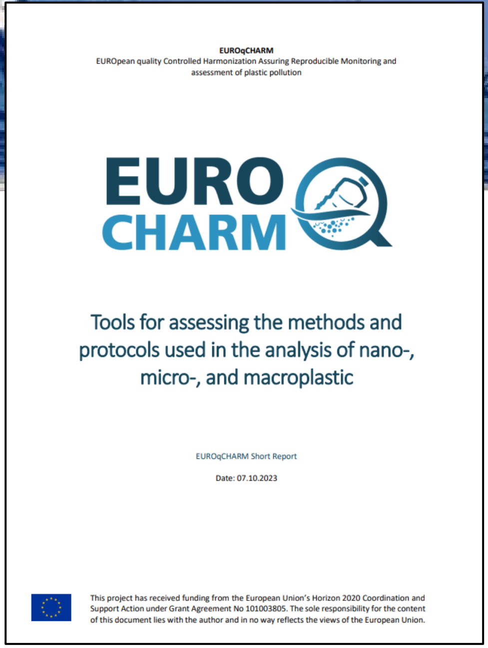
Amy L. Lusher* and Sebastian Primpke

Cite This: Environ. Sci. Technol. 2023, 57, 6033−6039

ACCESS

KEYWORDS: plastic litter, debris, environmental pollution, harmonization, microplastics

ACS Publications


EUROqCHARM

EUROpean quality Controlled Harmonization Assuring Reproducible Monitoring and assessment of plastic pollution

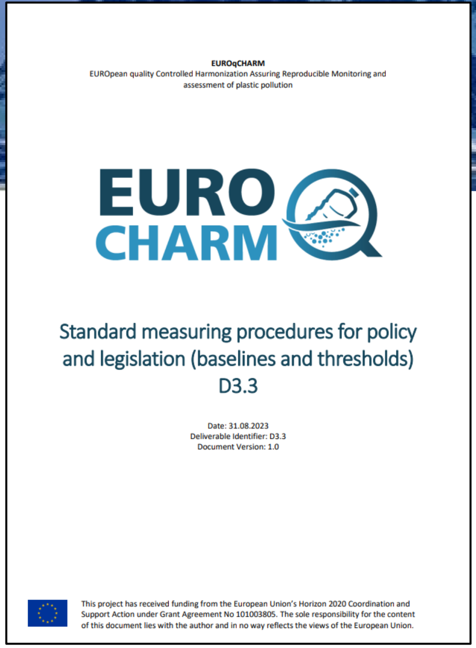
EURO CHARM

Tools for assessing the methods and protocols used in the analysis of nano-, micro-, and macroplastic

EUROqCHARM Short Report

Date: 07.10.2023

This project has received funding from the European Union's Horizon 2020 Coordination and Support Action under Grant Agreement No 101003805. The sole responsibility for the content of this document lies with the author and in no way reflects the views of the European Union.


EUROqCHARM

EUROpean quality Controlled Harmonization Assuring Reproducible Monitoring and assessment of plastic pollution

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Standard measuring procedures for policy and legislation (baselines and thresholds) D3.3

Date: 31.08.2023

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Document Version: 1.0

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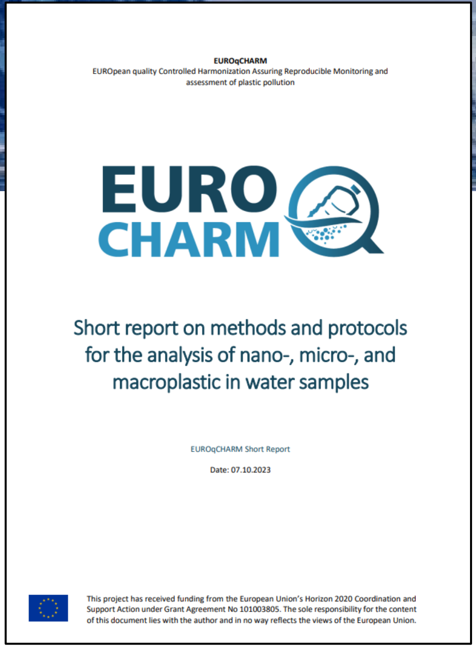
EUROqCHARM

EUROpean quality Controlled Harmonization Assuring Reproducible Monitoring and assessment of plastic pollution

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Short report on methods and protocols for the analysis of nano-, micro-, and macroplastic in water samples

EUROqCHARM Short Report

Date: 07.10.2023

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