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EUROqCHARM
WP1

Screening and analysis of existing methods and protocols for plastic pollution monitoring

Stefano Aliani

WP1 leader

Webinar "Presenting Euroqcharm project outcomes to foster global database synchronization",

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Screening and analysis of existing methods and protocols for plastic pollution monitoring

Monitoring is a key step in plastic pollution control and management and harmonization of methods is paramount for it

Objective: Compile and criticize methods used to quantify plastics in environmental samples from all **environmental matrices** and **plastic sizes** using a **robust and systematic approach**

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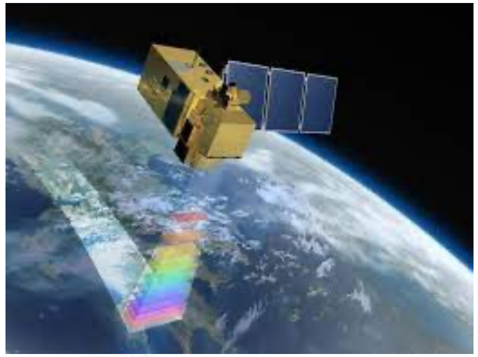
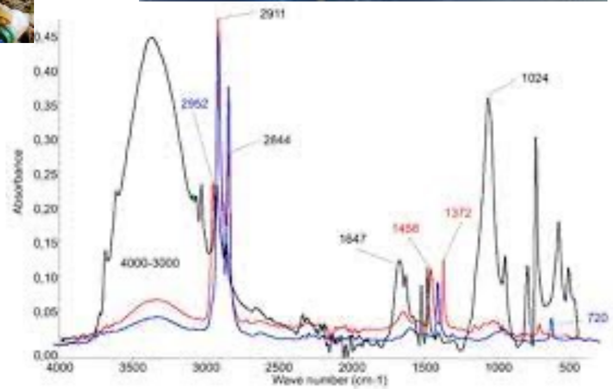
Screening and analysis of existing methods and protocols for plastic pollution monitoring

How many methods?
Which method?
Who use what?





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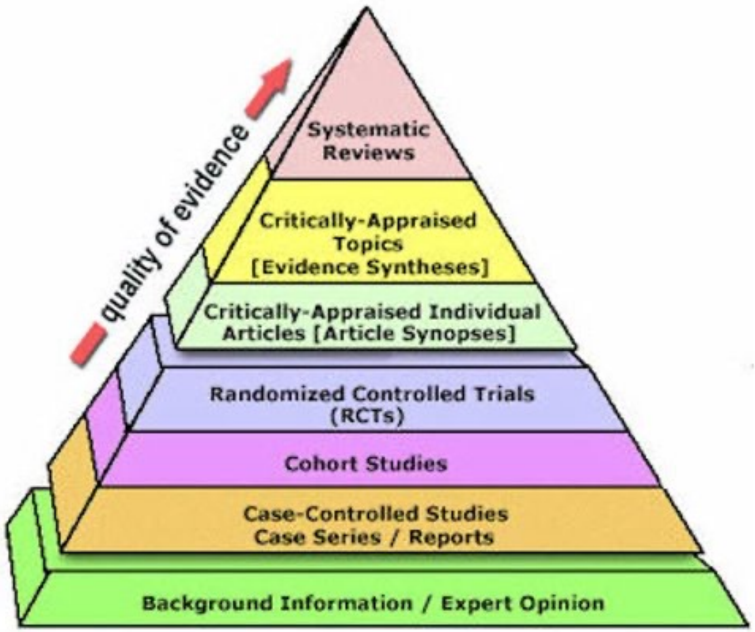
Systematic Review

A **systematic review** (SR) is a research summary that uses a **structured, reproducible approach**, often supplemented by a meta-analysis to produce an ***evidence synthesis*** report



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Screening and analysis of existing methods and protocols for plastic pollution monitoring

Step1: search terms identification

Step2: main search

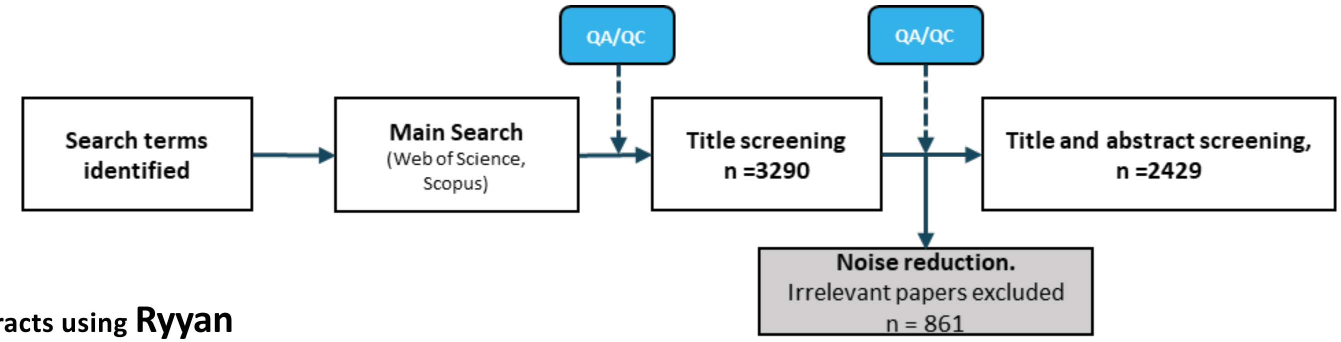
Step3: QA/QC

Step4: Title screening

Step5: QA/QC

Step 6: Pairwise screening of titles and abstracts using Ryyan

Step7:Gray literature



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Literature Analysis

D**ropdown menus** in Excel file to standardise the extraction of information

Sampling	Sample prep	Density for separation	Sample prep - detail
Manta	Density separation	density <1.2	NaCl
Bongo	Acid digestion	density >2.2	Na2WO4.2H2O
Neuston nets	Alkaline digestion	density 1.2 (sat. NaCl)	NaBr
WP2 nets	Enzymatic digestion	density 1.3	3Na2WO4.9WO3.H2O
Trawl	Oxidative digestion	density 1.4	Li6(H2W12O40)
Divers	Flow cytometry	density 1.5	ZnCl2
ROV	Filtration	density 1.6	ZnBr2
Pump	Visual separation	density 1.7	NaI
Core	Mixed solution for alkaline	density 1.8	KOH
Grab & Bucket	Other	density 1.9	NaOH
Scoop/shovel/spoon	Not reported	density 2.0	HNO3
Biota (passive net)	Not applicable	density 2.1	HCL
Biota (trawl)	Sieving	density 2.2	HClO4
Biota (hook/lin)	Gravimetric separation	saturated solution	HNO3/HClO4
Hand collection		Other	H2O2
Air (Active filtration)		Not reported	K2S2O8
Air (Passive sampling; deposition)		Not applicable	Proteinase K

Articles divided between researchers who then went through all the titles and abstracts:

- blinded manner using Rayyan, a web application for SR
- Researchers agree on what included and excluded
- Some tags added (to ease separation later)

Reading teams organized by matrix:

- Teams of blind readers per matrix
- Experts readers

Reading teams read all the articles :

- Compiled excel data base of results
- Couples of blind researchers agree on outcomes

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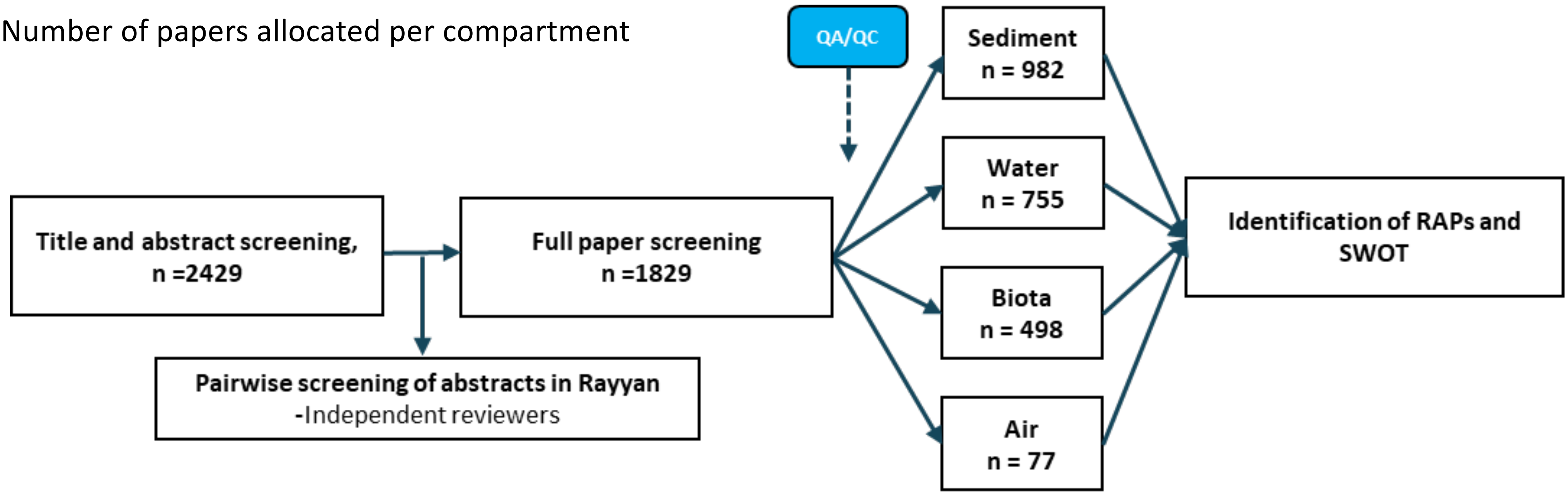
Number of papers allocated per compartment



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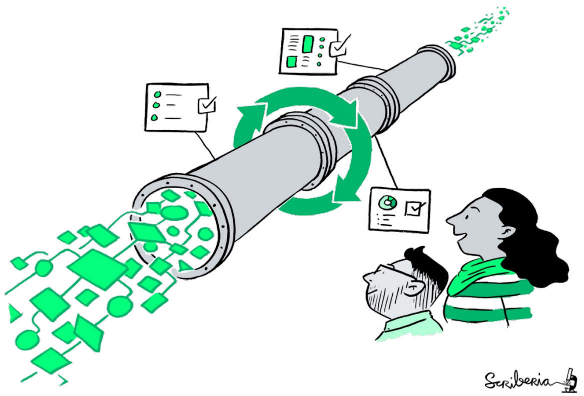
Reproducible Analytical Pipelines were first developed in software engineering

RAP has been indicated as the way of achieving highest standards



Reproducible analysis is about
breaking down the process of plastic analysis into manageable steps

The analysis of plastic samples is arranged in recurrent fundamental steps which are addressed to obtain reliable results and **can represent the workflow of plastic analysis.**

There is **no standard procedure to define RAPs in plastic analysis,** given that this a completely new approach

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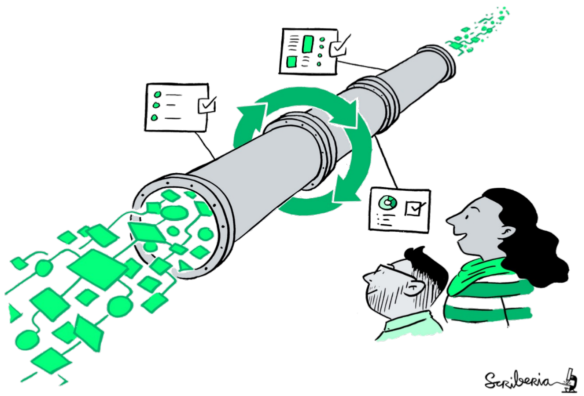
Reproducible Analytical Pipelines (RAPs)



What is a Reproducible Analytical Pipeline?

In our application:
The workflow of a usual analytical process characterised by a wide use of methods and operations and a quality assurance process.

RAP aims to be very simple and our focus is on **Reproducible.**

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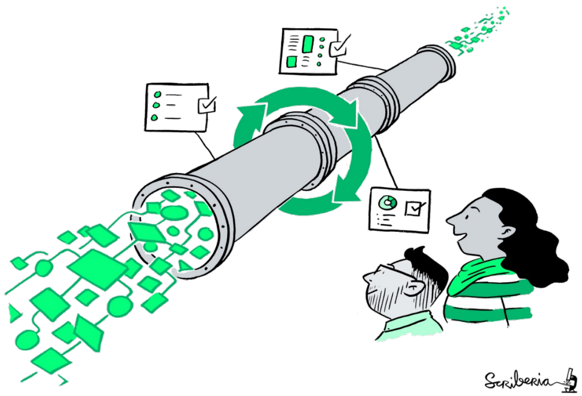

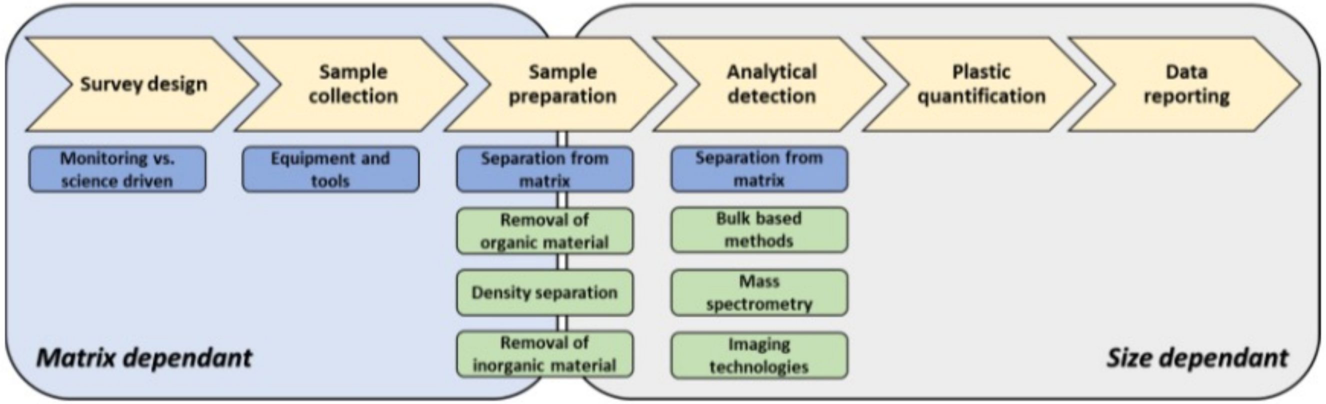

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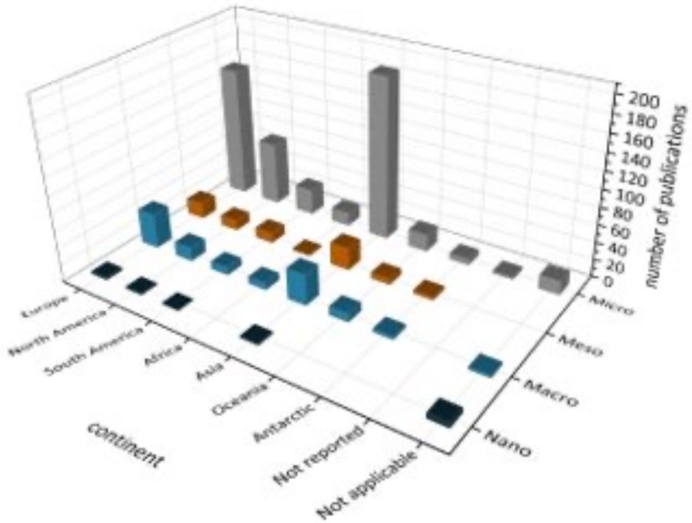
Some examples

- Number of microplastic papers by geographic area and size classes



Europe and Asia published a similar number of papers on micro and macroplastics.
America is less active

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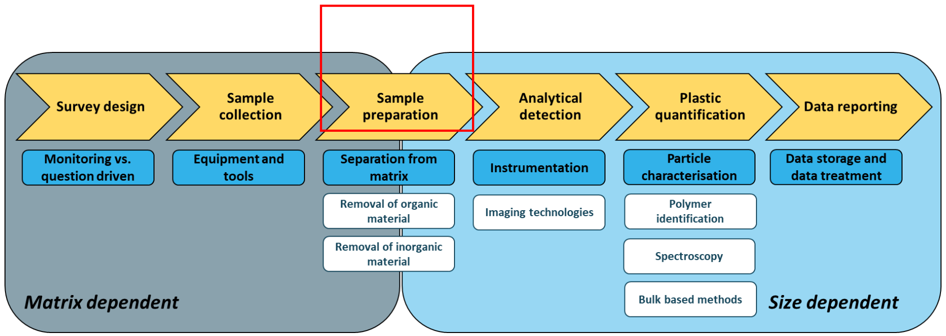
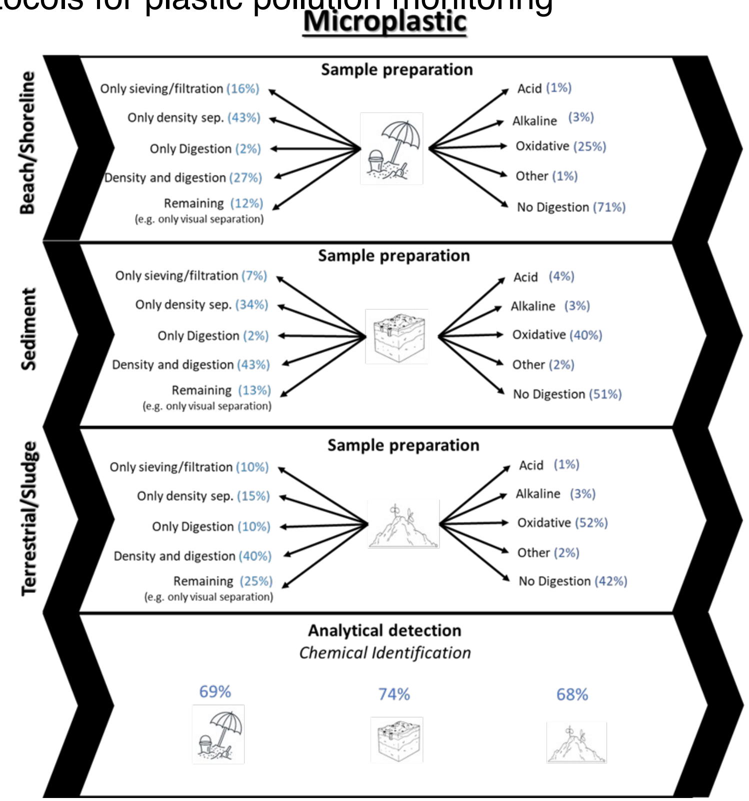
Some examples

- RAP sample separation

Number of papers that used a certain method





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SWOT Analysis - Net sampling for microplastics in water

Strengths

- Mesh sizes are available across the different sampling devices
- Frequently applied in the field
- Many sampling device designs available
- Sample splitting possible
- Meso plastic sampling possible
- Decreased sampling costs
- Sampling can be performed from existing structures like bridges or existing monitoring stations (**terrestrial**)
- Easier access to samples in **terrestrial** systems
- Could be used to targeted specific emissions sources in **terrestrial** system

Weaknesses

- Lower detection limit set by the net mesh size
- On board (marine) / onsite (terrestrial) sample processing necessary
- Various mesh types and sampler types can be applied
- Low number of quality control measure currently applied

Opportunities

- Available to broad range of size ranges
- Cost efficiency allows for numerous samples
- Improved knowledgebase on abundance
- Could be used to provide advice to regulators when specific emissions are targeted
- Increased knowledge base on micro- and mesoplastics abundance

Threats

- Non-comparable data caused by unharmonised sampling equipment
- Poor data quality
- Underestimation of lower size range MPs
- Unreliable data result in conflicting advice to regulators and wrong response of society

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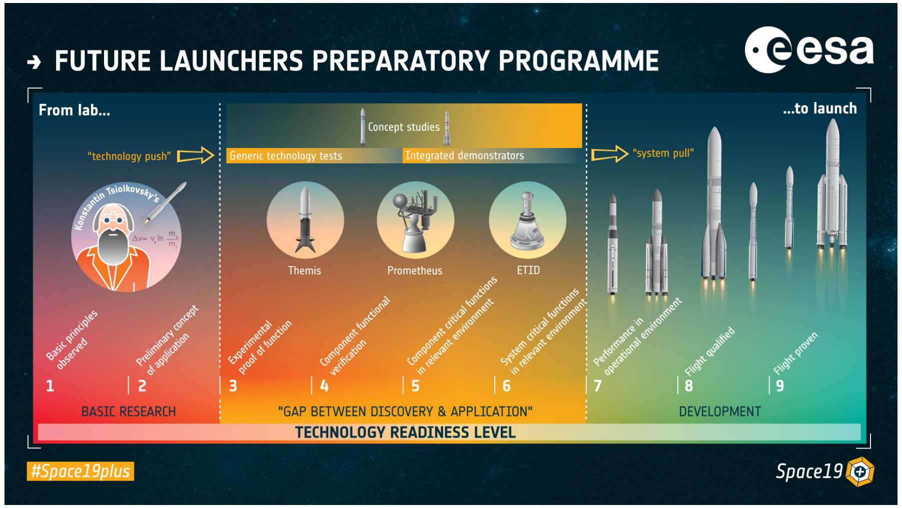
Technological Readiness

A Technology Readiness Assessment (TRA) is a systematic, metric-based process that assesses the maturity of certain technologies. It performs three different functions:

- Identifies the deficiencies during phases; demonstrates the current readiness level and provides the steps needed for their resolution;
- Identifies the technologies with highest risk and provides the essential information for their development;
- Identifies immature technology for increasing transparency in management decisions.



The TRL scale first in space technology ranking from 1 to 9 with 9 the most mature

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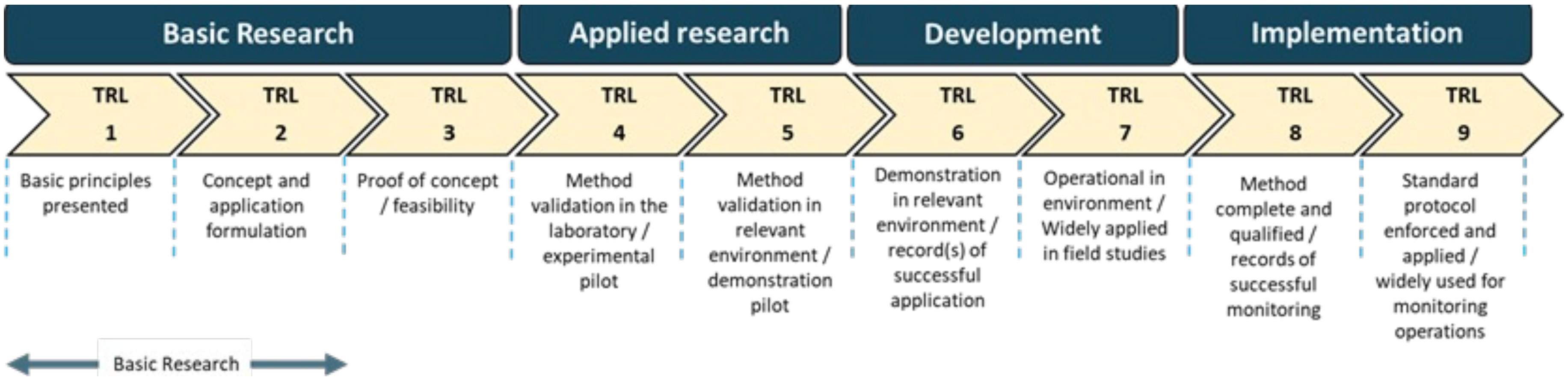
The TRL scale was invented with space technologies in mind where the environment does not change and the more physical the nature of a discipline, the better TRL can be applied

- TRL for the first time into plastic monitoring to sustain an innovative and robust discussion about monitoring methods.



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Technological Readiness

TRL is not the only, and probably not the optimal, method to analyse technological innovation and applicability (Smith 2005), but it is widely used and relatively efficient (Mankins 2002).

The European Commission adopted the TRL approach (Commission Decision C(2014)4995, part 19) and the TRL scale became, through various modifications, an innovation policy tool of the European Union (EU) (Héder 2017).

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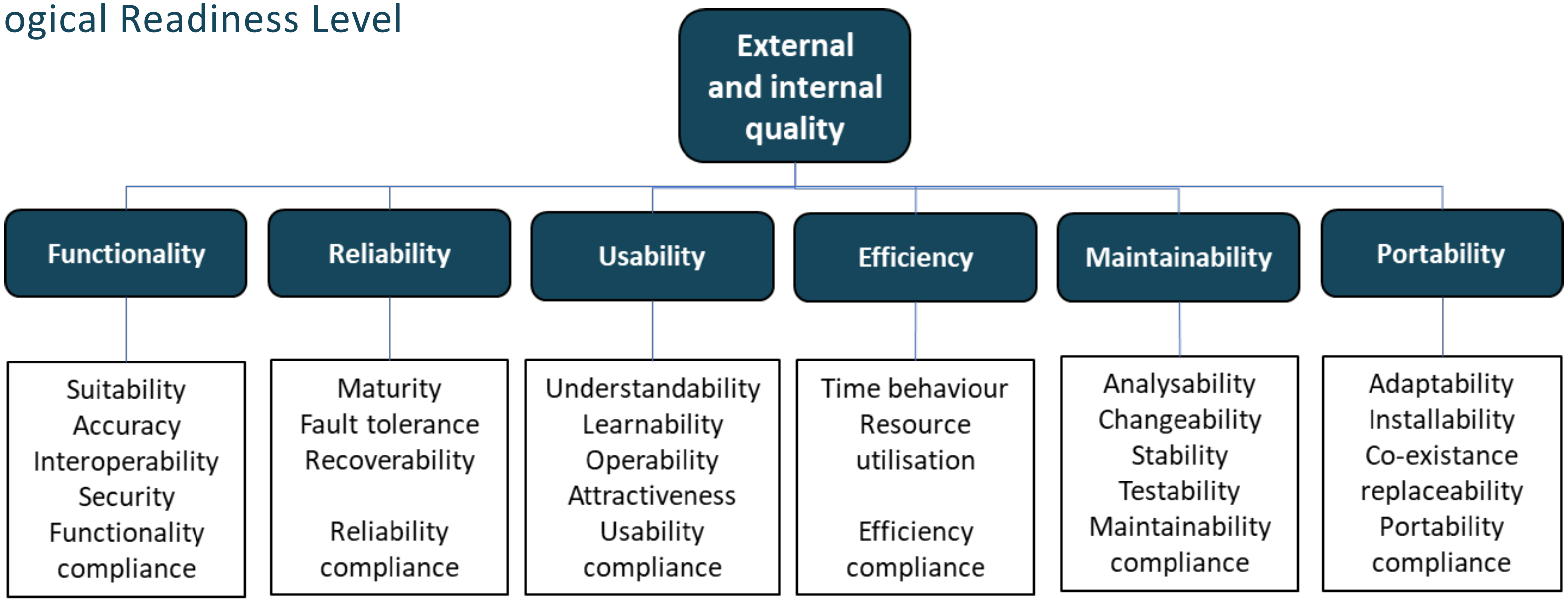
Criteria for expert identification of Technological Readiness Level



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TRL of macrolitter and macroplastic analysis in water samples

TRL	Survey design	Sample collection	Sample preparation	Analytical detection	Plastic quantification	QA/QC	Data reporting
1							
2							
3							
4	Terrestrial water						
5			Not relevant			Not relevant	
6		Net sampling					
7	Sea water	Visual surveys		Object identification	Object identification		Protocols
8							
9							

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TRLs for nanoplastic analysis in water samples

TRL	Survey design	Sample collection	Sample preparation	Analytical detection	Plastic quantification	QA/QC	Data reporting
1	Protocols for all compartments						Not available
2		Method development	Method development	Method development	Method development	Method development	
3							
4							
5							
6							
7							
8							
9							

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TRLs for microplastic (<1 mm) analysis in biota

TRL	Survey design	Sample collection	Sample preparation	Analytical detection	Plastic quantification	QA/QC	Data reporting
1							
2							
3							
4				Hyperspectral imaging			
5	Plants, amphibian			Pyr-GC/MS Fluorometric		Field blanks, Positive controls	
6	Non-bivalve invertebrates		Enzymatic digestion, acid digestion		µg/g	Air blanks	
7	Bivalves, fish		Alkaline digestion, oxidative digestion, density separation	Optical microscopy, FTIR, µFTIR, Raman, µRaman	Items/individual, items/g, %	Air filtrations systems	
8						Procedure blanks	
9		Hand collection, nets, hooks/lines					

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Grey literature.

There is a lot of grey literature on environmental plastics available on the internet or in repositories of organisations and companies. In some instances, **reports do not have the minimal requirements to be considered**.

For example, they were a simple collection of items and did not report aims and methods. In other cases, there was a **strong bias toward an opinion**, which limited scientific contribution.

Thematic working groups and official reports of national entities or scientific projects described **expert identified protocols and suggested their use** including detailed lists of procedures and steps.

In general, reports did **not make an assessment of the performance** of their guidelines.

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FINAL REMARKS

- Within Europe, **research studies on plastics are not equally distributed** (e.g. for the matrix biota, no publications were identified in the Black Sea)
- **Description of methods provided by authors is insufficient** and do not reach an acceptable scientific level
- Much of the recent literature **does not follow the latest methodological recommendations**
- **Differences** can be identified **between continents**
- Only a small proportion of publications make their full **dataset publicly available**

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FINAL REMARKS

- There are **size barriers** in analysis and no universal method is good for all sizes.
- There is a large and **increasing number of methods**, resulting in high heterogeneity.
- For biota, is a **clear link between the selected target species and the corresponding plastic size**
- Publications on **nanoplastics** in each of the compartments are **limited**
- Only a few methods fit the requirements to be **considered mature** (e.g. plastic ingested by **some species of birds**)

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Screening and analysis of existing methods and protocols for plastic pollution monitoring

QUESTIONS FOR DISCUSSION

It is important to cover knowledge gaps developing hi tech methods and new procedures to improve quality of data and information, but it is also important to consider sustainable and shareable methods that provide large distributed data set, possibly covering the global environment

- Are the concepts of reliability, wide use and data sharing included in your programs? (y/n)
- Are your monitoring programs sustainable? (y/n)
- Are capacity building and technological expertise of personnel included in your programs? (y/n)

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Screening and analysis of existing methods and protocols for plastic pollution monitoring

QUESTIONS FOR DISCUSSION

A critical analysis of current methods is compulsory. To simplify and improve the critical process, the analytical workflow can be split into Reproducible Analytical Pipelines (RAP). Assessing the TRL of RAPs can enhance the process of revision and implementation of guidelines.

TRLs and RAPs are not new ideas; indeed, they are widely used in industry and TRL is a key policy tool of the European Union (Commission Decision C (2017)7124). Applying them to plastic research helps expert groups in harmonizing monitoring protocols. This integrated framework allows researchers to better advise governments and policymakers.

- Do you believe the critical assessment of methods is important? (y/n)
- Have you ever heard about TRL and RAPs? (y/n)
- Do you have alternative methods to suggest?

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Screening and analysis of existing methods and protocols for plastic pollution monitoring

QUESTIONS FOR DISCUSSION

After a Systematic Review we found a large number of papers on monitoring but there is also a large diversity of methods currently used. For instance, units can be very different and transformation is not always possible (items/km3 vs kg/km2); or different densities used for separation may select lighter or heavier polymers. There is a strong need for harmonization to make data reproducible and robust, no matter whether data may come from academia, ONG or citizen science.

- Do you already have experience with this kind of review? (y/n)
- Are you aware of critical harmonization lacks? (y/n)
- Are you ready to improve harmonization in your projects? (y/n)
- How do you see it possible for you?

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Thank your for your attention

This work is the result of a very wide teamwork, it is not possible to list all of them but everybody is acknowledged

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