Overview of methods and challenges for microplastic analysis

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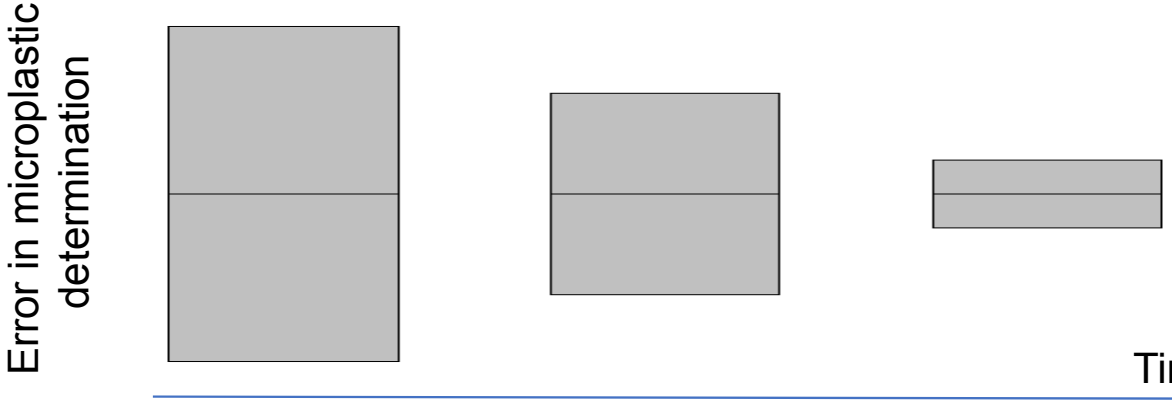
A major challenge

BASEMAN
Defining the baselines and standards for microplastics analyses in European waters

JPI OCEANS
www.jpi-oceans.eu

Citation from BASEMAN:

Although microplastics (MP) are recognized as an emerging contaminant in the environment, currently neither sampling, extraction, purification nor identification approaches are standardized, making the increasing numbers of MP studies hardly -if at all- comparable.



The scientific community works hard to reach valid methods

– but we are not there yet

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Standardized and trustworthy analytical methods are needed

- Without proper analytical methods we cannot:
  - Assess the amount of microplastic in the environment
  - Distinguish which are the most important sources
  - Quantify impacts of microplastic

- We (the scientific community) do not (yet) have the final answer to how microplastic should be analyzed
- Over the later years, certain methods have shown promising results, while others have been deemed unsatisfactory

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Lack of **S**tandardized **O**peration **P**rotocols

Analyzing for microplastic in the environment, there are many ways of doing:

- Experimental design
  - where and how to look for MP?
- Sample collection
  - Mesh sizes? Sample sizes?
- Sample purification
  - How to get rid of irrelevant substances without biasing the analysis?

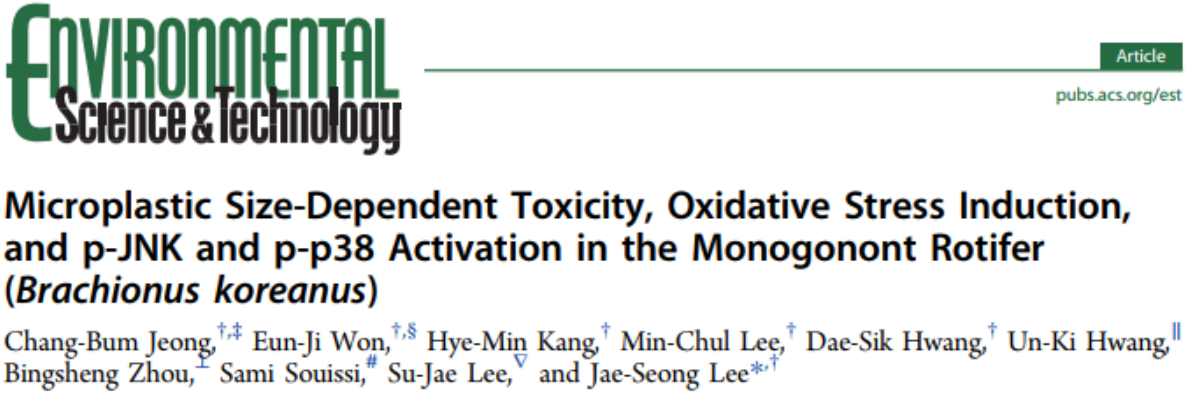
Lack of **S**tandardized **O**peration **P**rotocols

Analyzing for microplastic in the environment, there are many ways of doing:

- Microplastic identification
  - How to safely distinguish artificial polymers from naturally occurring substances?
- How to report results
  - Particle sizes: What is the “size” of a particle? Particle mass: How best to quantify the mass of a particle?
- Document the validity of the analysis – this is often forgotten …
- Document uncertainties – this is often forgotten …

Size – why is it important?

- The traditional wisdom is that microplastic toxicity increases with decreasing size



Environmental Science & Technology

Article

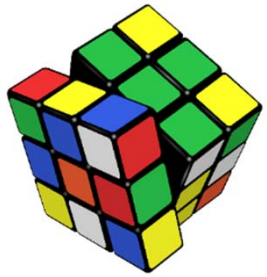
pubs.acs.org/est

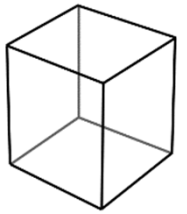
Microplastic Size-Dependent Toxicity, Oxidative Stress Induction, and p-JNK and p-p38 Activation in the Monogonont Rotifer (*Brachionus koreanus*)

Chang-Bum Jeong,[†,‡] Eun-Ji Won,[†,§] Hye-Min Kang,[†] Min-Chul Lee,[†] Dae-Sik Hwang,[†] Un-Ki Hwang,[∥] Bingsheng Zhou,[⊥] Sami Souissi,[#] Su-Jae Lee,[▽] and Jae-Seong Lee*[,†]

- So size matters

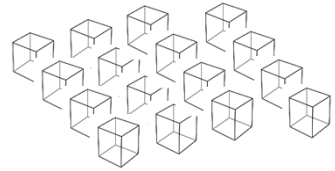
Size – why is it problematic?





1 particle of
1000 x 1000 x 1000 µm

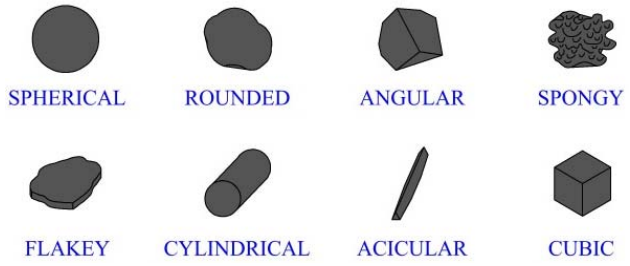
Because $100^3 = 1{,}000{,}000$



1,000,000 particles of
10 x 10 x 10 µm

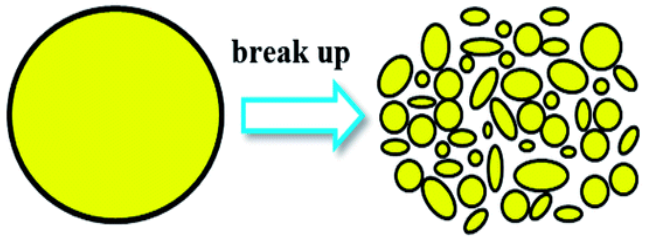
- Microplastic degrades in the environment, continuously creating smaller particles
  - One **Big** Particle becomes **Many Small** Particles
  - So what does a particle number really tell you?

- What dimension is it we report when we say “size”?



There is no clear consensus on this

Size – why is it problematic?



- Any sample preparation applies forces on the particles
  - Sample preparation causes large particles to break up into smaller ones – the extent hereof is unknown

- Particle number is not a conserved unit – there is no law of particle number conservation

- Hence particle numbers and sizes cannot be used to establish balances like “which source is the more important”

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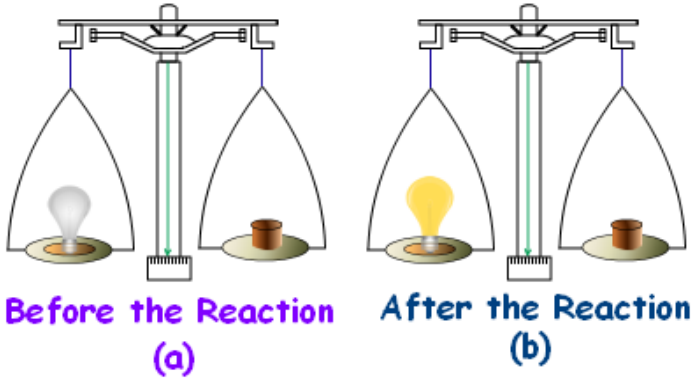
Mass – why is it important?

- Mass is a consistent measure
  - There does exist a law of mass conservation !!!
  - Only mineralization will affect this measure

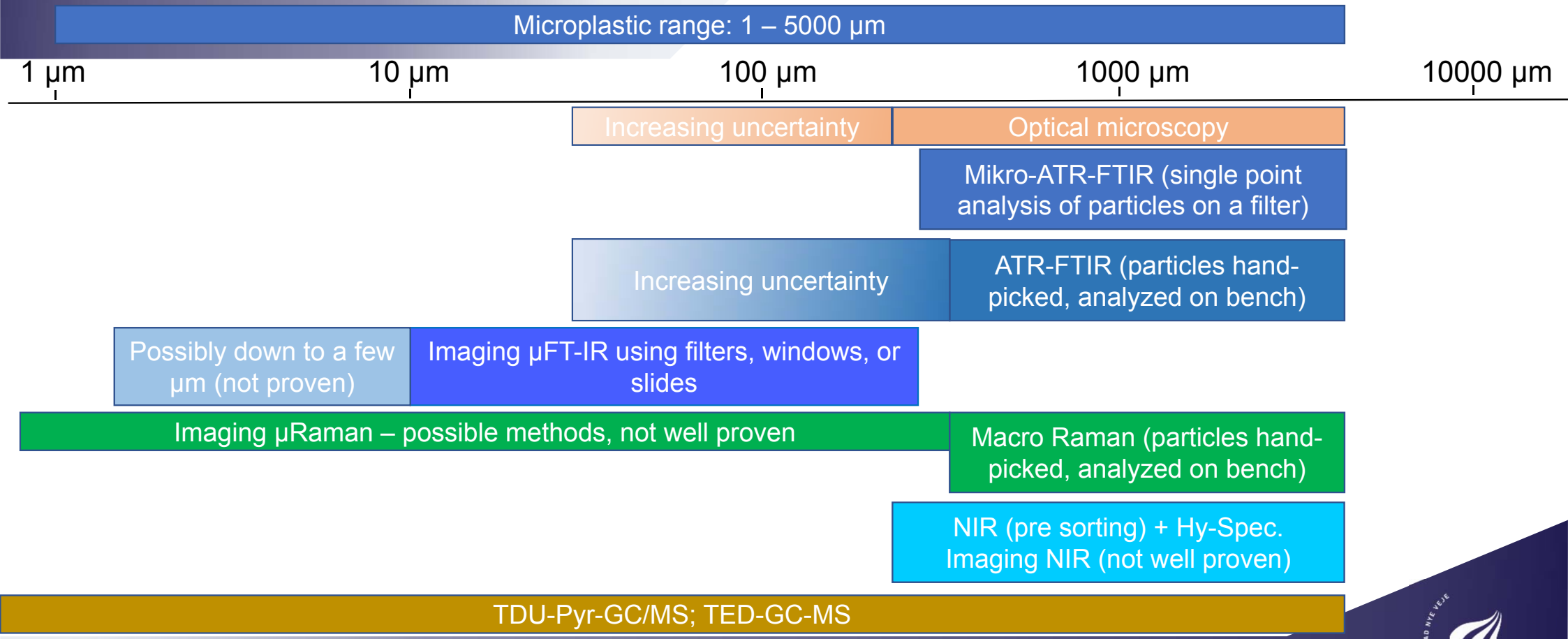


- Estimates on plastic loads to the environment must be made in units of mass (particle numbers make no sense here)
  - Mass must be measured to allow this

Mass – why is it problematic?

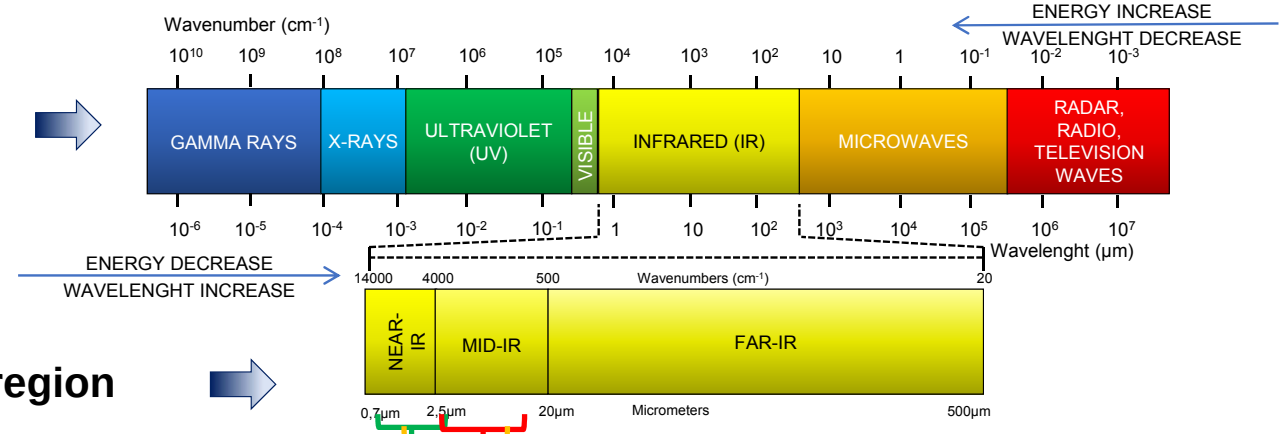
- Plastic is not one thing
  - Measuring plastic mass requires measuring the mass of many different polymer particles
  - No analytical method can actually detect all polymer types …
- µFT-IR imaging
  - Yields a mass estimates with unknown accuracy
  - Cannot measure car tire rubber
- TDU-Pyr-GC/MS; TED-GC-MS
  - Can measure many but not all polymers (PVC?)
  - (But it cannot measure particle sizes ….)

Size ranges and analytical methods

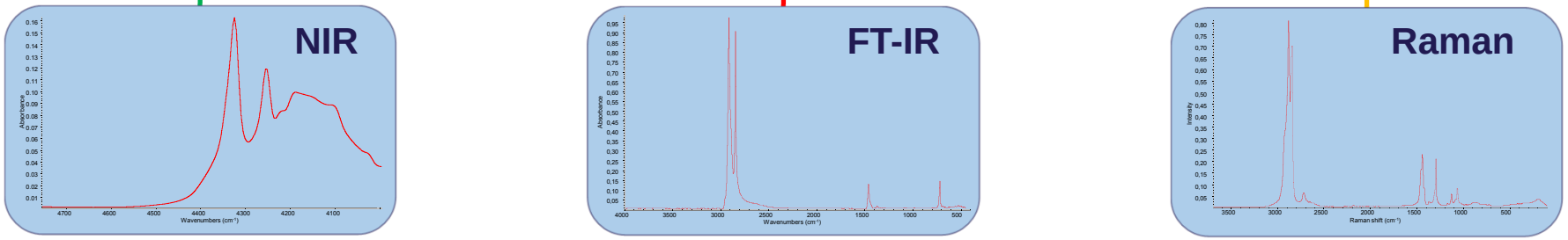


Infrared is the most suitable wavelengths for spectroscopic methods

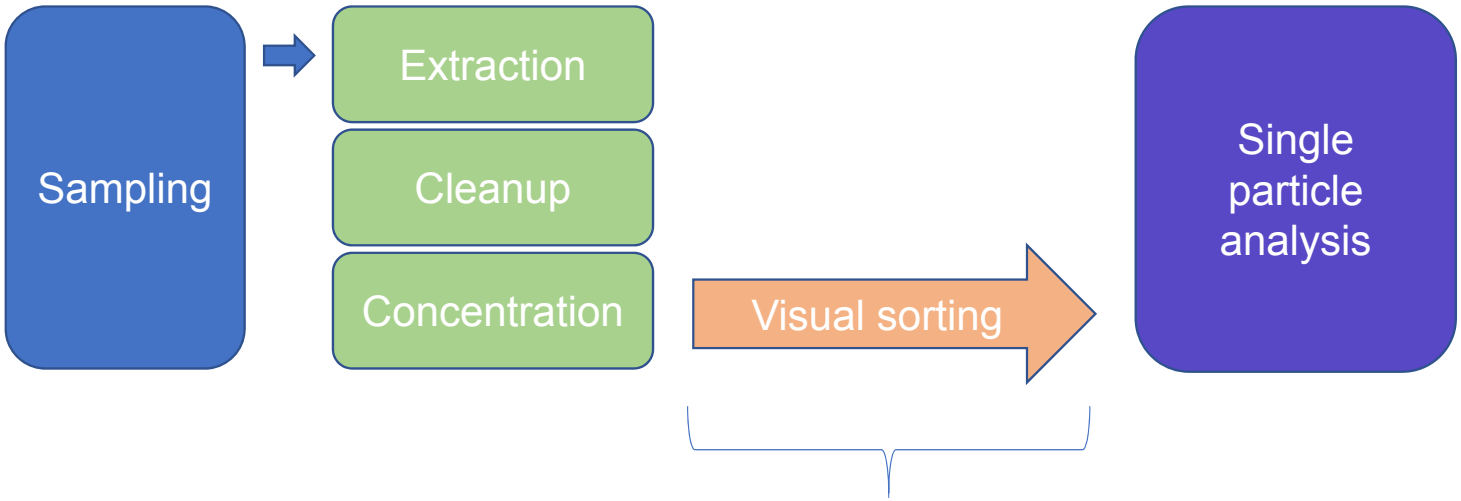
Electromagnetic spectrum



IR region



Typical work flow for single-particle analysis

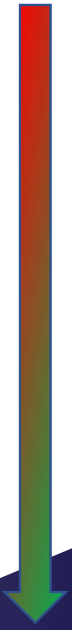


Main issues:

- Sorting is operator dependent
- Very difficult and time consuming for small particles

Methods ranked according to certainty (in my opinion….)

- Compound or stereo microscopy
- Fluorescence microscopy
- Single point Raman
- TDU-Pyr / TGA-GC-MS
- Single point FT-IR
- ATR-FT-IR



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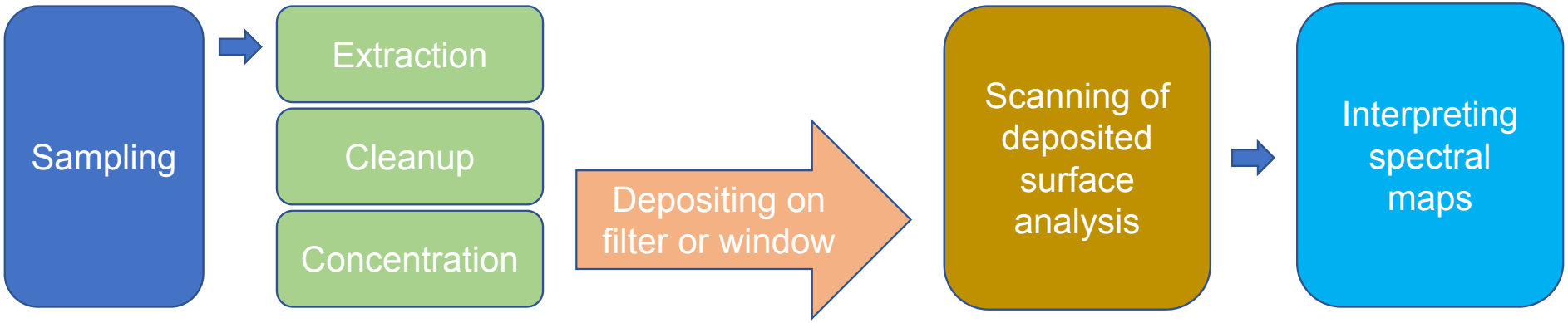
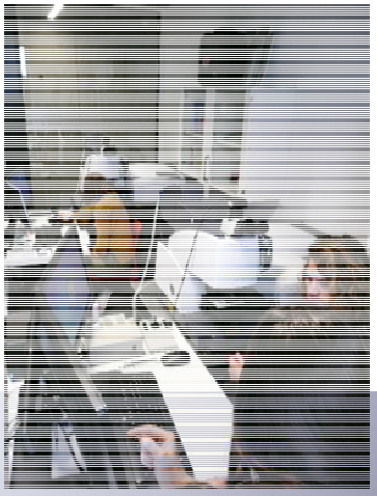
The work flow for imaging analysis





Alvise will talk about this method in the next lecture

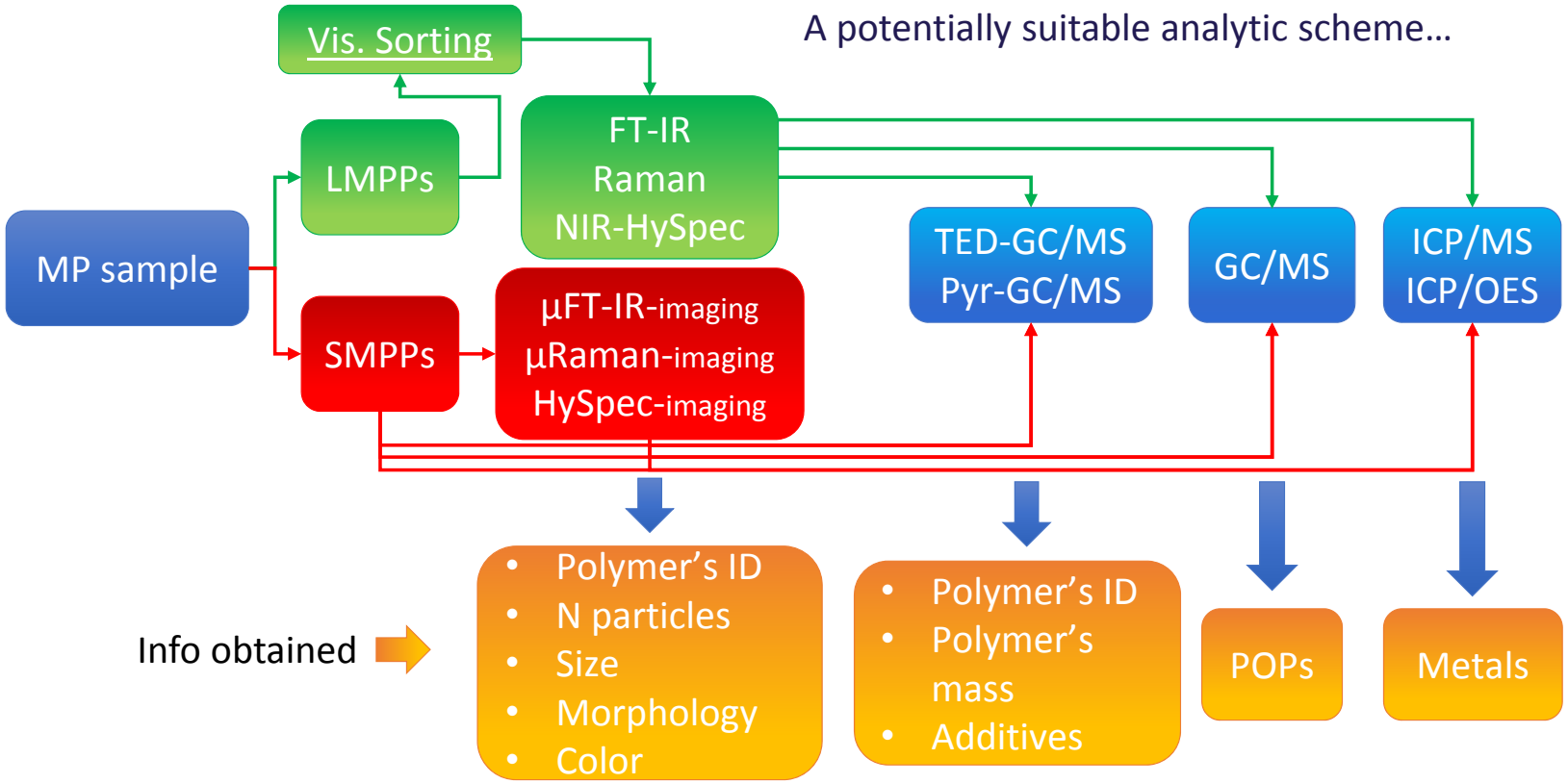
μFT-IR
- Well proven and tested. Most used approach

μRaman
- Possible method but not well proven and tested

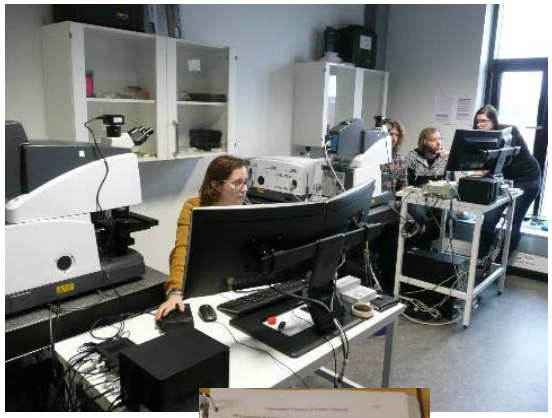
I believe the solution is not one method, but a suit of methods

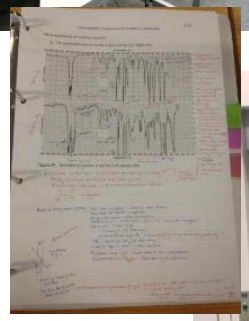
Analytical flow

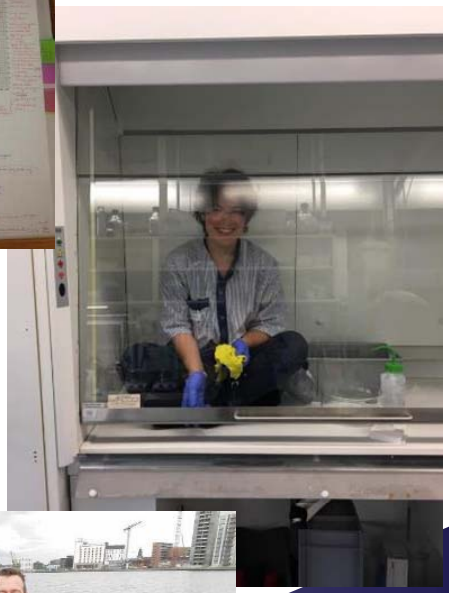
A potentially suitable analytic scheme…



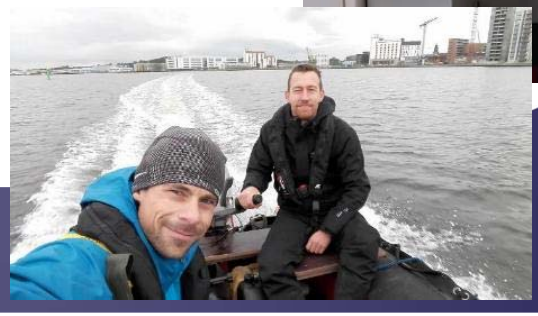
The Aalborg University microplastic research group







- Foundation in urban polluted waters
  - Wastewater, stormwater, sludge,
- Receiving environment impacted here by
  - Soil, water, air
- Focus on developing better, faster, and more valid methods for microplastic quantification
- Focus on quantifying microplastic in the environment



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