VALUE FOR MONEY: A cost-effectiveness analysis of microplastic sampling and analytics.

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INTRODUCTION | MATERIAL & METHODS

A rapid diversification of microplastic (MP) analysis techniques has obstructed cross-study comparability and confuses researchers that look for an optimal technique. Moreover, many of these techniques are perceived as expensive and laborious. To tackle this problem, we performed a cost-effectiveness analysis (CEA) to compare investment and labour costs with the effectiveness of different, commonly used methods for the analysis of microplastics in seawater on a European scale.

This analysis will help provide concrete and useful recommendations on which workflows provide the greatest value for money when analyzing microplastics.

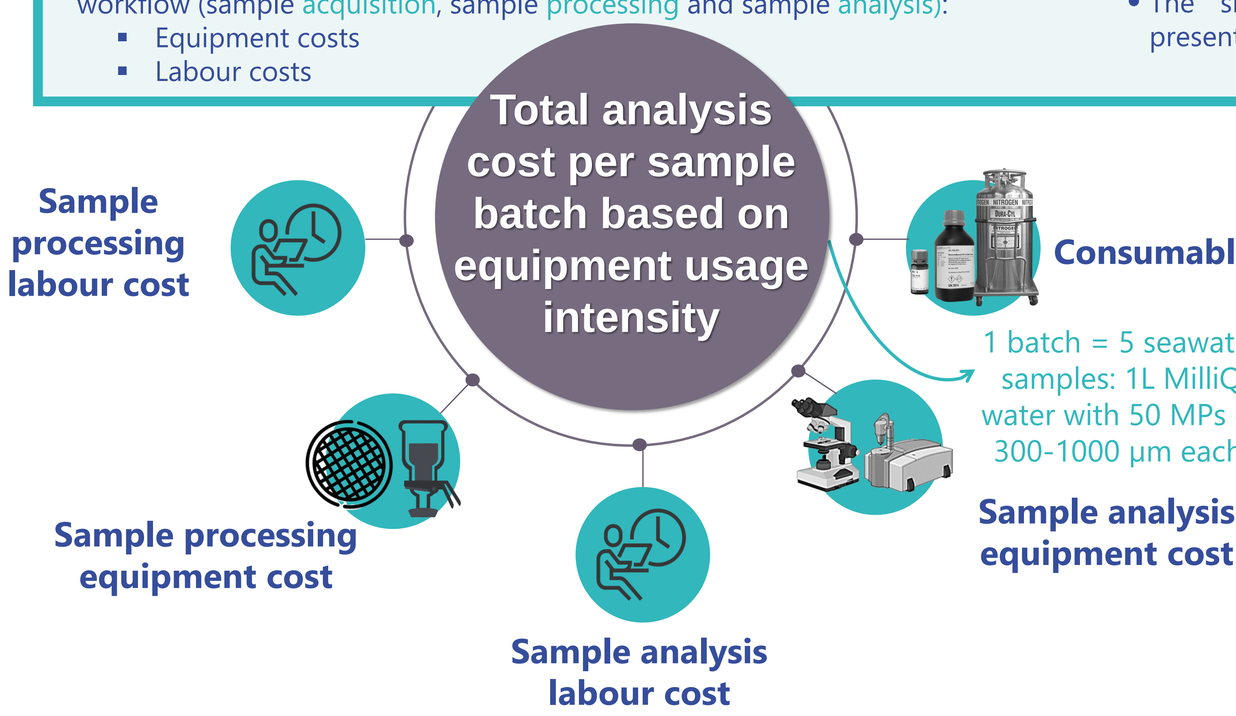
A 4-step procedure was performed, consisting of 1. an online survey (total of 64 participants); 2. data analysis; 3. a 1st workshop for scientific validation (10 participants); and 4. a 2nd workshop for policy feedback (9 participants). Results of step 1 and 2 are presented here.

Online survey

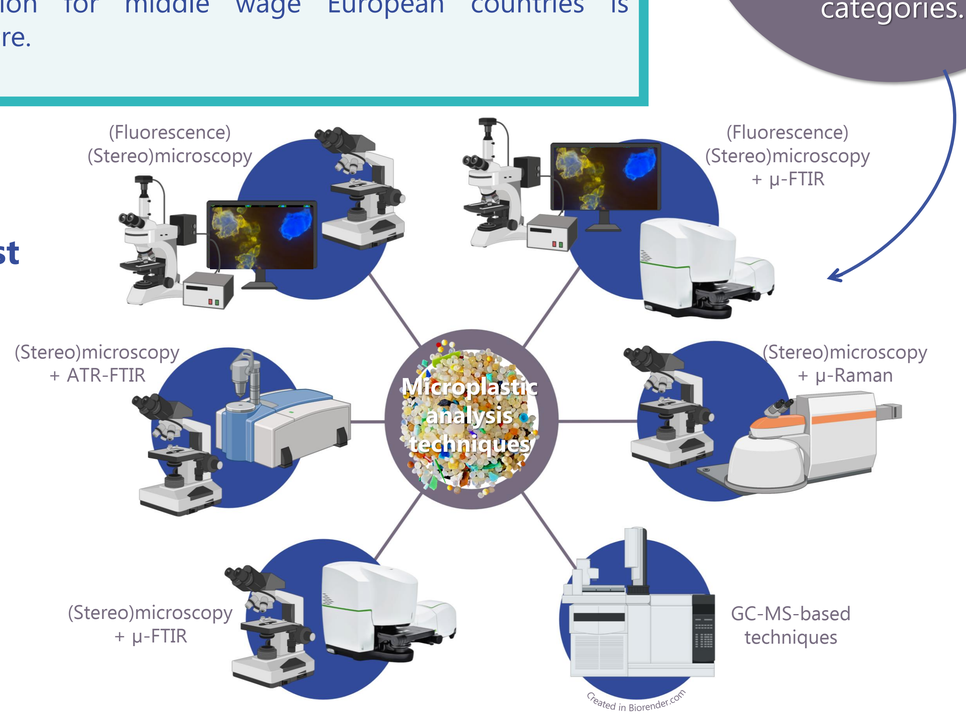
- Data obtained through online survey sent around to MP experts in autumn 2022.
- A scenario was described:
  - Five seawater samples (a batch) acquired with manta net in the North Sea
  - 50 heterogeneously shaped MPs in 1L MilliQ water per sample
  - MP size range of 300-1000 µm
  - Suspended particulate matter content = 25 mg/L (Neukermans et al. 2012)
- Questions targeted two types of costs for each step within the MP analysis workflow (sample acquisition, sample processing and sample analysis):
  - Equipment costs
  - Labour costs

Data analysis

- Calculated equipment and labour costs per technique
  → Used to simulate total analysis cost per sample batch of seawater samples in terms of equipment usage intensity.
- Three different simulations were created, i.e. for lower, middle and higher wage European countries (respectively GNI per capita (p.c.) < 29,620 EUR; 52,681 – 29,620 EUR and > 52,681 EUR) as defined by the World Bank (World Bank 2021).
- The simulation for middle wage European countries is presented here.



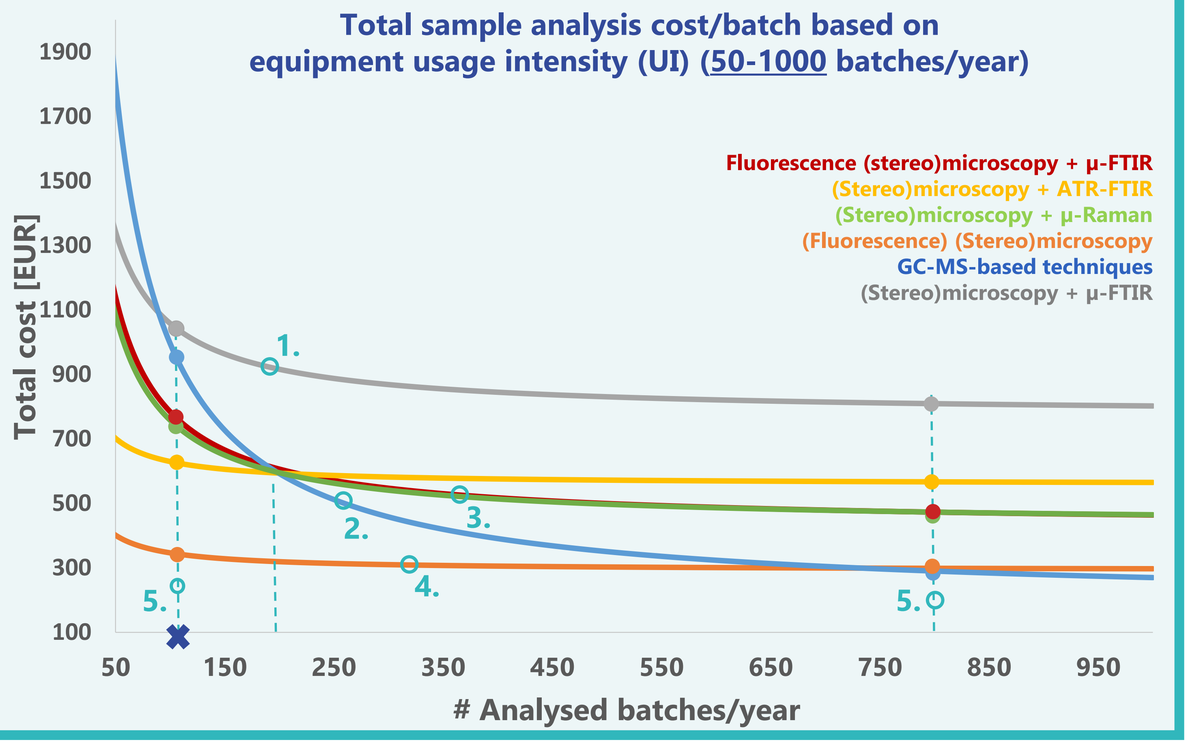
Based on the obtained data, the techniques used by survey participants could be classified into six major analysis technique categories.



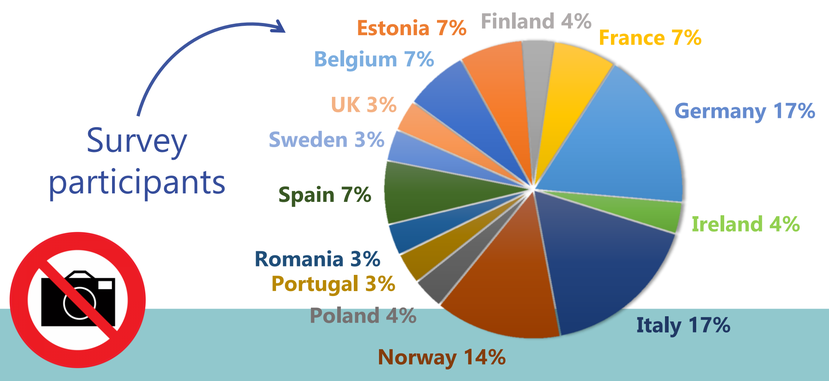
RESULTS

Countries with GNI per capita of 64,010 – 35,990 USD (52,681 – 29,620 EUR) (World Bank, 2021).

Total sample analysis cost/batch based on equipment usage intensity (UI) (50-1000 batches/year)



1. **(Stereo)microscopy + µ-FTIR-based analyses do not decrease much in cost with increasing equipment UI, due to the high labour costs and potential low degree of automation.**
2. **For GC-MS-based techniques, equipment costs weigh in more than labour costs, therefor costs are much higher for low equipment UI than for other techniques. Costs however drop rapidly with more intense equipment usage.**
3. **Analyses based on (stereo)microscopy + µ-Raman and fluorescence (stereo)microscopy + µ-FTIR are similar in cost, regardless of equipment UI. Costs for the latter are lower than for (stereo)microscopy + µ-FTIR-based techniques as fluorescent staining helps with the initial particle selection and automation may be easier e.g. through image analysis.**
4. **Costs of techniques based on solely (fluorescence) (Stereo)microscopy are mainly determined by labour costs and consequently the degree of automation.**
5. **The most cost-effective method is highly dependent of equipment UI.**
6. **Location also plays an important role for determining the most cost-effective method due to varying labour costs.**



✖ Total sample analysis cost for 100 batch analyses/year per technique

6.	Countries with GNI p.c. of > 64,010 USD (> 52,681 EUR)	Countries with GNI p.c. of 64,010 – 35,990 USD (52,681 – 29,620 EUR)	Countries with GNI p.c. of < 35,990 USD (< 29,620 EUR)
Fluorescence (stereo)microscopy + µ-FTIR	€ 988/batch	€ 784/batch	€ 630/batch
(Stereo)microscopy + ATR-FTIR	€ 896/batch	€ 630/batch	€ 425/batch
(Stereo)microscopy + µ-Raman	€ 962/batch	€ 758/batch	€ 606/batch
(Fluorescence) (Stereo)microscopy	€ 485/batch	€ 346/batch	€ 242/batch
GC-MS-based techniques	€ 1085/batch	€ 995/batch	€ 928/batch
(Stereo)microscopy + µ-FTIR	€ 1427/batch	€ 1058/batch	€ 773/batch

CONCLUSION

- The CEA supports the **identification of cost-effective techniques** for given scenarios:
  - Location dependent
  - Dependent on equipment usage intensity
- The resulting equations allow to **calculate the actual total analysis cost** associated with these techniques.
- The developed **predictive tool** can support researchers, policy makers and other stakeholders in their decision process of choosing between different microplastic workflows.
  - e.g. for monitoring strategies
- Next steps:
  - **Quantify effectiveness** of the different techniques to compare their cost and effectiveness for MP analysis.

The World Bank, World Development Indicators (2012). GNI per capita, Atlas method (current US$). Last update in 2021.
Neukermans, G., Ruddick, K., Loisel, H., & Roose, P. (2012). Optimization and quality control of suspended particulate matter concentration measurement using turbidity measurements. *Limnology and Oceanography: Methods, 10*(12), 1011-1023.