Detection of manufactured nanomaterials in complex environmental compartments – An expert review

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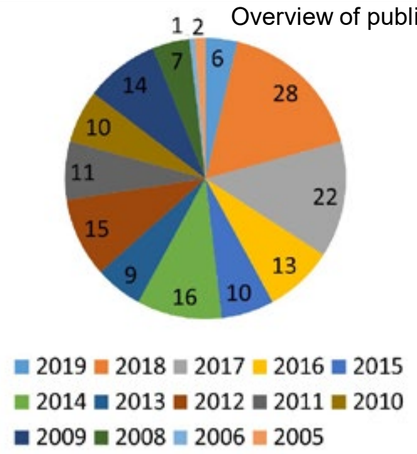
Motivation

Despite considerable scientific efforts, the selective detection of manufactured Nanomaterials (NMs) in environmental compartments is still a very complex and challenging task. An expert review of the literature has been conducted on behalf of the German Environment Agency (UBA) to identify relevant methods for nanomaterial detection in complex media in the context of environmental monitoring and a need for action was concluded from the existing body of work.

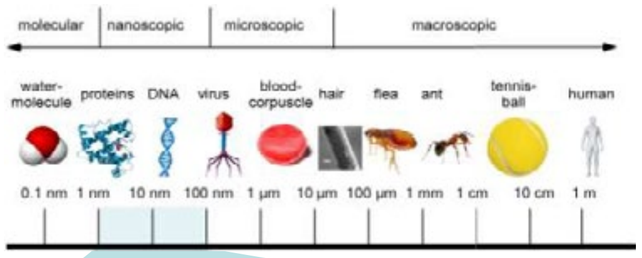
Methodology

- *Web of Science* Literature Review:
  - →> 150 publications
  - →> 10 000 sources
- Expert interviews
- Conference proceedings
- Project reports

Overview of publications



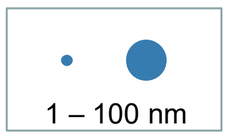
Manufactured Nanomaterials



Challenge:
wide variety of composition, size distributions

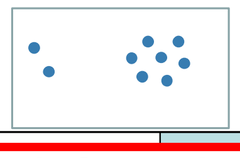
Detection needs

Size (distribution)

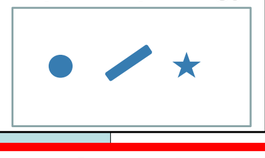


Chemical composition

Concentration



Shape/morphology



Environmental compartments

Sediment

Water

Air

Soil

Sludge

Biota

Challenge:
complex media with high backgrounds, NMs at low concentration

Needs for environmental monitoring:

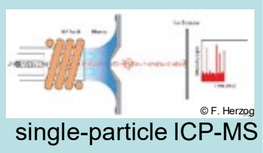
Methods with **high throughput** for the **detection**, **characterization** and **quantification** of **non-specific NMs** at **minimal concentrations** in **complex media** against **high particulate** and **elemental backgrounds**.

practicality

information depth

Size (distribution)

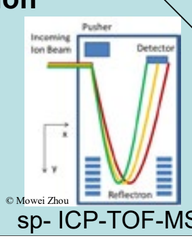
- sp-ICP-MS
- light scattering
- sequential filtration
- chromatography
- electron microscopy



single-particle ICP-MS

Concentration

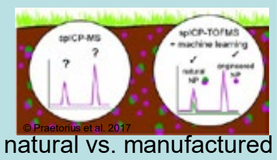
- sp-ICP-TOF-MS
- sp-ICP-MS
- ICP-MS/AES
- light scattering
- electron microscopy



sp- ICP-TOF-MS

Chemical composition

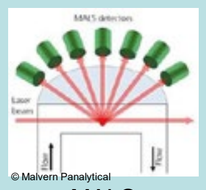
- sp-ICP-TOF-MS
- sp-ICP-MS
- ICP-MS/AES
- electron microscopy + EDX



natural vs. manufactured via sp-ICP-TOF-MS

Shape/morphology

- multiple angle light scattering (MALS)
- electron microscopy



MALS

→ Complete information can only be provided with a combination of different detection methods ←

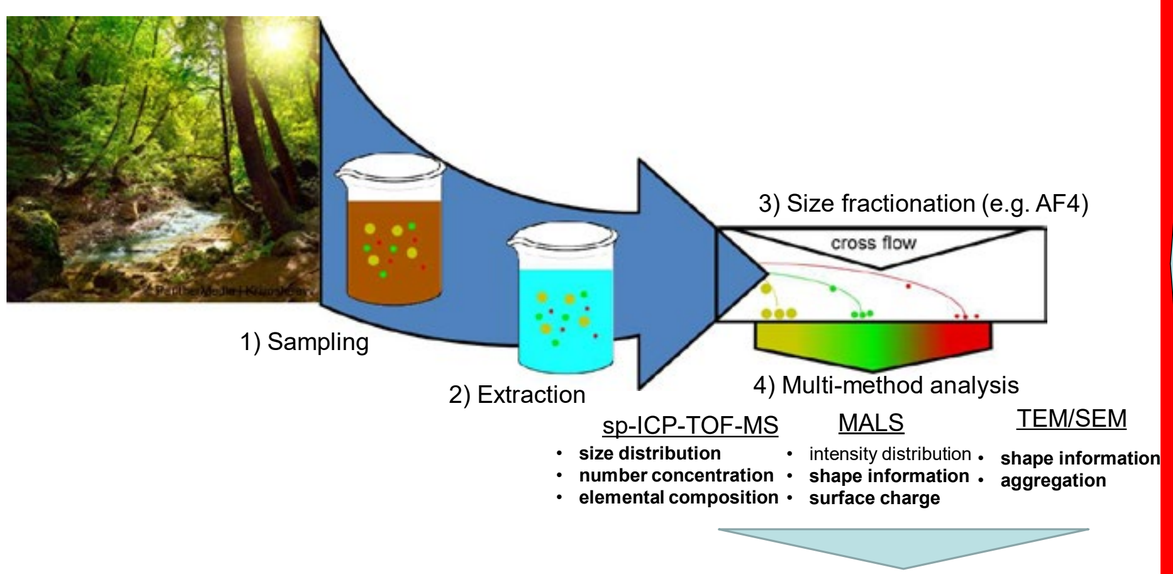
→ Extraction of NMs from complex matrix necessary ←

→ Size fractionation advisable ←

Extraction

- Cloud point extraction (CPE)
  → micelle mediated extraction of specific size ranges
- Ultrasound assisted extraction
  → extraction media: water, alcohol, surfactant solution, toluene, etc.
  → validated recovery rates needed
- Digestion
  → destruction of complex matrix
  → conc. acids/bases
  → enzymes
  → possible destruction/ alteration of NMs

Comprehensive scheme for NM detection in a combined approach



Size fractionation

- Chromatography
  → asymmetric flow field-flow fractionation (AF4)
  → hydrodynamic chromatography
  → size exclusion chromatography
  → NM need to be extracted and stabilized
- Centrifugation
  → simple technique for removal of NM from solution
  → sensitive to NM shape, surface coatings
- Filtration
  → sequential filtration of extracted samples
  → simple technique
  → risk of loss of NMs

Need for action

Short term

- Identification of most relevant NM/compartment
- Development of extraction techniques for specific NM
- Choice of combined approach/SOP for specific NM
- Standard reference samples

Medium term

- Development of extraction techniques for NM classes
- Combined approach for wider NM classes
- International round robin tests for validation
- Automation of experimental steps/combined data handling

Long term

- Library of extraction techniques
- Automation/combination in single technical solution
- Library of natural/manufactured NM data for routine detection

H. Hildebrand, S. Schymura, K. Franke, C. Fischer: „Analysis of studies and research projects regarding the detection of nanomaterials in different environmental compartments and deduction of need for action regarding method development", *UBA Texte* 133/2019.

available from: https://www.umweltbundesamt.de/publikationen/

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Project No. 97417

PIE-0007