EMPIR Call 2019 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-v06**
Version: 1.0

Title: Metrology for the analysis of technology critical elements (TCE) as emerging pollutants in the environment

Abstract

Many technology critical elements (TCE) are widely used in key industrial products, but limited opportunities for recycling are resulting in their growing release as emerging environmental pollutants. Currently, little is known about their fate or their environmental/eco-toxicological behaviour. Therefore, an analytical basis needs to be developed for the accurate and traceable measurement of selected representative TCE (Li, Sb, Nb, Ga, In, Ge, Pt, La, Ce, Gd). Innovative mass spectrometry as well as hyphenated approaches are needed that will go beyond the current state of the art in terms of sensitivity, interference handling and accuracy. This is expected to lead to the provision of best practice guidance and to the development of new matrix certified reference materials and performance tests for TCE. These advances will enhance environmental TCE measurements, giving authorities a more robust framework for decision making in future pollution control and early environmental protection.

Keywords

Technology critical elements, certified reference materials, emerging pollutants, mass spectrometry, monitoring, sampling

Background to the Metrological Challenges

As a consequence of the growing usage of technology critical elements (TCE) in high technology mass market products, and limited economic opportunities for recycling, they are being released into the environment in increasing amounts. Therefore, they are emerging as environmental pollutants. Their eco-toxicological characteristics, environmental behaviour and mid-long term environmental impacts are essentially unknown. This includes the paucity of information on their transformation and transport between different environmental compartments, and on their total content in targeted compartments. Their transport is often governed by water systems and recent research demonstrated that TCE tend to be associated with suspended particulate matter.

TCE include Li, B, Sb, Be, Nb, Ta, Ga, In, Ge, Tl, Te, the platinum group elements (Pt, Os, Ru, Rh, Pd and Ir), and most of the rare-earth elements (Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Yb, Lu), but for this SRT, 10 TCE have been selected (Li, Sb, Nb, Ga, In, Ge, Pt, La, Ce, Gd) to represent different element groups in different relevant environmental matrices such as soil, water, sludge, sediments and biota.

There is a need for appropriate, fit for purpose, certified reference materials as well as analytical methods for the measurement of TCE and their compounds in different environmental compartments. These would allow their traceable quantification or the analysis of their origin and fate within the environment. Current knowledge gaps need to be closed to ensure that data is traceable to international standards and reference materials, and to support the assessment and future long-term monitoring of the origin, fate and distribution of TCE in different environmental compartments by authorities and industry. This information will be used to support the Marine Strategy Framework Directive (2008/56/EC), the Water Framework Directive (Directive 2000/60/EC) and the quality assurance/quality control Directive 2009/90/EC, which demand the monitoring of hazardous substances in inland and marine waters.

TCE are inhomogeneously distributed in most environments, consequently their representative, unbiased sampling from solids, such as those found in marine or limnic environments is a major challenge. Therefore, effective sampling methods are needed which are capable of reliably and reproducibly collecting relevant representative samples, including in liquid environments, where TCE's are expected to occur at concentrations that are often below 1 ng/L. In addition, innovative sample enrichment and matrix removal approaches, e.g. online solid phase extraction, passive sampling, need to be developed for use prior to analysis for the reduction of the natural matrix, which can cause interference during analysis.

Inductively coupled plasma mass spectrometry (ICP-MS) is currently used for trace metal analysis in the environment. However, these systems do not provide the required sensitivity and capabilities to handle the interferences associated with the analysis of TCE at typical environmental concentration levels (ng/L or sub ng/L). Therefore, accurate and traceable methods based on e.g. ICP-MS/MS, HR-ICP-MS, MC-ICP-MS, Hyphenated techniques, HR-ESI-MS/MS (e.g. using new cell gases) combined with validated sample preparation methods, including suitable matrix removal and enrichment approaches, need to be developed for traceable quantification and for determining the environmental origin and fate of TCE.

It is important to determine the source and toxicological impact of the different TCE contaminants (e.g. Gd, Pt, Sb) which occur in the environment so that controls can be put in place. However, there are currently no standardised measurement procedures for the accurate and comparable measurement of different TCE or their species. Therefore, traceable, powerful and harmonised methods need to be developed for speciation analysis and for the analysis of the chemical behaviour of TCE in the environment. Suitable extraction protocols need to be developed as well as methods for the targeted determination of the individual species at ng/L concentrations.

Reference materials currently exist for typical environmental samples such as water, soil, sediment and biota. However, most of these either only cover a few of the required analytes, or they are not certified for the relevant analytes. In some cases, values exist in the literature, but the quality of the data is not always clear. Therefore, appropriate calibrants need to be developed for the traceable determination of TCE in targeted environmental matrices. At least one matrix certified reference material is needed, with clearly defined TCE concentrations at natural levels, for use in the validation of analytical procedures and to support proficiency testing and quality control in future monitoring campaigns. Best practice guidance is also required for the analysis of TCE abundance, fate and effects in the environment.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the traceable measurement and characterisation of technology critical elements in the environment.

The specific objectives are

1. To develop effective sampling and sample preparation methods for relevant environmental matrices. This should include the reliable and reproducible collection of representative samples from challenging solid (e.g. marine or limnic) and liquid environments where TCE are expected to occur at low concentrations (often below 1 ng/L). In addition, innovative sample enrichment and matrix removal approaches (e.g. online solid phase extraction, passive sampling) should be developed for use prior to analysis.

2. To develop accurate and traceable methods for determining TCE in targeted environmental matrices. This should include the development of validated sample preparation methods and mass spectrometric analytical methods (e.g. ICP-MS/MS, HR-ICP-MS, MC-ICP-MS, Hyphenated techniques, HR-ESI-MS/MS) for traceable quantification at the ng/L or sub ng/L level and for determining the origin and fate of the TCE, with the lowest achievable combined uncertainties.

3. To assess the toxicological impact of different TCE (e.g. Gd, Pt, Sb) by developing traceable, powerful and harmonised methods for speciation analysis and for the analysis of their chemical behaviour in the environment. This should include the development of suitable extraction protocols as well as methods for the targeted determination of the individual species at ng/L concentrations.

4. To provide the traceable determination of TCE in targeted environmental matrices using appropriate calibrants. This should include the development of at least one matrix certified reference material with clearly defined TCE concentrations at natural levels (in particular for surface waters) for use in the validation of analytical procedures and to support proficiency testing and quality control in future monitoring campaigns. In addition, to produce best practice guidance for the analysis of TCE abundance, fate and effects in the environment.

5. To facilitate the take up of the technology and measurement infrastructure developed in the project by: the measurement supply chain (accredited laboratories, instrumentation manufacturers), standards developing organisations (CEN, ISO) and end users (e.g. environmental monitoring and regulation bodies).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.0 M€, and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % of the total EU Contribution across all selected projects in this TP.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the environmental sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.