Final Public Report for 21GRD09 MetroPOEM
Metrology for the harmonisation of measurements of environmental pollutants in Europe

Overview

The European Green Deal's ambition for zero pollution requires the ability to detect and determine ultra-low amounts of pollutants and their isotope ratios; mass spectrometry is a key technique for such measurements. This project bridged the gap between radiometric and mass spectrometry measurements through the project deliverables.
Outcomes from this project delivered direct traceability for users to international standards for both radionuclides and element isotope ratios via the reference materials prepared in this project. In turn, this enabled users to reduce uncertainties and detection limits. The scientific reports aided users to identify appropriate instrumentation and traceably determine mass bias effects.

Need

This project supported the strategies described by the European Metrology Network (EMN) on Pollution Monitoring and the established EMN on Radiation Protection supporting the Basic Safety Standards directive. According to their strategies, there was a strong need to improve data quality for monitoring and reporting pollution in the air, water, and soil. In addition, the lack of suitable traceability chains and appropriate quality control compromised the comparability and robustness of measurements.
To detect radioactive isotopes and stable polluting elements in the environment, fast, sensitive and inexpensive analytical procedures are needed. Mass spectrometry techniques have a great potential to address this requirement. Despite the increasing application of single collector ICP-MS (Inductively Coupled Plasma Mass Spectrometry), this potential cannot be fully realised unless techniques can be validated with traceable multi-element reference materials. However, multi-element certified reference materials were usually not available and even single-element certified reference materials were limited to very few elements. Nevertheless, these reference materials were urgently needed to calibrate mass spectrometric measurements, due to mass bias effects occurring during the measurements in mass spectrometers.
The orientation document, issued by EURAMET´s Ionising Radiation Technical Committee and the EMN on Radiation Protection, clearly described a metrological need for '*traceability of radionuclide concentration measurements in the environment*'. This topic referred to the classification of the Green Deal as '*a zero-pollution ambition for a toxic-free environment*'. There was a need to increase the use of modern mass spectrometric techniques for measurements of both radioactive and non-radioactive pollutants in monitoring labs and beyond. However, this required increased access to certified reference materials traceable to the SI.

Objectives

The overall aim of the project was to bridge the gap between radiometric techniques and mass spectrometry for the characterisation and detection of polluting long lived radionuclides and stable elements and element tracers by comparing and linking both techniques, thus significantly improving measurement uncertainties and detection limits. The specific objectives of the project were:

1. To establish and compare the selectivity and detection limits of different types of mass spectrometers (e.g., AMS, HR-ICP-MS, ICP-MS/MS, ICP-QMS, MC-ICP-MS, SIMS, SNMS, TIMS) for selected radioactive pollutants (e.g., U, Np, Pu, Am) using isotope reference materials and/or activity standards. This includes assessing relative instrument performance with respect to current measurement challenges and establishing detection limits in relation to regulatory waste criteria levels or environmental regulations.
2. To develop measurement methods for isotope ratios that are traceable to the SI by using multi-collector ICP-MS and apply these methods on more commonly available techniques (ICP-MS/MS, ICP-QMS) by

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providing suitable operating procedures focussing on stable polluting elements (e.g., Li, B, Cr, Cd, Ni, Sb, Pb, U). To produce recommendations for sample processing, treatment, uncertainty budgets and, if feasible, the quantification of the mass bias.

3. To develop two radioactive reference materials with the sample matrix containing radioactive pollutants (e.g., U, Np, Pu, Am) for use in an inter-laboratory comparison employing techniques used in objective 1, which will demonstrate the variations in parameters including detection limits, sample preparation requirements, sample introduction methods, total procedural time, and uncertainty budgets.
4. To implement and validate the methods for isotope ratio measurements established in objective 2 by the development of one aqueous certified reference material (CRM) that is certified for the same stable polluting elements with lowest possible uncertainties using multi-collector instruments, in order to facilitate the calibration of single collector ICP-MS, instrument validation, as well as quality control.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (e.g., accredited laboratories), standards developing organisations and international organisations (JRC, CIPM CCs [CCQM-IRWG, CCQM-IAWG, CCRI], IAEA, ICRM) and end users (e.g., environmental monitoring agencies).

Progress beyond the state of the art and results

Objective 1: The capabilities of participating laboratories were surveyed to direct the preparation of traceable radionuclide standards for MetroPOEM. This led to the preparation of these measurement standards, with quantified impurities and these were further validated for homogeneity and purity, presented in table 1.

Table 1: Radionuclide standards prepared (all uncertainties at $k = 2$)

Nuclide		mBq g^{-1}	fg g^{-1}	Million atoms g^{-1}	± %
^{90}Sr		7,66 ± 0,070	1,50 5 ± 0,01 5	10,082 ± 0,095	~1,0
^{234}U		0,007 310 ± 0,000 061	31,75 ± 0,31	81,70 ± 0,80	~0,98
^{236}U		0,015 70 ± 0,000 15	6 561 ± 67	16 740 ± 170	~1,1
Natural U	^{234}U	0,258 0 ± 0,008 9	1121 ± 40	2 880 ± 110	~3,6
	^{235}U	0,012 30 ± 0,000 42	153 900 ± 5 300	394 000 ± 14 000	~3,5
	^{238}U	0,258 0 ± 0,006 9	20 720 000 ± 560 000	52 400 000 ± 1 500 000	~2,8
^{237}Np		0,194 0 ± 0,001 6	7 454 ± 79	18 940 ± 200	~1,1
^{239}Pu		4,120 ± 0,017	1 795,2 ± 8,7	4 522 ± 22	~0,49
^{240}Pu		5,400 ± 0,028	643,0 ± 3,7	1 613,0 ± 9,1	~0,58
Mix Pu	^{239}Pu	10,30 ± 0,34	4 490 ± 150	11 310 ± 380	~3,4
	^{240}Pu	2,390 ± 0,014	284,6 ± 1,8	713,9 ± 4,5	~0,64
^{241}Am		4,760 ± 0,052	37,53 ± 0,43	93,7 ± 1,1	~1,2

As can be seen from the table, standards at the µBq g^{-1} to mBq g^{-1} level were prepared. In terms of mass concentration, the levels ranged between fg g^{-1} to ng g^{-1}. For ^{90}Sr, ^{234}U and ^{241}Am this corresponds to atom concentrations between 10^7 and 10^8 atoms g^{-1}. It is the first time in the world/Europe that traceable activity standards of these radionuclides have been prepared at such low levels and this represents a major step forward in extending direct measurement traceability down to these levels with relative uncertainties approaching those of other, more easily measured radionuclides. Additionally, some of the radionuclides thus standardised (^{234}U, ^{235}U, ^{236}U, ^{238}U, U_{nat} and ^{237}Np) were characterised for potential use in the preparation of the solid and liquid reference materials produced as part of objective 3. The preparation of these standards facilitated the testing, via an interlaboratory comparison, of a range of mass spectrometry modalities, listed below, for the measurement of these radionuclides at challengingly low concentrations and determining the analytical performance. The mass spectrometry modalities tested were:

- Accelerator Mass Spectrometry/Spectrometer (AMS),
- High Resolution Inductively Coupled Plasma Mass Spectrometry/Spectrometer (HR-ICP-MS),
- Inductively Coupled Plasma Tandem Mass Spectrometry/Spectrometer (ICP-MS/MS),
- Inductively Coupled Plasma Quadrupole Mass Spectrometry/Spectrometer (ICP-QMS), and
- Multi-Collector Inductively Coupled Plasma Mass Spectrometry/Spectrometer (MC-ICP-MS).

In some cases, radiometric techniques (α spectrometry, liquid scintillation counting and γ spectrometry) were also used. The outcome of the interlaboratory comparison was published as Deliverable 1 for the project.

Additionally, the information gathered from the comparison was used to prepare a good practice guide on the use of mass spectrometry for radionuclide measurement (Deliverable 2), covering sample preparation, measurement, uncertainties and thus characteristic limits for such measurements.

Objective 2: This advanced the development of high-accuracy methods for isotope ratio determination of environmentally relevant elements (Li, B, Cr, Cd, Ni, Sb, Pb, and U) and demonstrated that both multi-collector and single-collector ICP-MS instruments can provide reliable results when supported by appropriate calibration strategies and isotopic reference materials. The comparison of different platforms confirmed that accuracy is highly dependent on the availability of well-characterised iRMs, highlighting a critical need for the continued development and certification of such materials to ensure comparability across laboratories. In parallel, the development and optimisation of manual and automated analyte separation procedures have significantly improved the robustness and efficiency of sample preparation. Automated platforms such as prepFAST and seaFAST demonstrated strong potential for increasing throughput, reducing contamination risks, and improving reproducibility, thereby supporting large-scale studies and the wider adoption of isotope ratio methods. Manual separation methods remain indispensable, particularly for specialised applications requiring tailored chemistries or higher precision.

The evaluation of collision/reaction cell technologies confirmed their utility in mitigating spectral interferences for selected isotope systems, particularly in complex matrices such as seawater. While these approaches broaden the applicability of quadrupole- and sector-field-based ICP-MS instruments, their precision and accuracy remain limited compared to multi-collector systems. Further optimisation of reaction gas conditions and a deeper understanding of their influence on mass bias are needed to reduce uncertainties to levels suitable for demanding applications.

Overall, work towards meeting this objective has substantially improved isotope ratio measurements for key pollutant elements by combining advanced mass spectrometric techniques with optimised separation procedures and interference mitigation strategies. These developments provide a stronger analytical basis for environmental monitoring, source tracing, and regulatory applications. At the same time, the work underscores the importance of accessible isotopic reference materials, continued interlaboratory comparisons, and further refinement of instrumental approaches. The outcome of the work done to meet this objective was published as deliverable 3 for the project. Additionally, the information gathered from the comparison was used to prepare a good practice guide on the use of mass spectrometry for nuclide ratio measurement (deliverable 4), covering sample preparation, measurement and correction of isotope ratios for fractionation, uncertainties and thus characteristic limits for such measurements.

Objective 3: This was concerned with the preparation of solid and liquid radioactive reference materials for radionuclide measurement by both radiometric techniques (α-spectrometry, and γ-spectrometry) and mass spectrometric techniques. In part, some of the outputs from objective 1 (standardised ^{234}U, ^{235}U, ^{236}U, ^{238}U, U_{nat} and ^{237}Np) were used to prepare both reference materials, with the work carried out on seawater for stable element reference materials (as part of objective 4) providing the base material for the liquid radioactive reference material. The solid material was prepared by a modification of the sol-gel process to prepare high purity silica from a range of different organic/silicon compounds; these were optimised by laboratory studies within the project. A mix of α-emitting radionuclides used to prepare the material at the levels given in table 2.

Table 2: Silica reference material prepared (all uncertainties at *k* = *2*)

Nuclide	mBq g^{-1}	fg g^{-1}	Million atoms g^{-1}	± %
^{234}U	0,419 ± 0,02	7,78 ± 0,19	4 680 ± 120	~2,4
^{235}U	0,026 9 ± 0,001 1	1 430 ± 28	861 000 ± 17 000	~2,0
^{236}U	0,005 69 ± 0,000 36	10,08 ± 0,32	6 070 ± 200	~3,2
^{238}U	0,415 ± 0,017	140 000 ± 2 800	84 300 000 ± 1 700 000	~2,0
^{237}Np	14,91 ± 0,29	2 417 ± 24	1 455 000 ± 15 000	~0,97
^{239}Pu	2 630 ± 170	4 800 ± 160	2 889 000 ± 93 000	~3,2
^{240}Pu	217 ± 14	107,8 ± 3,5	64 900 ± 2 100	~3,3
^{241}Am	53 110 ± 860	1 737 ± 15	1 046 000 ± 8 500	~0,81

Except for ^{239}Pu and ^{241}Am, the activity concentrations are in the µBq g^{-1} to mBq g^{-1} range with mass concentrations (excepting ^{238}U) in the fg g^{-1} to pg g^{-1} range. The measurements undertaken to verify the activity concentrations by MetroPOEM participants confirmed the activity levels and further verified the homogeneity

of the material. This material represents a major advance for radioactive reference materials in that the quality of the material and the concentrations of radionuclides therein were controlled throughout the preparation of the material, resulting in a reference material with known chemical and physical characteristics that contains traceable quantities of radionuclides at lower levels than have been achieved before.

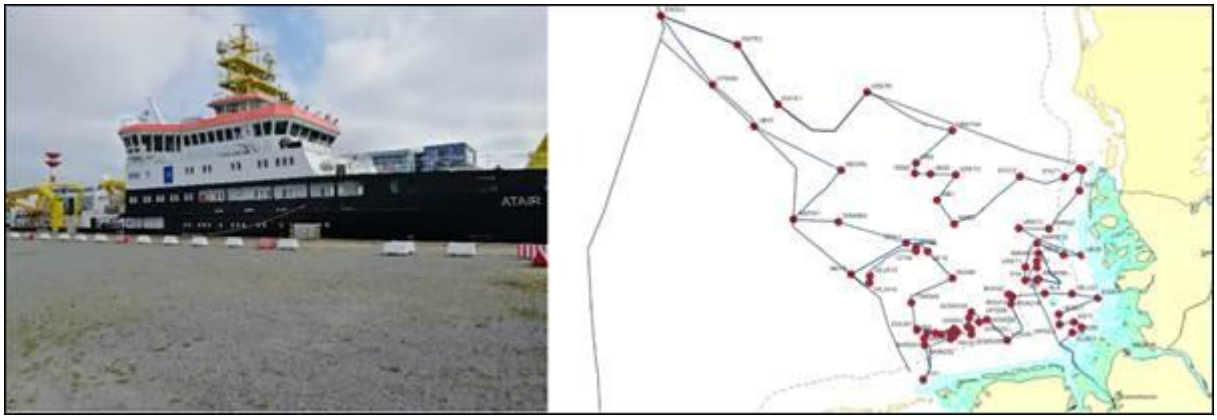
A similar achievement was made with the seawater material in terms of activity and mass concentrations at the comparable level. As the starting material had been processed and prepared as part of the work carried out to deliver objective 4, little was required in preparation of this material, apart from ensuring that the material was prepared in a manner that resulted in a homogenous spiked material. As the seawater reference material was prepared directly from previously standardised radionuclide solutions and a processed and stabilised seawater, the resulting reference material has radionuclide concentration values that are directly traceable to international standards of radioactivity, an achievement that is a world/European first. The concentration values in the seawater reference material are given in table 3. The preparation of both materials was reported in deliverable 5 and the outcome of measurements by MetroPOEM participants were reported in deliverable 6.

Table 3: Seawater reference material prepared (all uncertainties at $k = 2$)

Nuclide	mBq g^{-1}	fg g^{-1}	Million atoms g^{-1}	± %
^{234}U	0,463 ± 0,013	8,59 ± 0,13	5 170 ± 80	~1,4
^{235}U	0,021 1 ± 0,000 2	1 124,0 ± 3,0	676 900 ± 1 800	~0,26
^{236}U	0,000 58 ± 0,000 03	1,025 ± 0,026	617 ± 16	~2,50
^{238}U	0,457 ± 0,003	154 120 ± 410	92 820 000 ± 250 000	~0,26
^{237}Np	12,99 ± 0,22	2 105 ± 18	1 268 000 ± 11 000	~0,85
^{239}Pu	1 480 ± 10	2 696,3 ± 4,2	1 623 800 ± 2 500	~0,15
^{240}Pu	526 ± 2	260,95 ± 0,43	157 150 ± 260	~0,16
^{241}Am	10 910 ± 140	356,8 ± 2,3	214 900 ± 1 400	~0,64

Objective 4 The work centred on the preparation of a reference material for isotope ratio measurement for B, Cd, Li, Pb and U and was thus closely linked to objective 2. In all, 250 litres of seawater were collected from the edge of the German North Sea Exclusive Economic Zone to provide the raw material for the development of reference materials for (i) stable isotope ratio measurements and (ii) radionuclides in seawater. The material was sampled and processed to provide a stable material for the production of the reference materials in the project.

Figure 1: Seawater reference material sampling route



The material for the radionuclide reference material was used to meet objective 3 (see above). For the rest, most of the isotope ratios of B, Cd, Li, Pb and U were successfully certified within the limits of target uncertainties aimed at the beginning of the project. A collaborative study conducted with the involvement of participants produced the seawater CRM for isotope ratios of the target elements listed above. A total number of 470 aliquots of the material were produced for MetroPOEM, with ~30 % consumed within the project to certify the material. The material is particularly relevant for measurements related to tracing the environmental pollutants. The certified reference material can be used as QC material for validation of the methods, including trueness, for measurements of isotope ratios in seawater matrices. The material is suitable for checking the

sample preparation processes prior to stable isotopic measurements. The certification of the reference material was described in deliverable 7.

All of the project's objectives were fully achieved.

Outcomes and impact

Key dissemination and communication activities

- A total of 8 papers were published during the lifetime of the project and are listed in the next section.
- The paper with the furthest reach was published in *Analytical Chemistry* (Lancaster et al $\delta(^{18}O/^{16}O)$ and $\delta(^{17}O/^{16}O)$ determinations in water using inductively coupled plasma–tandem mass spectrometry).
- There were 45 presentations made of the work of MetroPOEM at various events, including the Conférence Internationale de Métrologie, Global Industry Exhibition and the One Ocean Science conference
- The project was disseminated at three formal workshops at PTB (2022), LNE (2024) and NPL (2025), as well as interim project workshops at NMBU (2023) and DTU (2024). A training workshop was held at DTU in 2024, attended by over 100 delegates representing 60 organisations from 20 countries. Two good practice guides were also published – deliverables 2 and 4.
- The stakeholder committee comprised 24 members, representing 9 partner countries, the EU, including JRC Geel, and 6 international organisations. There are an additional 56 stakeholders representing 10 EEA countries, the EU, 3 European countries outside the EEA, 3 international organisations (BIPM, IAEA and ICRM) and 2 non-European countries (Taiwan and the USA).

Further project dissemination was achieved through the issue of 5 project newsletters, dedicated pages on LinkedIn and ResearchGate, 4 press releases and 2 trade press articles and general dissemination by participants.

Outcomes for industrial and other user communities

The project aimed to bridge the gap between radiometric and mass-based determinations of radionuclides and isotope ratios and this was achieved as follows:

- Assessment of the capabilities of various mass spectrometry capabilities, and guidance on mass spectrometry determinations of radionuclides (D1 and D2).
- Advancing the determination of high accuracy and traceable isotope ratio measurements and guidance on their implementation (D3 and D4).
- Provision of three reference materials for stable and radioactive isotope measurements (D5, D6 and D7).
- Stakeholders provided measurement facilities and instrumentation as well as generating data for, and contributing knowledge to, aspects of the project. Stakeholders also participated in the measurement of reference materials generated within the projects, particularly for deliverables 6 and 7 where both measurement data and scientific input was shared.
- Agilent received low level radionuclide standards (objective 1) and the candidate RMs (objective 3), enabling them to take part in the comparison exercise, which will be useful for future demonstrations to customers.
- TrisKem have advanced the use of impregnated membrane filters as a result of this project for both mass and decay counting measurements.

Outcomes for the metrology and scientific communities

These CMCs are planned for submission:

- Measuring δ^7Li in solutions with a lithium content from 1 ng/g to 10 ng/g using a desolvator, and
- Measuring δ7Li in solid lithium carbonate with a lithium content from 70 ng/g to 2000 ng/g.

The project has:

- Established the link between radiometric techniques and mass spectrometry, bridging the gap between the activity (Bq) and the amount of substance (mol) of an isotope.
- Generated traceable aqueous radionuclide standards (U, Np, Pu, Am, Sr, Ra) suitable for mass spectrometry systems.
- Closed the traceability gap for isotope ratio measurement resulting from isotopic fractionation (mass bias).
- Provided:
  - A user guide on the use of mass spectrometry for low level radionuclide detection,
  - A report on different mass spectrometry instruments advantages and limitations, and
  - Three Si-traceable reference materials,

- Established an Si-traceable calibration chain for single collector ICP-MS, and
- Harmonised methods for the measurement of polluting elements using mass spectrometric techniques.

These outputs addressed some technical and scientific ambitions for the SI in the field of radionuclide metrology and were recognised by the BIPM Director as '…exactly the type of example I am searching for…'.

- A CCRI (II) task group on mass spectrometry was set up in 2023 and has run in parallel with MetroPOEM. A joint workshop, as well as presentation of the project results in other workshops and the main CCRI(II) meeting in November 2025. It was decided at the meeting to prolong the work of the task group for two more years and the possibility to build a CCRI(II) working group for mass spectrometry.
- Traceable standards and reference materials with direct traceability to primary standards relevant to mass spectrometry are now available to the growing number of NMIs using this capability.

As an outcome from the project, a new sub-group of the International Committee for Radionuclide Metrology's Low-Level Measurement Techniques Working Group has been set up to further the work under this project and to liaise with the CCRI(II) working group mentioned above. A further four papers will be published in 2026 (after the end of the project):

- Flierl *et al*. Relative and absolute lithium isotope ratios – final report of CCQM K182 and P233
- Russell *et al*. Investigating the potential of methyl fluoride cell gas for radionuclide interference removal and measurement using ICP-MS/MS.
- Russel *et al*. The CCRI Task Group on the Use of Mass Spectrometry in Radionuclide Metrology
- Wagner *et al*. Time-Integrated Analysis of Sr, Ba, and $^{87}Sr/^{86}Sr$ in Freshwater using DGT Passive Samplers.

Outcomes for relevant standards

The project had significant input to these standards:

- DIN 51013:2023-07 Anorganische Isotopenanalytik - Begriffe und Verfahren
- Assessment of absolute isotope ratios for the international isotope delta measurement standards, https//iupac.org/project/2020-013-1-2000
- Terminology and definitions of quantities relating to isotopic analyses, https//iupac.org/project/2023-014-2-200
- Within ISO TC 147 SC3 WG14, a standard is being written on the determination of ^{237}Np and Pu isotopes and this project has provided input into this standard.

During the lifetime of the project, ISO/REMCO Committee on reference materials was transformed into ISO/TC 334 (Reference materials).

Longer-term economic, social and environmental impacts

The outcomes of the project benefit the EU population in general through improved traceability of measurement through shorter and direct traceability chains. This leads to improved analytical services that address pollution issues across the EU at lower cost and with more rapid sample turnaround. Additionally, this better supports policy decisions and directives on the area of environmental pollution monitoring, with the longer-term effect of reducing health issues for individuals and improving the general environment of the EU member states.

Specific improvements include:

- Implementation of new procedures and sample protocols developed within the project.
- Better isotope ratio measurements of, and analytical techniques for Li, B, Ni, Cd and U by MC-ICP-MS.
- New calibration services for isotopes of Li, U and Pu by MC-ICP-MS.
- Establishment of production, characterisation and provision of traceable solid and liquid reference materials containing U, Np, Pu and Am for mass spectrometry measurements in general.
- Establishment of production, characterisation and provision of liquid calibration standards containing U, Np, Pu and Am for mass spectrometry measurements in general.

In many cases these have accelerated development of these improvements and also given the impetus to participants to provide these improvements as new services. Across the project, this led to a mean estimated improvement in turnover of 10-25 k€ per participant.

During the project, the availability of standards and reference materials was surveyed and was instrumental in setting some priorities within the project. The report is available at:
https://www.bipm.org/documents/20126/262812598/Mass+Spectrometry+for+Radionuclide+Measurements+Survey+Results/5fac1883-d514-3344-fef1-1bade7f2ad9f

List of publications

Arnold, Dirk et al (2025) 'Progress achieved in EURAMET project 21GRD09 MetroPOEM: Metrology for the harmonisation of measurements of environmental pollutants in Europe'. Available at *Applied Radiation and Isotopes.* https://doi.org/10.1016/j.apradiso.2025.112182 https://oar.ptb.de/resources/show/10.7795/810.20

Arnold, Dirk et al (2025) 'Progress achieved in EURAMET project 21GRD09 MetroPOEM: Metrology for the harmonisation of measurements of environmental pollutants in Europe', *European Physical Journal.* Available at https://doi.org/10.1051/epjconf/202532311004

Chambon, L. et al (2025) 'Production of radioactive traceable reference materials for measuring radioactive pollutants in the environment', *Applied Radiation and Isotopes.* Available at https://doi.org/10.1016/j.apradiso.2025.112204

Christl, Marcus et al (2025) 'Results from the Zurich sea water (ZSW) intercomparison study for U- and Pu-isotopes', *Nuclear Instruments and Methods in Physics Research Section B.* Available at https://doi.org/10.1016/j.nimb.2025.165750

Flierl, Lukas et al (2024) 'An advancement of the gravimetric isotope mixture method rendering the knowledge of the spike purity superfluous', *Analytical and Bioanalytical Chemistry.* Available at https://doi.org/10.1007/s00216-024-05465-9

Lancaster, Shaun T. et al (2025) 'δ(18O/16O) and δ(17O/16O) determinations in water using inductively coupled plasma–tandem mass spectrometry', *Analytical Chemistry.* Available at https://doi.org/10.1021/acs.analchem.5c02607

Lancaster, Shaun T. et al (2025) 'Isobaric interference removal for selected radionuclides using nitrous oxide and ammonia with inductively coupled plasma tandem mass spectrometry', Journal of Analytical Atomic Spectroscopy. Available at https://doi.org/10.1039/d5ja00254k

Pérez-Tribouillier, H. et al (2025) 'The Role of the St. Anna Trough in Atlantic Water Transport Into the Arctic Ocean: A Novel Radiogenic Isotope Assessment Using Iodine, Uranium, and Neodymium', *Journal of Geophysical Research: Oceans.* Available at https://doi.org/10.1029/2024JC022050

List of technical deliverables and the data management plan

Deliverable number	Title	Confidentiality status	Clickable links to 'Public' documents
D1	Inter-laboratory comparison report describing low-level radioactive pollutants (e.g., U, Np, Pu, Am) by different types of mass spectrometers	PU - Public, fully open	https://doi.org/10.7795/120.20251017C
D2	Good Practice Guide on the use of mass spectrometry for low-level radioactive pollutants detection	PU - Public, fully open	https://doi.org/10.7795/120.20251017D
D3	Report describing the development of measurement methods for isotope ratios that are traceable to the SI and summarising the advantages/ disadvantages of applying them on more commonly available techniques by providing suitable operating procedures focussing on stable polluting elements	PU - Public, fully open	https://doi.org/10.7795/120.20251017A
D4	Good Practice Guide on sample processing, treatment, uncertainty budgets and if feasible, the quantification of the so-called mass bias	PU - Public, fully open	https://doi.org/10.7795/120.20251017B
D5	Document describing two radioactive reference materials, developed and shipped to participants for their radioactive content characterisation	PU - Public, fully open	https://doi.org/10.7795/110.20250603
D6	Inter-laboratory comparison report, describing detection limits, sample preparation requirements, sample introduction methods, total procedural time, and uncertainty budgets	PU - Public, fully open	https://doi.org/10.7795/810.20251106

D7	Report describing the development of one aqueous certified reference material that is certified for the same stable polluting elements with lowest possible uncertainties	PU - Public, fully open	https://doi.org/10.7795/120.20251218
n/a	Data management plan	PU - Public, fully open	https://www.npl.co.uk/euramet/metropoem

Project start date and duration:	1 October 2022, 36 months	
Coordinator: Dirk Arnold, PTB E-mail: dirk.arnold@ptb.de Project website address: https://www.npl.co.uk/euramet/metropoem		
Internal Beneficiaries: 1. PTB, Germany 2. BAM, Germany 3. CEA, France 4. CMI, Czechia 5. JSI, Slovenia 6. LNE, France 7. STUK, Finland 8. TUBITAK, Türkiye	External Beneficiaries: 9. AU, Denmark 10. DTU, Denmark 11. Hereon, Germany 12. HZDR, Germany 13. IFE, Norway 14. IFIN-HH, Romania 15. LUH, Germany 16. MUL, Austria 17. NMBU, Norway 18. UH, Finland 19. VINS, Serbia 20. UGOT; Sweden (joined 1/1/23)	Unfunded Beneficiaries: 21. UNIVIE, Austria
Associated Partners: 22. ETHZ; Switzerland 23. LGC; United Kingdom 24. NPL; United Kingdom		