

Title: Metrology for low-level radioactivity measurements in support of the Council Directive 2013/51/EURATOM on water for human consumption

Abstract

The radiological quality of water for human consumption (drinking water) needs to be guaranteed to protect the general public from potentially hazardous effects of ionising radiation. The general reference framework about radioactive substances in drinking water is laid down in the Council Directive 2013/51/EURATOM, which defines monitoring strategies and reference values for radioactive substances. However, current measurement methods show inconsistencies and are often not comparable, and there is a lack of standardised materials necessary to establish traceability. Proposals addressing this SRT should contribute to further development and improvement of radioactivity measurement methods for drinking water by establishing reference samples to assure the reliability and comparability of the results.

Keywords

radionuclide measurements, radioactivity screening methods, Council Directive 2013/51/EURATOM, gas flow proportional counting, liquid scintillation counting, gamma-ray spectrometry, mass spectrometry

Background to the Metrological Challenges

Natural water resources can, to a varying extent, contain radionuclides of both natural and artificial origin. Water, either in its natural state or after treatment, has different uses: direct consumption, domestic purposes (e.g. cooking and food preparation) or industrial food-production, and thus the radionuclides present can be incorporated into humans through many different pathways. Given the crucial importance of the radiological quality of drinking water for human health, the European Council has adopted the Council Directive 2013/51/EURATOM, laying down requirements for the protection of the health of the general public with regard to radioactive substances present in water intended for human consumption. Specifically, it establishes parametric values for the indicative dose, Rn^{222} and H_3 activity concentrations, as well as requirements regarding monitoring programs (e.g. frequencies) and the performance characteristics of the methods used for monitoring radioactive substances.

Since the indicative dose cannot be directly measured, its value must be calculated based on measurements of the radionuclide concentration of alpha- and beta-particle emitting isotopes. This can be done either by measuring the activity concentrations of selected radionuclides or by performing screening analyses to measure gross alpha and gross beta activities, which inform about the total content of alpha- and beta-particle emitting isotopes, respectively. When parametric values for gross alpha and gross beta activity are exceeded, it is necessary to determine the concentrations of selected specific radionuclides. The measurement of gross alpha and gross beta activities is the screening strategy chosen by most countries within the European Union for both practical and economic reasons: methods are straightforward, fast and cheap, and give information on the total activity concentration in the sample. There are several standard procedures for the determination of these parameters, but there is sound evidence that such measurements are often not comparable and that methods need to be critically revised to obtain reliable and traceable results.

There is a variety of methods available to determine specific radionuclides in water samples, generally based on the radiochemical isolation of the selected element from other interfering radionuclides and subsequent measurement using diverse techniques. These methods are well established, but the counting times necessary to achieve the required detection limits typically range from a few days to weeks, which limits the number of samples that can be processed and makes them not suitable in the case that rapid measurements are required.

In order to guarantee that radioactivity measurements in drinking water are robust, reliable and comparable, well established methods must be validated and periodically verified. This requires suitable materials to be available to testing laboratories, health agencies and radiation protection bodies involved in drinking water monitoring. Moreover, currently there is a lack of such reference materials. Furthermore, the radioactive content in the available reference material does not equate to that of actual radionuclides usually found in real drinking water and the reference activity concentrations are typically above the detection limits. In addition, in most cases reference samples are synthetic, so no effect of other physicochemical parameters of drinking water can be evaluated and the stability of aqueous reference materials is not guaranteed.

In order to significantly improve the assessment of radioactivity in drinking water, both screening and radionuclide specific measurement methods need to become reliable, traceable and comparable. Furthermore, tools to develop traceable reference water samples should be provided.

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 development of metrological capacity in methods for radioactivity measurement.

The specific objectives are

1. To improve the comparability of radioactivity screening methods for the measurement of gross alpha and gross beta activities and to reduce the variability of the results to a maximum factor of two. This should include assessment of existing methodologies (e.g. partial or total evaporation and co-precipitation of the radionuclides with subsequent gas flow proportional counting or liquid scintillation counting).
2. To improve methods for radionuclide measurement and analysis for a quick, cost-effective and reliable assessment of selected radionuclides (U^{238} , U^{234} , Ra^{228} , Ra^{226} , Pb^{210} and Po^{210}) in drinking water with detection limits according to the Directive 2013/51/EURATOM and with uncertainties in the order of 10 % to 20 % at the derived activity concentrations.
3. To establish methods for the preparation of drinking water samples with traceable reference activity concentrations of selected radionuclides (U^{238} , U^{234} , Ra^{228} , Ra^{226} , Pb^{210} and Po^{210}) in the activity concentration range and uncertainties lower than 5 % by applying classical measurement techniques combined with the most advanced ones, including ultra low-level gamma-ray spectrometry and modern mass spectrometry.
4. To determinate the radioactive noble gas (Rn^{222}) in water. This should include the development of methodologies for sampling, storage and analysis, and an assessment of the specific challenges of Rn^{222} in the preparation and distribution of drinking water samples with traceable activity concentrations.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (NMIs, calibration laboratories), standards developing organisations (BIPM-CCRI, EURAMET TC-IR, ICRM, IAEA, CEN, CENELEC) and end users (radiation protection authorities, water suppliers).

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 radiation protection 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.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

- [1] COUNCIL DIRECTIVE 2013/51/EURATOM of 22 October 2013 laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption, Official journal of the European Union, Nov 7, 2013