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Characterization and calibration of a novel detection system for real time monitoring of radioactive contamination in water processed at water treatment facilities

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Content

A novel detection system was designed and constructed in the frame of the TAp WAter RAdioactivity Real Time Monitor (TAWARA_RTM) project, financed by the EU under the FP7 research programme (FP7-SEC-2012-1). The TAWARA_RTM system is intended to be used for real time monitoring of radioactive contamination in water processed at water treatment facilities providing fast radiological alarm and radionuclide identification. The system is based on three different units. An Early Alarm Detector (EAD), based on a gamma-ray monitor, for gamma radioactivity early detection. A Real Time Monitor (RTM), based on a number of plane windowless ZnS scintillation detectors, is used for continuous monitoring of gross alpha and beta radioactivity in water. In case of any positive detection (gamma, alpha or beta) water samples are further analysed by a Spectroscopy Detector (SPEC) equipped with ion-exchange resin concentrator and aiming at radionuclide identification and quantification. Signals form all TAWARA detectors are processed by modern digitizing techniques. Dedicated software as well as ICT infrastructure were developed for system operation and alarm management. The TAWARA_RTM platform was conceived to detect a gross alpha/beta activity of the order of 1 Bq/l in several tens of minutes. Detailed description of the design and construction are reported in [1]. A number of characterization tests and calibration measurements were carried out, during the last part of the project, at the National Institute of Ionizing Radiation Metrology of ENEA (Italian Primary Metrology Institute for ionising radiation). This work is described in the present paper. As far as possible, tests were carried out with reference to available national and international Standards such as those issued by CEN, IEC and ISO. Reference radiations and radionuclides for testing and calibration were chosen in order to reflect energy ranges and radiation types of the major water radioactive contaminants possibly arising from environmental, industrial or terroristic origin. The following radionuclides were used: Am-241, Sr-90, F-18, Co-60, K-40, Cs-137, Cd-109, Ce-139, Y-88, Co-57, Sn-113. Starting from single-nuclide aqueous solutions, a set of spiked water reference materials were developed and calibrated with traceability to the ENEA national standard of radionuclide activity. Calibrations were carried out in field-close conditions simulating, as far as possible, the application of the instrument to the intended use. To this purpose a special standard radioactive-water-generator was constructed to allow transfer of water reference material samples from original vessels into the instrument, simulating water sampling from a pipeline. Special precautions and solution treatment were required to avoid internal contamination of system detectors. Liquid solutions were complemented by solid point and annular sources prepared on plastic supports and hermetically sealed for system check and SPEC calibration. The following instrument parameters were tested: sensitivity, selectivity, background, short/long term stability, linearity with respect to activity, defined as the amount of error change throughout the instrument's measurement range, identification of main external influence parameters (temperature, relative humidity, air pressure, water acidity and chemical composition, accuracy of software algorithms for calculation of measurement results and associated uncertainties.

[1] TAWARA collaboration, "TAWARA_RTM - the Detection System for Real Time Monitoring of Radioactive Contamination in Water Processed at Water Treatment Facilities", paper accepted for poster presentation at the Symposium on Radiation Measurements and Applications-West Coast (SORMA West 2016), University of California, Berkeley, USA, 22-26 May 2016.

About the Presenter

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