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Probability for type I errors in γ-ray spectrometric measurements of drinking water samples

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In gamma-ray spectrometry the activities are calculated from areas of the peaks appearing in the spectrum. If a peak used in the activity calculations appears in the spectrometer background its count rate must be corrected for the background contribution. The significance of this correction becomes essential in spectral analyzes where activities close to the minimum detectable activity need to be determined.

The presence of radionuclei in the sample, that contribute to the spectrometer background, can only be detected from the excess of the count rate in the peaks over their background level. Therefore, the radionuclei can be categorized in two groups:
- Radionuclei that do not appear in the spectrometer background. The probability of the wrong detection of these radionuclides is given by the sensitivity at which the peak-search algorithm recognizes the background fluctuations as peaks.
- Radionuclei that appear in the spectrometer background. Here, a radionucleus is identified if the count rate in its peaks exceeds the background level. In this case the probability of a false detection is given by a criterion, on the basis of which the number and the significance of the peaks where the excess occurred decide on the presence of the radionucleus in the sample.

It follows that for the second group, the minimum detectable activity that can be attained depends on the accuracy with which the background is determined and on its stability over time. It should be noted that if the contribution from the sample to a peak area is small as compared to the contribution of the background, there exist an equal probability that the result of the background subtraction is larger than zero or smaller than zero.

To check the rate of falsely detected radionuclides (type I errors) an analysis was made in which the background spectra were treated as sample spectra. From this it is known that in the analysis of these spectra all the detections of radionuclides are false.

The spectral analyzes were preformed with Canberra's GENE ESP spectroscopy system. The nuclide library that was used is composed of radionuclei usually found in the environment and radionuclei that occur in the effluents from nuclear power reactors and hospitals. In the case of multi-gamma-ray emitters, the nuclide library includes the most abundant gamma-rays as well as the gamma-rays that cause interferences with other radionuclides, in order to correct the activities for these interferences. The criterion that determines whether a radionucleus has been detected is based on a comparison of the sum of the emission probabilities of the gamma-rays, where the count rate in the spectrum exceeds its background value and the sum of the emission probabilities for all the gamma-rays of this radionucleus that are included in the library. If the ratio of both sums exceeds a predetermined value, the gamma-ray emitter is considered as being present in the sample.

In the presentation the rates of type 1 errors will be presented for single gamma-ray emitters and multi gamma-ray emitters. The empirical minimum detectable activities for water samples for these radionuclei will be given.

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