RESULTS OF THE FIRST WORLDWIDE PROFICIENCY TEST OF GAMMA LABORATORY IN ALBANIA

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Abstract

The first intercomparison of gamma-ray spectrometry measurements in the Institute of Applied Nuclear Physics (IANP) is carried out to improve the laboratory's ability to measure the radioactivity in the environment and food stuffs at typical routine levels. The activity concentration of the test samples and the evaluation of the associated uncertainties are the main requirements of the test results. The aim of this study is to present the results of the intercomparison and discuss the quality of the gamma spectrometry measurements performed at the IANP. For this proficiency test the Laboratory Sourceless Calibration Software (LabSOCS) is used for simulating the absolute efficiency curve. The results are found to be satisfactory and in general better than the average. This paper provides a summary of the results obtained during this intercomparison exercise.

Keywords: proficiency test, gamma spectrometry, HPGe detector, radionuclides, environmental radioactivity

1. Introduction

The implementation of quality assurance (QA) in testing laboratories is a total process to guarantee the quality of the laboratory reports, and assure confidence and comparability of their results. A total of 267 laboratories from 66 different countries including our gamma laboratory at the Institute of Applied Nuclear Physics in Tirana have participated in the frame of the International Atomic Energy Agency (IAEA) proficiency test exercise. In our daily lives the results of analytical measurement play an important role. Analytical data may be the basis upon which economic, legal or environmental management decisions are made. For that reason, it is essential that such measurements must be accurate, reliable and defensible. In addition, measurements performed by laboratories located worldwide should yield traceable and comparable results.

It is now widely recognized that for a laboratory to produce consistently reliable data it must implement an appropriate programme of quality assurance measures. Amongst such measures is the need for the laboratory to demonstrate that is analytical systems are under statistical control, that is uses methods of analysis that are validated, that its results are 'fit-for-purpose', and that it participates in proficiency testing exercises (ISO, Geneva, Switzerland, 2000) The Gamma Spectrometry Laboratory at the IANP undergoes routine analyses of natural and artificial gamma emitters in various matrices for various purposes such as research, service and radiation monitoring. The main sample's types that are covered are environmental samples such as soil, sediment, water, organic dry and wet, etc. The obtained data are important for public dose assessment, economic, legal and environmental radiation management decisions as well as for national laws.

2. Materials and methods

2.1 Samples

Three different samples (two spiked water and one agricultural soil) were prepared and measured in the adopted fixed counting geometry. The water was gravimetrically spiked with known amounts of standard solution containing a mixture of certified radionuclides and acidified with 0.05M HNO_3 for stability. The water sample 1 was spiked with anthropogenic gamma emitter radionuclides and water sample 2 was spiked with a primary coolant of the nuclear power reactor (A. Mauring *et al.*, 2018)

2.2 Measurements

For the measurement of samples a gamma spectrometer with high purity P-type coaxial germanium detectors (HPGe) of relative efficiency 40% was used. The detector was connected to standard electronics and the spectra were accumulated in 8192 Multichannel analyzer. In order to reduce background radiation the detectors were housed in 10 cm lead shield surrounded by 0.5 cm copper layer to attenuate X-rays emitted by the lead. Energy calibration is carried out routinely, using multi-gamma-ray emitter source. Efficiency calibration for various compositions and densities were performed by using the Laboratory Sourceless Calibration Software (LabSOCS) (Shyti, M., 2019). An example of efficiency calibration curve simulation in the case of soil sample is shown in figure 1. An empty container was counted 120 hours to obtain background spectra that were used to correct samples activity concentrations. The counting time of samples was set to be 48 hours with good statistical significance for the gamma-ray energy peaks of the radionuclides of interest in the samples. The spectra were analyzed using Genie 2000 software from Canberra Version 3.3.1 that includes peak search, nuclide identification, activity and uncertainty calculation modules. For calculation of MDA (Minimum Detectable Activity) Curie formula was used (L.E. De Geer., 2004). The main sources of uncertainty that were taken into account were the net peak area (N), background correction, full energy peak efficiency (ε), emission probability ($P\gamma$) of the corresponding gamma line, the radionuclide half-life ($T1/2$) and sample mass (C. Dovlete, and P.P. Povinec., 2004).

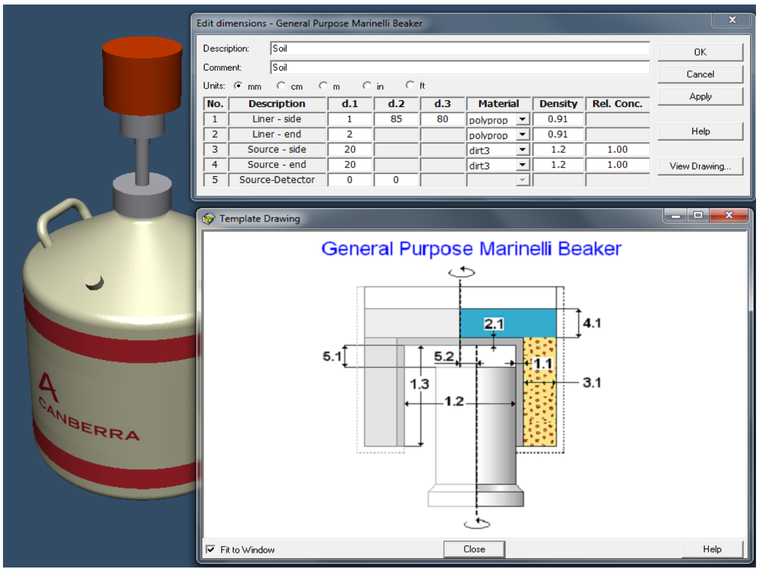

Figure 1. Simulation of efficiency calibration curve using LabSOCS

2.3 Evaluation criteria

To evaluate the bias of the reported results, the relative bias between the reported and the target value (the best estimation of the true value) is expressed by the following equation:

$$Bias_{relative} = \frac{Value_{reported} - Value_{target}}{Value_{target}} * 100\% \qquad (1)$$

If the $|Bias_{relative}| \leq$ MARB (Maximum Acceptable Relative Bias) given in equation 1, the result will be "Accepted" for accuracy.

For evaluation of precision an estimator P is calculated for each participant according to the following equation:

$$P = \sqrt{\left(\frac{u_{target}}{A_{target}}\right)^2 + \left(\frac{u_{reported}}{A_{reported}}\right)^2} * 100 \qquad (2)$$

If both the $P \leq$ MARB and $Bias_{relative} \leq k*P$ are fulfilled according equation 2, the reported results will be "Accepted" for the precision. If one of them is insufficient, the result will be assigned the "Not accepted" status for precision.

In addition, the z-score is calculated in accordance with following formula:

$$z = \left|\frac{Value_{reported} - Value_{target}}{robustsd}\right| \qquad (3)$$

The laboratory performance is evaluated from equation 3. If |z-score| ≤ 2 is satisfactory; questionable for 2 < |z-score| < 3, and unsatisfactory for |z-score| ≥ 3.

3. Results and discussions

The results and evaluation for the proficiency test conducted within the IAEA-TEL-2018-03 world wide open proficiency test exercise are shown in tables 1, 2 and 3. The natural and artificial radionuclides determined in this exercise has been as following: ^{40}K, ^{228}Ac, ^{214}Bi, ^{214}Pb, ^{212}Pb, ^{208}Tl, ^{226}Ra, ^{7}Be, ^{54}Mn, ^{133}Ba, ^{58}Co, ^{60}Co, ^{134}Cs, ^{136}Cs, ^{137}Cs and ^{131}I. For each of the analytes in scope the target value, the target uncertainty and the MARB are listed. On the other hand in scope the reported value (Rep. Value), reported uncertainty, relative bias and z-score are listed too.

Table 1 Evaluation result for sample 1 (spiked water)

Sample Code	Analyte	Target Value	Target Unc.	MARB	Rep. Value	Rep. Unc	Rel. Bias	Robust SD	z-score	Accuracy	P	Precision	Final Score
1	Ba-133	28.6	0.2	15%	27	1.2	-5.59%	1.9	0.84	A	4.5	A	A
1	Co-60	97.6	0.8	15%	91.4	2.6	-6.35%	4	1.55	A	2.96	A	A
1	Cs-134	58.2	0.3	15%	54.2	2.2	-6.87%	2.6	1.54	A	4.09	A	A
1	Cs-137	29	0.2	15%	27.2	1.6	-6.21%	1.1	1.64	A	5.92	A	A

Table 2 Evaluation result for sample 2 (spiked water)

Sample Code	*Analyte*	*Target Value*	*Target Unc.*	*MARB*	*Rep. Valure*	*Rep. Unc*	*Rel. Bias*	*Robust SD*	*z - score*	*Accuracy*	*P*	*Precision*	*Final Score*
2	Be-7	440	12	15%	441	27.5	0.23%	30.6	0.03	A	6.81	A	A
2	Co-58	15.5	1.2	30%	13.5	0.8	-12.90%	1.5	1.33	A	9.75	A	A
2	Cs-134	3010	60	15%	2900	115	-3.65%	152.2	0.72	A	4.44	A	A
2	Cs-136	29.2	0.7	30%	23.1	2.6	-20.89%	3.4	1.79	A	11.51	A	A
2	Cs-137	2010	40	15%	1900	114.3	-5.47%	71.3	1.54	A	6.34	A	A
2	I-131	241	7	20%	234	42	-2.90%	17.1	0.41	A	18.18	A	A
2	Mn-54	61.3	1.4	20%	57.8	3	-5.71%	3	1.17	A	5.67	A	A

Table 3 Evaluation Result for Sample 4 (agriculture soil)

Sample Code	*Analyte*	*Target Value*	*Target Unc.*	*MARB*	*Rep. Valure*	*Rep. Unc*	*Rel. Bias*	*Robust SD*	*z - score*	*Accuracy*	*P*	*Precision*	*Final Score*
4	K-40	374	15	20%	388.4	19.7	3.85%	32.7	0.44	A	6.47	A	A
4	Ac-228	32.6	1.3	25%	33	1	1.23%	2.3	0.17	A	5.01	A	A
4	Ba-133	56.8	0.9	20%	59.7	2.6	5.11%	5.9	0.49	A	4.63	A	A
4	Bi-214	31.2	1.5	20%	32.5	1.3	4.17%	5.8	0.22	A	6.25	A	A
4	Co-60	141.8	2.7	20%	144	0.4	1.55%	8.3	0.27	A	1.92	A	A
4	Cs-134	112.2	1.6	20%	113	4.5	0.71%	9.1	0.09	A	4.23	A	A
4	Cs-137	64.9	1.2	20%	65.7	4	1.23%	4	0.2	A	6.36	A	A
4	Pb-212	32.6	1.3	25%	33.5	2.7	2.76%	3.1	0.29	A	8.99	A	A
4	Pb-214	31.2	1.5	20%	33.1	1.5	6.09%	3.4	0.56	A	6.61	A	A
4	Ra-226	31.2	1.5	20%	36.1	5.1	15.71%	19	0.26	A	14.92	A	A
4	Tl-208	11.7	0.4	25%	12.1	0.7	3.42%	1.3	0.31	A	6.72	A	A

The performance of the laboratory was assessed based on z-score values obtained for various radionuclides, analyzed in different matrices for each proficiency tests. These covered low, medium and high energy ranges. The laboratory showed high performance as all values of z score lied between 0.03 and 1.79.

Conclusions

The main goal of this paper has been validation of method in order to verify that the method used fits to its intended use. Participation in different intercomparisons is essential tool to assure confidence and increase reliability and accuracy of results. The obtained results in this world wide proficiency test provide a very good performance and credibility of the gamma laboratory in Institute of Applied Nuclear Physics (IANP) in Tirana, Albania. In many cases the results were very satisfactory resulting better than the general average.

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