The IAEA-TERC-2022-01 world wide proficiency test on the determination of anthropogenic and natural radionuclides in water, soil and contaminated surface samples

Laboratory's Individual Evaluation Report
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IAEA-TERC-2022-01 World Wide Open Proficiency Test Exercise, Individual Evaluation Report Part I

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Abstract

This report describes the evaluation method for the Proficiency Test Exercise on the determination of anthropogenic and natural radionuclides in water, soil (gamma-ray spectrum analysis exercise), and simulated contaminated surface samples IAEA-TERC-2022-01. The evaluation is performed by the proficiency test team of the Terrestrial Environmental Radiochemistry Laboratory of the IAEA using their standard approach.

1 Sample preparation and analysis instructions

1.1 Spiked water - Samples 01 to 03 and QC

1.1.1 Sample preparation:

The sample matrix (drinking water sourced from Seibersdorf, Austria) was gravimetrically spiked with known amounts of prepared standard solution, containing a mixture of certified radionuclides and acidified to < pH 2 for stability.

1.1.2 Analysis:

Sample 01, Sample 02 and Sample 03 were spiked with several radionuclides. The identification of gamma emitting radionuclides was one of the tasks of this proficiency test and were not specified in advance. The Sample QC was provided as a quality control sample and its radionuclide content together with activity concentration was provided in the instructions.

1.2 Simulated contaminated surface sample

1.2.1 Sample preparation:

A 10 cm x 15 cm rectangle was printed (blue ink) using our in-house printing technique on a matte polyester canvas carrier material. A blank sample of the same size was provided for background measurements.

1.2.2 Analysis:

Measurements using a portable surface contamination monitor for alpha and beta surface emission rate should be reported as $counts/cm^2/second$. Correction for the detection efficiency was possible, since the radionuclides were specified in advance. Using the detection efficiency of the portable monitor, the activity concentration in Bq/cm^2 could be estimated. Additionally, the activity concentration of the sample could be measured by gamma-ray spectrometry for ^{137}Cs and by radiochemistry for ^{239}Pu. The results from the portable monitors and radioanalytical techniques could be compared to estimate the deviation between measurement methods.

1.3 Soil gamma-ray spectrum analysis exercise

A package of files (no physical sample) including instructions was provided to participants via download from the reporting platform.

2 Evaluation criteria

The data is evaluated according to the following steps:

1. The relative bias between the reported and the target value (the best estimation of the true value) is expressed by the following equation:

$$Bias_{relative} = \frac{Value_{reported} - Value_{target}}{Value_{target}} * 100\%$$

2. The relative bias is compared to the Maximum Acceptable Relative Bias (MARB) which has been determined for each analyte, considering the radioanalytical methods, the level of radioactivity and the complexity of the analysis.

If the $|Bias_{relative}| \leq MARB$, the result will be "Accepted" for accuracy.

3. Based on fit-for-purpose and good laboratory practice principles, the expanded relative combined uncertainty should cover the relative bias:

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

$$|Bias_{relative}| \leq k * P$$

where k is the coverage factor, for the 99% confidential level, $k = 2.58$. 4. If the result is between the $\pm MARB$ values, but it is not overlapping the target value within the uncertainty, this equation is used to decide if they are significantly different or not.

5. The P value is compared to the MARB also. If both the:

$$P \leq MARB$$

and

$$|Bias_{relative}| \leq k * P$$

are fulfilled, the reported results will be "Accepted" for precision. The result will be assigned "Not Accepted" for precision if either conditions are not fulfilled.

6. The final score is assigned according to the detailed evaluation described above. The possible scores are listed below:

- "Accepted" when both, accuracy and precision achieved "Accepted" status

- "Not Accepted" when the accuracy is "Not Accepted"

- "Warning" when accuracy is "Accepted" but the precision is "Not Accepted"

7. As additional information, a Z-Score parameter is shown in the evaluation tables that is calculated by using the robust standard deviation described in [2]:

$$z = \left| \frac{Value_{reported} - Value_{target}}{robust\, sd} \right|$$

8. If the analyte is included in the proficiency test evaluation scheme, the stated target value is used to calculate the Z-Score. For those analytes, which are subject of an intercomparison only, the robust mean of the values reported is used instead.

9. For analytes evaluated by intercomparison, the final scores (Z-Score evaluation) are assigned as follows:

- "Accepted" for Z-Scores less than 2

- "Not Accepted" Z-Scores above 3

- "Warning" for Z-Scores less than 3 and larger than 2

3 Tables of Target Values and Evaluation Criteria for Proficiency Test Parameters

Target Values for Gamma Spectrometry Analysis in Sample 1

TABLE 1. Target values

Sample	Analyte	Massic Activity, [Bq/kg]	Uncertainty, [Bq/kg]	MARB, [%]
1	Co-60	17.7	1.1	20.00
1	Cs-134	15.9	1	20.00
1	Cs-137	24.2	1.5	20.00
1	Pb-210	31.3	1.9	30.00

Target Values for Alpha/Beta Spectrometry Analysis in Sample 1

TABLE 2. Target values

Sample	Analyte	Massic Activity, [Bq/kg]	Uncertainty, [Bq/kg]	MARB, [%]
1	Sr-90	26.4	1.6	30.00
1	Po-210	31.6	1.9	30.00

Target Values for Gamma Spectrometry Analysis in Sample 2

TABLE 3. Target values

Sample	Analyte	Massic Activity, [Bq/kg]	Uncertainty, [Bq/kg]	MARB, [%]
2	Cs-137	8.36	0.50	20.00
2	Pb-210	5.20	0.31	30.00
2	Am-241	10.1	0.6	30.00

Target Values for Alpha/Beta Spectrometry Analysis in Sample 2

TABLE 4. Target values

Sample	Analyte	Massic Activity, [Bq/kg]	Uncertainty, [Bq/kg]	MARB, [%]
2	H-3	10.8	0.6	30.00
2	Sr-90	7.42	0.45	30.00
2	Po-210	5.20	0.31	30.00

Target Values for Gamma Spectrometry Analysis in Sample 3

TABLE 5. Target values

Sample	Analyte	Massic Activity, [Bq/kg]	Uncertainty, [Bq/kg]	MARB, [%]
3	Cs-134	12.1	0.7	20.00
3	Cs-137	22.6	1.4	20.00
3	Am-241	0.902	0.054	30.00

Target Values for Alpha/Beta Spectrometry Analysis in Sample 3

TABLE 6. Target values

Sample	Analyte	Massic Activity, [Bq/kg]	Uncertainty, [Bq/kg]	MARB, [%]
3	Pu-239	5.16	0.31	30.00

4   Tables of Robust Statistics for Intercomparison Parameters

Robust Statistic Parameters for Intercomparison Parameters in Sample 1

TABLE 7. Intercomparison values

Sample	Analyte	Robust Mean, [Bq/kg]	Robust SD, [Bq/kg]	N
1	gross alpha	23.98	7.78	211
1	gross beta	124.75	29.46	213

Robust Statistic Parameters for Intercomparison Parameters in Sample 2

TABLE 8. Intercomparison values

Sample	Analyte	Robust Mean, [Bq/kg]	Robust SD, [Bq/kg]	N
2	gross alpha	12.72	3.73	207
2	gross beta	28.94	6.35	209

Robust Statistic Parameters for Intercomparison Parameters in Sample 3

TABLE 9. Intercomparison values

Sample	Analyte	Robust Mean, [Bq/kg]	Robust SD, [Bq/kg]	N
3	gross alpha	8.93	3.04	206
3	gross beta	27.63	6.78	210
3	Cm-244	4.51	0.66	38

Robust Statistic Parameters for Intercomparison Parameters in Sample 5

TABLE 10. Intercomparison values

Sample	Analyte	Robust Mean	Robust SD	Unit	N
5	gross alpha	0.081	0.052	$counts/cm^2/sec$	182
5	gross beta	0.158	0.084	$counts/cm^2/sec$	189
5	Cs-137	0.332	0.048	Bq/cm^2	196
5	Pu-239	0.236	0.073	Bq/cm^2	79

Robust Statistic Parameters for Intercomparison Parameters in Sample 7

TABLE 11. Intercomparison values

Sample	Analyte	Robust Mean, [Bq/kg]	Robust SD, [Bq/kg]	N
7	K-40	449.74	31.25	193
7	Mn-54	0.59	0.08	17
7	Co-60	123.96	8.12	175
7	Cd-109	55.50	39.40	8
7	Sn-113	1.84	0.26	27
7	Ba-133	62.13	8.76	165
7	Cs-134	39.80	3.85	175
7	Cs-137	83.20	4.79	175
7	Tl-208	13.25	1.92	90
7	Pb-210	621.79	80.10	126
7	Pb-212	38.24	3.99	96
7	Bi-212	39.39	5.02	81
7	Pb-214	32.86	2.50	94
7	Bi-214	31.49	3.39	100
7	Ra-224	39.91	5.74	27
7	Ra-226	38.00	10.91	146
7	Ac-227	1.56	0.21	5
7	Th-227	1.65	0.41	15
7	Ra-228	37.77	2.20	29
7	Ac-228	36.27	3.03	118
7	Th-228	38.98	4.11	27
7	Th-230	39.65	4.58	4
7	Th-231	7.30	6.82	5
7	Th-232	36.55	4.41	11
7	Pa-234m	26.57	10.19	35
7	Th-234	28.60	6.56	66
7	U-235	1.46	0.55	117
7	U-238	28.00	6.45	16
7	Am-241	78.89	7.59	169

5 References

References

[1] International Organization for Standardization (ISO). (2010). Conformity assessment - General requirements for proficiency testing, ISO/IEC 17043:2010. Geneva: Switzerland.

[2] International Organization for Standardization (ISO). (2015). Statistical methods for use in proficiency testing by interlaboratory comparison, ISO 13528:2015. Geneva: Switzerland.

Individual Evaluation Report

for the World-Wide Open Proficiency Test IAEA-TERC-2022-01 Part II

Individual Evaluation Report

for

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Proficiency Test IAEA-TERC-2022-01 Evaluation Report Part II

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Evaluation Tables for Labcode 126. (Values and uncertainties expressed in Bq/kg)

Evaluation Result Table for Sample 1

Sample Code	Analyte	Target Value	Target Unc.	MARB	Rep. Value	Rep. Unc	Rel. Bias	Robust SD	Z-Score	Accuracy	P	Precision	Final Score
1	Co-60	17.7	1.1	20 %	18.8	1.1	6.21 %	1.1	1.00	A	8.54	A	A
1	Cs-134	15.9	1	20 %	16.6	1.2	4.40 %	1	0.70	A	9.58	A	A
1	Cs-137	24.2	1.5	20 %	25.4	1.8	4.96 %	1.5	0.80	A	9.41	A	A
1	Pb-210	31.3	1.9	30 %	30	2.3	-4.15 %	1.9	0.68	A	9.78	A	A

Evaluation Result Table for Sample 2

Sample Code	Analyte	Target Value	Target Unc.	MARB	Rep. Value	Rep. Unc	Rel. Bias	Robust SD	Z-Score	Accuracy	P	Precision	Final Score
2	Am-241	10.1	0.6	30 %	10.39	0.6	2.87 %	0.6	0.48	A	8.28	A	A
2	Cs-137	8.36	0.5	20 %	8.11	0.72	-2.99 %	0.5	0.50	A	10.70	A	A

Evaluation Result Table for Sample 3

Sample Code	Analyte	Target Value	Target Unc.	MARB	Rep. Value	Rep. Unc	Rel. Bias	Robust SD	Z-Score	Accuracy	P	Precision	Final Score
3	Cs-134	12.1	0.7	20 %	11.77	0.86	-2.73 %	0.7	0.47	A	9.32	A	A
3	Cs-137	22.6	1.4	20 %	23.3	1.5	3.10 %	1.4	0.50	A	8.93	A	A

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Values and uncertainties for Sample 5

Evaluation Result Table for Sample 5

Sample Code	Analyte	Target Value	Target Unc.	MARB	Rep. Value	Rep. Unc	Rel. Bias	Robust SD	Z-Score	Accuracy	P	Precision	Final Score

Proficiency Test IAEA-TERC-2022-01 Evaluation Report Part II

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Intercomparison Parameter Evaluation: (Units specified in Part I)

Sample Code	Analyte	Robust Mean	Robust SD	Rep. Value	Rep. Unc	Z-Score	Z-Score Evaluation
1	gross_alpha	23.98	7.78	32.7	2.5	1.12	A
1	gross_beta	124.75	29.46	120	10	0.16	A
2	gross_alpha	12.72	3.73	17.0	1.4	1.15	A
2	gross_beta	28.94	6.35	20.2	2.8	1.38	A
3	gross_alpha	8.93	3.04	12.9	1.1	1.31	A
3	gross_beta	27.63	6.78	26.0	3.1	0.24	A
5	gross_alpha	0.081	0.052	0.098	0.014	0.33	A
5	gross_beta	0.158	0.084	0.141	0.017	0.20	A
7	Ac-228	36.27	3.03	36.5	1.3	0.08	A
7	Am-241	78.89	7.59	80.9	3.7	0.26	A
7	Ba-133	62.13	8.76	66.6	2.6	0.51	A
7	Co-60	123.96	8.12	126.6	4.1	0.33	A
7	Cs-134	39.8	3.85	41.5	1.6	0.44	A
7	Cs-137	83.2	4.79	85.1	3.6	0.40	A
7	K-40	449.74	31.25	444	20	0.18	A
7	Pa-234m	26.57	10.19	< 52		n.a.	n.a.
7	Pb-210	621.79	80.1	646	31	0.30	A
7	Pb-212	38.24	3.99	38.2	2.1	0.01	A
7	Ra-224	39.91	5.74	38	1.3	0.33	A
7	Ra-226	38	10.91	37.9	5	0.01	A
7	Ra-228	37.77	2.2	36.5	1.3	0.58	A
7	Th-228	38.98	4.11	37.9	1.3	0.26	A
7	Th-234	28.6	6.56	27.5	1.9	0.17	A
7	Tl-208	13.25	1.92	13.62	0.57	0.19	A
7	U-235	1.46	0.55	1.27	0.1	0.35	A
7	U-238	28	6.45	27.5	1.9	0.08	A