The IAEA-TERC-2024-01 world wide proficiency test on the determination of anthropogenic and natural radionuclides in water, sediment, bauxite and contaminated surface samples

Laboratory's Individual Evaluation Report
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Certificate of Participation

in the IAEA-TERC-2024-01 proficiency test exercise

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IAEA-TERC-2024-01 World Wide Proficiency Test Exercise Individual Evaluation Report for Labcode 2

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Abstract

The IAEA Terrestrial Environmental Radiochemistry Laboratory (TERC) provided a Proficiency Test (PT) on determination of anthropogenic and natural radionuclides in water, sediment, bauxite and simulated contaminated surface samples.

0.1 Reference date for decay correction

The reference date for decay correction in all samples is 2024-01-01.

0.2 Codes for analytical techniques in evaluation tables

Due to the limited space available in the evaluation tables, the analytical techniques are abbreviated in the tables as shown in the following list:

- alpha: Alpha Spectrometry

- beta: Beta Counting

- gamma: Gamma-ray Spectrometry

- ICP-MS: Inductively Coupled Plasma Mass Spectrometry.

1 Evaluation of results

Results reported by participants were evaluated using the following stepwise approach.
The evaluation follows the methodology applied for the annual IAEA proficiency testing schemes in the area of radionuclide measurements.

1.1 Relative bias (Samples 1, 3, 4 and 5)

The relative bias is the relative difference between the reported and the target value (the best estimate of the true value)

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

The relative bias is compared to the Maximum Acceptable Relative Bias (MARB) which has been determined for each property value, considering the analytical methods, the analyte level in the sample and the complexity of the analysis.

When $|Bias_{relative}| \leq MARB$, the result will be rated "Accepted (A)" for trueness.

1.2 Evaluation approach for radionuclide activity concentration values (Samples 1, 3 and 4) and activity values per sample (Samples 5)

Based on fit-for-purpose and good laboratory practice principles, the expanded relative uncertainty should cover the relative bias (as defined in 1.1):

The P value is calculated as follows:

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

The relative bias is then compared to the P value, expanded by a coverage factor k:

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

where k is the coverage factor: $k = 2.58$ for a level of confidence of 99%.

When the above criterion is fulfilled, the reported result is not significantly different from the target values considering the uncertainties associated with both values. The reported uncertainty of measurement is large enough to cover the bias of the method.

In addition, the P value is compared to the MARB.

$$P \leq MARB$$

When this criterion is fulfilled, the measurement uncertainty is not overestimated and fit-for-purpose in relation to the MARB criterion of this PT exercise. When both criteria related to the measurement uncertainty are fulfilled, the reported result is rated "accepted (A)" for precision (measurement uncertainty). The result is rated "Not Accepted (N)" for precision if either of the two conditions is not fulfilled.

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

- "Accepted (A)" when both, trueness and precision were rated "Accepted"

- "Not Accepted (N)" when the trueness rating is "Not Accepted"

- "Warning (W)" when the trueness rating is "Accepted" but the precision rating is "Not Accepted"

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1.3 Evaluation parameters calculated for intercomparison analyte values

1.3.1 Z-Score

The z score is calculated as follows

$$z = \frac{Value_{reported} - Value_{target}}{\sigma_{PT}}$$

Where $Value_{target}$ is the target value, calculated as the robust mean of all results reported by participating laboratories. $sigma_{PT}$ is the standard deviation for proficiency assessment, calculated as the robust standard deviation of all results reported by participating laboratories.

The following criteria apply for performance ratings based on obtained z scores

- $|z| \leq 2$ ... accepted (A)

- $2 < |z| < 3$ ... questionable (Q)

- $|z| \geq 3$ ... not accepted (N)

1.3.2 Zeta-Score

The ζ (zeta) score allows a combined assessment of the reported value and the reported uncertainty of measurement, and thus of the accuracy of the reported result.

$$\zeta = \frac{Value_{reported} - Value_{target}}{\sqrt{(u_{reported})^2 + (u_{target})^2}}$$

The following criteria apply for performance ratings based on obtained zeta scores

- $|\zeta| \leq 2$ ... accepted (A)

- $2 < |\zeta| < 3$ ... questionable (Q)

- $|\zeta| \geq 3$ ... not accepted (N)

2 Data Evaluation Tables

Target Values for activity concentration of radionuclides in Sample 1

TABLE 1. Target values

Sample	Analyte	Technique	Target Value	Uncertainty ($k=1$)	Unit	MARB [%]
1	Eu-152	gamma	14.8	0.7	Bq/kg	20.00
1	H-3	beta	19.5	1.0	Bq/kg	30.00
1	Na-22	gamma	19.1	1.0	Bq/kg	20.00
1	Pb-210	gamma	10.20	0.90	Bq/kg	30.00
1	Pb-210	beta	10.20	0.90	Bq/kg	30.00
1	Po-210	alpha	10.20	0.90	Bq/kg	30.00
1	Ra-226	gamma	13.0	0.7	Bq/kg	20.00
1	Ra-226	alpha	13.0	0.7	Bq/kg	30.00
1	Sr-90	beta	23.6	1.2	Bq/kg	30.00
1	Total U	ICP-MS	2.251	0.0068	ng/g	30.00
1	U-235	ICP-MS	0.0160	0.0006	ng/g	30.00
1	U-238	ICP-MS	2.235	0.068	ng/g	30.00

Evaluation Table for Sample 1

TABLE 2. Evaluation Results for Sample 1

Analyte	Technique	Target Value	Target Unc.	MAB	Reported value [Bq/kg]	Reported uncertainty ($k=1$) [Bq/kg]	Relative bias [%]	P-Test [%]	Trueness evaluation	Precision evaluation	Final Score
Eu-152	gamma	14.800	0.7000	20	15.0	1.1	1.4	8.73	A	A	A
Na-22	gamma	19.100	1.0000	20	19.6	1.9	2.6	11.02	A	A	A
Pb-210	gamma	10.200	0.9000	30	10.8	1.8	5.9	18.86	A	A	A
Po-210	alpha	10.200	0.9000	30	10.4	1.2	2.0	14.53	A	A	A
Ra-226	gamma	13.000	0.7000	20	13.5	1.4	3.8	11.68	A	A	A
Ra-226	alpha	13.000	0.7000	30	12.4	1.5	-4.6	13.24	A	A	A

Target Values for activity concentration of radionuclides in Sample 3

TABLE 3. Target values

Sample	Analyte	Technique	Target Value	Uncertainty ($k = 1$)	Unit	MARB [%]
3	Ac-228	gamma	307	17	Bq/kg	30.00
3	Bi-212	gamma	307	12	Bq/kg	30.00
3	Bi-214	gamma	340	13	Bq/kg	30.00
3	K-40	gamma	873	44	Bq/kg	30.00
3	Pa-234m	gamma	246	11	Bq/kg	30.00
3	Pb-210	gamma	306	17	Bq/kg	30.00
3	Pb-212	gamma	307	12	Bq/kg	30.00
3	Pb-214	gamma	340	13	Bq/kg	30.00
3	Ra-226	gamma	340	13	Bq/kg	30.00
3	Ra-228	gamma	307	17	Bq/kg	30.00
3	Th-232	gamma	307	17	Bq/kg	30.00
3	Th-234	gamma	246	11	Bq/kg	30.00
3	Tl-208	gamma	110	4	Bq/kg	30.00
3	U-235	gamma	11.4	1	Bq/kg	30.00
3	U-238	gamma	246	11	Bq/kg	30.00

Evaluation Table for Sample 3

TABLE 4. Evaluation Results for Sample 3

Analyte	Technique	Target Value	Target Unc.	MAB	Reported value [Bq/kg]	Reported uncertainty ($k = 1$) [Bq/kg]	Relative bias [%]	P-Test [%]	Trueness evaluation	Precision evaluation	Final Score

Target values for activity concentration of radionuclides in Sample 4

TABLE 5. Target values

Sample	Analyte	Technique	Target Value	Uncertainty ($k = 1$)	Unit	MARB [%]
4	Ac-228	gamma	130	8	Bq/kg	30.00
4	Bi-212	gamma	130	7	Bq/kg	30.00
4	Bi-214	gamma	144	5	Bq/kg	30.00
4	Cs-137	gamma	2.44	0.26	Bq/kg	30.00
4	Pa-234m	gamma	143	7	Bq/kg	30.00
4	Pb-210	gamma	140	6	Bq/kg	30.00
4	Pb-212	gamma	130	6	Bq/kg	30.00
4	Pb-214	gamma	144	5	Bq/kg	30.00
4	Ra-226	gamma	144	5	Bq/kg	30.00
4	Ra-228	gamma	130	8	Bq/kg	30.00
4	Th-232	gamma	130	8	Bq/kg	30.00
4	Th-234	gamma	143	7	Bq/kg	30.00
4	Tl-208	gamma	46.7	1.8	Bq/kg	30.00
4	U-235	gamma	6.66	0.58	Bq/kg	30.00
4	U-238	gamma	143	7	Bq/kg	30.00

Evaluation Table for Sample 4

TABLE 6. Evaluation Results for Sample 4

Analyte	Technique	Target Value	Target Unc.	MAB	Reported value [Bq/kg]	Reported uncertainty ($k = 1$) [Bq/kg]	Relative bias [%]	P-Test [%]	Trueness evaluation	Precision evaluation	Final Score
Ac-228	gamma	130.00	8.00	30	141	11	8.5	9.94	A	A	A
Bi-214	gamma	144.00	5.00	30	144	14	0.0	10.32	A	A	A
Pb-210	gamma	140.00	6.00	30	151	11	7.9	8.45	A	A	A
Pb-212	gamma	130.00	6.00	30	129.7	8.1	-0.2	7.77	A	A	A
Pb-214	gamma	144.00	5.00	30	155	11	7.6	7.90	A	A	A
Ra-226	gamma	144.00	5.00	30	154	12	6.9	8.53	A	A	A
Ra-228	gamma	130.00	8.00	30	141	11	8.5	9.94	A	A	A
Th-232	gamma	130.00	8.00	30	133.7	8.1	2.8	8.64	A	A	A
Th-234	gamma	143.00	7.00	30	171	12	19.6	8.56	A	A	A
Tl-208	gamma	46.70	1.80	30	46.7	4.7	0.0	10.78	A	A	A

TABLE 6. Evaluation Results for Sample 4

Analyte	Technique	Target Value	Target Unc.	MAB	Reported value [Bq/kg]	Reported uncertainty ($k=1$) [Bq/kg]	Relative bias [%]	P-Test [%]	Trueness evaluation	Precision evaluation	Final Score
U-235	gamma	6.66	0.58	30	7.59	0.60	14.0	11.76	A	A	A
U-238	gamma	143.00	7.00	30	163	12	14.0	8.84	A	A	A

Target values for massic activity of radionuclides in Samples 5(surface samples)

TABLE 7. Target values

Sample	Analyte	Technique	Target Value	Uncertainty ($k = 1$)	Unit	MARB [%]
5	Cs-134	gamma	7.71	0.39	Bq/sample	30.00
5	Sr-90	beta	3.28	0.16	Bq/sample	30.00

Evaluation Table for Samples 5 (surface samples)

TABLE 8. Evaluation Results for surface samples

Sample	Analyte	Technique	Target Value	Target Unc	MAB	Reported value [Bq/sample]	Reported uncertainty ($k = 1$) [Bq/sample]	Relative bias [%]	P-Test [%]	Trueness evaluation	Precision evaluation	Final Score
5	Cs-134	gamma	7.71	0.39	30	7.54	0.42	-2.2	7.52	A	A	A
5	Sr-90	beta	3.28	0.16	30	3.39	0.57	3.4	17.51	A	A	A

Intercomparison parameters for activity concentration of radionuclides in Sample 1

TABLE 9. Robust mean and sd

Sample	Analyte	Robust mean	Robust standard deviation	Unit	MARB [%]
1	Gross Alpha	24.1	9.6	Bq/kg	40
1	Gross Beta	80.1	14.7	Bq/kg	40

Evaluation Table for Sample 1

TABLE 10. Evaluation Results for Sample 1

Analyte	Reported value [Bq/kg]	Reported uncertainty ($k = 1$) [Bq/kg]	Relative bias [%]	Trueness evaluation	z score	z score evaluation	zeta score	zeta score evaluation
Gross Alpha	31.0	4.9	28.6	A	0.72	A	0.64	A
Gross Beta	87	16	8.6	A	0.47	A	0.32	A

Intercomparison parameters for activity concentration of radionuclides in Sample 4

TABLE 11. Robust mean and sd

Sample	Analyte	Robust mean	Robust standard deviation	Unit	MARB [%]
4	K-40	35.1	8.5	Bq/kg	30

Evaluation Table for Sample 4

TABLE 12. Evaluation Results for Sample 4

Analyte	Reported value [Bq/kg]	Reported uncertainty ($k = 1$) [Bq/kg]	Relative bias [%]	Trueness evaluation	z score	z score evaluation	zeta score	zeta score evaluation

3 Contributors to evaluation and report

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References

[1] International Organization for Standardization (ISO). Conformity assessment - General requirements for the competence of proficiency test providers, ISO/IEC 17043:2023. Geneva: Switzerland.

[2] International Organization for Standardization (ISO). Statistical methods for use in proficiency testing by interlaboratory comparison, ISO 13528:2022. Geneva: Switzerland.