

# Proficiency Test of Ukrainian Laboratories Determination of Gamma Emitting Radionuclides



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International Atomic Energy Agency

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Determination of Gamma Emitting Radionuclides

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## 1. INTRODUCTION

The results of analytical measurements play a vital role in our daily lives. Analytical data may be the basis upon which economic, legal or environmental management decisions are made, and they are essential in international trade, environmental protection, safe transportation, law enforcement, consumer safety and the preservation of human health. As an incorrect decision can be extremely costly and detrimental, it is essential that such measurements are accurate, reliable, cost effective 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 its analytical systems are under statistical control, that it uses methods of analysis that are validated, that its results are 'fit-for-purpose', and that it participates in proficiency testing exercises [1]. The competence of laboratories is demonstrated in accreditation processes according to the ISO/IEC 17025:2005 [2] and in the frame of accreditation systems, the use of reference materials, both for quality control and proficiency testing, has therefore increased in recent years.

Proficiency testing is a method for regularly assessing the accuracy of the analytical data produced by the laboratories of particular measurements. In analytical chemistry, proficiency testing usually comprises the distribution of effectively homogenous portions of the test material to each participant for analysis as an unknown. The laboratories conduct the test under routine conditions, and report the result to the organiser by a deadline. The results generated in proficiency testing should be used for the purpose of a continuing assessment of the technical competence of the participating laboratories [1]. With the advent of 'mutual recognition' on a world wide basis, it is now essential that laboratories participate in proficiency testing schemes that will provide an interpretation and assessment of results which is transparent to the participating laboratory and its 'users'. Participation in proficiency testing exercises provides also laboratories with an objective means of assessing and documenting the reliability of the data they are producing.

Since the 1960s the International Atomic Energy Agency has played an important role assisting laboratories in Member States to improve the quality of their analytical results and their traceability to basic standards. This is accomplished through the provision of matrix reference materials and validated procedures, training in the implementation of quality control, and the evaluation of measurement performance by the organization of proficiency tests and intercomparison exercises. The Chemistry Unit is actively involved in the production and characterization of matrix reference materials of terrestrial origin, widely used for method and measurement validation and organization of proficiency tests and intercomparison exercises. The Chemistry Unit is a part of the Physics, Chemistry and Instrumentation Laboratory.

Within the frame of IAEA TC-project UKR/9/023 'Improvement of Environmental Radiation Monitoring' upon a request of State Committee of Nuclear Regulation of Ukraine (SCNRR) a proficiency test was organized and conducted by the Chemistry Unit. The proficiency test was addressed to assess the analytical performance of 7 laboratories from Ukraine on the determination of gamma emitting radionuclides in spiked soil and water.

Soil and water test materials were prepared according to a validated procedure by the Chemistry Unit staff with the participation of a fellow from Ukrainian Hydrometeorological institute during his fellowship programme in Seibersdorf Laboratories.

In January 2006 the 8 sets of test samples (1 soil sample and 4 water samples) and 6 soil samples were distributed among the participating laboratories. The deadline for receiving the results from the participants was set to 17 December 2007. The participating laboratories were requested to analyse the samples employing the methods used in their routine work, so that their performance on the test samples could be directly related to the real performance of the laboratory. Each laboratory was given a confidential code to assure the anonymity of the evaluation results.

Seven laboratories from the 14 initially registered reported to the IAEA their results. The analytical results of the participating laboratories were compared with the reference values assigned to the reference materials, and a rating system was applied.

This report describes the sample preparation methodology, data evaluation approach, summary evaluation of each nuclide and individual evaluation report for each laboratory. It also provides information on performance of the participating laboratories and allows the assessment of laboratory performance on a wider basis, e.g. comparison between measurement techniques, sample preparation and dissolution methods, better identification of possible sources of bias and reliable evaluation of measurement uncertainties reported.

## **2. PROFICIENCY TEST OBJECTIVES**

Four distinct aims of the proficiency test can be formulated:

- To check the accuracy and precision of the analytical results produced by the participating laboratories from Ukraine for the determination of gamma-emitting radionuclides in spiked soil and water;
- to encourage the participating laboratories in finding remedial actions where shortcoming in analytical performance are detected;
- to encourage the use of proper routine quality control measures within individual laboratories;
- to provide general evaluation and comments on the overall performance of participating laboratories; and in order to enable the laboratories to compare their performances with those of other laboratories.

## **3. PROFICIENCY TEST MATERIALS**

### **3.1. Composition of proficiency test materials**

The proficiency test materials set consisted of 5 samples. The following PT design was applied:

- one soil sample (sample code 01, 200 g) spiked with a mixture of gamma-emitting radionuclides (Mn-54, Co-60, Zn-65, Cd-109, Cs-134, Cs-137, Pb-210, Am-241);
- one demineralised blank water sample (sample code 02, 500 g);
- one spiked demineralised water sample (sample code 03, 500 g)
- one duplicated demineralised water samples (sample codes 04, 05, 500 g each)

Tables 1 and 2 present the target values and the combined standard uncertainties of the PT samples. The participants received the test set, together with handling instructions and the reporting forms. The deadline for data return was set to 28 February 2007.

### 3.2. Preparation of the spiking solution

The mixed gamma-emitting radionuclides solution for spiking soil and water samples was obtained by mixing appropriate amounts of certified standard solutions of selected radionuclides with the carrier solution. For Co-60 the dilution was conducted in 3 step (1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> Dilutions), for the rest radionuclides – in 2 step (1<sup>st</sup> Dilution and 2<sup>nd</sup> Dilution). All dilutions were prepared gravimetrically, using an analytical balance which weighed to the fifth decimal place. The activities of mixed gamma-emitting radionuclides solution are given in Table 1.

TABLE 1: ACTIVITIES OF GAMMA-EMITTING RADIONUCLIDES SOLUTION FOR SPIKING SOIL & WATER SAMPLES

Unit	Mn-54	Co-60	Zn-65	Cd-109	Cs-134	Cs-137	Pb-210	Am-241
[Bq/g]	11.307	19.27	16.895	44.925	19.887	17.897	74.86	35.39

### 3.3. Preparation of test samples

#### 3.3.1. Preparation of the spiked soil sample 01

A soil from China was used to prepare a spiked mineral matrix with 8 gamma-emitting radionuclides. Before using the soil for spiking, it was milled and sieved to collect the appropriate fraction at mesh size less than 0.25 mm, and then homogenized in Turbula mixer during 6 hours. The soil material is free from man-made radionuclides, except for Cs-137, which was present at  $2.6 \pm 0.2$  Bq/kg based on dry mass (Ref. Date: 2006-01-01) and Pb-210 at  $48 \pm 1.5$  Bq/kg d.w. The moisture content determined at 105<sup>0</sup>C was found to be  $2.3 \pm 0.2\%$ .

The preparation of the spiked soil sample was performed according to a validated procedure [3]. 1.0 ml (1.0025 g) of the spiking solution was diluted with 120 ml of methanol in polypropylene containers and transferred to 200.00 $\pm$ 0.07 g soil portions previously weighed in polypropylene bottles. The slurry formed was thoroughly mixed; the mixer was washed with methanol inside the bottle.

Each sample was spiked separately using a calibrated pipette with known uncertainty. The soil portions were then dried in an oven at 40<sup>0</sup>C during 20 hours to become completely dry. The samples were left to cool to room temperature, which allowed reaching equilibrium with ambient humidity before sealing. After such treatment the residual moisture contents was found  $2.4 \pm 0.2\%$ . After sealing the samples were homogenized in a Turbula mixer for 60 min to provide the within-bottle homogeneity.



TABLE 2: FINAL ACTIVITIES USED FOR EVALUATION OF PT RESULTS IN SPIKED SOIL SAMPLES (REFERENCE DATE: 1 JANUARY 2007)

Radionuclide	Activity (A)	u (A)	u (homogeneity)	Dry mass ratio	u (dry mass)	Sample mass	u (sample mass)	Activity in soil	Combined standard uncertainty
	Bq/sample	%	Bq/sample	%	%	g	%	Bq kg <sup>-1</sup>	%
Mn-54	11.335	0.032	0.227	2.0	0.976	200.0	0.002	58.1	1.18
Co-60	19.314	0.146	0.444	2.3	0.976	200.0	0.002	98.9	2.40
Zn-65	16.937	0.181	0.525	3.1	0.976	200.0	0.002	86.8	2.85
Cd-109	45.038	0.230	0.901	2.0	0.976	200.0	0.002	230.7	4.79
Cs-134	19.936	0.152	0.558	2.8	0.976	200.0	0.002	102.1	2.97
Cs-137	18.566	0.139	0.334	1.8	0.976	200.0	0.002	95.1	1.86
Pb-210	85.247	2.251	2.898	3.4	0.976	200.0	0.002	436.7	18.8
Am-241	35.481	0.216	0.933	2.8	0.976	200.0	0.002	181.8	5.22

### *3.3.1.1. Homogeneity of PT soil samples*

The method of spiking soil samples was developed in the Agency's Laboratories in Seibersdorf [3] and demonstrated to yield reliable and reproducible results within 1-2% for all radionuclides tested.

In this PT the homogeneity study was not carried out because the numerous homogeneity test results, obtained experimentally in previous years, had provided evidence that:

- satisfactory within-bottle homogeneity has been attained for all radionuclides for sub-samples weighing 60 g or more;
- the whole amount of radionuclides was associated with the soil matrix without any losses of radionuclides due to adsorption on the wall of the bottles in which the samples were spiked.

There was not need to check the between-bottle homogeneity, since each bottle was spiked individually with the same amount of radionuclides and then each bottle was also individually homogenized. Therefore, the value of between-bottle heterogeneity uncertainty is limited to the weighing uncertainty and it was estimated that combined uncertainties arising from heterogeneity is less than 2% and it was included in the total uncertainty budget.

### *3.3.1.2. Target values and associated combined uncertainty*

The target values were calculated from the certified activity values to each radionuclide, taking into account the successive dilution steps, the mass of spiking solutions and the amount of matrix being spiked. The target values for Cs-137 and Pb-210 were calculated taking in consideration the initial content of these radionuclides in soil matrix. The combined standard uncertainty includes three major components: uncertainty of spiking solution, uncertainty originated from heterogeneity and one arising from variability of moisture content in samples. The two first sources are the largest contributors to the overall uncertainties which are, nevertheless, gratifyingly small for all radionuclides used in the PT. Summary of the target values and associated total uncertainties are presented in Table 2.

### *3.3.2. Preparation of blank water sample*

Blank water sample 02 was prepared from demineralized water. This water was acidified by hydrochloric acid at 0.5 mol/l. Ten blank samples of 500 ml each were prepared.

### *3.3.3. Preparation of the spiked water samples 03, 04, 05*

Demineralised water was used for preparation of samples 03, 04 and 05. To prevent the adsorption of radionuclides on the walls of the polypropylene containers – the water was acidified by hydrochloric acid at 0.5 mol/l. Also, the mixed carriers solution was added and diluted with water to obtain a final concentration 0.1 mg/ml for each carrier.

The spiked water samples were prepared in two batches: one batch for sample 03 and batch for samples 04 and 05 (i.e. duplicate samples, in order to verify the repeatability of the method). The mixed gamma-emitting radionuclides solution was used to spike water samples (Table 1).

25 liters container was used for preparation of samples. Container was washed by acid prior to use and carefully rinsed (3 times) by the distilled water.

To spike the sample number 03 (5000 g) the 0.50573 g of spiking solution was used. To spike the sample number 04, 05 (10067 g) the 10.01885 g of spiking solution was used.

A pump with multiple outlets was used to homogenise the bulk water samples in a 25 L tank. The 500 ml bottles were cleaned by the acidified water, labeled and then filled up to 500 g.

The final target activity concentration for each radionuclide was calculated from the certified activity values assigned to each radionuclide, taking into account the successive dilution steps, the mass of spiking mixture and the amount of water being spiked as determined from weighing. The combined standard uncertainty includes two major components: uncertainty of the certified solution and weighing uncertainty.

Table 3 presents the target values and the respective standard combined uncertainties used in the evaluation in this PT.

TABLE 3: THE TARGET VALUES AND THE ASSOCIATED COMBINED STANDARD UNCERTAINTY OF THE PROFICIENCY TEST SAMPLES OF WATER.

Radionuclide	Sample 02	Sample 03	Sample 04 and 05
	Bq kg <sup>-1</sup>	Bq kg <sup>-1</sup>	Bq kg <sup>-1</sup>
Mn-54	Blank	1.14±0.003	11.25±0.032
Co-60	Blank	1.95±0.015	19.17±0.146
Zn-65	Blank	1.71±0,018	16.81±0.18
Cd-109	Blank	4.54±0.023	44.71±0.228
Cs-134	Blank	2.01±0.016	19.79±0.15
Cs-137	Blank	1.81±0.009	17.81±0.085
Pb-210	Blank	7.57±0.132	74.50±1.304
Am-241	Blank	3.58±0.023	35.22±0.222

#### 3.3.4. Reference time

The reference time for all activity concentrations is 1 January 2007.

## 4. PERFORMANCE CRITERIA

Several rating systems have been developed for determining a laboratory's performance and the meaning of the results of the different scoring systems are not always comparable. Among various statistics, z-scores and u-scores are most often used. The drawback of z-scores is that the uncertainty of the participant's measurement result is not taken into account for the evaluation of performance. In the case of u-scores, the evaluation includes uncertainties of the participant measurements and the standard uncertainty of the assigned value. Laboratories

performing well in classical proficiency testing (z-scores) will not necessarily exhibit the same level of performance when their analytical uncertainties are considered in the evaluation.

The proficiency testing scoring system applied by the Chemistry Unit in the Agency's laboratories takes into consideration the trueness and the precision of the reported data and it includes in the evaluation both the combined standard uncertainty associated with the target value of proficiency testing samples and the combined standard uncertainty laboratories. This approach is aligned with the new requirements of the (ISO/IEC 17025:2005) [2] which require that laboratories have to express their measurement uncertainty.

According to the newly adopted approach, the reported results are evaluated against the acceptance criteria for accuracy and precision and assigned the status 'acceptable' or 'not acceptable' accordingly. A result must pass both criteria to be assigned the final status of 'acceptable'. The advantage of this approach is that it checks the credibility of uncertainty statement given by the participating laboratories. Results are no longer compared against fixed criteria but participants establish their individual acceptance range on the basis of the uncertainties assigned to the values. Such an approach highlights not only methodological problems affecting the accuracy of the reported data but also identifies shortcomings in uncertainty estimation.

In addition, three other statistical parameters namely: relative bias, z-score and IAEA/Laboratory result ratio are calculated as complementary information for the participating laboratories.

#### 4.1. Relative bias

The first stage in producing a score for a result  $Value_{Analyst}$  (a single measurement of analyte concentration in a test material) is obtaining the estimate of the bias. To evaluate the bias of the reported results, the relative bias between the Analyst's value and the IAEA value is calculated and expressed as a percentage:

$$Relative\ bias = \frac{Value_{Analyst} - Value_{IAEA}}{Value_{IAEA}} \times 100\%$$

#### 4.2. PT evaluation criteria

The proficiency test results were evaluated against the acceptance criteria for trueness and precision and assigned the status 'acceptable', 'warning' or 'not acceptable' accordingly [4].

##### 4.2.1. Trueness

The participant result is assigned 'acceptable' status for trueness if:

$$A1 \leq A2$$

where:

$$A1 = |Value_{IAEA} - Value_{Analyst}|$$

$$A2 = 2.58 \times \sqrt{u_{IAEA}^2 + u_{Analyst}^2}$$

#### 4.2.2. Precision

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

$$P (\%) = \sqrt{\left(\frac{u_{IAEA}}{Value_{IAEA}}\right)^2 + \left(\frac{u_{Analyst}}{Value_{Analyst}}\right)^2} \times 100$$

P directly depends on the measurement uncertainty claimed by the participant. The Limit of Acceptable Precision (LAP) for each analyte respectively is defined for the respective proficiency test in advance, including any adjustment due to the concentration or activity level of the analytes concerned and the complexity of the analytical problem. Participants' results are scored as 'acceptable' for precision when  $P \leq LAP$ . The LAP value used in the evaluation of all radionuclides is listed in Table 4.

In the final evaluation, both scores for trueness and precision are combined. A result must obtain an 'acceptable' score in both criteria to be assigned the final score 'acceptable'. Obviously, if a score of 'not acceptable' was obtained for both trueness and precision, the final score will also be 'not acceptable'. In cases where either precision or trueness is 'not acceptable', a further check is applied. The reported result relative bias (R. Bias) is compared with the maximum acceptable bias (MAB). If  $R. Bias > MAB$ , the result will be 'not acceptable'. However, if  $R. Bias \leq MAB$ , the final score will be 'warning'. A 'warning' will reflect mainly two situations. The first situation will be a result with small measurement uncertainty; however its bias is still within MAB. The second situation will appear when results close to the assigned property value are reported, but the associated uncertainty is large. The MAB value used in the evaluation of all radionuclides is listed in Table 4.

If the evaluation approach and/or acceptance criteria applied in this PT are not appropriate for the types of analyses and application performed in one of the participating laboratories, it is suggested to apply a self-scoring evaluation system which could fit specific requirements.

#### 4.3. The z-score value

The z-score is calculated from the laboratory results, the assigned value and a standard deviation in accordance with the following equation:

$$z_{Score} = \frac{Value_{Analyst} - Value_{IAEA}}{\sigma}$$

On the basis of the 'fitness for purpose' principle, the target value for the standard deviation ( $\sigma$ ) is:

$$0.10 \times Value_{IAEA}$$

The laboratory performance is evaluated as satisfactory if  $|z \text{ Score}| \leq 2$ ; questionable for  $2 < |z \text{ Score}| < 3$ , and unsatisfactory for  $|z \text{ Score}| \geq 3$ .

#### 4.4. The u-score value

The value of the  $u_{test}$  was calculated according to the following equation [5]

$$u_{test} = \frac{|Value_{IAEA} - Value_{Analyst}|}{\sqrt{u_{IAEA}^2 + u_{Analyst}^2}}$$

TABLE 4: THE ACCEPTABLE LIMITS FOR LAP AND MAB USED FOR THE EVALUATION

Radionuclide	LAP (%)		MAB (%)	
	Samples 01, 03	Samples 04, 05	Samples 01, 03	Samples 04, 05
Mn-54	15	10	15	10
Co-60	15	10	15	10
Zn-65	15	10	15	10
Cd-109	20	15	20	15
Cs-134	15	10	15	10
Cs-137	15	10	15	10
Pb-210	25	25	25	25
Am-241	15	15	15	15

This value is compared with the critical value listed in the t-statistic tables to determine if the reported result differs significantly from the expected value at a given level of probability. The advantage of the  $u_{test}$  is that it takes into consideration the propagation of measurement uncertainties when defining the normalized error. This is especially useful when evaluating results, which uncertainty may overlap with the reference interval.

It should be noted that the choice of the significance level is subjective. For this proficiency test we have set the limiting value for the u-test parameter to 2.58 for a level of probability at 99% to determine if a result passes the test ( $u < 2.58$ ).

## 5. RESULTS AND DISCUSSION

### 5.1. General

162 measurement results were reported to the IAEA in this PT from 7 laboratories. The participants' data along with the statistical performance evaluation were compiled and presented in two tables which constitute an integral part of this report. Appendix I shows the data evaluation tables sorted by radionuclide.

Performance evaluation tables sorted by laboratory code are reported in Appendix II.

The proficiency test data evaluation has demonstrated that five of seven laboratories could produce analytical results within the acceptable limits set for this proficiency test. The analytical uncertainties associated with the results were, in general, appropriate for the analytes and matrices considered in the current proficiency test.

The overall evaluation showed that 67% of all reported results fulfilled the PT criteria for both trueness and precision. 24% of all reported results were not acceptable against the PT criteria.

The following figure reports the summary of the analytical data evaluation of this proficiency test. 67% of 162 measurement results were ‘acceptable’.

Table 5 reports the summary evaluation of the analytical results reported by participating laboratories in percentage for each nuclide.

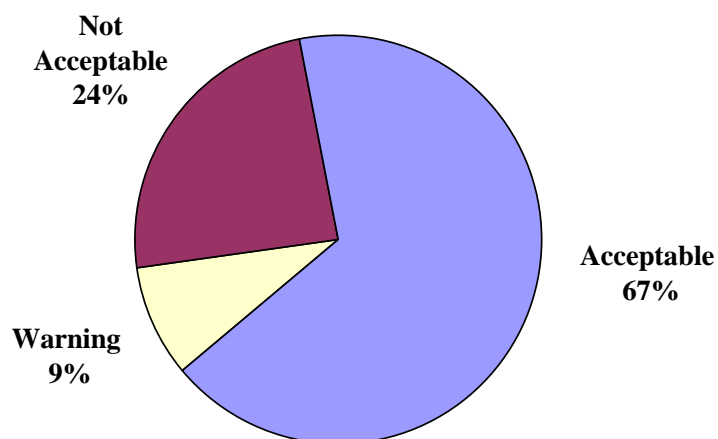


TABLE 5: SUMMARY EVALUATION OF THE ANALYTICAL RESULTS REPORTED BY PARTICIPATING LABORATORIES IN PERCENTAGE FOR EACH NUCLIDE

	Mn-54	Co-60	Zn-65	Cd-109	Cs-134	Cs-137	Pb-210	Am-241
Number of reported results	24	25	22	14	25	25	8	19
Acceptable (%)	75	68	55	72	68	48	100	79
Warning (%)	12,5	24	36	21	12	12	0	0
Not acceptable (%)	12,5	8	9	7	20	40	0	21

## 5.2. Recommendations to the participating laboratories

The results submitted by the laboratories were evaluated against the reference values; the uncertainties claimed by the laboratories were revised and taken into consideration during the evaluation. Due to the limited technical information provided by the participants about the details of their analytical procedure, it was not possible to define the detailed root causes of the discrepancies. Based on the results of this proficiency test, analysts could investigate their problems and take necessary remedial actions.

Upon a request for assistance on a specific issue, the proficiency test organizer could give technical advice which might help in resolving remaining issues. Therefore, it is recommended, later on, to confirm whether the participating laboratories have resolved the problem through another proficiency test.

### ***Laboratory No. 01***

The laboratory No. 01 reported results of 6 nuclides, Cd-109 and Pb-210 were not reported. In all samples the laboratory had a not acceptable score with a positive bias 20-83% for Cs-137, and 63-78% for Am-241 in water samples.

1,49 Bq/kg of Cs-137 was reported for the blank water sample, while the real value was below 0.5 Bq/kg.

### ***Laboratory No. 02***

The laboratory No. 02 reported results for all radionuclides.

All of the reported results obtained acceptable score for trueness criteria except Cs-137 in sample 03 and Zn-65 in sample 04. Not acceptable scores were assigned due to the low reported uncertainties. For example the reported uncertainty for Cs-137 in sample 03 was around 3.5% while the relative bias for this nuclide was around 15%.

A revision of the uncertainty budget is recommended. References [6, 7] could be a useful source of information.

The duplicate samples 04 and 05 were analysed with the gap of 4 days. However, the deviation between the results of these samples was acceptable and demonstrated an acceptable within laboratory reproducibility.

Although the laboratory demonstrated a good level, it is recommended to use water reference material for the validation and quality control.

The laboratory No. 02 reported zero results for the sample 02, which is the blank sample.

The Z-score evaluation was satisfactory for all radionuclides in all samples.

### ***Laboratory No. 03***

The laboratory No. 03 reported results for all radionuclides.

The laboratory demonstrated acceptable results for all nuclides in sample 01 (soil).

All reported results for spiked water samples were acceptable for the trueness criteria, excluding Cd-109 in sample 03, where the relatively high bias was obtained.

The final scores 'warning' and 'not acceptable' were assigned mainly due the reported comparatively high uncertainty, therefore a revision of the uncertainty budget is recommended. The values of each uncertainty component should be revised. References [6, 7] could be a useful source of information.

The duplicate samples 04 and 05 were analysed with the gap of 3 days. However, the deviation between the results of these samples was acceptable and demonstrated an acceptable within laboratory reproducibility except for Pb-210.

There is no score for the blank sample 02 since the reported values carry poor information due high uncertainty.

Laboratory 03 obtained acceptable Z-score for all of the results except for Cd-109 in sample 03 and Pb-210 in sample 05.

The results for all nuclides except for Pb-210 and Am-241 were reported below of target value, that indicate the possible errors in efficiency calibration of the detector

Although the laboratory demonstrated a satisfactory level, it is recommended to use water reference material for the validation and quality control.



#### ***Laboratory No. 04***

The laboratory No. 03 reported results for 5 radionuclides; Pb-210 and Am-241 were reported only for soil sample (with very high bias), but because the uncertainty was not reported – these results were not evaluated.

The laboratory No. 3 obtained the final warning score for Cs-134 in samples 01, 04 and 05. The rest results were evaluated as ‘not acceptable’ due to the high bias. The highest bias values (70-1800%) were obtained for Cs-137.

Uncertainty, values of 20% is reported for all results. Probably, uncertainties were not calculated according to normal procedure, but were assigned subjectively.

The laboratory reported extremely high Cs-137 result for the blank sample 02 (53.3 Bq/kg), while the real value was below 0.5 Bq/kg.

The Z-score evaluation of the laboratory 04 was not satisfactory for all reported results, except for Cs-134 in samples 01, 04 and 05

#### ***Laboratory No. 05***

The laboratory No. 05 reported results for 7 radionuclides; Pb-210 was not reported. The Cd-109 was not reported for the sample 03

The reported results for Cd-109 and Cs-137 in sample 01 had the high positive bias from the target values; the results for other nuclides were acceptable.

All of the reported results obtained acceptable score for trueness criteria in sample 03, but due to the overestimated uncertainty the final warning score was assigned for Co-60 and not acceptable final score was assigned for Am-241.

The high positive bias from the target value and high associated uncertainty were demonstrated for Cd-109 in samples 04 and 05, that has led to a not acceptable final score.

A systematic positive bias up to 41% is observed in Cd-109 results, root cause should be investigated.

The results of duplicate samples 04 and 05 were in good agreement and indicated an acceptable repeatability for all reported nuclides.

In general, a revision of the uncertainty budget is recommended. The values of each uncertainty component should be revised. References [6, 7] could be a useful source of information.

The laboratory did not report any value for the blank sample 02.

Laboratory 05 obtained acceptable Z-score for all of the results except for Cd-109.

#### ***Laboratory No. 06***

The laboratory No. 06 reported results for 7 radionuclides; Pb-210 was not reported. Also, the Cd-109, Pb-210, Am-241 and Zn-65 were not reported for the sample 03

All reported results of laboratory 06 were acceptable with regard to the trueness criteria. Few warning scores were obtained due to underestimated uncertainty. For example the reported uncertainty for Mn-54 in sample 01 was around 1.6%, while the relative bias for the same nuclide was around 10%, which indicates an underestimation of the combined standard uncertainty.

A revision of the uncertainty budget is recommended. The values of each uncertainty component should be revised. References [6, 7] could be a useful source of information.

Although the laboratory demonstrated a good level, it is recommended to choose the appropriate matrix reference material for the validation and quality control. The IAEA-375 is a soil RM and the best application of this RM is when analysing similar matrices.

The duplicate samples 04 and 05 were analysed with the gap of 3 days. However, the deviation between the results of these samples was acceptable and demonstrated an acceptable within laboratory reproducibility.

The laboratory reported results < MDA for the sample 02, which is the blank sample.

The Z-score evaluation was satisfactory for all radionuclides in all samples.

#### ***Laboratory No. 09***

The laboratory 09 received and analysed a soil sample.

The results for 5 radionuclides were reported; Cd-109, Pb-210 and Am-241 were not reported.

All of the reported results obtained acceptable score for trueness criteria except Co-60.

The bias of Co-60 was significant (24%). In this case root cause should be investigated.

The Z-score evaluation was satisfactory for all reported radionuclides except Co-60.

## **6. CONCLUSIONS**

Among the participating laboratories there were two laboratories which reported results for all radionuclides in all samples. One of these laboratories has demonstrated acceptable results for trueness and precision, other laboratory has reported results with acceptable trueness, but some results were reported with overestimated uncertainty.

Three more laboratories, in general, reported satisfactory results for trueness and precision.

One laboratory reported results with a high bias for Cs-137 and Am-241 and one laboratory reported all results with a high bias (except for Cs-134) and high uncertainty.

The largest number of not acceptable results were reported for Cs-137 (40%).

In all samples submitted for testing Cs-137 target value activity was ca.7% below of that for Cs-134. However, 70% of the reported by the laboratories values showed the opposite results.

One possible explanation of this fact may be inappropriate cascade summing correction for Cs-134 results used by the laboratories.

The results of testing could be much better, if the laboratories adequately estimated the measurement uncertainties.

It seems that correct estimation of combined uncertainty propagation of the measurements results is an issue for a number of laboratories.

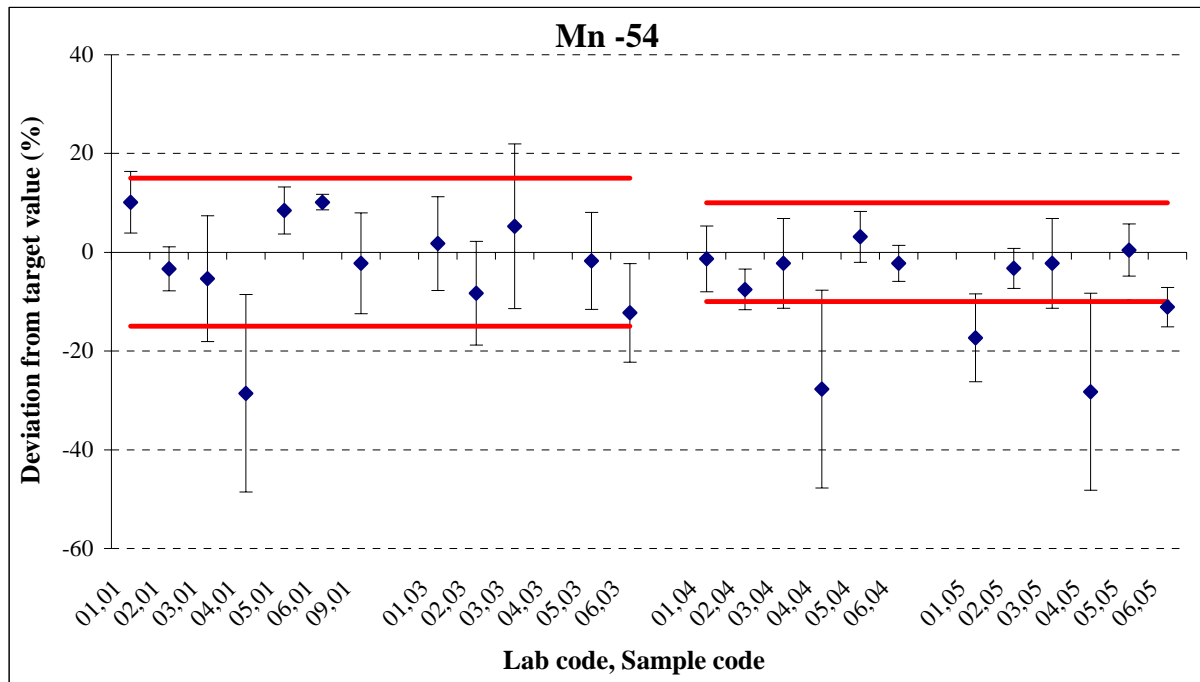


## Appendix I

### DATA EVALUATION TABLES SORTED BY RADIONUCLIDE

#### Data evaluation of Mn -54 in spiked soil and water

Figure A-01



#### Sample 01

Target value: 58,1 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 1,18 [Bq.kg<sup>-1</sup>]

	Laboratories results							Acceptance criteria					Final Score	
	Lab. Code	Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]					%	A1	A2	Score	P		Score
Sample 01	01	64,0	4,0	6,25	10,2	1,02	1,41	1,10	5,9	10,8	A	6,57	A	A
	02	56,2	2,5	4,45	-3,32	-0,33	0,70	0,97	1,93	7,13	A	4,89	A	A
	03	55,0	7,0	12,7	-5,34	-0,53	0,44	0,95	3,1	18,3	A	12,9	A	A
	04	41,5	8,3	20,0	-28,6	-2,86	1,98	0,71	16,6	21,6	A	20,1	N	N
	05	63,0	3,0	4,76	8,43	0,84	1,52	1,08	4,9	8,32	A	5,18	A	A
	06	64,0	1,0	1,56	10,2	1,02	3,81	1,10	5,9	3,99	N	2,56	A	W
	09	56,8	5,8	10,2	-2,24	-0,22	0,22	0,98	1,3	15,3	A	10,4	A	A

#### Sample 03

Target value: 1,14 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0,003 [Bq.kg<sup>-1</sup>]

	Laboratories results							Acceptance criteria					Final Score		
	Lab. Code	Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision					
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]					%	A1	A2	Score	P		Score	
Sample 03	01	1,16	0,11	9,48	1,75	0,18	0,18	1,02	0,02	0,284	A	9,49	A	A	
	02	1,05	0,11	10,5	-8,29	-0,83	0,86	0,92	0,09	0,284	A	10,5	A	A	
	03	1,20	0,20	16,7	5,26	0,53	0,30	1,05	0,06	0,516	A	16,7	N	W	
	04	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05	1,12	0,11	9,82	-1,75	-0,18	0,18	0,98	0,02	0,284	A	9,83	A	A	
	06	1,00	0,10	10,0	-12,3	-1,23	1,40	0,88	0,14	0,258	A	10,0	A	A	

**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

**Sample 04, 05**

Target value: 11,25 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0,032 [Bq.kg<sup>-1</sup>]

	Lab. Code	Laboratories results							Acceptance criteria					Final Score
		Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]					%	A1	A2	Score	P	Score	
Sample 04	01	11,1	0,74	6,67	-1,33	-0,13	0,20	0,99	0,15	1,91	A	6,67	A	A
	02	10,4	0,43	4,13	-7,53	-0,75	1,97	0,92	0,85	1,11	A	4,14	A	A
	03	11,0	1,00	9,09	-2,22	-0,22	0,25	0,98	0,25	2,58	A	9,10	A	A
	04	8,13	1,63	20,05	-27,73	-2,77	0,16	0,72	3,12	4,21	A	20,1	N	N
	05	11,6	0,60	5,17	3,11	0,31	0,58	1,03	0,35	1,55	A	5,18	A	A
	06	11,0	0,40	3,64	-2,22	-0,22	0,62	0,98	0,25	1,04	A	3,65	A	A
Sample 05	01	9,3	0,83	8,92	-17,33	-1,73	2,35	0,83	1,95	2,14	A	8,93	A	A
	02	10,9	0,44	4,04	-3,26	-0,33	0,83	0,97	0,37	1,14	A	4,05	A	A
	03	11,0	1,0	9,09	-2,22	-0,22	0,25	0,98	0,25	2,58	A	9,10	A	A
	04	8,1	1,61	19,95	-28,27	-2,83	0,16	0,72	3,18	4,15	A	20,0	N	N
	05	11,3	0,6	5,31	0,44	0,04	0,08	1,00	0,05	1,55	A	5,32	A	A
	06	10,0	0,4	4,00	-11,11	-1,11	3,12	0,89	1,25	1,04	N	4,01	A	W

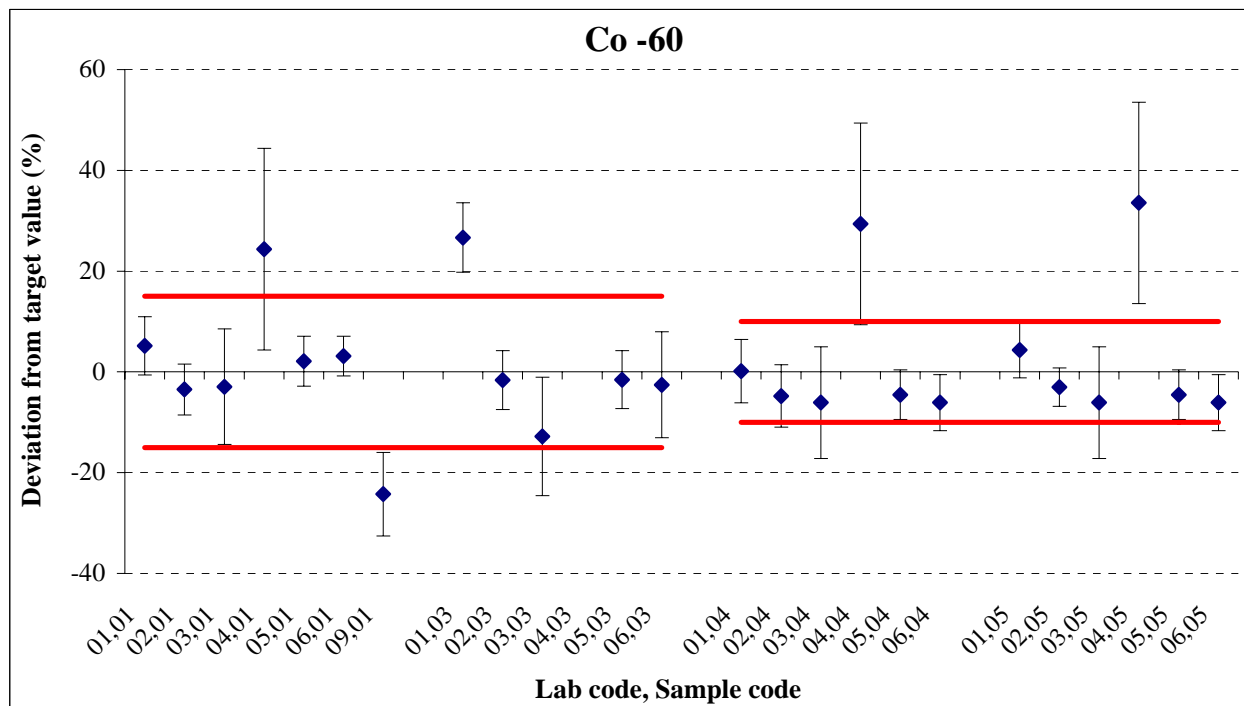
**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

## Data evaluation of Co -60 in spiked soil and water

Figure A-02



### Sample 01

Target value: 98,9 [Bq.kg<sup>-1</sup>]

Uncertainty: 2,40 [Bq.kg<sup>-1</sup>]

	Laboratories results								Acceptance criteria					Final Score
	Lab. Code	Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]					A1	A2	Score	P	Score		
Sample 01	01	104	6,0	5,8	5,2	0,52	0,79	1,1	5,1	16,7	A	6,26	A	A
	02	95,4	4,8	5,0	-3,5	-0,35	0,64	0,97	3,5	13,8	A	5,58	A	A
	03	96	11,0	11,5	-2,9	-0,29	0,26	1,0	2,9	29,0	A	11,7	A	A
	04	123	24,6	20,0	24,4	2,44	0,98	1,2	24,1	63,8	A	20,1	N	N
	05	101	5,0	5,0	2,1	0,21	0,38	1,02	2,1	14,3	A	5,51	A	A
	06	102	4,0	3,9	3,1	0,31	0,66	1,03	3,1	12,0	A	4,61	A	A
	09	74,9	6,2	8,3	-24,3	-2,43	3,61	0,8	24,0	17,2	N	8,63	A	N

### Sample 03

Target value: 1,95 [Bq.kg<sup>-1</sup>]

Uncertainty: 0,015 [Bq.kg<sup>-1</sup>]

	Laboratories results								Acceptance criteria					Final Score
	Lab. Code	Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]					A1	A2	Score	P	Score		
Sample 03	01	2,47	0,17	6,88	26,67	2,67	3,05	1,27	0,52	0,44	N	6,92	A	N
	02	1,92	0,11	5,84	-1,60	-0,16	0,28	0,98	0,031	0,3	A	5,89	A	A
	03	1,70	0,20	11,76	-12,82	-1,28	1,25	0,87	0,25	0,5	A	11,8	N	N
	04	3,75	0,75	20,00	92,31	-9,23	0,09	1,92	1,8	1,94	A	20,0	N	N
	05	1,92	0,11	5,73	-1,54	-0,15	0,27	0,98	0,03	0,29	A	5,78	A	A
	06	1,90	0,20	10,53	-2,56	-0,26	0,25	0,97	0,05	0,5	A	10,6	N	W

**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

**Sample 04, 05**

Target value: 19,17 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0,146 [Bq.kg<sup>-1</sup>]

	Lab. Code	Laboratories results						Acceptance criteria					Final Score	
		Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]					%	A1	A2	Score	P		Score
Sample 04	01	19,2	1,21	6,30	0,16	0,02	0,02	1,00	0,03	3,14	A	6,35	A	A
	02	18,3	1,13	6,19	-4,79	-0,48	0,81	0,95	0,92	2,94	A	6,24	A	A
	03	18,0	2,00	11,11	-6,10	-0,61	0,58	0,94	1,17	5,17	A	11,1	N	W
	04	24,8	4,96	20,00	29,37	2,94	0,28	1,29	5,63	12,8	A	20,0	N	N
	05	18,3	0,90	4,92	-4,54	-0,45	0,95	0,95	0,87	2,35	A	4,98	A	A
	06	18,0	1,00	5,56	-6,10	-0,61	1,16	0,94	1,17	2,61	A	5,61	A	A
Sample 05	01	20,0	1,1	5,50	4,33	0,43	0,75	1,04	0,83	2,86	A	5,55	A	A
	02	18,6	0,71	3,82	-3,03	-0,30	0,80	0,97	0,58	1,87	A	3,89	A	A
	03	18,0	2,0	11,11	-6,10	-0,61	0,58	0,94	1,17	5,17	A	11,1	N	W
	04	25,6	5,12	20,00	33,54	3,35	0,32	1,34	6,43	13,2	A	20,0	N	N
	05	18,3	0,9	4,92	-4,54	-0,45	0,95	0,95	0,87	2,35	A	4,98	A	A
	06	18,0	1	5,56	-6,10	-0,61	1,16	0,94	1,17	2,61	A	5,61	A	A

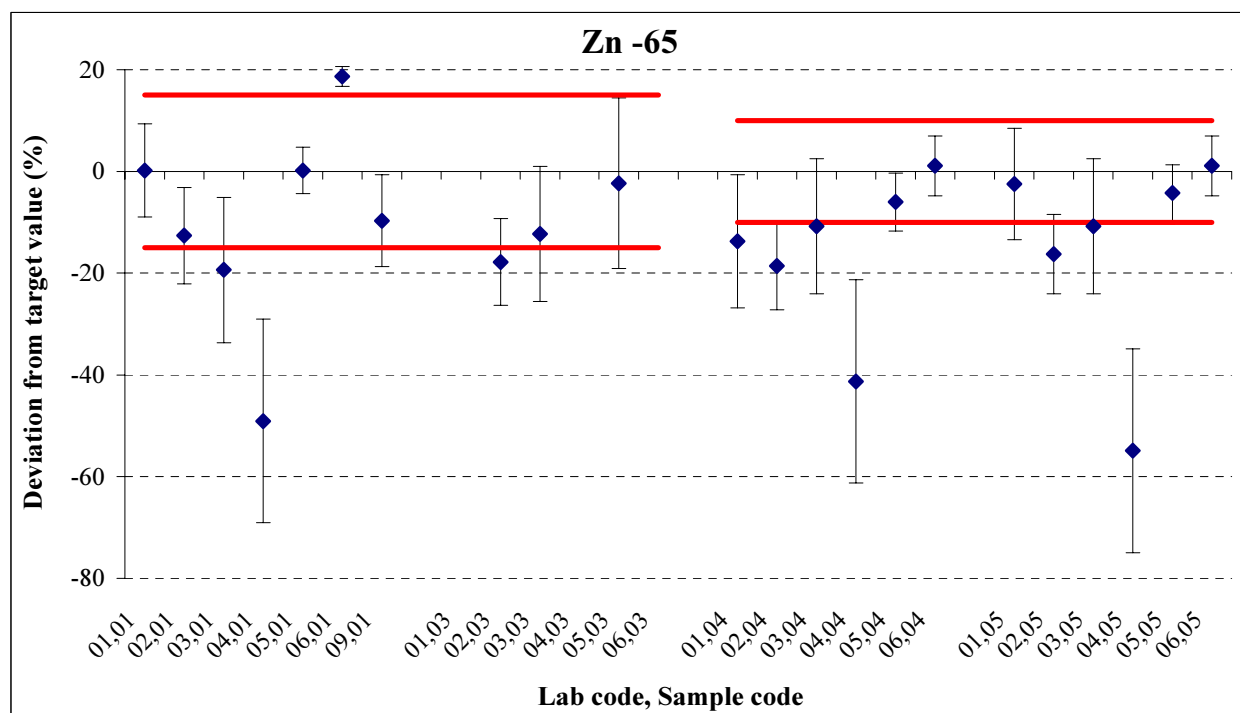
**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

## Data evaluation of Zn -65 in spiked soil and water

Figure A-03



### Sample 01

Target value: 86.8 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 2.85 [Bq.kg<sup>-1</sup>]

	Laboratories results							Acceptance criteria					Final Score	
	Lab. Code	Value [Bq.kg <sup>-1</sup> ]	Unc [Bq.kg <sup>-1</sup> ]	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
								A1	A2	Score	P	Score		
Sample 01	01	87	8	9.20	0.23	0.02	1.0	0.2	21.9	A	9.76	A	A	
	02	75.8	7.2	9.49	-12.62	-1.26	0.9	11.0	20.0	A	10.0	A	A	
	03	70	10	14.29	-19.35	-1.94	0.8	16.8	26.8	A	14.7	A	A	
	04	44.2	8.84	20.00	-49.08	-4.91	4.59	0.5	42.6	24.0	N	20.3	N	N
	05	87	4	4.60	0.23	0.02	0.04	1.0	0.2	12.7	A	5.65	A	A
	06	103	2	1.94	18.66	1.87	4.65	1.2	16.2	8.98	N	3.81	A	N
	09	78.4	7.1	9.06	-9.68	-0.97	1.10	0.9	8.4	19.7	A	9.63	A	A

### Sample 03

Target value: 1.71 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0.018 [Bq.kg<sup>-1</sup>]

	Laboratories results							Acceptance criteria					Final Score		
	Lab. Code	Value [Bq.kg <sup>-1</sup> ]	Unc [Bq.kg <sup>-1</sup> ]	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision					
								A1	A2	Score	P	Score			
Sample 03	01	≤0,44													
	02	1.41	0.12	8.5	-17.8	-1.78	2.51	0.8	0.30	0.31	A	8.60	A	A	
	03	1.50	0.20	13.3	-12.3	-1.23	1.05	0.9	0.21	0.5	A	13.4	N	N	
	04	-	-												
	05	1.67	0.28	16.8	-2.3	-0.23	0.14	0.98	0.04	0.72	A	16.8	N	W	
	06	<4,4													

**A: Acceptable**

**W: Warning**

**N: Not Acceptable**



**Sample 04, 05**

Target value: 16.81 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0.18 [Bq.kg<sup>-1</sup>]

	Lab. Code	Laboratories results						Acceptance criteria					Final Score	
		Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]					%	A1	A2	Score	P		Score
Sample 04	01	14.5	1.90	13.10	-13.74	-1.37	1.21	0.86	2.31	4.92	A	13.1	N	N
	02	13.7	1.18	8.62	-18.59	-1.86	2.62	0.81	3.13	3.08	N	8.69	A	N
	03	15.0	2.00	13.33	-10.77	-1.08	0.90	0.89	1.81	5.2	A	13.4	N	N
	04	9.9	1.97	19.96	-41.28	-4.13	0.35	0.6	6.94	5.1	N	20.0	N	N
	05	15.8	0.90	5.70	-6.01	-0.60	1.10	0.94	1.01	2.37	A	5.80	A	A
	06	17.0	1.00	5.88	1.13	0.11	0.19	1.01	0.19	2.62	A	5.98	A	A
Sample 05	01	16.4	1.8	10.98	-2.44	-0.24	0.23	0.98	0.41	4.67	A	11.0	N	W
	02	14.1	1.1	7.81	-16.27	-1.63	2.45	0.84	2.73	2.88	A	7.89	A	A
	03	15.0	2.0	13.33	-10.77	-1.08	0.90	0.89	1.81	5.2	A	13.4	N	N
	04	7.6	1.52	20.05	-54.91	-5.49	0.46	0.5	9.23	3.9	N	20.1	N	N
	05	16.1	0.9	5.59	-4.22	-0.42	0.77	0.96	0.71	2.37	A	5.69	A	A
	06	17.0	1	5.88	1.13	0.11	0.19	1.01	0.19	2.62	A	5.98	A	A

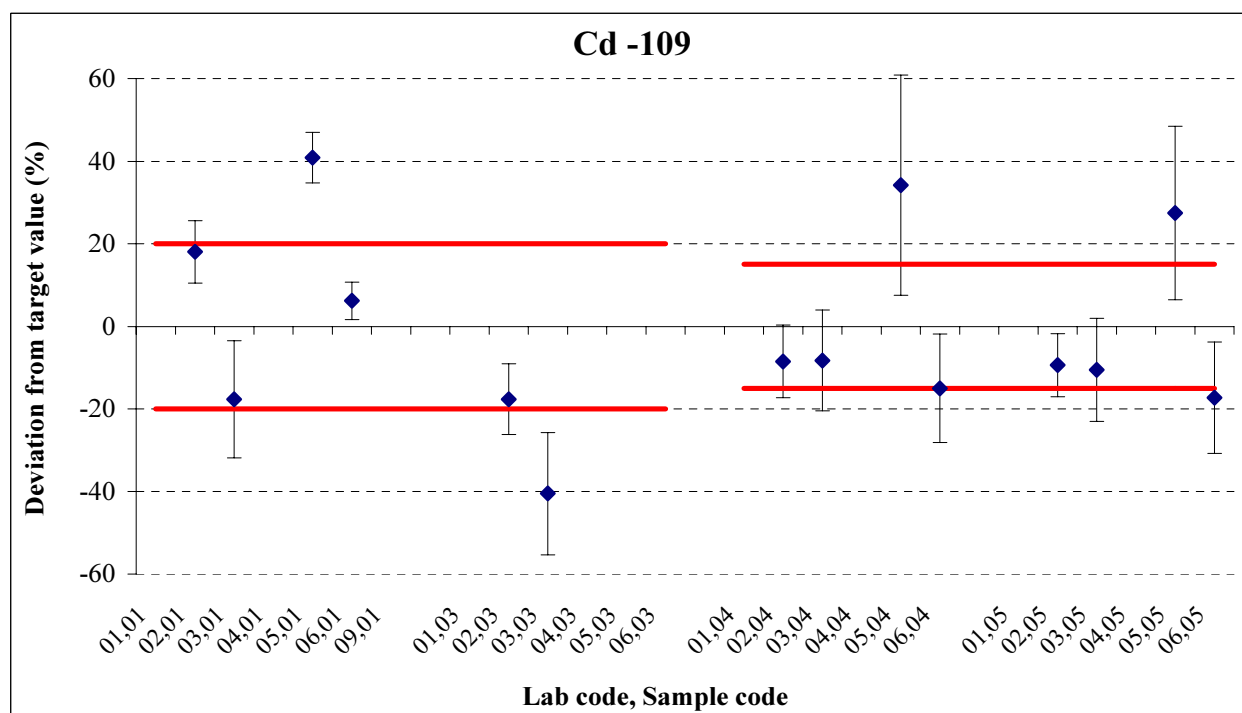
**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

## Data evaluation of Cd -109 in spiked soil and water

Figure A-04



### Sample 01

Target value: 230.7 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 4.79 [Bq.kg<sup>-1</sup>]

	Laboratories results							Acceptance criteria					Final Score	
	Lab. Code	Value [Bq.kg <sup>-1</sup> ]	Unc [Bq.kg <sup>-1</sup> ]	Bias, %	Z-score	U-score	Lab/IAEA	Trueness A1	A2	Score	Precision P	Score		
Sample 01	01	≤ 81												
	02	272.3	20.6	7.57	18.0	1.80	2.0	1.2	41.6	54.6	A	7.84	A	A
	03	190	27	14.2	-17.6	-1.76	1.5	0.8	40.7	70.7	A	14.4	A	A
	04	-	-											
	05	325	20	6.15	40.88	4.09	4.6	1.4	94.3	53.1	N	6.49	A	N
	06	245	11	4.49	6.20	0.62	1.2	1.06	14.3	31.0	A	4.95	A	A

### Sample 03

Target value: 4.54 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0.023 [Bq.kg<sup>-1</sup>]

	Laboratories results							Acceptance criteria					Final Score	
	Lab. Code	Value [Bq.kg <sup>-1</sup> ]	Unc [Bq.kg <sup>-1</sup> ]	Bias, %	Z-score	U-score	Lab/IAEA	Trueness A1	A2	Score	Precision P	Score		
Sample 03	01	≤ 9,2												
	02	3.74	0.32	8.56	-17.63	-1.76	2.5	0.82	0.80	0.83	A	8.57	A	A
	03	2.70	0.40	14.81	-40.53	-4.05	4.6	0.6	1.84	1.0	N	14.8	A	N
	04	-	-											
	05	-	-											
	06	<21												

**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

**Sample 04, 05**

Target value: 44.71 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0.228 [Bq.kg<sup>-1</sup>]

	Lab. Code	Laboratories results						Acceptance criteria					Final Score		
		Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision					
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]					%	A1	A2	Score	P		Score	
Sample 04	01	≤ 21													
	02	40.9	3.60	8.80	-8.47	-0.85	1.05	0.92	3.79	9.31	A	8.81	A	A	
	03	41.0	5.00	12.20	-8.30	-0.83	0.74	0.9	3.71	12.9	A	12.2	A	A	
	04	-	-												
	05	60.0	16.00	26.67	34.20	3.42	0.96	1.34	15.3	41.3	A	26.7	N	N	
	06	38.0	5.00	13.16	-15.01	-1.50	1.34	0.85	6.71	12.9	A	13.2	A	A	
Sample 05	01	≤ 14													
	02	40.5	3.09	7.63	-9.40	-0.94	1.36	0.91	4.20	8.00	A	7.65	A	A	
	03	40.0	5.0	12.50	-10.53	-1.05	0.94	0.9	4.71	12.9	A	12.5	A	A	
	04	-	-												
	05	57.0	12.0	21.05	27.49	2.75	1.02	1.27	12.3	31.0	A	21.1	N	N	
	06	37.0	5	13.51	-17.24	-1.72	1.54	0.83	7.71	12.9	A	13.5	A	A	

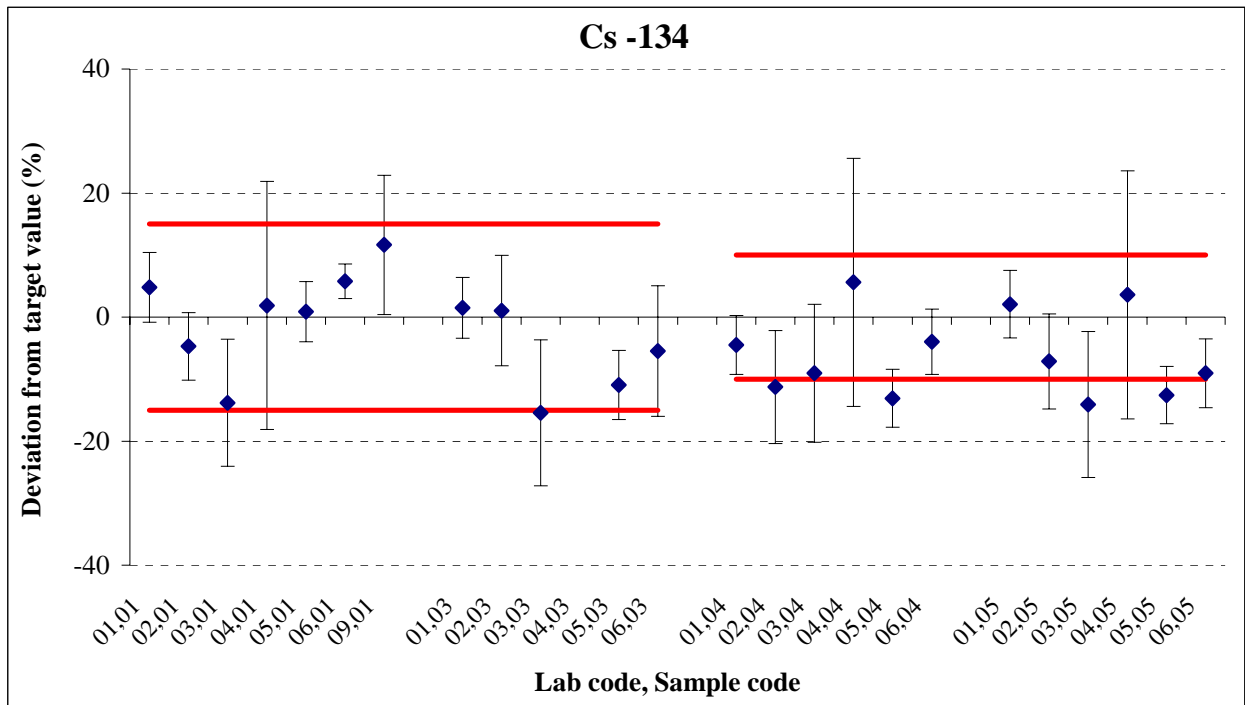
**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

## Data evaluation of Cs -134 in spiked soil and water

Figure A-05



### Sample 01

Target value: 102,1 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 2,97 [Bq.kg<sup>-1</sup>]

	Laboratories results							Acceptance criteria					Final Score	
	Lab. Code	Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]	%				A1	A2	Score	P	Score		
Sample 01	1	107	6	5,61	4,80	0,48	0,7	1,0	4,9	17,3	A	6,32	A	A
	2	97,3	5,3	5,45	-4,71	-0,47	0,8	1,0	4,81	15,7	A	6,18	A	A
	3	88	9	10,23	-13,81	-1,38	1,5	0,9	14,1	24,5	A	10,6	A	A
	4	104	20,8	20,00	1,86	0,19	0,1	1,0	1,9	54,2	A	20,2	N	W
	5	103	5	4,85	0,88	0,09	0,2	1,0	0,9	15,0	A	5,66	A	A
	6	108	3	2,78	5,78	0,58	1,40	1,1	5,9	10,9	A	4,02	A	A
	9	114	12,8	11,23	11,66	1,17	0,9	1,1	11,9	33,9	A	11,6	A	A

### Sample 03

Target value: 2,01 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0,015 [Bq.kg<sup>-1</sup>]

	Laboratories results							Acceptance criteria					Final Score	
	Lab. Code	Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]	%				A1	A2	Score	P	Score		
Sample 03	01	2,04	0,10	4,90	1,5	0,15	0,30	1,01	0,03	0,26	A	4,96	A	A
	02	2,03	0,18	8,9	1,0	0,10	0,11	1,01	0,02	0,47	A	8,94	A	A
	03	1,70	0,20	11,8	-15,4	-1,54	1,5	0,8	0,31	0,5	A	11,8	N	N
	04	3,47	0,69	20,0	72,6	-7,26	0,07	1,7	1,46	1,8	A	20,0	N	N
	05	1,79	0,10	5,59	-10,95	-1,09	2,17	0,89	0,22	0,3	A	5,64	A	A
	06	1,9	0,20	10,5	-5,5	-0,55	0,55	0,9	0,11	0,5	A	10,6	N	W

**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

**Sample 04, 05**

Target value: 19,79 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0,15 [Bq.kg<sup>-1</sup>]

	Lab. Code	Laboratories results						Acceptance criteria					Final Score	
		Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]					%	A1	A2	Score	P		Score
Sample 04	01	18,9	0,90	4,76	-4,50	-0,45	0,98	0,96	0,89	2,4	A	4,82	A	A
	02	17,6	1,60	9,11	-11,26	-1,13	1,39	0,89	2,23	4,15	A	9,14	A	A
	03	18,0	2,00	11,11	-9,04	-0,90	0,9	0,9	1,79	5,2	A	11,1	N	W
	04	20,9	4,18	20,00	5,61	0,56	0,1	1,1	1,11	10,8	A	20,0	N	W
	05	17,2	0,80	4,65	-13,09	-1,31	3,18	0,9	2,59	2,1	N	4,71	A	N
	06	19,0	1,00	5,26	-3,99	-0,40	0,78	1,0	0,79	2,6	A	5,32	A	A
Sample 05	01	20,2	1,1	5,45	2,07	0,21	0,37	1,02	0,41	2,9	A	5,50	A	A
	02	18,4	1,41	7,67	-7,14	-0,71	1,00	0,93	1,41	3,66	A	7,71	A	A
	03	17,0	2,0	11,76	-14,10	-1,41	1,4	0,9	2,79	5,2	A	11,8	N	N
	04	20,5	4,1	20,00	3,59	0,36	0,04	1,0	0,71	10,6	A	20,0	N	W
	05	17,3	0,8	4,62	-12,58	-1,26	3,06	0,9	2,49	2,1	N	4,69	A	N
	06	18,0	1	5,56	-9,04	-0,90	1,77	0,9	1,79	2,6	A	5,61	A	A

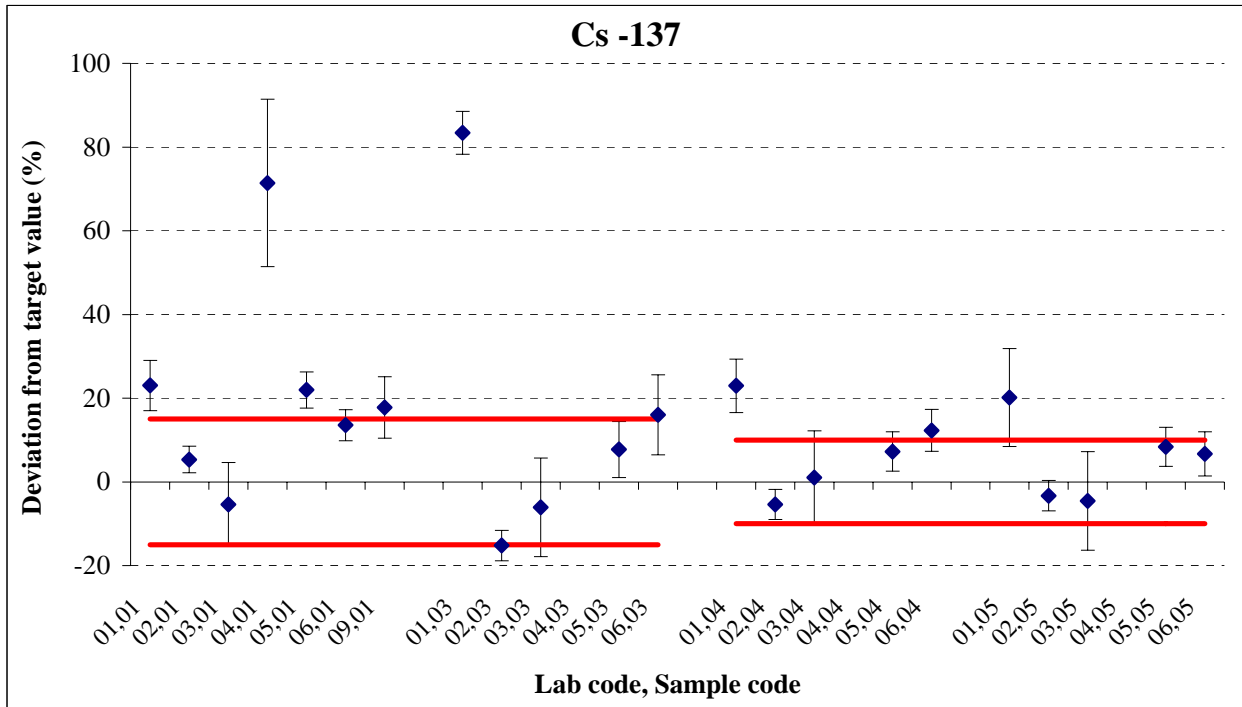
**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

## Data evaluation of Cs -137 in spiked soil and water

Figure A-06



### Sample 01

Target value: 95,1 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 1,86 [Bq.kg<sup>-1</sup>]

	Laboratories results								Acceptance criteria					Final Score
	Lab. Code	Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness	Precision		Score			
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]	%				A1	A2	P				
Sample 01	01	117	7	5,98	23,03	2,30	3,0	1,2	21,9	18,7	N	6,29	A	N
	02	100,2	3,2	3,19	5,34	0,53	1,4	1,1	5,08	9,55	A	3,75	A	A
	03	90	9	10,00	-5,36	-0,54	0,6	0,9	5,1	23,7	A	10,2	A	A
	04	163	32,6	20,00	71,40	7,14	2,1	1,7	67,9	84,2	A	20,1	N	N
	05	116	5	4,31	21,98	2,20	3,9	1,2	20,9	13,8	N	4,73	A	N
	06	108	4	3,70	13,56	1,36	2,9	1,1	12,9	11,4	N	4,19	A	W
	09	112	8,2	7,32	17,77	1,78	2,0	1,2	16,9	21,7	A	7,58	A	A

### Sample 03

Target value: 1,81 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0,009 [Bq.kg<sup>-1</sup>]

	Laboratories results								Acceptance criteria					Final Score
	Lab. Code	Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness	Precision		Score			
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]	%				A1	A2	P				
Sample 03	01	3,32	0,17	5,12	83,43	8,34	8,87	1,83	1,51	0,44	N	5,14	A	N
	02	1,53	0,06	3,65	-15,20	-1,52	4,85	0,85	0,28	0,15	N	3,68	A	N
	03	1,70	0,20	11,76	-6,08	-0,61	0,5	0,9	0,11	0,5	A	11,8	N	W
	04	35,60	7,12	20,00	1866,9	-187	1,7	19,7	33,8	18,4	N	20,0	N	N
	05	1,95	0,13	6,67	7,73	0,77	1,07	1,1	0,14	0,34	A	6,68	A	A
	06	2,1	0,20	9,52	16,02	1,60	1,4	1,2	0,29	0,5	A	9,54	A	A

A: Acceptable

W: Warning

N: Not Acceptable

**Sample 04, 05**

Target value: 17,81 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0,085 [Bq.kg<sup>-1</sup>]

	Lab. Code	Laboratories results						Acceptance criteria					Final Score	
		Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]					%	A1	A2	Score	P		Score
Sample 04	01	21,9	1,40	6,39	22,96	2,30	2,92	1,2	4,09	3,62	N	6,41	A	N
	02	16,9	0,61	3,62	-5,38	-0,54	1,56	0,95	0,96	1,59	A	3,65	A	A
	03	18,0	2,00	11,11	1,07	0,11	0,1	1,0	0,19	5,2	A	11,1	N	W
	04	52,8	10,60	20,08	196,46	19,6	1,7	3,0	34,99	27,3	N	20,1	N	N
	05	19,1	0,90	4,71	7,24	0,72	1,4	1,1	1,29	2,33	A	4,74	A	A
	06	20,0	1,00	5,00	12,30	1,23	2,2	1,1	2,19	2,59	A	5,02	A	A
Sample 05	01	21,4	2,5	11,68	20,16	2,02	1,44	1,2	3,59	6,45	A	11,7	N	N
	02	17,2	0,62	3,63	-3,30	-0,33	0,93	0,97	0,59	1,63	A	3,66	A	A
	03	17,0	2,0	11,76	-4,55	-0,45	0,4	1,0	0,81	5,2	A	11,8	N	W
	04	47,4	9,48	20,00	166,14	16,6	1,5	2,7	29,6	24,5	N	20,0	N	N
	05	19,3	0,9	4,66	8,37	0,84	1,6	1,1	1,49	2,33	A	4,69	A	A
	06	19,0	1	5,26	6,68	0,67	1,2	1,1	1,19	2,59	A	5,29	A	A

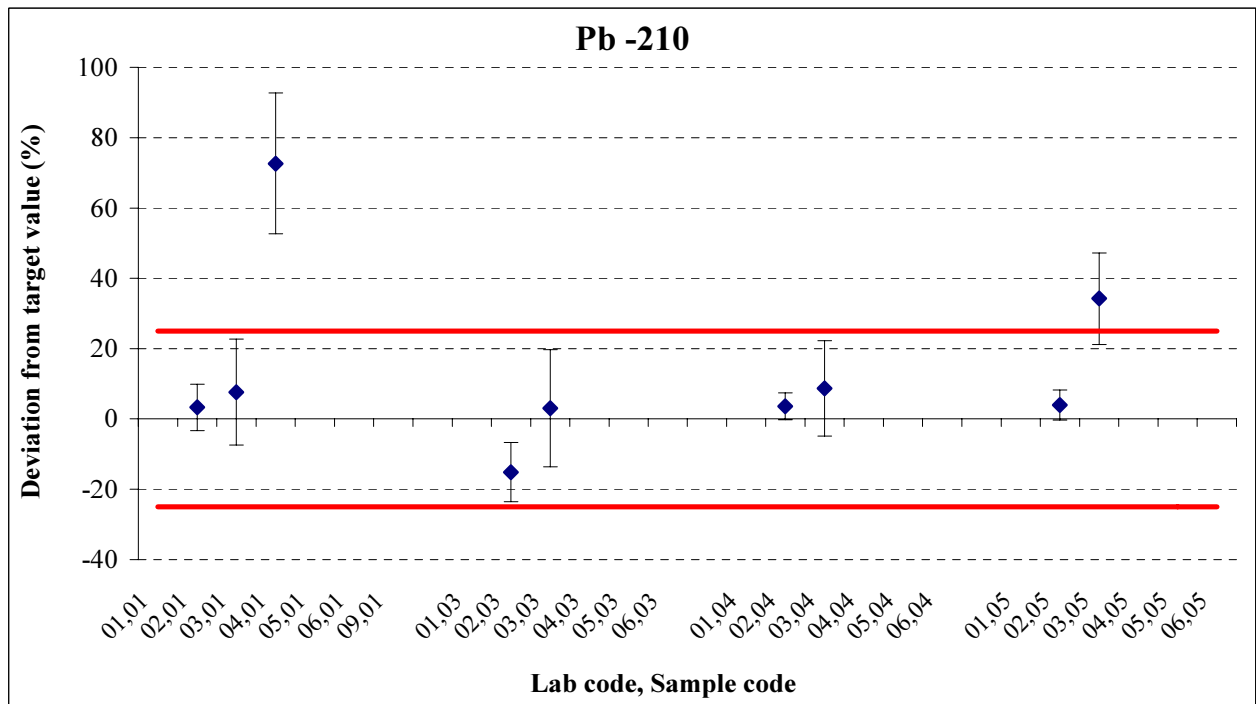
**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

## Data evaluation of Pb -210 in spiked soil and water

Figure A-07



### Sample 01

Target value: 436.7 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 18.8 [Bq.kg<sup>-1</sup>]

	Laboratories results							Acceptance criteria					Final Score
	Lab. Code	Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision			
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]	%				A1	A2	Score	P	Score	
Sample 01	01	≤ 265											
	02	451.0	29.9	6.63	3.28	0.33	0.4	1.0	14.3	91.1	A	7.90	A A
	03	470	71	15.11	7.63	0.76	0.5	1.1	33.3	189	A	15.7	A A
	04	754	150.8	20.00	72.66	7.27	2.1	1.7	317	392	A	20.5	A A
	05	-	-										
	06	-	-										
	09	-	-										

### Sample 03

Target value: 7.57 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0.132 [Bq.kg<sup>-1</sup>]

	Laboratories results							Acceptance criteria					Final Score
	Lab. Code	Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision			
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]	%				A1	A2	Score	P	Score	
Sample 03	01	≤ 34											
	02	6.42	0.54	8.45	-15.16	-1.52	2.05	0.85	1.15	1.44	A	8.63	A
	03	7.80	1.30	16.67	3.04	0.30	0.2	1.0	0.23	3.4	A	16.8	A
	04	-	-										
	05	-	-										
	06	-	-										

**A: Acceptable**

**W: Warning**

**N: Not Acceptable**



**Sample 04, 05**

Target value: 74.5 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 1.304 [Bq.kg<sup>-1</sup>]

	Lab. Code	Laboratories results						Acceptance criteria					Final Score	
		Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]					%	A1	A2	Score	P		Score
Sample 04	01	≤ 81												
	02	77.2	2.98	3.86	3.61	0.36	0.83	1.04	2.69	8.39	A	4.24	A	A
	03	81.0	11.00	13.58	8.72	0.87	0.6	1.1	6.5	28.6	A	13.7	A	A
	04	-	-											
	05	-	-											
	06	-	-											
Sample 05	01	≤ 55												
	02	77.4	3.30	4.26	3.95	0.39	0.83	1.04	2.94	9.14	A	4.60	A	A
	03	100.0	13.0	13.00	34.23	3.42	2.0	1.3	25.5	33.7	A	13.1	A	A
	04	-	-											
	05	-	-											
	06	-	-											

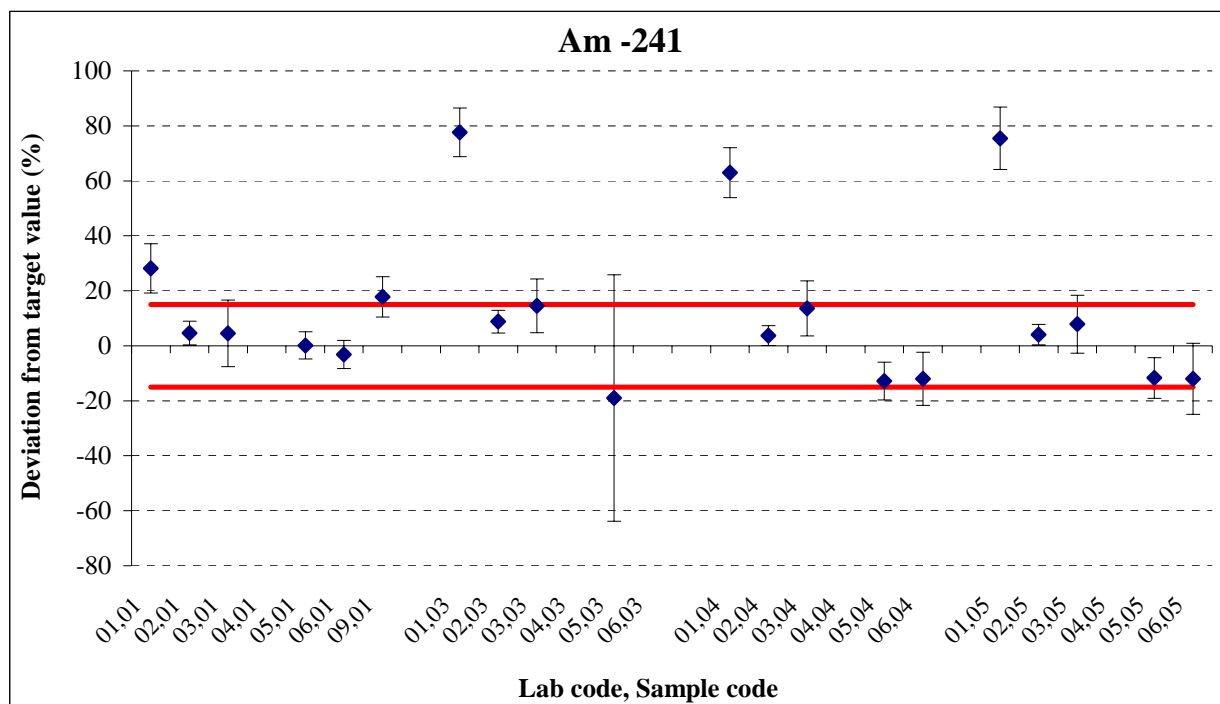
**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

## Data evaluation of Am -241 in spiked soil and water

Figure A-08



### Sample 01

Target value: 181,8 [Bq.kg<sup>-1</sup>]

Uncertainty: 5,22 [Bq.kg<sup>-1</sup>]

	Laboratories results								Acceptance criteria					Final Score
	Lab. Code	Value [Bq.kg <sup>-1</sup> ]	Unc [Bq.kg <sup>-1</sup> ]	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision				
								A1	A2	Score	P	Score		
Sample 01	01	233	21	9,01	<b>28,16</b>	2,82	2,4	1,3	51,2	55,8	A	9,46	A	A
	02	190,2	8,1	4,26	<b>4,64</b>	0,46	0,9	1,05	8,44	24,9	A	5,14	A	A
	03	190	23	12,11	<b>4,51</b>	0,45	0,3	1,0	8,2	60,8	A	12,4	A	A
	04	569	113,8	20,00	<b>212,98</b>	21,3	3,4	3,1	387	294	N	20,2	N	N
	05	182	9	4,95	<b>0,11</b>	0,01	0,0	1,0	0,2	26,8	A	5,72	A	A
	06	176	9	5,11	<b>-3,19</b>	-0,32	0,6	1,0	5,8	26,8	A	5,86	A	A
	09	112	8,2	7,32	<b>17,77</b>	1,78	2,0	1,2	16,9	21,7	A	7,58	A	A

### Sample 03

Target value: 3,58 [Bq.kg<sup>-1</sup>]

Uncertainty: 0,023 [Bq.kg<sup>-1</sup>]

	Laboratories results								Acceptance criteria					Final Score	
	Lab. Code	Value [Bq.kg <sup>-1</sup> ]	Unc [Bq.kg <sup>-1</sup> ]	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision					
								A1	A2	Score	P	Score			
Sample 03	01	6,36	0,56	8,81	77,65	7,77	4,96	1,78	2,78	1,45	N	8,83	A	N	
	02	3,90	0,16	4,16	8,80	0,88	1,92	1,09	0,32	0,42	A	4,21	A	A	
	03	4,10	0,40	9,76	14,53	1,45	1,3	1,1	0,52	1,0	A	9,78	A	A	
	04	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	05	2,90	1,30	44,83	-18,99	-1,90	0,5	0,81	0,68	3,35	A	44,8	N	N	
	06	<8,1	-	-	-	-	-	-	-	-	-	-	-	-	-

A: Acceptable

W: Warning

N: Not Acceptable

**Sample 04, 05**

Target value: 35,22 [Bq.kg<sup>-1</sup>]  
 Uncertainty: 0,222 [Bq.kg<sup>-1</sup>]

	Lab. Code	Laboratories results							Acceptance criteria					Final Score	
		Value	Unc	Bias, %	Z-score	U-score	Lab/IAEA	Trueness		Precision					
		[Bq.kg <sup>-1</sup> ]	[Bq.kg <sup>-1</sup> ]	%				A1	A2	Score	P	Score			
Sample 04	01	57,4	5,20	9,06	62,98	6,30	4,3	1,63	22,2	13,4	N	9,08	A	N	
	02	36,5	1,33	3,63	3,70	0,37	0,97	1,04	1,30	3,47	A	3,68	A	A	
	03	40,0	4,00	10,00	13,57	1,36	1,2	1,1	4,78	10,3	A	10,0	A	A	
	04	-	-												
	05	30,7	2,10	6,84	-12,83	-1,28	2,1	0,87	4,52	5,45	A	6,87	A	A	
	06	31,0	3,00	9,68	-11,98	-1,20	1,4	0,88	4,22	7,76	A	9,70	A	A	
Sample 05	01	61,8	7	11,33	75,47	7,55	3,8	1,75	26,6	18,1	N	11,3	A	N	
	02	36,6	1,37	3,73	4,06	0,41	1,03	1,04	1,43	3,58	A	3,79	A	A	
	03	38,0	4,0	10,53	7,89	0,79	0,7	1,1	2,78	10,3	A	10,5	A	A	
	04	-	-												
	05	31,1	2,3	7,40	-11,70	-1,17	1,8	0,88	4,12	5,96	A	7,42	A	A	
	06	31,0	4	12,90	-11,98	-1,20	1,1	0,88	4,22	10,3	A	12,9	A	A	

**A: Acceptable**

**W: Warning**

**N: Not Acceptable**

Appendix II

DATA EVALUATION TABLES SORTED BY LABORATORY CODE

Performance evaluation of laboratory No. 01

Radionuclides in spiked soil

*Reference date: 01 January 2007*

Sample 01	Analyte	IAEA		Laboratory		z-Score	U-test	Trueness		Acceptance criteria		Final score				
		Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]			A1	A2	Score	P		Score	P		
	<sup>54</sup> Mn	58,1	1,18	64	4	6,25	10,2	1,02	1,41	1,10	5,9	10,8	A	6,57	A	A
	<sup>60</sup> Co	98,9	2,40	104	6	5,77	5,16	0,52	0,79	1,05	5,1	16,7	A	6,26	A	A
	<sup>65</sup> Zn	86,8	2,85	87	8	9,20	0,23	0,02	0,02	1,00	0,2	21,9	A	9,76	A	A
	<sup>109</sup> Cd	230,7	4,79	≤ 81												
	<sup>134</sup> Cs	102,1	2,97	107	6	5,61	4,80	0,48	0,73	1,05	4,9	17,3	A	6,32	A	A
	<sup>137</sup> Cs	95,1	1,86	117	7	5,98	23,0	2,30	3,02	1,23	21,9	18,7	N	6,29	A	N
	<sup>210</sup> Pb	436,7	18,8	≤ 265												
	<sup>241</sup> Am	181,8	5,22	233	21	9,01	28,2	2,82	2,37	1,28	51,2	55,8	A	9,46	A	A

Performance evaluation of laboratory No. 01

Blank sample of water

Sample 02	Analyte	IAEA		Laboratory		z-Score	U-test	Trueness		Acceptance criteria		Final score					
		Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]			A1	A2	Score	P		Score	P			
	<sup>54</sup> Mn	blank		≤ 0,13												A	
	<sup>60</sup> Co	blank		≤ 0,15													A
	<sup>65</sup> Zn	blank		≤ 0,29													A
	<sup>109</sup> Cd	blank		≤ 7,9													A
	<sup>134</sup> Cs	blank		≤ 0,14													A
	<sup>137</sup> Cs	blank		1,49													N
	<sup>210</sup> Pb	blank		≤ 30													A
	<sup>241</sup> Am	blank		≤ 1,9													A

**Performance evaluation of laboratory No. 01  
Radionuclides in spiked water**

Sample 03	Laboratory														
	IAEA					Laboratory					Acceptance criteria				
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	R. bias %	z-Score	U-test	Lab./IAEA	Trueness A1	A2	Score	P	Score	Final score
<sup>54</sup> Mn	1,14	0,003	1,16	0,11	9,48	1,75	0,18	0,18	1,02	0,02	0,28	A	9,49	A	A
<sup>60</sup> Co	1,95	0,015	2,47	0,17	6,88	26,7	2,67	3,05	1,27	0,52	0,44	N	6,92	A	N
<sup>65</sup> Zn	1,71	0,018	≤ 0,44												
<sup>108</sup> Cd	4,54	0,023	≤ 9,2												
<sup>134</sup> Cs	2,01	0,015	2,04	0,1	4,90	1,49	0,15	0,30	1,01	0,03	0,26	A	4,96	A	A
<sup>137</sup> Cs	1,81	0,009	3,32	0,17	5,12	83,4	8,34	8,87	1,83	1,51	0,44	N	5,14	A	N
<sup>210</sup> Pb	7,57	0,132	≤ 34												
<sup>241</sup> Am	3,58	0,023	6,36	0,56	8,81	77,7	7,77	4,96	1,78	2,78	1,45	N	8,83	A	N

**Performance evaluation of laboratory No. 01  
Radionuclides in spiked water**

Sample 04	Laboratory														
	IAEA					Laboratory					Acceptance criteria				
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	R. bias %	z-Score	U-test	Lab./IAEA	Trueness A1	A2	Score	P	Score	Final score
<sup>54</sup> Mn	11,25	0,032	11,1	0,74	6,67	-1,33	-0,13	0,20	0,99	0,15	1,91	A	6,67	A	A
<sup>60</sup> Co	19,17	0,146	19,2	1,21	6,30	0,16	0,02	0,02	1,00	0,03	3,14	A	6,35	A	A
<sup>65</sup> Zn	16,81	0,18	14,5	1,9	13,1	-13,7	-1,37	1,21	0,86	2,31	4,92	A	13,1	N	N
<sup>108</sup> Cd	44,71	0,228	≤ 21												
<sup>134</sup> Cs	19,79	0,15	18,9	0,9	4,76	-4,50	-0,45	0,98	0,96	0,89	2,35	A	4,82	A	A
<sup>137</sup> Cs	17,81	0,085	21,9	1,4	6,39	23,0	2,30	2,92	1,23	4,09	3,62	N	6,41	A	N
<sup>210</sup> Pb	74,5	1,304	≤ 81												
<sup>241</sup> Am	35,22	0,222	57,4	5,2	9,06	63,0	6,30	4,26	1,63	22,18	13,4	N	9,08	A	N

**Performance evaluation of laboratory No. 01  
Radionuclides in spiked water**

Sample 05	IAEA										Laboratory				Acceptance criteria			
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	R. bias %	z-Score	U-test	Lab./IAEA	Trueness		Precision		Final score				
										A1	A2	Score	P		Score	P		
<sup>54</sup> Mn	11,25	0,032	9,3	0,83	8,92	-17,3	-1,73	2,35	0,83	1,95	2,1	A	8,93	A	A			
<sup>60</sup> Co	19,17	0,146	20	1,1	5,50	4,33	0,43	0,75	1,04	0,83	2,9	A	5,55	A	A			
<sup>65</sup> Zn	16,81	0,18	16,4	1,8	11,0	-2,44	-0,24	0,23	0,98	0,41	4,7	A	11,03	N	W			
<sup>109</sup> Cd	44,71	0,228	≤14															
<sup>134</sup> Cs	19,79	0,15	20,2	1,1	5,45	2,07	0,21	0,37	1,02	0,41	2,9	A	5,50	A	A			
<sup>137</sup> Cs	17,81	0,085	21,4	2,5	11,7	20,2	2,02	1,44	1,20	3,59	6,5	A	11,69	N	N			
<sup>210</sup> Pb	74,5	1,304	≤55															
<sup>241</sup> Am	35,22	0,222	61,8	7	11,3	75,5	7,55	3,80	1,75	26,58	18,1	N	11,34	A	N			

**Performance evaluation of laboratory No. 02  
Radionuclides in spiked soil**

**Sample 01**

Analyte	IAEA		Laboratory		U-test Lab./IAEA	z-Score	R. bias %	Uncert %	U-test Lab./IAEA	Acceptance criteria		Final score			
	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]						Trueness A1	Trueness A2		Score	P	Score
<sup>54</sup> Mn	58,1	1,18	56,2	2,5	0,97	-0,33	-3,32	4,45	0,70	1,93	7,13	A	4,89	A	A
<sup>60</sup> Co	98,9	2,40	95,4	4,8	0,97	-0,35	-3,50	5,03	0,64	3,46	13,8	A	5,58	A	A
<sup>65</sup> Zn	86,8	2,85	75,8	7,2	0,87	-1,26	-12,6	9,49	1,41	11,0	20,0	A	10,0	A	A
<sup>109</sup> Cd	230,7	4,79	272,3	20,6	1,18	1,80	18,0	7,57	1,97	41,6	54,6	A	7,84	A	A
<sup>134</sup> Cs	102,1	2,97	97,3	5,3	0,95	-4,71	-4,71	5,45	0,79	4,81	15,7	A	6,18	A	A
<sup>137</sup> Cs	95,1	1,86	100,2	3,2	1,05	0,53	5,34	3,19	1,37	5,08	9,55	A	3,75	A	A
<sup>210</sup> Pb	436,7	18,8	451,0	29,9	1,03	0,33	3,28	6,63	0,41	14,3	91,1	A	7,90	A	A
<sup>241</sup> Am	181,8	5,22	190,2	8,1	1,05	0,46	4,64	4,26	0,88	8,44	24,9	A	5,14	A	A

**Performance evaluation of laboratory No. 02  
Blank sample of water**

**Sample 02**

Analyte	IAEA		Laboratory		U-test Lab./IAEA	z-Score	R. bias %	Uncert %	U-test Lab./IAEA	Acceptance criteria		Final score
	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]						Trueness A1	Trueness A2	
<sup>54</sup> Mn	blank	-	0,00	-	-	-	-	-	-	-	-	A
<sup>60</sup> Co	blank	-	-0,06	-	-	-	-	-	-	-	-	A
<sup>65</sup> Zn	blank	-	0,00	-	-	-	-	-	-	-	-	A
<sup>109</sup> Cd	blank	-	0,00	-	-	-	-	-	-	-	-	A
<sup>134</sup> Cs	blank	-	0,00	-	-	-	-	-	-	-	-	A
<sup>137</sup> Cs	blank	-	-0,02	-	-	-	-	-	-	-	-	A
<sup>210</sup> Pb	blank	-	-0,05	-	-	-	-	-	-	-	-	A
<sup>241</sup> Am	blank	-	0,00	-	-	-	-	-	-	-	-	A

**Performance evaluation of laboratory No. 02**  
**Blank sample of water**

Sample 03	Laboratory														
	IAEA			Laboratory			U-test Lab./IAEA			Trueness		Acceptance criteria			
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	%	R. bias %	z-Score	U-test	A1	A2	Score	P	Score	Final score
<sup>54</sup> Mn	1,14	0,003	1,05	0,11	10,52	-8,29	-0,83	0,86	0,92	0,095	0,284	A	10,53	A	A
<sup>60</sup> Co	1,95	0,015	1,92	0,11	5,84	-1,6	-0,16	0,28	0,98	0,031	0,292	A	5,89	A	A
<sup>65</sup> Zn	1,71	0,018	1,41	0,12	8,54	-17,8	-1,78	2,51	0,82	0,304	0,313	A	8,60	A	A
<sup>109</sup> Cd	4,54	0,023	3,74	0,32	8,56	-17,6	-1,76	2,50	0,82	0,801	0,828	A	8,57	A	A
<sup>134</sup> Cs	2,01	0,015	2,03	0,18	8,90	1,03	0,10	0,11	1,01	0,021	0,468	A	8,94	A	A
<sup>137</sup> Cs	1,81	0,009	1,53	0,06	3,65	-15,2	-1,52	4,85	0,85	0,275	0,146	N	3,68	A	N
<sup>210</sup> Pb	7,57	0,132	6,42	0,54	8,45	-15,2	-1,52	2,05	0,85	1,147	1,442	A	8,63	A	A
<sup>241</sup> Am	3,58	0,023	3,90	0,16	4,16	8,8	0,88	1,92	1,09	0,315	0,422	A	4,21	A	A

**Performance evaluation of laboratory No. 02**  
**Radionuclides in spiked water**

Sample 04	Laboratory														
	IAEA			Laboratory			U-test Lab./IAEA			Trueness		Acceptance criteria			
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	%	R. bias %	z-Score	U-test	A1	A2	Score	P	Score	Final score
<sup>54</sup> Mn	11,25	0,032	10,40	0,43	4,13	-7,53	-0,75	1,97	0,92	0,85	1,11	A	4,14	A	A
<sup>60</sup> Co	19,17	0,146	18,25	1,13	6,19	-4,79	-0,48	0,81	0,95	0,92	2,94	A	6,24	A	A
<sup>65</sup> Zn	16,81	0,18	13,68	1,18	8,62	-18,6	-1,86	2,62	0,81	3,13	3,08	N	8,69	A	N
<sup>109</sup> Cd	44,71	0,228	40,92	3,60	8,80	-8,47	-0,85	1,05	0,92	3,79	9,31	A	8,81	A	A
<sup>134</sup> Cs	19,79	0,15	17,56	1,60	9,11	-11,3	-1,13	1,39	0,89	2,23	4,15	A	9,14	A	A
<sup>137</sup> Cs	17,81	0,085	16,85	0,61	3,62	-5,38	-0,54	1,56	0,95	0,96	1,59	A	3,65	A	A
<sup>210</sup> Pb	74,5	1,304	77,19	2,98	3,86	3,61	0,36	0,83	1,04	2,69	8,39	A	4,24	A	A
<sup>241</sup> Am	35,22	0,222	36,52	1,33	3,63	3,70	0,37	0,97	1,04	1,30	3,47	A	3,68	A	A



**Performance evaluation of laboratory No. 02  
Radionuclides in spiked water**

Sample 05	Laboratory										Acceptance criteria						
	IAEA		Value		Uncert		R. bias		z-Score		U-test Lab./IAEA		Trueness		Precision		Final score
	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	%	%			A1	A2	Score	P	Score		
<sup>54</sup> Mn	11,25	0,032	10,9	0,44	4,04	-3,26	-0,33	0,83	0,97	0,37	1,14	A	4,05	A	A		
<sup>60</sup> Co	19,17	0,146	18,6	0,71	3,82	-3,03	-0,30	0,80	0,97	0,58	1,87	A	3,89	A	A		
<sup>65</sup> Zn	16,81	0,18	14,1	1,10	7,81	-16,3	-1,63	2,45	0,84	2,73	2,88	A	7,89	A	A		
<sup>109</sup> Cd	44,71	0,228	40,5	3,09	7,63	-9,40	-0,94	1,36	0,91	4,20	8,00	A	7,65	A	A		
<sup>134</sup> Cs	19,79	0,15	18,4	1,41	7,67	-7,14	-0,71	1,00	0,93	1,41	3,66	A	7,71	A	A		
<sup>137</sup> Cs	17,81	0,085	17,2	0,62	3,63	-3,30	-0,33	0,93	0,97	0,59	1,63	A	3,66	A	A		
<sup>210</sup> Pb	74,5	1,304	77,4	3,30	4,26	3,95	0,39	0,83	1,04	2,94	9,14	A	4,60	A	A		
<sup>241</sup> Am	35,22	0,222	36,6	1,37	3,73	4,06	0,41	1,03	1,04	1,43	3,58	A	3,79	A	A		

**Performance evaluation of laboratory No. 03  
Radionuclides in spiked soil**

**Sample 01**

Analyte	IAEA		Laboratory		U-test Lab./IAEA	z-Score	R. bias %	Uncert %	Ucert [Bq/kg]	Value [Bq/kg]	Acceptance criteria				
	[Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]							Trueness		Precision		Final score
											A1	A2	Score	P	
<sup>54</sup> Mn	58,1	1,18	55,0	7	12,7	-5,34	-0,53	0,44	0,95	3,1	18,3	A	12,9	A	A
<sup>60</sup> Co	98,9	2,40	96,0	11	11,5	-2,93	-0,29	0,26	0,97	2,9	29,0	A	11,7	A	A
<sup>65</sup> Zn	86,8	2,85	70,0	10	14,3	-19,4	-1,94	1,62	0,81	16,8	26,8	A	14,7	A	A
<sup>109</sup> Cd	230,7	4,79	190,0	27	14,2	-17,6	-1,76	1,48	0,82	40,7	70,7	A	14,4	A	A
<sup>134</sup> Cs	102,1	2,97	88,0	9	10,2	-13,8	-1,38	1,49	0,86	14,1	24,5	A	10,6	A	A
<sup>137</sup> Cs	95,1	1,86	90,0	9	10,0	-5,36	-0,54	0,55	0,95	5,1	23,7	A	10,2	A	A
<sup>210</sup> Pb	436,7	18,8	470,0	71	15,1	7,63	0,76	0,45	1,08	33,3	189	A	15,7	A	A
<sup>241</sup> Am	181,8	5,22	190,0	23	12,1	4,51	0,45	0,35	1,05	8,2	60,8	A	12,4	A	A

**Performance evaluation of laboratory No. 03  
Blank sample of water**

**Sample 02**

Analyte	IAEA		Laboratory		U-test Lab./IAEA	z-Score	R. bias %	Uncert %	Ucert [Bq/kg]	Value [Bq/kg]	Acceptance criteria				
	[Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]							Trueness		Precision		Final score
											A1	A2	Score	P	
<sup>54</sup> Mn	blank		0,27	0,27	100										
<sup>60</sup> Co	blank		0,15	0,15	100										
<sup>65</sup> Zn	blank		0,69	0,69	100										
<sup>109</sup> Cd	blank		0,82	0,82	100										
<sup>134</sup> Cs	blank		0,2	0,2	100										
<sup>137</sup> Cs	blank		0,15	0,15	100										
<sup>210</sup> Pb	blank		1,31	1,31	100										
<sup>241</sup> Am	blank		0,53	0,53	100										

**Performance evaluation of laboratory No. 03  
Radionuclides in spiked water**

**Sample 03**

Analyte	IAEA				Laboratory				Acceptance criteria					
	Value	Uncert	Value	Uncert	Value	Uncert	R. bias	z-Score	U-test	Lab./IAEA	Trueness	Precision	Final score	
	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	%	%	%			A1	A2	P	Score	
<sup>54</sup> Mn	1,14	0,003	1,2	0,2	16,67	5,26	0,53	0,30	1,05	0,06	0,52	16,7	N	W
<sup>60</sup> Co	1,95	0,015	1,7	0,2	11,76	-12,8	-1,28	1,25	0,87	0,25	0,52	11,8	A	A
<sup>65</sup> Zn	1,71	0,018	1,5	0,2	13,33	-12,3	-1,23	1,05	0,88	0,21	0,52	13,4	A	A
<sup>109</sup> Cd	4,54	0,023	2,7	0,4	14,81	-40,5	-4,05	4,59	0,59	1,84	1,03	14,8	A	N
<sup>134</sup> Cs	2,01	0,015	1,7	0,2	11,76	-15,4	-1,54	1,55	0,85	0,31	0,52	11,8	A	A
<sup>137</sup> Cs	1,81	0,009	1,7	0,2	11,76	-6,08	-0,61	0,55	0,94	0,11	0,52	11,8	A	A
<sup>210</sup> Pb	7,57	0,132	7,8	1,30	16,67	3,04	0,30	0,18	1,03	0,23	3,37	16,8	A	A
<sup>241</sup> Am	3,58	0,023	4,1	0,40	9,76	14,5	1,45	1,30	1,15	0,52	1,03	9,78	A	A

**Performance evaluation of laboratory No. 03  
Radionuclides in spiked water**

**Sample 04**

Analyte	IAEA				Laboratory				Acceptance criteria					
	Value	Uncert	Value	Uncert	Value	Uncert	R. bias	z-Score	U-test	Lab./IAEA	Trueness	Precision	Final score	
	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	%	%	%			A1	A2	P	Score	
<sup>54</sup> Mn	11,25	0,032	11	1	9,09	-2,22	-0,22	0,25	0,98	0,25	2,58	9,10	A	A
<sup>60</sup> Co	19,17	0,146	18	2	11,1	-6,10	-0,61	0,58	0,94	1,17	5,17	11,1	N	W
<sup>65</sup> Zn	16,81	0,18	15	2	13,3	-10,8	-1,08	0,90	0,89	1,81	5,18	13,4	N	N
<sup>109</sup> Cd	44,71	0,228	41	5	12,2	-8,30	-0,83	0,74	0,92	3,71	12,9	12,2	A	A
<sup>134</sup> Cs	19,79	0,15	18	2	11,1	-9,04	-0,90	0,89	0,91	1,79	5,17	11,1	N	W
<sup>137</sup> Cs	17,81	0,085	18	2	11,1	1,07	0,11	0,09	1,01	0,19	5,16	11,1	N	W
<sup>210</sup> Pb	74,5	1,304	81	11	13,6	8,72	0,87	0,59	1,09	6,5	28,6	13,7	A	A
<sup>241</sup> Am	35,22	0,222	40	4	10,0	13,6	1,36	1,19	1,14	4,78	10,3	10,0	A	A

**Performance evaluation of laboratory No. 03  
Radionuclides in spiked water**

Sample 05	Laboratory										Acceptance criteria						
	IAEA		Value		Uncert		R. bias		z-Score		U-test Lab./IAEA		Trueness		Precision		Final score
	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	%	%	%	%	A1	A2	Score	P	Score			
<sup>54</sup> Mn	11,25	0,032	11	1	9,09	-2,22	-0,22	0,25	0,98	0,25	2,58	A	9,10	A	A		
<sup>60</sup> Co	19,17	0,146	18	2	11,1	-6,10	-0,61	0,58	0,94	1,17	5,17	A	11,1	N	W		
<sup>65</sup> Zn	16,81	0,18	15	2	13,3	-10,8	-1,08	0,90	0,89	1,81	5,18	A	13,4	N	N		
<sup>109</sup> Cd	44,71	0,228	40	5	12,5	-10,5	-1,05	0,94	0,89	4,71	12,9	A	12,5	A	A		
<sup>134</sup> Cs	19,79	0,15	17	2	11,8	-14,1	-1,41	1,39	0,86	2,79	5,17	A	11,8	N	N		
<sup>137</sup> Cs	17,81	0,085	17	2	11,8	-4,55	-0,45	0,40	0,95	0,81	5,16	A	11,8	N	W		
<sup>210</sup> Pb	74,5	1,304	100	13	13,0	34,2	3,42	1,95	1,34	25,5	33,7	A	13,1	A	A		
<sup>241</sup> Am	35,22	0,222	38	4	10,5	7,89	0,79	0,69	1,08	2,78	10,3	A	10,5	A	A		

**Performance evaluation of laboratory No. 04  
Radionuclides in spiked soil**

**Sample 01**

Analyte	IAEA		Laboratory		U-test Lab./IAEA	U-test	Acceptance criteria				Final score				
	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]			R. bias %	z-Score	Score	P		Score			
<sup>54</sup> Mn	58,1	1,18	41,5	8,3	0,71	1,98	-2,86	20	28,6	16,6	21,6	A	20,1	N	N
<sup>60</sup> Co	98,9	2,40	123	24,6	1,24	0,98	2,44	20	24,4	24,1	63,8	A	20,1	N	N
<sup>65</sup> Zn	86,8	2,85	44,2	8,84	0,51	4,59	-4,91	20	-49,1	42,6	24,0	N	20,3	N	N
<sup>109</sup> Cd	230,7	4,79													
<sup>134</sup> Cs	102,1	2,97	104	20,8	1,02	0,09	0,19	20	1,86	1,90	54,2	A	20,2	N	W
<sup>137</sup> Cs	95,1	1,86	163	32,6	1,71	2,08	7,14	20	71,4	67,9	84,2	A	20,1	N	N
<sup>210</sup> Pb	436,7	18,8	754												
<sup>241</sup> Am	181,8	5,22	569												

**Performance evaluation of laboratory No. 04  
Blank sample of water**

**Sample 02**

Analyte	IAEA		Laboratory		U-test Lab./IAEA	U-test	Acceptance criteria				Final score					
	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]			R. bias %	z-Score	Score	P		Score				
<sup>54</sup> Mn	blank															
<sup>60</sup> Co	blank															
<sup>65</sup> Zn	blank															
<sup>109</sup> Cd	blank															
<sup>134</sup> Cs	blank															
<sup>137</sup> Cs	blank		53,3	10,7				20								N
<sup>210</sup> Pb	blank															
<sup>241</sup> Am	blank															

**Performance evaluation of laboratory No. 04  
Radionuclides in spiked water**

Sample 03	Laboratory													
	IAEA					Acceptance criteria								
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Uncert %	R. bias %	z-Score	U-test Lab./IAEA	A1	A2	Score	P	Score	Final score	
<sup>54</sup> Mn	1,14	0,003					1,80	1,94	A	20,0	N	N		
<sup>60</sup> Co	1,95	0,015	3,75	0,75	20	92,3	-9,23	0,09	1,92	1,80	1,94	A	20,0	N
<sup>65</sup> Zn	1,71	0,018												
<sup>109</sup> Cd	4,54	0,023												
<sup>134</sup> Cs	2,01	0,015	3,47	0,694	20	72,6	-7,26	0,07	1,73	1,46	1,79	A	20,0	N
<sup>137</sup> Cs	1,81	0,009	35,6	7,12	20	1867	-187	1,69	19,7	33,8	18,4	N	20,0	N
<sup>210</sup> Pb	7,57	0,132												
<sup>241</sup> Am	3,58	0,023												

**Performance evaluation of laboratory No. 04  
Radionuclides in spiked water**

Sample 04	Laboratory													
	IAEA					Acceptance criteria								
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Uncert %	R. bias %	z-Score	U-test Lab./IAEA	A1	A2	Score	P	Score	Final score	
<sup>54</sup> Mn	11,25	0,032	8,13	1,63	20,0	-27,7	-2,77	0,16	0,72	3,12	4,2	A	20,1	N
<sup>60</sup> Co	19,17	0,146	24,8	4,96	20,0	29,4	2,94	0,28	1,29	5,63	12,8	A	20,0	N
<sup>65</sup> Zn	16,81	0,18	9,87	1,97	20,0	-41,3	-4,13	0,35	0,59	6,94	5,1	N	20,0	N
<sup>109</sup> Cd	44,71	0,228												
<sup>134</sup> Cs	19,79	0,15	20,9	4,18	20,0	5,61	0,56	0,06	1,06	1,11	10,8	A	20,0	N
<sup>137</sup> Cs	17,81	0,085	52,8	10,6	20,1	196	19,6	1,74	2,96	35,0	27,3	N	20,1	N
<sup>210</sup> Pb	74,5	1,304												
<sup>241</sup> Am	35,22	0,222												

**Performance evaluation of laboratory No. 04  
Radionuclides in spiked water**

Sample 05	Laboratory										Acceptance criteria				
	IAEA		Value		Uncert		R. bias		U-test Lab./IAEA		Trueness		Precision		Final score
	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	%	%	A1	A2	Score	P	Score		
<sup>54</sup> Mn	11,25	0,032	8,07	1,61	20,0	-28,3	-2,83	0,16	0,72	3,18	4,2	A	20,0	N	
<sup>60</sup> Co	19,17	0,146	25,6	5,12	20,0	33,5	3,35	0,32	1,34	6,43	13,2	A	20,0	N	
<sup>65</sup> Zn	16,81	0,18	7,58	1,52	20,1	-54,9	-5,49	0,46	0,45	9,23	3,9	N	20,1	N	
<sup>109</sup> Cd	44,71	0,228													
<sup>134</sup> Cs	19,79	0,15	20,5	4,10	20,0	3,59	0,36	0,04	1,04	0,71	10,6	A	20,0	W	
<sup>137</sup> Cs	17,81	0,085	47,4	9,48	20,0	166	16,6	1,48	2,66	29,6	24,5	N	20,0	N	
<sup>210</sup> Pb	74,5	1,304													
<sup>241</sup> Am	35,22	0,222													

**Performance evaluation of laboratory No. 05  
Radionuclides in spiked soil**

Sample 01	Laboratory														
	IAEA					Laboratory			Acceptance criteria						
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	R. bias %	z-Score	U-test	Lab./IAEA	Trueness A1	A2	Score	P	Score	Final score
<sup>54</sup> Mn	58,1	1,18	63	3	4,76	8,43	0,84	1,52	1,08	4,9	8,32	A	5,18	A	A
<sup>60</sup> Co	98,9	2,40	101	5	4,95	2,12	0,21	0,38	1,02	2,1	14,3	A	5,51	A	A
<sup>65</sup> Zn	86,8	2,85	87	4	4,60	0,23	0,02	0,04	1,00	0,2	12,7	A	5,65	A	A
<sup>109</sup> Cd	230,7	4,79	325	20	6,15	40,9	4,09	4,59	1,41	94,3	53,1	N	6,49	A	N
<sup>134</sup> Cs	102,1	2,97	103	5	4,85	0,88	0,09	0,15	1,01	0,9	15,0	A	5,66	A	A
<sup>137</sup> Cs	95,1	1,86	116	5	4,31	22,0	2,20	3,92	1,22	20,9	13,8	N	4,73	A	N
<sup>210</sup> Pb	436,7	18,8													
<sup>241</sup> Am	181,8	5,22	182	9	4,95	0,11	0,01	0,02	1,00	0,2	26,8	A	5,72	A	A

**Performance evaluation of laboratory No. 05  
Blank sample of water**

Sample 02	Laboratory														
	IAEA					Laboratory			Acceptance criteria						
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	R. bias %	z-Score	U-test	Lab./IAEA	Trueness A1	A2	Score	P	Score	Final score
<sup>54</sup> Mn	blank		-	-											
<sup>60</sup> Co	blank		-	-											
<sup>65</sup> Zn	blank		-	-											
<sup>109</sup> Cd	blank		-	-											
<sup>134</sup> Cs	blank		-	-											
<sup>137</sup> Cs	blank		-	-											
<sup>210</sup> Pb	blank		-	-											
<sup>241</sup> Am	blank		-	-											



**Performance evaluation of laboratory No. 05  
Radionuclides in spiked water**

**Sample 03**

Analyte	Laboratory										Acceptance criteria				
	IAEA					Laboratory					Precision				
	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	%	R. bias %	z-Score	U-test	Lab./IAEA	A1	A2	Score	P	Score	Final score
<sup>54</sup> Mn	1,14	0,003	1,12	0,11	9,82	-1,75	-0,18	0,18	0,98	0,02	0,28	A	9,83	A	A
<sup>60</sup> Co	1,95	0,015	1,92	0,11	5,73	-1,54	-0,15	0,27	0,98	0,03	0,29	A	5,78	A	A
<sup>65</sup> Zn	1,71	0,018	1,67	0,28	16,8	-2,34	-0,23	0,14	0,98	0,04	0,72	A	16,8	N	W
<sup>109</sup> Cd	4,54	0,023													
<sup>134</sup> Cs	2,01	0,015	1,79	0,1	5,59	-10,9	-1,09	2,17	0,89	0,22	0,26	A	5,64	A	A
<sup>137</sup> Cs	1,81	0,009	1,95	0,13	6,67	7,73	0,77	1,07	1,08	0,14	0,34	A	6,68	A	A
<sup>210</sup> Pb	7,57	0,132													
<sup>241</sup> Am	3,58	0,023	2,9	1,3	44,8	-19,0	-1,90	0,52	0,81	0,68	3,35	A	44,8	N	N

**Performance evaluation of laboratory No. 05  
Radionuclides in spiked water**

**Sample 04**

Analyte	Laboratory										Acceptance criteria				
	IAEA					Laboratory					Precision				
	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	%	R. bias %	z-Score	U-test	Lab./IAEA	A1	A2	Score	P	Score	Final score
<sup>54</sup> Mn	11,25	0,032	11,6	0,6	5,17	3,11	0,31	0,58	1,03	0,35	1,55	A	5,2	A	A
<sup>60</sup> Co	19,17	0,146	18,3	0,9	4,92	-4,54	-0,45	0,95	0,95	0,87	2,35	A	5,0	A	A
<sup>65</sup> Zn	16,81	0,18	15,8	0,9	5,70	-6,01	-0,60	1,10	0,94	1,01	2,37	A	5,8	A	A
<sup>109</sup> Cd	44,71	0,228	60	16	26,7	34,2	3,42	0,96	1,34	15,29	41,3	A	26,7	N	N
<sup>134</sup> Cs	19,79	0,15	17,2	0,8	4,65	-13,1	-1,31	3,18	0,87	2,59	2,10	N	4,7	A	N
<sup>137</sup> Cs	17,81	0,085	19,1	0,9	4,71	7,24	0,72	1,43	1,07	1,29	2,33	A	4,7	A	A
<sup>210</sup> Pb	74,5	1,304													
<sup>241</sup> Am	35,22	0,222	30,7	2,1	6,84	-12,8	-1,28	2,14	0,87	4,52	5,45	A	6,9	A	A

**Performance evaluation of laboratory No. 05  
Radionuclides in spiked water**

Sample 05	IAEA		Laboratory				Acceptance criteria								
	Value	Uncert	Value	Uncert	R. bias	z-Score	U-test	Lab./IAEA	Trueness		Precision		Final score		
	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	%	%		A1	A2	Score	P	Score			
<sup>54</sup> Mn	11,25	0,032	11,3	0,6	5,31	0,44	0,04	0,08	1,00	0,05	1,55	A	5,3	A	A
<sup>60</sup> Co	19,17	0,146	18,3	0,9	4,92	-4,54	-0,45	0,95	0,95	0,87	2,35	A	5,0	A	A
<sup>65</sup> Zn	16,81	0,18	16,1	0,9	5,59	-4,22	-0,42	0,77	0,96	0,71	2,37	A	5,7	A	A
<sup>109</sup> Cd	44,71	0,228	57	12	21,1	27,5	2,75	1,02	1,27	12,29	30,97	A	21,1	N	N
<sup>134</sup> Cs	19,79	0,15	17,3	0,8	4,62	-12,6	-1,26	3,06	0,87	2,49	2,10	N	4,7	A	N
<sup>137</sup> Cs	17,81	0,085	19,3	0,9	4,66	8,37	0,84	1,65	1,08	1,49	2,33	A	4,7	A	A
<sup>210</sup> Pb	74,5	1,304													
<sup>241</sup> Am	35,22	0,222	31,1	2,3	7,40	-11,7	-1,17	1,78	0,88	4,12	5,96	A	7,4	A	A

**Performance evaluation of laboratory No. 06  
Radionuclides in spiked soil**

**Sample 01**

Analyte	IAEA		Laboratory		U-test	Lab./IAEA	Acceptance criteria			Final score						
	Value	Uncert	Value	Uncert			R. bias	z-Score	Trueness		Precision					
	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]					A1		A2	Score	P	Score		
<sup>54</sup> Mn	58,1	1,18	64	1	1,56	10,2	satisf	3,81	1,10	5,9	3,99	N	2,56	A	W	
<sup>60</sup> Co	98,9	2,40	102	4	3,92	3,13	satisf	0,66	1,03	3,1	12,0	A	4,61	A	A	
<sup>65</sup> Zn	86,8	2,85	103	2	1,94	18,7	satisf	4,65	1,19	16,2	8,98	N	3,81	A	N	
<sup>109</sup> Cd	230,7	4,79	245	11	4,49	6,20	satisf	1,19	1,06	14,3	31,0	A	4,95	A	A	
<sup>134</sup> Cs	102,1	2,97	108	3	2,78	5,78	satisf	1,40	1,06	5,9	10,9	A	4,02	A	A	
<sup>137</sup> Cs	95,1	1,86	108	4	3,70	13,6	satisf	2,92	1,14	12,9	11,4	N	4,19	A	W	
<sup>210</sup> Pb	436,7	18,8														
<sup>241</sup> Am	181,8	5,22	176	9	5,11	-3,19	satisf	0,56	0,97	5,8	26,8	A	5,86	A	A	

**Performance evaluation of laboratory No. 06  
Blank sample of water**

**Sample 02**

Analyte	IAEA		Laboratory		U-test	Lab./IAEA	Acceptance criteria			Final score							
	Value	Uncert	Value	Uncert			R. bias	z-Score	Trueness		Precision						
	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]					A1		A2	Score	P	Score			
<sup>54</sup> Mn	blank	< 1,5														A	
<sup>60</sup> Co	blank	< 0,8															A
<sup>65</sup> Zn	blank	< 4,3															A
<sup>109</sup> Cd	blank	< 20															A
<sup>134</sup> Cs	blank	< 1,1															A
<sup>137</sup> Cs	blank	< 0,8															A
<sup>210</sup> Pb	blank																
<sup>241</sup> Am	blank	< 8,1															A

**Performance evaluation of laboratory No. 06  
Radionuclides in spiked water**

Sample 03	Laboratory														
	IAEA				Laboratory				Acceptance criteria						
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	U-test	R. bias %	z-Score	U-test Lab./IAEA	AI	A2	Score	P	Score	Final score
<sup>54</sup> Mn	1,14	0,003	1,0	0,1	10,0	-12,3	satisf	1,40	0,88	0,14	0,26	A	10,0	A	A
<sup>60</sup> Co	1,95	0,015	1,9	0,2	10,5	-2,56	satisf	0,25	0,97	0,05	0,52	A	10,6	A	A
<sup>65</sup> Zn	1,71	0,018	<4,4												
<sup>109</sup> Cd	4,54	0,023	<21												
<sup>134</sup> Cs	2,01	0,015	1,9	0,2	10,5	-5,47	satisf	0,55	0,95	0,11	0,52	A	10,6	A	A
<sup>137</sup> Cs	1,81	0,009	2,1	0,2	9,5	16,0	satisf	1,45	1,16	0,29	0,52	A	9,54	A	A
<sup>210</sup> Pb	7,57	0,132													
<sup>241</sup> Am	3,58	0,023	<8,1												

**Performance evaluation of laboratory No. 06  
Radionuclides in spiked water**

Sample 04	Laboratory														
	IAEA				Laboratory				Acceptance criteria						
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	U-test	R. bias %	z-Score	U-test Lab./IAEA	AI	A2	Score	P	Score	Final score
<sup>54</sup> Mn	11,25	0,032	11	0,4	3,64	-2,22	satisf	0,62	0,98	0,25	1,04	A	3,65	A	A
<sup>60</sup> Co	19,17	0,146	18	1	5,56	-6,10	satisf	1,16	0,94	1,17	2,61	A	5,61	A	A
<sup>65</sup> Zn	16,81	0,18	17	1	5,88	1,13	satisf	0,19	1,01	0,19	2,62	A	5,98	A	A
<sup>109</sup> Cd	44,71	0,228	38	5	13,2	-15,0	satisf	1,34	0,85	6,71	12,9	A	13,2	A	A
<sup>134</sup> Cs	19,79	0,15	19	1	5,26	-3,99	satisf	0,78	0,96	0,79	2,61	A	5,32	A	A
<sup>137</sup> Cs	17,81	0,085	20	1	5,00	12,3	satisf	2,18	1,12	2,19	2,59	A	5,02	A	A
<sup>210</sup> Pb	74,5	1,304													
<sup>241</sup> Am	35,22	0,222	31	3	9,68	-12,0	satisf	1,40	0,88	4,22	7,76	A	9,70	A	A

**Performance evaluation of laboratory No. 06  
Radionuclides in spiked water**

Sample 05	IAEA		Laboratory				Acceptance criteria								
	Value	Uncert	Value	Uncert	R. bias	z-Score	U-test	Lab./IAEA	Trueness		Precision		Final score		
	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	%	%			A1	A2	Score	P	Score		
<sup>54</sup> Mn	11,25	0,032	10	0,4	4,00	-11,1	satisf	3,12	0,89	1,25	1,04	N	4,01	A	W
<sup>60</sup> Co	19,17	0,146	18	1	5,56	-6,10	satisf	1,16	0,94	1,17	2,61	A	5,61	A	A
<sup>65</sup> Zn	16,81	0,18	17	1	5,88	1,13	satisf	0,19	1,01	0,19	2,62	A	5,98	A	A
<sup>109</sup> Cd	44,71	0,228	37	5	13,5	-17,2	satisf	1,54	0,83	7,71	12,9	A	13,5	A	A
<sup>134</sup> Cs	19,79	0,15	18	1	5,56	-9,04	satisf	1,77	0,91	1,79	2,61	A	5,61	A	A
<sup>137</sup> Cs	17,81	0,085	19	1	5,26	6,68	satisf	1,19	1,07	1,19	2,59	A	5,29	A	A
<sup>210</sup> Pb	74,5	1,304													
<sup>241</sup> Am	35,22	0,222	31	4	12,9	-12,0	satisf	1,05	0,88	4,22	10,34	A	12,9	A	A

**Performance evaluation of laboratory No. 09  
Radionuclides in spiked soil**

Sample 01	Laboratory													
	IAEA			U-test Lab./IAEA					Trueness			Acceptance criteria		
	Analyte	Value [Bq/kg]	Uncert [Bq/kg]	Value [Bq/kg]	Uncert [Bq/kg]	R. bias %	z-Score	U-test	A1	A2	Score	P	Score	Final score
<sup>54</sup> Mn	58,1	1,18	56,8	5,8	10,2	-2,24	-0,22	0,22	0,98	1,3	15,3	10,4	A	A
<sup>60</sup> Co	98,9	2,40	74,9	6,2	8,28	-24,3	-2,43	3,61	0,76	24	17,2	8,63	N	N
<sup>65</sup> Zn	86,8	2,85	78,4	7,1	9,06	-9,68	-0,97	1,10	0,90	8,4	19,7	9,63	A	A
<sup>109</sup> Cd	230,7	4,79												
<sup>134</sup> Cs	102,1	2,97	114	12,8	11,2	11,7	1,17	0,91	1,12	11,9	33,9	11,6	A	A
<sup>137</sup> Cs	95,1	1,86	112	8,2	7,32	17,8	1,78	2,01	1,18	16,9	21,7	7,58	A	A
<sup>210</sup> Pb	436,7	18,8												
<sup>241</sup> Am	181,8	5,22												



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