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Report

on the IAEA-CU-2006-08 Proficiency Test on the Determination of Gamma Emitting Radionuclides in Sea Water

Chemistry Unit, Seibersdorf, March 2007

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Department of Nuclear Sciences and Applications

Physics, Chemistry and Instrumentation Laboratory

Chemistry Unit

REPORT ON THE IAEA-CU-2006-08 PROFICIENCY TEST ON THE DETERMINATION OF GAMMA EMITTING RADIONUCLIDES IN SEA WATER

"Within the frame of the Radiation Measurements Cross Calibration Project for the Middle East"

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Seibersdorf, March 2007

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"**The Mission of the IAEA Department of Nuclear Sciences and Applications** is to contribute to sustainable development in Member States through the use of nuclear sciences and their applications in food and agriculture, human health, industry, water resources management, and environment monitoring, research and protection, with due regard to safety".

Executive summary

The Cooperative Monitoring Centre of Sandia National Laboratories of the United States (SNL) has initiated the Radiation Measurements Cross Calibration (RMCC) project. The RMCC aims to promote regional cooperation in the Middle East for preparedness for radiological emergencies. The International Atomic Energy Agency (IAEA) is cooperating with Sandia National Laboratories in this project.

On a practical level, the initial aim of the RMCC is to establish a network of experts to cooperatively standardize nuclear monitoring and measurement capabilities in the Middle East by applying internationally recognized standards for laboratory radiation measurements [1]. One of the project activities is to assist selected radiation measurement laboratories to participate in a quality assurance program and proficiency tests.

During the second Workshop of the RMCC Project, organised by Sandia National Laboratories in Doha, Qatar, 12-17 November 2005, it was agreed to request the Chemistry Unit at the Agency's Seibersdorf laboratories to organise a special Proficiency Test (PT) for participants, for gamma-emitters in sea water [2].

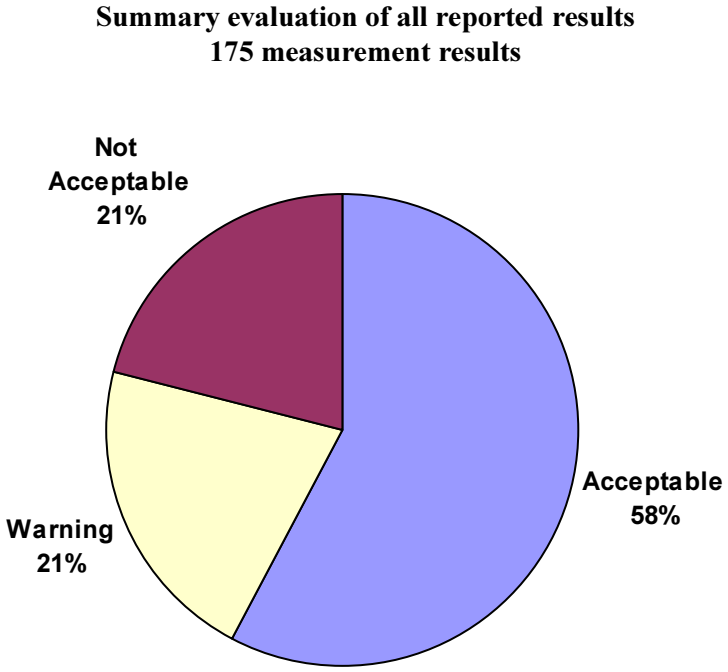
It is well known that proficiency testing is a method for regularly assessing the accuracy of the analytical data produced by the laboratories of particular measurements.

According to the requirements of the RMCC project the IAEA-CU-2006-08 proficiency test (PT) on the determination of gamma emitting radionuclides in sea water was conducted by the Chemistry Unit of the IAEA's Laboratories located in Seibersdorf (Austria). The Chemistry Unit is actively involved in the production and characterization of matrix reference materials of terrestrial origin, widely used for method validation and organization of proficiency tests and intercomparison studies. The Chemistry Unit is a part of the Physics, Chemistry and Instrumentation Laboratory.

This report describes the sample preparation methodology, data evaluation approach, summary evaluation of each nuclide and individual evaluation report for each laboratory.

In this PT 35 test samples (reference materials) were prepared and distributed to the participating laboratories in October 2006. The deadline for receiving the results from the participants was set at 15 December 2006. 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. Five laboratories 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. The proficiency test data evaluation has demonstrated that four of five 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. Only one laboratory reported relatively overestimated measurement uncertainty.

The following figure reports the summary of the analytical data evaluation of this proficiency test. 58 % of all reported results were “Acceptable”.



The following table reports the summary evaluation 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	25	25	25	16	25	29	10	20
Acceptable (%)	60	52	48	81	28	55	100	85
Warning (%)	16	28	32	6	20	28	0	10
Not Acceptable (%)	24	20	20	13	52	17	0	05

Acknowledgement

The participants and laboratories responded to this proficiency test and contributed their efforts to the present work are highly appreciated and acknowledged.

1. INTRODUCTION

Environmental radioactivity data may be the basis upon which economic, legal or environmental management decisions are made, and they are also essential in international trade, environmental protection, law enforcement, consumer safety and the protection 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 in different countries should yield traceable and comparable results.

With an objective to promote regional cooperation in the Middle East for preparedness for radiological emergencies the Cooperative Monitoring Centre of Sandia National Laboratories of the United States. (SNL) has initiated the Radiation Measurements Cross Calibration (RMCC) project. On a practical level, the initial aim of the RMCC is to establish a network of experts to cooperatively standardize nuclear monitoring and measurement capabilities in the Middle East by applying internationally recognized standards for laboratory radiation measurements [1]. The International Atomic Energy Agency (IAEA) is cooperating with Sandia National Laboratories in this project.

One of the project activities is to assist selected radiation measurement laboratories to participate in a quality assurance program and proficiency tests.

During the second Workshop of the RMCC Project, organised by Sandia National Laboratories in Doha, Qatar, 12-17 November 2005, it was agreed to request the Chemistry Unit at the Agency's Seibersdorf laboratories to organise a special PT for participants, for gamma-emitters in sea water [2].

According to the requirements of the RMCC project the IAEA-CU-2006-08 proficiency test (PT) on the determination of gamma emitting radionuclides in sea water was conducted by the Chemistry Unit of the IAEA's Seibersdorf Laboratories.

This document reports the execution of the IAEA-CU-2006-08 proficiency test, to assess the participating laboratories performance.

The main task of the participating laboratories was to identify and/or traceably quantify the activity levels of radionuclides present in the sea water samples. The tasks of the IAEA were to prepare and distribute the samples to the participating laboratories, to collect and interpret analysis results and to compile a comprehensive report.

The certified massic activity values of all radionuclides used in this PT were traceable to national standards of radioactivity. This traceability to national standards in turn is linked to an international level to the ultimate reference point of all measurements, the SI reference value maintained by the Bureau International des Poids et Mesures (BIPM).

2- MATERIALS AND METHODS

2.1 Proficiency test objectives

The measurement of sea water, containing a mixture of radionuclides with an unknown (to the participants) composition was aimed at (i) checking the accuracy and precision of the analytical results produced by the participating laboratories from the RMCC project, (ii) testing the regional comparability of radiological measurements and (iv) encouraging the participating laboratories to find remedial actions where shortcomings in analytical performance are detected.

2.2 Participants

Five laboratories reported their results to the IAEA. List of participants is given in Table 1.

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ROSE PRESTON, SONOYA SHANKS SANDIA NATIONAL LABORATORIES 1515 EUBANK S.E., BLDG. 957 ALBUQUERQUE, NM 87185-1103

Table 1: *List of participants*

2.3 Composition and preparation of proficiency test materials

The proficiency test materials set consisted of 6 samples each 1 L. The following proficiency test design was applied:

- one Irish sea water (sample code 01) at low activity. This sample was used as raw material to spike the test materials,
- duplicate spiked sea water samples (sample codes 02, 06),
- duplicate spiked sea water samples (sample codes 03, 05),
- one spiked demineralised water sample (sample code 04).

Table 3 lists the target values and the associated combined standard uncertainty of the PT set of materials.

2.3.1 Preparation of the spiked samples

The spiked sea water samples were gravimetrically prepared in two batches: one batch for samples 02 and 06 and one batch for samples 03 and 05. To prepare each batch 24 kg of acidified Irish sea water reference material IAEA-381 was spiked with a mixture of certified single radionuclide solutions traceable to a national standard of radioactivity. Then a pump with multiple outlets was used to homogenise the bulk water sample in a 50 L tank. The first batch was divided in two samples: 02 and 06, the second batch in samples 03 and 05. Four bottles from each batch were measured using gamma spectrometry in the Agency's Seibersdorf Laboratories to verify the homogeneity. Measurement results of homogeneity testing are presented in Table 2. The symbol R in the Table 2 represents the count per second per kg, u is the standard uncertainty and B is the between bottles relative standard deviation in percentage. The obtained between bottles variations are comparable to the method repeatability and therefore it can be concluded that the between bottles homogeneity is satisfactory.

Sample 04 was the same water sample used in the IAEA-CU-2006-03 world wide open PT. Sample 04 was prepared by spiking demineralised water

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 04 presents the identification of certified solutions used in this PT.

Figure 1 shows the PT materials set.

2.4 Reference time

The reference time for all activity concentrations is 1 October 2006.

Figure 1: A set of the PT material.

Table 2: *Summary results of homogeneity test measurements of eight sea water samples with two different detectors. The results R were reported in counts-per-second per kilogram (cps/kg) on 2006-08-14. The symbol B refers to the between bottles relative standard deviation [3].*

Batch No.	Sample ID	R (cps/kg)	u(R) (cps/kg)	u(R)/R	B
Mn-54, 835 keV					
1	03-11	0.2201	0.0068	3.1%	
1	03-12	0.2020	0.0069	3.4%	
1	05-11	0.2197	0.0068	3.1%	
1	05-12	0.2078	0.0066	3.2%	4.2%
2	02-11	0.1285	0.0054	4.2%	
2	02-12	0.1391	0.0056	4.0%	
2	06-11	0.1414	0.0057	4.0%	
2	06-12	0.1374	0.0056	4.1%	4.1%
Co-60, 1173 keV					
1	03-11	0.2089	0.0061	2.9%	
1	03-12	0.2184	0.0059	2.7%	
1	05-11	0.2090	0.0059	2.8%	
1	05-12	0.1983	0.0059	3.0%	3.9%
2	02-11	0.1350	0.0049	3.6%	
2	02-12	0.1337	0.0020	1.5%	
2	06-11	0.1391	0.0049	3.5%	
2	06-12	0.1393	0.0050	3.6%	2.1%
Co-60, 1333 keV					
1	03-11	0.2159	0.0056	2.6%	
1	03-12	0.1996	0.0056	2.8%	
1	05-11	0.1944	0.0054	2.8%	
1	05-12	0.1954	0.0055	2.8%	5.0%
2	02-11	0.1232	0.0043	3.5%	
2	02-12	0.1287	0.0045	3.5%	
2	06-11	0.1272	0.0046	3.6%	
2	06-12	0.1314	0.0046	3.5%	2.7%
Zn-65, 1116 keV					
1	03-11	0.1293	0.0056	4.3%	
1	03-12	0.1345	0.0055	4.1%	
1	05-11	0.1410	0.0055	3.9%	
1	05-12	0.1274	0.0052	4.1%	4.6%
2	02-11	0.0807	0.0045	5.6%	
2	02-12	0.0827	0.0045	5.4%	
2	06-11	0.0738	0.0045	6.1%	
2	06-12	0.0859	0.0047	5.5%	6.3%

Batch No.	Sample ID	R (cps/kg)	u(R) (cps/kg)	u(R)/R	B
Cd-109, 88 keV					
1	03-11	0.1409	0.0080	5.7%	
1	03-12	0.1417	0.0081	5.7%	
1	05-11	0.1470	0.0082	5.6%	
1	05-12	0.1324	0.0074	5.6%	4.3%
2	02-11	0.0858	0.0088	10.2%	
2	02-12	0.0923	0.0070	7.6%	
2	06-11	0.1044	0.0071	6.8%	
2	06-12	0.0889	0.0085	9.6%	8.8%
Cs-134, 605 keV					
1	03-11	0.3370	0.0081	2.4%	
1	03-12	0.3419	0.0085	2.5%	
1	05-11	0.3260	0.0085	2.6%	
1	05-12	0.3401	0.0085	2.5%	2.1%
2	02-11	0.2050	0.0055	2.7%	
2	02-12	0.2102	0.0071	3.4%	
2	06-11	0.1978	0.0067	3.4%	
2	06-12	0.2159	0.0069	3.2%	3.7%
Cs-134, 796 keV					
1	03-11	0.2595	0.0062	2.4%	
1	03-12	0.2534	0.0061	2.4%	
1	05-11	0.2478	0.0059	2.4%	
1	05-12	0.2477	0.0059	2.4%	2.2%
2	02-11	0.1522	0.0047	3.1%	
2	02-12	0.1592	0.0049	3.1%	
2	06-11	0.1518	0.0049	3.2%	
2	06-12	0.1526	0.0049	3.2%	2.3%
Cs-137, 662 keV					
1	03-11	0.2684	0.0070	2.6%	
1	03-12	0.2740	0.0071	2.6%	
1	05-11	0.2635	0.0069	2.6%	
1	05-12	0.2493	0.0067	2.7%	4.0%
2	02-11	0.1664	0.0055	3.3%	
2	02-12	0.1697	0.0056	3.3%	
2	06-11	0.1569	0.0055	3.5%	
2	06-12	0.1756	0.0061	3.5%	4.7%
Pb-210, 46 keV					
1	03-11	0.2149	0.0084	3.9%	
1	03-12	0.2178	0.0085	3.9%	
1	05-11	0.2084	0.0085	4.1%	
1	05-12	0.2054	0.0078	3.8%	2.7%

Batch No.	Sample ID	R (cps/kg)	u(R) (cps/kg)	u(R)/R	B
Pb-210, 46 keV					
2	02-11	0.1387	0.0086	6.2%	
2	02-12	0.1192	0.0073	6.1%	
2	06-11	0.1575	0.0076	4.8%	
2	06-12	0.1487	0.0098	6.6%	3.9%
Am-241, 60 keV					
1	03-11	0.912	0.013	1.4%	
1	03-12	0.920	0.014	1.5%	
1	05-11	0.901	0.014	1.6%	
1	05-12	0.879	0.012	1.4%	2.0%
2	02-11	0.580	0.013	2.3%	
2	02-12	0.579	0.010	1.8%	
2	06-11	0.584	0.011	1.8%	
2	06-12	0.578	0.013	2.3%	0.5%

Radionuclide	Sample 01 IAEA-381	Sea water samples 02 and 06	Sea water samples 03 and 05	Demineralised water sample 04
	$Bq.kg^{-1}$	$Bq.kg^{-1}$	$Bq.kg^{-1}$	$Bq.kg^{-1}$
Mn-54	-	6.94±0.02	11.56±0.04	3.73±0.02
Co-60	-	9.96±0.06	16.60±0.13	5.55±0.06
Zn-65	-	10.97±0.10	18.28±0.19	5.14±0.10
Cd-109	-	25.79±0.11	42.97±0.21	16.34±0.11
Cs-134	-	10.82±0.07	18.03±0.14	11.65±0.07
Cs-137	0.36±0.03	9.48±0.04	15.00±0.07	16.59±0.04
Pb-210	-	37.73±0.47	62.87±0.95	9.45±0.47
Am-241	-	17.71±0.09	29.51±0.18	3.66±0.09

Table 3: *Shows the target values and the associated combined standard uncertainty of the proficiency test samples.*

For all samples the reference date is 1 October 2006, the combined standard uncertainty is expressed at 1σ level.

Analyte	Identification. of the certified solutions used for spiking water samples
Mn-54	AMERSHAM: MFZ64; NO S3/28/12
Co-60	CERCA-LEA FRAMATOME: CO60-ELSB50; NO 72452
Zn-65	CERCA-LEA FRAMATOME: ZN65-ELSB50; NO 7020
Cd-109	AMERSHAM: CUZ64;NO S3/36/23
Cs-134	CERCA-LEA FRAMATOME: CS134-ELSB50; NO 70823
Cs-137	AMERSHAM: CDZ64; NO S4/14/70
Pb-210	AEA Technology RBZB44; NO KE 800
Am-241	CERCA-LEA FRAMATOME: AM241-ELSB30; NO 5104

Table 4: *Shows the identification of the certified solutions used in this PT is shown for each radionuclide*.

3. PERFORMANCE CRITERIA

Currently most laboratories produce test results accompanied, at best, with an indication of their repeatability only and provide no indication of their analytical uncertainty. However, testing laboratories intending to follow international best practice will need to quantify and report their measurement uncertainty. In particular, this is a requirement under international standard ISO/IEC 17025:2005 [4].

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 in the evaluation of performance. In the case of u-scores, the evaluation includes uncertainties of the participant measurements and the 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 reported by the participating laboratories. 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 the 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.

3.1 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:

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

3.2 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 [5].

3.2.1 Trueness

The participant result is assigned "Acceptable" status for trueness if:

$$A1 \leq A2$$

where:

$$A1 = \left| Value_{IAEA} - Value_{Analyst} \right|$$

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

3.2.2 Precision

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

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

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 ≤ LAP. The LAP value used in the evaluation of all radionuclides is listed in Table 5.

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 ≤ 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 5.

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.

Radionuclide	LAP (%)	MAB (%)
Mn-54	15	15
Co-60	15	15
Zn-65	15	15
Cd-109	25	25
Cs-134	15	15
Cs-137	15, 20*	15, 20*
Pb-210	25	25
Am-241	15	15

Table 5: *The acceptable limits for LAP and MAB used for the evaluation in this PT.*
** Only for sample 01 due to low activity concentration of Cs-137 in this sample.*

3.3 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 (σ) is:

$$0.10 \text{ x } Value_{IAEA}$$

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

3.4 The u-score value

The value of the u_{test} was calculated according to the following equation [6]

$$u_{test} = \frac{\left| Value_{IAEA} - Value_{Analyst} \right|}{\sqrt{Unc._{IAEA}^2 + Unc._{Analyst}^2}}$$

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 normalised 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 ($u < 2.58$).

4. RESULTS AND DISCUSSION

4.1 General

175 measurement results were reported to the IAEA in this PT from 5 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 A shows the data evaluation tables sorted by radionuclide. Performance evaluation tables sorted by laboratory code are reported in Appendix B.

The overall evaluation showed that 56 % of all reported results fulfilled the PT criteria for both trueness and precision. 22 % of all reported results were not acceptable against the PT criteria.

The results' evaluation demonstrated that four of five laboratories were able to measure Mn-54, Co-60, Zn-65, Cd-109, Cs-137, Pb-210 and Am-241 in sea water within 15 % of deviation from the target values.
However, Cs-134 results showed a consistent negative bias which could be attributed to inappropriate correction or calibration.

4.2 Technical information provided by the participants

The technical information provided by the participants on the analytical procedures used in their own laboratories is compiled in Appendix C and coded with the same laboratory code used in data evaluation. The participants can benefit from the information exchange without revealing the laboratories' identity.

The provided technical information was compiled in the same format as it was received, without any modification or editing.

4.3 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 organiser 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.

4.3.1 Laboratory No. 01

The laboratory No. 01 reported results of seven nuclides; Pb-210 was not reported since a p-type coaxial HPGe detector was used. The laboratory 01 applies the standard methods ASTM E181-98 and ISO 10703:97. Efficiency calibration was performed using a ten radionuclide mixed gamma standard. True summing corrections were applied to the resulting efficiency curve for correction of summing by Co-60 and Y-88 present in the standard. Validation was performed for the applied corrections.

The analyst gave a comprehensive description of the measurement uncertainty budget, the sources of uncertainty components and the applied approach in the estimation of each uncertainty component. The uncertainty budget included the following components: peak area, counting time, sample mass, nuclear data (decay yield and half live), efficiency calibration (uncertainty in the standards and in the mathematical curve fitting), cascade summing correction factor, self-attenuation correction factor. Full details can be found in Appendix C.

The laboratory is accredited and applying a quality assurance system.
The analysts stated that the efficiency curve is validated using a Eu-152 standard of the same matrix and density as the calibration standard. This quality control check aims to verify the trueness of the applied true summing correction method.

The laboratory 01 results showed acceptable performance for all reported nuclides. The reported measurement uncertainties passed the PT criteria except for Am-241 in sample 04 which caused a warning score. Figure A-08 shows the relatively high uncertainty of Am-241 in sample 04. Considering that the 22 % uncertainty is considerably higher than that reported for other samples, this could be due to a transcription error.

The duplicate samples 02, 06 and 03, 05 were analysed on different days with gap of 10 days. However, the deviation between the results of these samples was acceptable and demonstrated an acceptable within laboratory reproducibility.

The laboratory did not report any false positive in the results of the sample 01, which is the blank sample, the determination of low level activity of Cs-137 was also acceptable.

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

4.3.2 Laboratory No. 02

The laboratory No. 02 reported results for all radionuclides including Pb-210. A mixed gamma source was used to perform calibrations. The IAEA-375 was used to perform method validation. Control charts are used in checking the statistical control of humidity, temperature, background and FWHM.

The laboratory No. 02 considered the following uncertainty components in the uncertainty budget: sample mass, peak area, emission probability, detector

efficiency, attenuation and summing corrections. It was not clear from the reported information how the uncertainty components are estimated and what is the contribution (weight) of each component in the combined standard uncertainty. Also it was not mentioned if the uncertainty of the calibration source was accounted for in the uncertainty budget.

All reported results of laboratory 02 were acceptable with regard to the trueness criteria. Few warning scores were obtained due to underestimated uncertainty. For example the reported uncertainty for Cs-134 was around 1 %, while the relative bias for the same nuclide was around 10 %, which indicates an underestimation of the combined standard uncertainty. The reported method validation data of the laboratory shows a reproducibility limit of 10 % and a relative bias of 1.8 % for Cs-137. This demonstrates that a combined standard uncertainty at around 1 % is too optimistic. A revision of the uncertainty budget is recommended. References [7, 8] could be a useful source of information. In z-score evaluation scheme the laboratory 02 obtained acceptable scores for all analytes and samples, this is due to the fact that z-score evaluates only the bias without considering the measurement uncertainty.

Although the laboratory demonstrated a good performance 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. In addition, the standard sources used in the calibration should not be used in the QC procedure according to ISO-Guide 35:2006 [9] which requires that *a reference material can only be used for a single purpose in a given measurement.*

The results of the duplicate samples 02, 06 and 03, 05 were in good agreement and indicate an acceptable repeatability. The dates of analysis of the samples were not reported.

The laboratory did not report any false positive in the results of the sample 01, which is the blank sample, the determination of low level of Cs-137 was also acceptable.

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

4.3.3 Laboratory No. 03

The Laboratory No. 03 reported that the PT samples were analysed using two different HPGe n-type detection systems calibrated with a standard source in 500 mL Marinelli beaker geometry with a density of 1.0 g/cm3. The method was validated and minimum detection limits were reported for a 120,000 second counting time. The analysts stated that a few of the samples were re-counted on the same system and showed good agreement/reproducibility.

The uncertainty budget of the laboratory 03 accounted for uncertainty due to isotope half-life; uncertainty associated with use of the balance for weight measurements, counting uncertainties (peak areas, background subtractions, etc…) and efficiency calibration uncertainties that encompass calibration source uncertainties. The laboratory estimated the combined standard uncertainty to be around 6.5 %.

The laboratory uses a known spike with known concentrations as a quality control check to ensure that the actual values are within the required limits. Background correction was also applied. More details can be found in Appendix C.

The laboratory No. 03 reported results for all radionuclides including Pb-210. The reported measurement uncertainties were appropriate and satisfied the PT criteria.
Acceptable scores were obtained for all radionuclides in all samples except for Cs-134. In samples 03, 04 and 05 the laboratory had for Cs-134 a not acceptable score with a negative bias around 17 %. For sample 02 and 06 the laboratory had an acceptable score, but with a negative bias around 10 %. The results of the laboratory

could be improved using the appropriate cascade summing effect factor to correct the results.
The laboratory 03 had a very good estimation of the value of Cs-137 in the blank sample 01. The detection limit of Cs-137 claimed by the laboratory (0.23 $Bq.kg^{-1}$) was proved to be correct since the laboratory was able to report 0.35 $Bq.kg^{-1}$ Cs-137 in sample 01 with a low uncertainty and bias.

The Z-score evaluation of the laboratory No. 03 was satisfactory for all reported results of the radionuclides in all samples.

4.3.4 Laboratory No. 04

The laboratory No. 04 reported results of seven nuclides; Pb-210 was not reported, no information was provided on the type of the detector.
There is no indication of any actions taken to validate the analytical procedure. The laboratory listed the following sources of uncertainty: net count, time, efficiency, intensity, and mass of sample. The laboratory did not report any information regarding the contribution of each source in the combined standard uncertainty.
The laboratory uses a multinuclide standard source in 1.0 g/c^3 epoxy matrix.

All of the reported results obtained acceptable score for trueness criteria except Cd-109 in samples 02 and 05.

Warning scores were assigned due to relatively high reported uncertainty; revision of the approach of uncertainty estimation and the values of each uncertainty component should be revised.
An analytical result with too high uncertainty carries less information and might not be useful for the decision maker.
Some possible reasons for different uncertainty estimations / calculations are:

- different and/or incomplete/over estimated evaluation of uncertainty sources, e.g. limiting uncertainties to counting statistics, weighing, dilution, factors (e.g. decay, fundamental parameters, uncertainty of calibration source);
- double counting of uncertainty source of one of the major components;
- increasing the uncertainty of one, perhaps major, component to be on the safe side and to follow the most "pessimistic" approach (e.g. counting time, calibration standards with large uncertainties);
- over considering possible uncertainty components due to e.g. matrix effects, physical properties of samples and standards, sample geometry or spectral interferences;
- over estimating of the uncertainty of the calibration procedure used (single standard, multi-standard, computational).

Worked examples of uncertainty budget estimation could be found in [7, 8].

The overestimation of the uncertainty results in not acceptable scoring for the precision. An unrealistic increase of the uncertainty to get an acceptable scoring for the accuracy should be avoided.
The results of duplicate samples 02, 06 and 03, 05 were in good agreement and indicated an acceptable repeatability for all reported nuclides except for Cd-109.

The laboratory did not report any false positive in the results of the sample 01, which is the blank sample, the determination of low level of Cs-137 was also acceptable.

The Z-score evaluation of the laboratory No. 04 was satisfactory for all reported results of the radionuclides in all samples.

4.3.5 Laboratory No. 05

The laboratory No. 05 reported results of five nuclides; Cd-109, Pb-210 and Am-241 were not reported. HPGe system was used. No further information was provided on the type of the detector.

The laboratory stated that multinuclide source was used for calibration without

specifying the density or geometry of the standard. The activity concentration levels of the used calibration source were much higher than those in the measured samples. No data was provided on method validation.
The reported uncertainty was calculated by commercial software.

The laboratory 05 obtained acceptable scores for precision for all reported radionuclides, which indicates an acceptable reproducibility. However, a consistent bias of around 20 % was observed in all results, which resulted in not acceptable scores. The root cause of such bias should be investigated. The laboratory stated that the activity concentrations of the calibration source were much higher than those of the PT samples. There was no indication of validation of the efficiency calibration or use of control sample with similar matrix as the analysed samples. It is recommended to run systematically a control sample with the analysed samples to check the consistency and the trueness of the results.

The laboratory did not report any false positive in the results of sample 01. However, a false negative was reported, where the Cs-137 result was reported below 0.29 $Bq.kg^{-1}$ while the target value is 0.36 $Bq.kg^{-1}$. This could indicate that the method is not able to detect such levels of Cs-137 and that the measurement conditions for low activity concentrations should be revised.
The Z-score evaluation of the laboratory No. 04 was not satisfactory for all reported results.

5. CONCLUSIONS

The IAEA-CU-2006-08 proficiency test was successfully completed.

Among the participating laboratories there were 3 laboratories which in general reported satisfactory results for trueness and precision, one laboratory reported results with acceptable trueness but with high uncertainty and one laboratory reported results with a relatively high bias.

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9. ISO/IEC Guide 35:2006, Certification of Reference Materials-General and Statistical Principles, ISO, Geneva, Switzerland.

List of Appendixes

Appendix A: Performance evaluation tables sorted by radionuclide

Appendix B: Performance evaluation tables sorted by laboratory code

Appendix C: Information provided by the laboratories

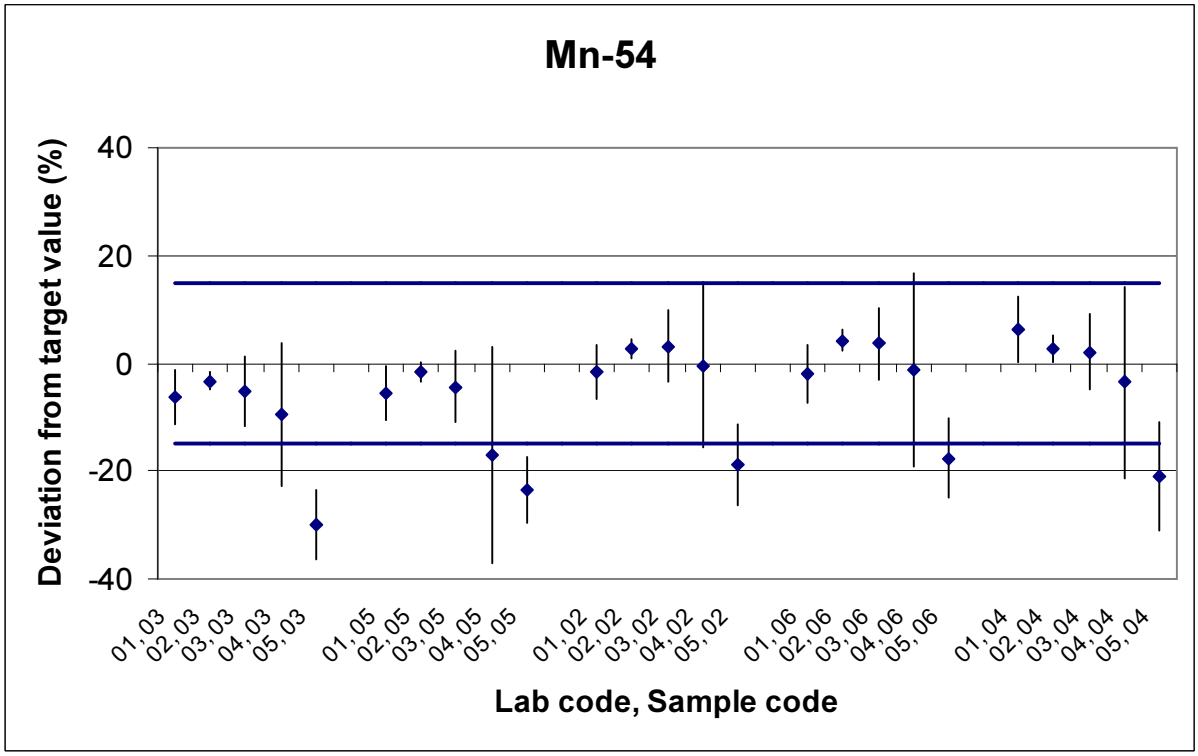
THE IAEA-CU-2006-08 PROFICIENCY TEST ON THE DETERMINATION OF GAMMA EMITTING RADIONUCLIDES IN SEA WATER

"Within the frame of the Radiation Measurements Cross Calibration Project for the Middle East"

Appendix A- Data evaluation tables sorted by radionuclide

Data evaluation of Mn-54 in spiked sea water

Figure A-01



Samples 02, 06

Target value:	6.94	**[Bq.kg^{-1}]**
Uncertainty:	0.02	

	Laboratories Results								Acceptance criteria					Final
	Lab. Code	Value	Unc.		Bias(%)	Z-Score	U-Score	Lab/IAEA	Trueness			Precision		Score
		[Bq.kg^{-1}]	[Bq.kg^{-1}]	[%]					A1	A2	Score	P	Score	
Sample 02	01	6.83	0.35	5.12	-1.6	-0.16	-0.31	0.98	0.11	0.90	**A**	5.1	**A**	**A**
	02	7.12	0.13	1.83	2.6	0.26	1.37	1.03	0.18	0.34	**A**	1.8	**A**	**A**
	03	7.16	0.47	6.56	3.2	0.32	0.47	1.03	0.22	1.21	**A**	6.6	**A**	**A**
	04	6.91	1.04	15.06	-0.5	-0.05	-0.03	1.00	0.03	2.68	**A**	15.1	**N**	**W**
	05	5.63	0.43	7.64	-18.9	-1.89	-3.04	0.81	1.31	1.11	**N**	7.6	**A**	**N**
Sample 06	01	6.81	0.37	5.43	-1.9	-0.19	-0.35	0.98	0.13	0.96	**A**	5.4	**A**	**A**
	02	7.23	0.14	1.94	4.2	0.42	2.05	1.04	0.29	0.36	**A**	2.0	**A**	**A**
	03	7.19	0.47	6.54	3.6	0.36	0.53	1.04	0.25	1.21	**A**	6.5	**A**	**A**
	04	6.86	1.23	38.19	-1.2	-0.12	-0.03	0.99	0.08	6.76	**A**	38.2	**N**	**W**
	05	5.71	0.42	7.36	-17.7	-1.77	-2.93	0.82	1.23	1.08	**N**	7.4	**A**	**N**

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Mn-54 in spiked sea water

Samples 03, 05

Target value: 11.60 **[Bq.kg^{-1}]**
Uncertainty: 0.04

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 03	01	10.87	0.53	4.88	-6	-0.6	-1.3	0.94	0.69	1.37	**A**	4.9	**A**	**A**
	02	11.22	0.18	1.6	-2.9	-0.29	-1.84	0.97	0.34	0.48	**A**	1.6	**A**	**A**
	03	11.00	0.71	6.45	-4.8	-0.48	-0.79	0.95	0.56	1.83	**A**	6.5	**A**	**A**
	04	10.48	1.39	30.92	-9.3	-0.93	-0.33	0.91	1.08	8.36	**A**	30.9	**N**	**W**
	05	8.13	0.53	6.52	-29.7	-2.97	-6.45	0.7	3.43	1.37	**N**	6.5	**A**	**N**
Sample 05	01	10.95	0.55	5.02	-5.3	-0.53	-1.11	0.95	0.61	1.42	**A**	5.0	**A**	**A**
	02	11.41	0.19	1.67	-1.3	-0.13	-0.77	0.99	0.15	0.5	**A**	1.7	**A**	**A**
	03	11.10	0.72	6.49	-4	-0.4	-0.64	0.96	0.46	1.86	**A**	6.5	**A**	**A**
	04	9.63	1.93	32.19	-16.7	-1.67	-0.62	0.83	1.93	8	**A**	32.2	**N**	**N**
	05	8.88	0.55	6.19	-23.2	-2.32	-4.86	0.77	2.68	1.42	**N**	6.2	**A**	**N**

Sample 04

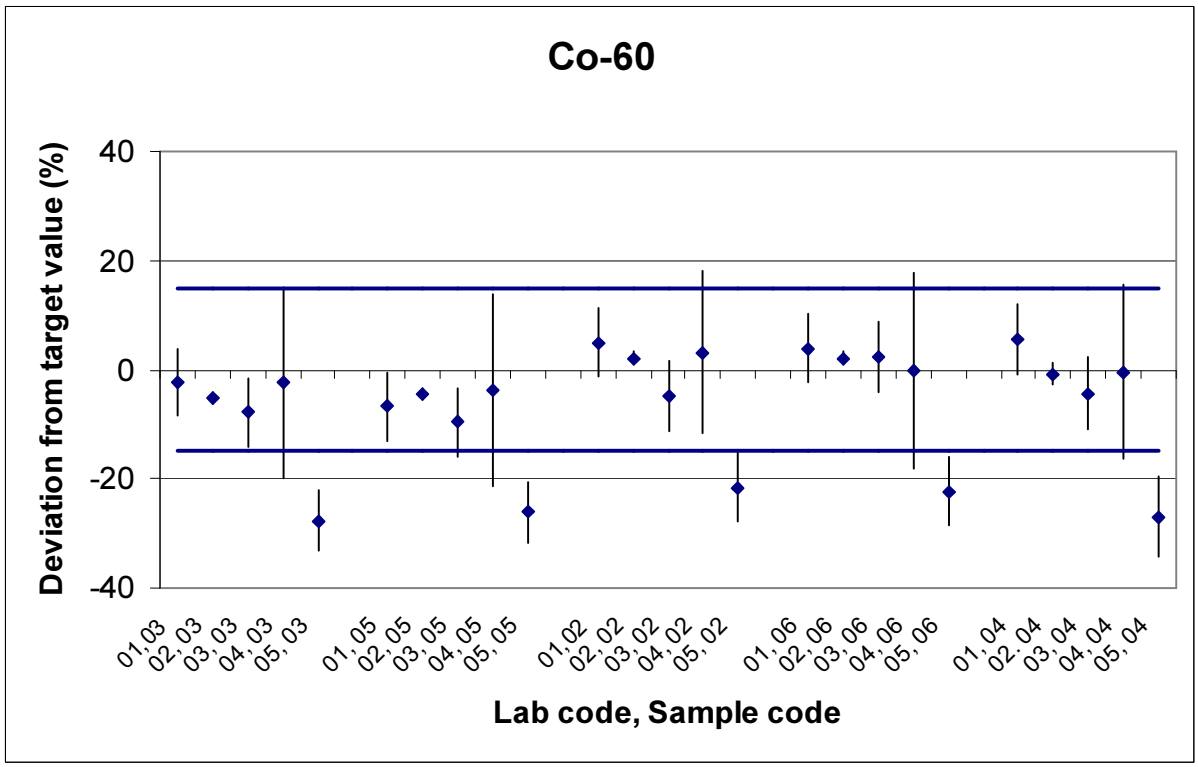
Target value: 3.73 **[Bq.kg^{-1}]**
Uncertainty: 0.02

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 04	01	3.96	0.24	6.06	6.2	0.33	0.96	1.06	0.23	0.62	**A**	6.1	**A**	**A**
	02	3.83	0.10	2.61	2.7	0.14	0.98	1.03	0.10	0.26	**A**	2.7	**A**	**A**
	03	3.81	0.26	6.82	2.1	0.12	0.31	1.02	0.08	0.67	**A**	6.8	**A**	**A**
	04	3.60	0.64	17.81	-3.5	-0.19	-0.20	0.97	0.13	1.65	**A**	17.8	**N**	**W**
	05	2.95	0.30	10.18	-21.0	-1.13	-2.61	0.79	0.78	0.78	**N**	10.2	**A**	**N**

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Co-60 in spiked sea water

Figure A-02



Samples 02, 06

Target value:	9.96	**[Bq.kg^{-1}]**
Uncertainty:	0.06	

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 02	01	10.46	0.65	6.21	5.0	0.50	0.77	1.05	0.50	1.68	A	6.2	A	A
	02	10.16	0.13	1.28	2.0	0.20	1.39	1.02	0.20	0.37	A	1.4	A	A
	03	9.47	0.61	6.44	-4.9	-0.49	-0.80	0.95	0.49	1.58	A	6.5	A	A
	04	10.27	1.53	14.90	3.1	0.31	0.20	1.03	0.31	3.95	A	14.9	A	A
	05	7.81	0.49	6.27	-21.6	-2.16	-4.35	0.78	2.15	1.27	N	6.3	A	N
Sample 06	01	10.34	0.65	6.29	3.8	0.38	0.58	1.04	0.38	1.68	A	6.3	A	A
	02	10.17	0.13	1.28	2.1	0.21	1.46	1.02	0.21	0.37	A	1.4	A	A
	03	10.2	0.66	6.47	2.4	0.24	0.36	1.02	0.24	1.71	A	6.5	A	A
	04	9.94	1.79	31.69	-0.2	-0.02	-0.01	1.00	0.02	8.13	A	31.7	N	W
	05	7.74	0.49	6.33	-22.3	-2.23	-4.49	0.78	2.22	1.27	N	6.4	A	N

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Co-60 in spiked sea water

Samples 03, 05

Target value: 16.60 **[Bq.kg^{-1}]**
Uncertainty: 0.13

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 03	01	16.21	0.99	6.11	-2.3	-0.23	-0.39	0.98	0.39	2.57	**A**	6.2	**A**	**A**
	02	15.75	0.17	1.08	-5.1	-0.51	-4.03	0.95	0.85	0.54	**N**	1.3	**A**	**W**
	03	15.30	0.97	6.34	-7.8	-0.78	-1.33	0.92	1.30	2.52	**A**	6.4	**A**	**A**
	04	16.20	2.82	24.81	-2.4	-0.24	-0.10	0.98	0.40	10.38	**A**	24.8	**N**	**W**
	05	12.00	0.67	5.58	-27.7	-2.77	-6.75	0.72	4.60	1.76	**N**	5.6	**A**	**N**
Sample 05	01	15.48	0.96	6.20	-6.7	-0.67	-1.16	0.93	1.12	2.50	**A**	6.2	**A**	**A**
	02	15.87	0.18	1.13	-4.4	-0.44	-3.33	0.96	0.73	0.57	**N**	1.4	**A**	**W**
	03	15.00	0.96	6.40	-9.6	-0.96	-1.65	0.90	1.60	2.50	**A**	6.4	**A**	**A**
	04	15.99	2.80	24.95	-3.7	-0.37	-0.15	0.96	0.61	10.30	**A**	25.0	**N**	**W**
	05	12.27	0.68	5.54	-26.1	-2.61	-6.26	0.74	4.33	1.78	**N**	5.6	**A**	**N**

Sample 04

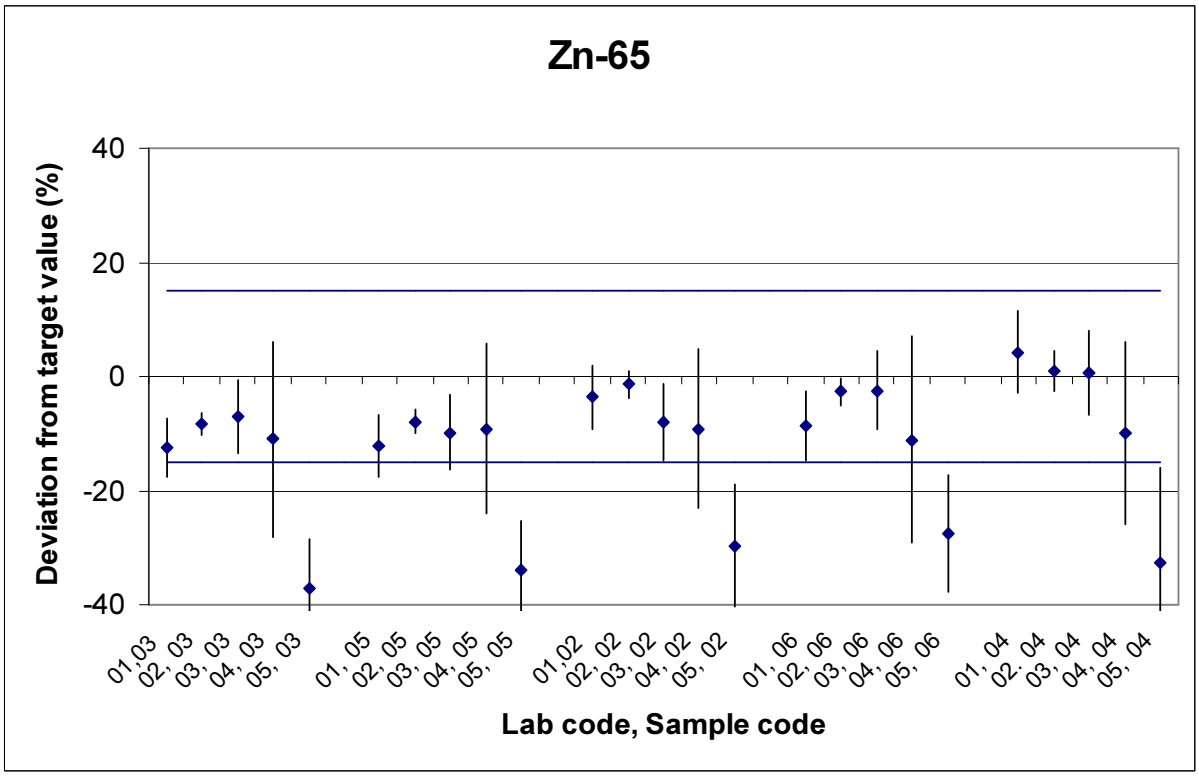
Target value: 5.55 **[Bq.kg^{-1}]**
Uncertainty: 0.06

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 04	01	5.86	0.38	6.48	5.6	0.31	0.81	1.06	0.31	0.99	**A**	6.6	**A**	**A**
	02	5.51	0.10	1.81	-0.7	-0.04	-0.34	0.99	0.04	0.30	**A**	2.1	**A**	**A**
	03	5.31	0.35	6.59	-4.3	-0.24	-0.68	0.96	0.24	0.92	**A**	6.7	**A**	**A**
	04	5.53	0.88	15.99	-0.4	-0.02	-0.02	1.00	0.02	2.29	**A**	16.0	**N**	**W**
	05	4.05	0.30	7.41	-27.0	-1.51	-4.90	0.73	1.50	0.79	**N**	7.5	**A**	**N**

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Zn-65 in spiked sea water

Figure A-03



Samples 02, 06

Target value:	10.97	**[Bq.kg^{-1}]**
Uncertainty:	0.10	

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 02	01	10.57	0.58	5.49	-3.6	-0.36	-0.68	0.96	0.40	1.52	**A**	5.6	**A**	**A**
	02	10.82	0.26	2.40	-1.4	-0.14	-0.54	0.99	0.15	0.72	**A**	2.6	**A**	**A**
	03	10.1	0.68	6.73	-7.9	-0.79	-1.27	0.92	0.87	1.77	**A**	6.8	**A**	**A**
	04	9.96	1.39	13.96	-9.2	-0.92	-0.72	0.91	1.01	3.59	**A**	14.0	**A**	**A**
	05	7.72	0.83	10.75	-29.6	-2.96	-3.89	0.70	3.25	2.16	**N**	10.8	**A**	**N**
Sample 06	01	10.02	0.60	5.99	-8.7	-0.87	-1.56	0.91	0.95	1.57	**A**	6.1	**A**	**A**
	02	10.68	0.26	2.43	-2.6	-0.26	-1.05	0.97	0.29	0.72	**A**	2.6	**A**	**A**
	03	10.7	0.73	6.82	-2.5	-0.25	-0.37	0.98	0.27	1.90	**A**	6.9	**A**	**A**
	04	9.75	1.76	18.05	-11.1	-1.11	-0.69	0.89	1.22	4.55	**A**	18.1	**N**	**W**
	05	7.96	0.81	10.18	-27.4	-2.74	-3.69	0.73	3.01	2.10	**N**	10.2	**A**	**N**

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Zn-65 in spiked sea water

Samples 03, 05

Target value: 18.3 **[Bq.kg^{-1}]**
Uncertainty: 0.19

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 03	01	16.01	0.83	5.18	-12.4	-1.24	-2.66	0.88	2.27	2.20	**N**	5.3	**A**	**W**
	02	16.77	0.33	1.97	-8.3	-0.83	-3.96	0.92	1.51	0.99	**N**	2.2	**A**	**W**
	03	17	1.09	6.41	-7.0	-0.70	-1.16	0.93	1.28	2.86	**A**	6.5	**A**	**A**
	04	16.29	2.78	17.07	-10.9	-1.09	-0.71	0.89	1.99	7.19	**A**	17.1	**N**	**W**
	05	11.48	1.01	8.80	-37.2	-3.72	-6.61	0.63	6.80	2.65	**N**	8.9	**A**	**N**
Sample 05	01	16.09	0.87	5.41	-12.0	-1.20	-2.46	0.88	2.19	2.30	**A**	5.5	**A**	**A**
	02	16.85	0.36	2.14	-7.8	-0.78	-3.50	0.92	1.43	1.05	**N**	2.4	**A**	**W**
	03	16.5	1.08	6.55	-9.7	-0.97	-1.62	0.90	1.78	2.83	**A**	6.6	**A**	**A**
	04	16.63	2.49	14.97	-9.0	-0.90	-0.66	0.91	1.65	6.44	**A**	15.0	**N**	**W**
	05	12.08	1.04	8.61	-33.9	-3.39	-5.86	0.66	6.20	2.73	**N**	8.7	**A**	**N**

Sample 04

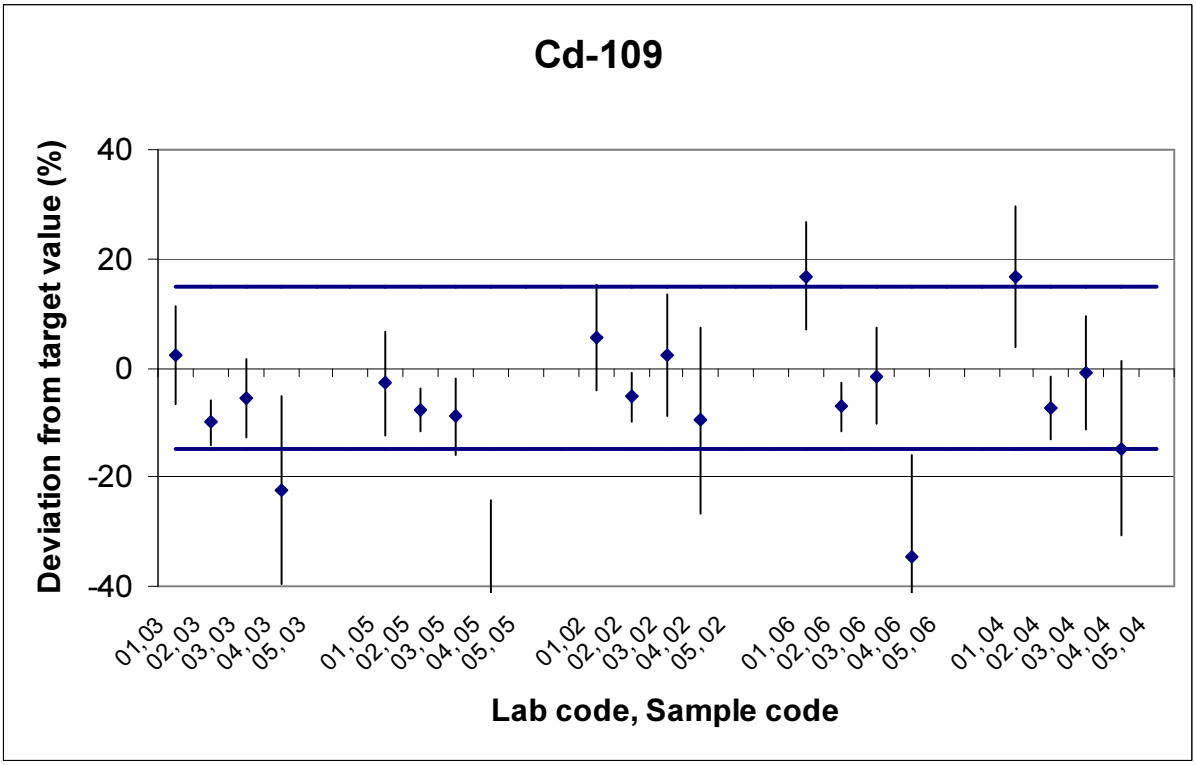
Target value: 5.14 **[Bq.kg^{-1}]**
Uncertainty: 0.10

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 04	01	5.36	0.39	7.28	4.3	0.20	0.55	1.04	0.22	1.04	**A**	7.5	**A**	**A**
	02	5.19	0.19	3.66	1.0	0.05	0.23	1.01	0.05	0.55	**A**	4.1	**A**	**A**
	03	5.17	0.38	7.35	0.6	0.03	0.08	1.01	0.03	1.01	**A**	7.6	**A**	**A**
	04	4.63	0.74	16.00	-9.9	-0.46	-0.68	0.90	0.51	1.93	**A**	16.1	**N**	**W**
	05	3.46	0.58	16.76	-32.7	-1.53	-2.86	0.67	1.68	1.52	**N**	16.9	**N**	**N**

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Cd-109 in spiked sea water

Figure A-04



Samples 02, 06

Target value: 25.79 [Bq.kg^{-1}]
Uncertainty: 0.11

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 02	01	27.26	2.65	9.72	5.7	0.57	0.55	1.06	1.47	6.84	A	9.7	A	A
	02	24.43	1.09	4.46	-5.3	-0.53	-1.24	0.95	1.36	2.83	A	4.5	A	A
	03	26.4	2.91	11.02	2.4	0.24	0.21	1.02	0.61	7.51	A	11.0	A	A
	04	23.33	3.97	17.02	-9.5	-0.95	-0.62	0.90	2.46	10.25	A	17.0	A	A
	05	ND	-											
Sample 06	01	30.11	2.95	9.80	16.8	1.68	1.46	1.17	4.32	7.62	A	9.8	A	A
	02	23.94	1.09	4.55	-7.2	-0.72	-1.69	0.93	1.85	2.83	A	4.6	A	A
	03	25.4	2.24	8.82	-1.5	-0.15	-0.17	0.98	0.39	5.79	A	8.8	A	A
	04	16.89	3.16	18.71	-34.5	-3.45	-2.81	0.65	8.90	8.16	N	18.7	A	N
	05	ND	-											

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Cd-109 in spiked sea water

Samples 03, 05

Target value: 43.0 **[Bq.kg^{-1}]**
Uncertainty: 0.21

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 03	01	44.04	3.95	8.97	2.5	0.25	0.27	1.02	1.07	10.21	**A**	9.0	**A**	**A**
	02	38.69	1.55	4.01	-10.0	-1.00	-2.74	0.90	4.28	4.04	**N**	4.0	**A**	**W**
	03	40.6	2.85	7.02	-5.5	-0.55	-0.83	0.94	2.37	7.37	**A**	7.0	**A**	**A**
	04	33.37	5.78	17.32	-22.3	-2.23	-1.66	0.78	9.60	14.92	**A**	17.3	**A**	**A**
	05	ND	-											
Sample 05	01	41.78	4.02	9.62	-2.8	-0.28	-0.30	0.97	1.19	10.39	**A**	9.6	**A**	**A**
	02	39.66	1.59	4.01	-7.7	-0.77	-2.06	0.92	3.31	4.14	**A**	4.0	**A**	**A**
	03	39.2	2.76	7.04	-8.8	-0.88	-1.36	0.91	3.77	7.14	**A**	7.1	**A**	**A**
	04	24.78	4.46	18.00	-42.3	-4.23	-4.07	0.58	18.19	11.52	**N**	18.0	**A**	**N**
	05	ND	-											

Sample 04

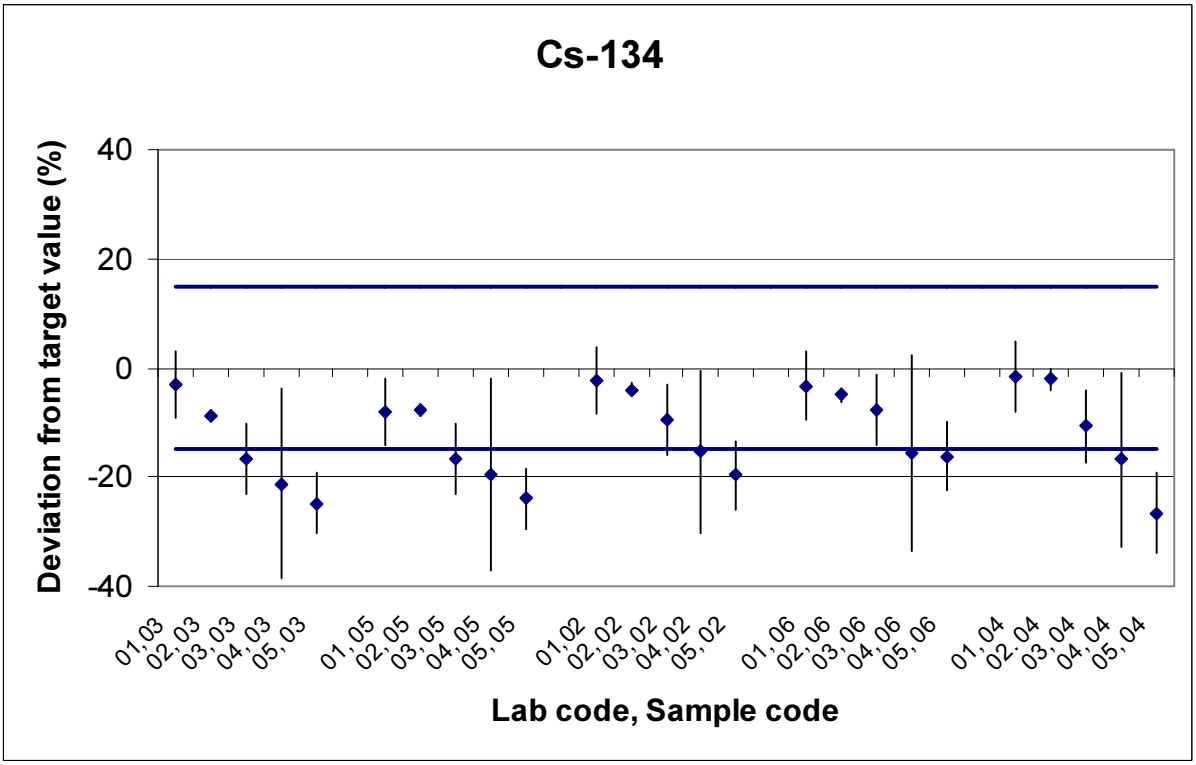
Target value: 16.34 **[Bq.kg^{-1}]**
Uncertainty: 0.11

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 04	01	19.08	2.46	12.89	16.8	1.06	1.11	1.17	2.74	6.35	**A**	12.9	**A**	**A**
	02	15.13	0.85	5.62	-7.4	-0.47	-1.41	0.93	1.21	2.21	**A**	5.7	**A**	**A**
	03	16.20	1.70	10.49	-0.9	-0.05	-0.08	0.99	0.14	4.39	**A**	10.5	**A**	**A**
	04	13.92	2.23	16.02	-14.8	-0.94	-1.08	0.85	2.42	5.76	**A**	16.0	**A**	**A**
	05													

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Cs-134 in spiked sea water

Figure A-05



Samples 02, 06

Target value:	10.82	**[Bq.kg^{-1}]**		
Uncertainty:	0.07			

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 02	01	10.57	0.57	5.39	-2.3	-0.23	-0.44	0.98	0.25	1.48	A	5.4	A	A
	02	10.38	0.12	1.16	-4.1	-0.41	-3.19	0.96	0.44	0.36	N	1.3	A	W
	03	9.78	0.63	6.44	-9.6	-0.96	-1.64	0.90	1.04	1.63	A	6.5	A	A
	04	9.16	1.47	16.05	-15.3	-1.53	-1.13	0.85	1.66	3.80	A	16.1	N	N
	05	8.69	0.41	4.72	-19.7	-1.97	-5.13	0.80	2.13	1.07	N	4.8	A	N
Sample 06	01	10.47	0.59	5.64	-3.2	-0.32	-0.59	0.97	0.35	1.53	A	5.7	A	A
	02	10.29	0.12	1.17	-4.9	-0.49	-3.84	0.95	0.53	0.36	N	1.3	A	W
	03	10	0.65	6.50	-7.6	-0.76	-1.25	0.92	0.82	1.69	A	6.5	A	A
	04	9.13	1.61	17.63	-15.6	-1.56	-1.05	0.84	1.69	4.16	A	17.6	N	N
	05	9.07	0.42	4.63	-16.2	-1.62	-4.11	0.84	1.75	1.10	N	4.7	A	N

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Cs-134 in spiked sea water

Samples 03, 05

Target value: 18.03 **[Bq.kg^{-1}]**
Uncertainty: 0.14

	Laboratories Results								Acceptance criteria					Final
	Lab. Code	Value	Unc.		Bias(%)	Z-Score	U-Score	Lab/IAEA	Trueness			Precision		Score
		[Bq.kg^{-1}]	[Bq.kg^{-1}]	[%]					A1	A2	Score	P	Score	
Sample 03	01	17.44	0.90	5.16	-3.3	-0.33	-0.65	0.97	0.59	2.35	**A**	5.2	**A**	**A**
	02	16.39	0.15	0.92	-9.1	-0.91	-8.07	0.91	1.64	0.52	**N**	1.2	**A**	**W**
	03	15.00	0.96	6.40	-16.8	-1.68	-3.12	0.83	3.03	2.50	**N**	6.4	**A**	**N**
	04	14.19	2.55	17.97	-21.3	-2.13	-1.50	0.79	3.84	6.59	**A**	18.0	**N**	**N**
	05	13.52	0.54	3.99	-25.0	-2.50	-8.10	0.75	4.51	1.44	**N**	4.1	**A**	**N**
Sample 05	01	16.54	0.87	5.26	-8.3	-0.83	-1.69	0.92	1.49	2.27	**A**	5.3	**A**	**A**
	02	16.6	0.17	1.02	-7.9	-0.79	-6.55	0.92	1.43	0.56	**N**	1.3	**A**	**W**
	03	15.00	0.96	6.40	-16.8	-1.68	-3.12	0.83	3.03	2.50	**N**	6.4	**A**	**N**
	04	14.49	2.67	18.43	-19.6	-1.96	-1.32	0.80	3.54	6.90	**A**	18.4	**N**	**N**
	05	13.68	0.57	4.17	-24.1	-2.41	-7.42	0.76	4.35	1.51	**N**	4.2	**A**	**N**

Sample 04

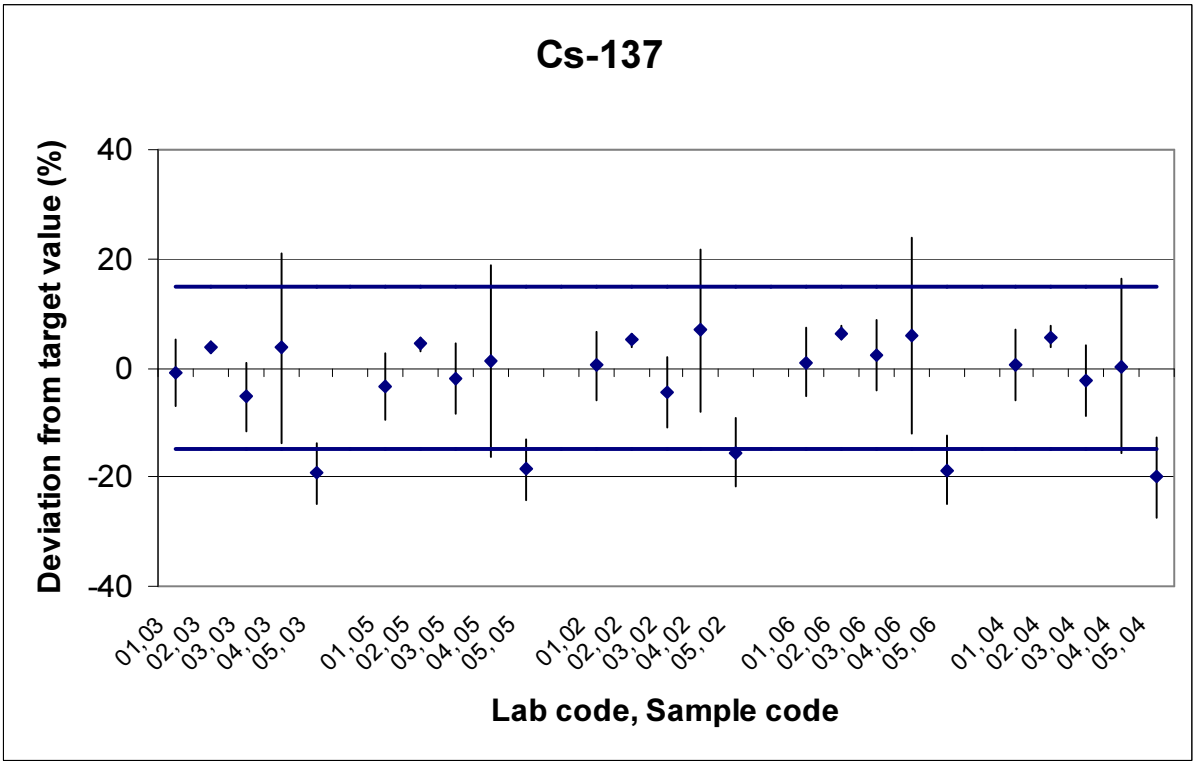
Target value: 11.65 **[Bq.kg^{-1}]**
Uncertainty: 0.07

	Laboratories Results								Acceptance criteria					Final
	Lab. Code	Value	Unc.		Bias(%)	Z-Score	U-Score	Lab/IAEA	Trueness			Precision		Score
		[Bq.kg^{-1}]	[Bq.kg^{-1}]	[%]					A1	A2	Score	P	Score	
Sample 04	01	11.47	0.63	5.49	-1.5	-0.17	-0.28	0.98	0.18	1.63	**A**	5.5	**A**	**A**
	02	11.40	0.12	1.05	-2.1	-0.23	-1.81	0.98	0.25	0.36	**A**	1.2	**A**	**A**
	03	10.40	0.67	6.44	-10.7	-1.16	-1.86	0.89	1.25	1.74	**A**	6.5	**A**	**A**
	04	9.69	1.74	17.96	-16.8	-1.81	-1.13	0.83	1.96	4.49	**A**	18.0	**N**	**N**
	05	8.55	0.40	4.68	-26.6	-2.87	-7.64	0.73	3.10	1.05	**N**	4.7	**A**	**N**

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Cs-137 in spiked sea water

Figure A-06



Samples 01

Target value: 0.36 [Bq.kg^{-1}]
Uncertainty: 0.03

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 01	01	0.48	0.06	12.50	33.3	0.13	1.79	1.33	0.12	0.17	A	15.0	A	A
	02	0.39	0.05	12.82	8.3	0.03	0.51	1.08	0.03	0.15	A	15.3	A	A
	03	0.35	0.04	11.43	-2.8	-0.01	-0.20	0.97	0.01	0.13	A	14.1	A	A
	04	0.41	0.07	18.05	13.9	0.05	0.63	1.14	0.05	0.21	A	19.9	A	A
	05	<0.28												

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Cs-137 in spiked sea water

Samples 02, 06

Target value: 9.48 **[Bq.kg^{-1}]**
Uncertainty: 0.04

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 02	01	9.52	0.46	4.83	0.4	0.04	0.09	1.00	0.04	1.19	A	4.8	A	A
	02	9.97	0.17	1.71	5.2	0.52	2.82	1.05	0.49	0.45	N	1.7	A	W
	03	9.06	0.59	6.51	-4.4	-0.44	-0.71	0.96	0.42	1.52	A	6.5	A	A
	04	10.14	1.38	13.61	7.0	0.70	0.48	1.07	0.66	3.56	A	13.6	A	A
	05	8.01	0.52	6.45	-15.5	-1.55	-2.84	0.84	1.47	1.34	N	6.5	A	N
Sample 06	01	9.58	0.48	5.01	1.1	0.11	0.21	1.01	0.10	1.24	A	5.0	A	A
	02	10.08	0.17	1.69	6.3	0.63	3.46	1.06	0.60	0.45	N	1.7	A	W
	03	9.70	0.63	6.49	2.3	0.23	0.35	1.02	0.22	1.63	A	6.5	A	A
	04	10.04	1.81	18.03	5.9	0.59	0.31	1.06	0.56	4.67	A	18.0	N	W
	05	7.71	0.49	6.36	-18.7	-1.87	-3.60	0.81	1.77	1.27	N	6.4	A	N

Samples 03, 05

Target value: 15.0 **[Bq.kg^{-1}]**
Uncertainty: 0.07

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 03	01	14.85	0.69	4.65	-1.0	-0.10	-0.22	0.99	0.15	1.79	A	4.7	A	A
	02	15.59	0.23	1.48	3.9	0.39	2.45	1.04	0.59	0.62	A	1.5	A	A
	03	14.2	0.92	6.48	-5.3	-0.53	-0.87	0.95	0.80	2.38	A	6.5	A	A
	04	15.55	3.11	20.00	3.7	0.37	0.18	1.04	0.55	8.03	A	20.0	N	W
	05	12.1	0.67	5.54	-19.3	-1.93	-4.30	0.81	2.90	1.74	N	5.6	A	N
Sample 05	01	14.48	0.69	4.77	-3.5	-0.35	-0.75	0.97	0.52	1.79	A	4.8	A	A
	02	15.65	0.24	1.53	4.3	0.43	2.60	1.04	0.65	0.65	A	1.6	A	A
	03	14.7	0.95	6.46	-2.0	-0.20	-0.31	0.98	0.30	2.46	A	6.5	A	A
	04	15.19	2.43	16.00	1.3	0.13	0.08	1.01	0.19	6.27	A	16.0	N	W
	05	12.22	0.67	5.48	-18.5	-1.85	-4.13	0.81	2.78	1.74	N	5.5	A	N

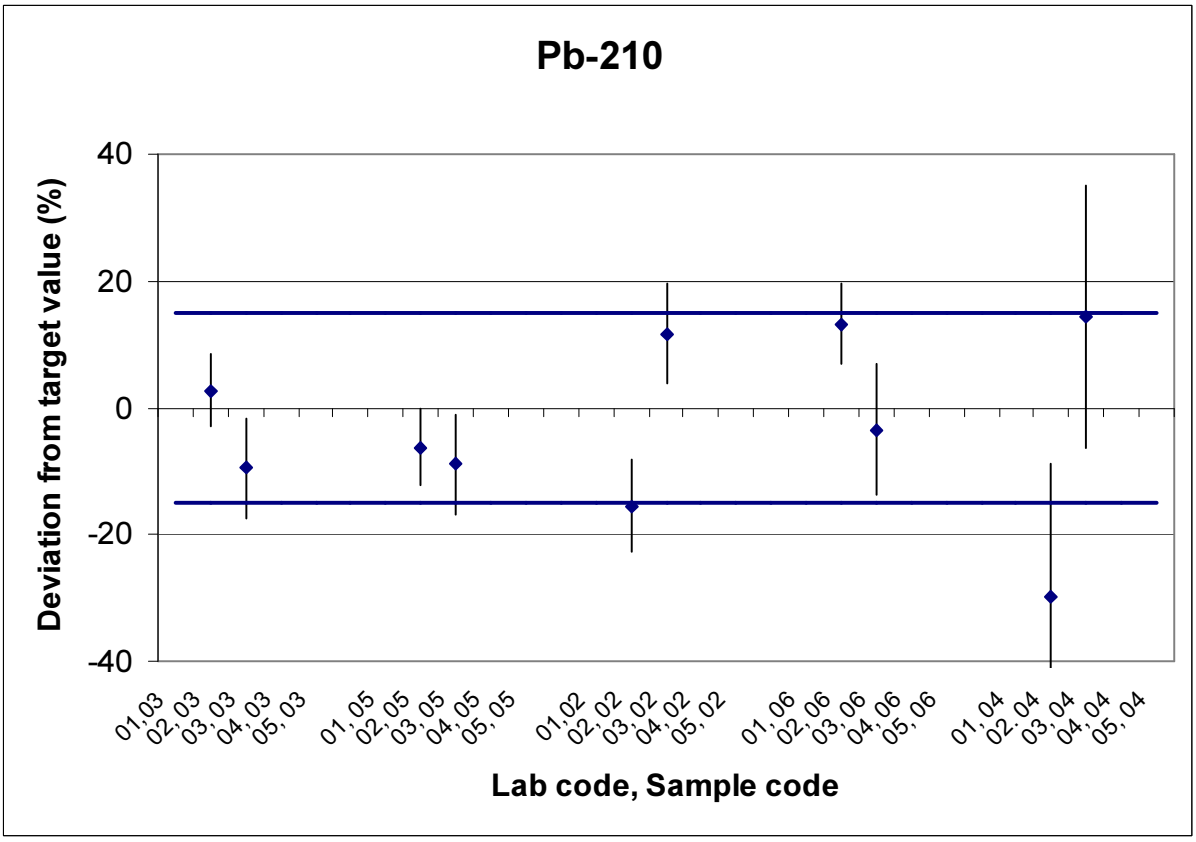
Samples 04

Target value: 16.59 **[Bq.kg^{-1}]**
Uncertainty: 0.04

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 04	01	16.67	0.78	4.68	0.5	0.08	0.10	1.00	0.08	2.01	A	4.7	A	A
	02	17.54	0.24	1.37	5.7	1.00	3.92	1.06	0.95	0.63	N	1.4	A	W
	03	16.20	1.04	6.42	-2.4	-0.41	-0.37	0.98	0.39	2.68	A	6.4	A	A
	04	16.64	3.16	18.99	0.3	0.05	0.02	1.00	0.05	8.15	A	19.0	N	W
	05	13.26	0.66	4.98	-20.1	-3.51	-5.04	0.80	3.33	1.71	N	5.0	A	N

Data evaluation of Pb-210 in spiked sea water

Figure A-07



Samples 02, 06

Target value: 37.73 **[Bq.kg^{-1}]**
Uncertainty: 0.47

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 02	01													
	02	31.85	2.30	7.22	-15.6	-1.56	-2.50	0.84	5.88	6.06	A	7.3	A	A
	03	42.10	3.35	7.96	11.6	1.16	1.29	1.12	4.37	8.73	A	8.1	A	A
	04	-	-											
	05	ND	-											
Sample 06	01	-	-											
	02	42.7	2.73	6.39	13.2	1.32	1.79	1.13	4.97	7.15	A	6.5	A	A
	03	36.4	3.8	10.44	-3.5	-0.35	-0.35	0.96	1.33	9.88	A	10.5	A	A
	04	-	-											
	05	ND	-											

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Pb-210 in spiked sea water

Samples 03, 05

Target value: 62.9 **[Bq.kg^{-1}]**
Uncertainty: 0.95

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	A2	Score	Precision P	Score	Final Score
Sample 03	01	<341	-											
	02	64.6	3.7	5.73	2.8	0.28	0.45	1.03	1.73	9.85	**A**	5.9	**A**	**A**
	03	56.9	4.46	7.84	-9.5	-0.95	-1.31	0.91	5.97	11.76	**A**	8.0	**A**	**A**
	04	-	-											
	05	ND	-											
Sample 05	01	<383	-											
	02	58.96	3.59	6.09	-6.2	-0.62	-1.05	0.94	3.91	9.58	**A**	6.3	**A**	**A**
	03	57.3	4.51	7.87	-8.9	-0.89	-1.21	0.91	5.57	11.89	**A**	8.0	**A**	**A**
	04	-	-											
	05	ND	-											

Sample 04

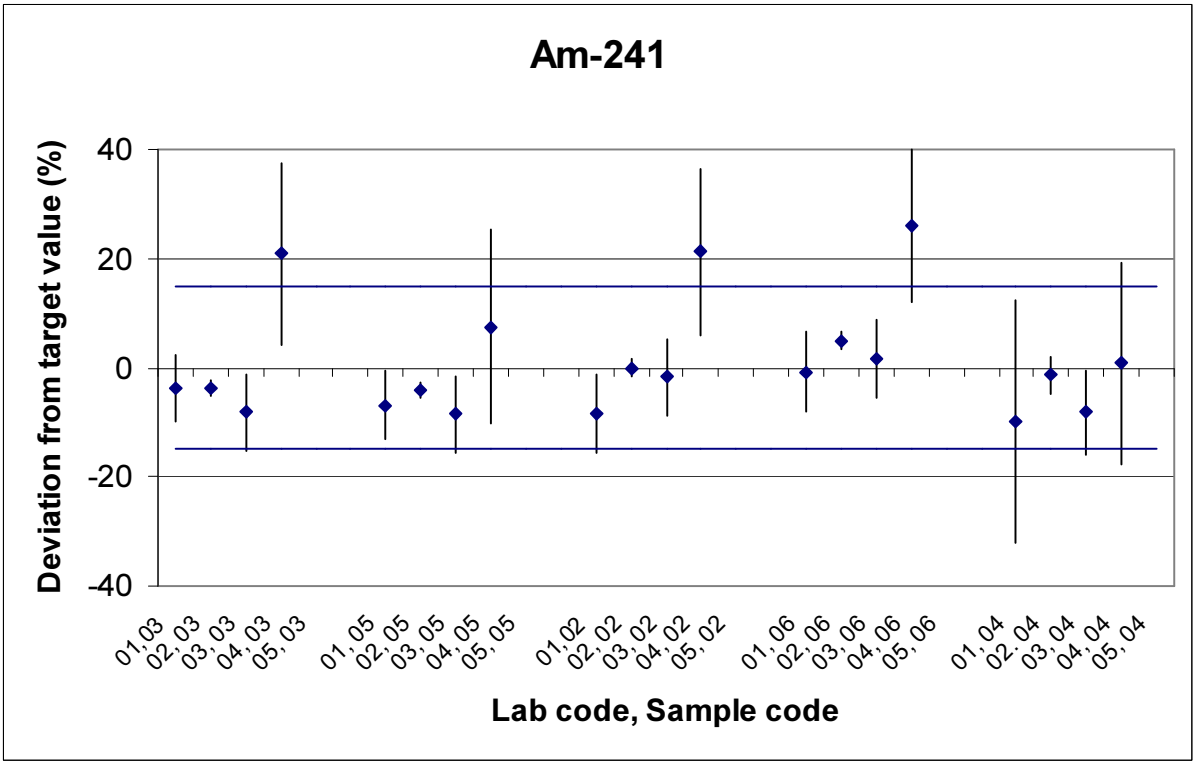
Target value: 9.45 **[Bq.kg^{-1}]**
Uncertainty: 0.47

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	A2	Score	Precision P	Score	Final Score
Sample 04	01													
	02	6.64	1.4	21.08	-29.7	-0.74	-1.90	0.70	2.81	3.81	**A**	21.7	**A**	**A**
	03	10.8	2.24	20.74	14.3	0.36	0.59	1.14	1.35	5.91	**A**	21.3	**A**	**A**
	04	-	-											
	05	ND	-											

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Am-210 in spiked sea water

Figure A-08



Samples 02, 06

	Target value:	17.71	[Bq.kg^{-1}]												
	Uncertainty:	0.09													
		Laboratories Results							**Acceptance criteria**						**Final**
	Lab. Code	**Value**	**Unc.**		**Bias(%)**	**Z-Score**	**U-Score**	**Lab/IAEA**	**Trueness**			**Precision**			**Score**
		[Bq.kg^{-1}]	[Bq.kg^{-1}]	[%]					A1	A2	Score	P	Score		
Sample 02	01	16.19	1.15	7.10	-8.6	-0.86	-1.32	0.91	1.52	2.98	**A**	7.1	**A**	**A**
	02	17.69	0.29	1.64	-0.1	-0.01	-0.07	1.00	0.02	0.78	**A**	1.7	**A**	**A**
	03	17.4	1.23	7.07	-1.8	-0.18	-0.25	0.98	0.31	3.18	**A**	7.1	**A**	**A**
	04	21.46	3.28	15.28	21.2	2.12	1.14	1.21	3.75	8.47	**A**	15.3	**A**	**A**
	05	<5.14	-											
Sample 06	01	17.57	1.31	7.46	-0.8	-0.08	-0.11	0.99	0.14	3.39	**A**	7.5	**A**	**A**
	02	18.57	0.3	1.62	4.9	0.49	2.75	1.05	0.86	0.81	**N**	1.7	**A**	**W**
	03	18	1.28	7.11	1.6	0.16	0.23	1.02	0.29	3.31	**A**	7.1	**A**	**A**
	04	22.29	3.12	14.00	25.9	2.59	1.47	1.26	4.58	8.05	**A**	14.0	**A**	**A**
	05	<5.32	-											

A: Acceptable **W: Warning** **N: Not Acceptable**

Data evaluation of Am-210 in spiked sea water

Samples 03, 05

Target value: 29.5 **[Bq.kg^{-1}]**
Uncertainty: 0.18

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 03	01	28.38	1.69	5.95	-3.8	-0.38	-0.67	0.96	1.13	4.38	**A**	6.0	**A**	**A**
	02	28.41	0.41	1.44	-3.7	-0.37	-2.46	0.96	1.10	1.15	**A**	1.6	**A**	**A**
	03	27.1	1.91	7.05	-8.2	-0.82	-1.26	0.92	2.41	4.95	**A**	7.1	**A**	**A**
	04	35.67	5.97	16.74	20.9	2.09	1.03	1.21	6.16	15.41	**A**	16.7	**A**	**A**
	05	<5.8	-											
Sample 05	01	27.44	1.72	6.27	-7.0	-0.70	-1.20	0.93	2.07	4.46	**A**	6.3	**A**	**A**
	02	28.3	0.42	1.48	-4.1	-0.41	-2.65	0.96	1.21	1.18	**N**	1.6	**A**	**W**
	03	27	1.9	7.04	-8.5	-0.85	-1.32	0.91	2.51	4.92	**A**	7.1	**A**	**A**
	04	31.68	5.63	17.77	7.4	0.74	0.39	1.07	2.17	14.53	**A**	17.8	**A**	**A**
	05	<5.7	-											

Sample 04

Target value: 3.66 **[Bq.kg^{-1}]**
Uncertainty: 0.09

	Lab. Code	Laboratories Results Value [Bq.kg^{-1}]	Unc. [Bq.kg^{-1}]	Unc. [%]	Bias(%)	Z-Score	U-Score	Lab/IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final Score
Sample 04	01	3.30	0.73	22.12	-9.8	-0.20	-0.49	0.90	0.36	1.90	**A**	22.3	**N**	**W**
	02	3.61	0.12	3.32	-1.4	-0.03	-0.33	0.99	0.05	0.39	**A**	4.1	**A**	**A**
	03	3.36	0.26	7.74	-8.2	-0.17	-1.09	0.92	0.30	0.71	**A**	8.1	**A**	**A**
	04	3.69	0.68	18.43	0.8	0.02	0.04	1.01	0.03	1.77	**A**	18.6	**A**	**A**
	05	<4.77	-											

A: Acceptable **W: Warning** **N: Not Acceptable**

THE IAEA-CU-2006-08 PROFICIENCY TEST ON THE DETERMINATION OF GAMMA EMITTING RADIONUCLIDES IN SEA WATER

"Within the frame of the Radiation Measurements Cross Calibration Project for the Middle East"

Appendix B- Data evaluation tables sorted by laboratory code

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

Sample 02 *Reference date: 01October 2006*

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	6.94	0.02	6.83	0.35	5.12	-1.59	-0.16	-0.31	0.98	0.11	0.90	**A**	5.13	**A**	**A**
^{60}Co	9.96	0.06	10.46	0.65	6.21	5.02	0.50	0.77	1.05	0.50	1.68	**A**	6.25	**A**	**A**
^{65}Zn	10.97	0.10	10.57	0.58	5.49	-3.65	-0.36	-0.68	0.96	0.40	1.52	**A**	5.56	**A**	**A**
^{109}Cd	25.79	0.11	27.26	2.65	9.72	5.70	0.57	0.55	1.06	1.47	6.84	**A**	9.73	**A**	**A**
^{134}Cs	10.82	0.07	10.57	0.57	5.39	-2.31	-0.23	-0.44	0.98	0.25	1.48	**A**	5.43	**A**	**A**
^{137}Cs	9.48	0.04	9.52	0.46	4.83	0.42	0.04	0.09	1.00	0.04	1.19	**A**	4.85	**A**	**A**
^{210}Pb	37.73	0.47	-	-											
^{241}Am	17.71	0.09	16.19	1.15	7.10	-8.58	-0.08	-1.32	0.91	1.52	2.98	**A**	7.12	**A**	**A**

Sample 06

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	6.94	0.02	6.81	0.37	5.43	-1.87	-0.19	-0.35	0.98	0.13	0.96	**A**	5.44	**A**	**A**
^{60}Co	9.96	0.06	10.34	0.65	6.29	3.82	0.38	0.58	1.04	0.38	1.68	**A**	6.32	**A**	**A**
^{65}Zn	10.97	0.10	10.02	0.60	5.99	-8.66	-0.87	-1.56	0.91	0.95	1.57	**A**	6.05	**A**	**A**
^{109}Cd	25.79	0.11	30.11	2.95	9.80	16.75	1.68	1.46	1.17	4.32	7.62	**A**	9.81	**A**	**A**
^{134}Cs	10.82	0.07	10.47	0.59	5.64	-3.23	-0.32	-0.59	0.97	0.35	1.53	**A**	5.67	**A**	**A**
^{137}Cs	9.48	0.04	9.58	0.48	5.01	1.05	0.11	0.21	1.01	0.10	1.24	**A**	5.02	**A**	**A**
^{210}Pb	37.73	0.47	-	-											
^{241}Am	17.71	0.09	17.57	1.31	7.46	-0.79	-0.01	-0.11	0.99	0.14	3.39	**A**	7.47	**A**	**A**

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

Sample 03

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	11.56	0.04	10.87	0.53	4.88	-5.97	-0.63	-1.30	0.94	0.69	1.37	**A**	4.89	**A**	**A**
^{60}Co	16.60	0.13	16.21	0.99	6.11	-2.35	-0.24	-0.39	0.98	0.39	2.57	**A**	6.15	**A**	**A**
^{65}Zn	18.28	0.19	16.01	0.83	5.18	-12.42	-1.42	-2.66	0.88	2.27	2.20	**N**	5.29	**A**	**W**
^{109}Cd	42.97	0.21	44.04	3.95	8.97	2.49	0.24	0.27	1.02	1.07	10.21	**A**	8.98	**A**	**A**
^{134}Cs	18.03	0.14	17.44	0.90	5.16	-3.27	-0.34	-0.65	0.97	0.59	2.35	**A**	5.22	**A**	**A**
^{137}Cs	15.00	0.07	14.85	0.69	4.65	-1.00	-0.10	-0.22	0.99	0.15	1.79	**A**	4.67	**A**	**A**
^{210}Pb	62.87	0.95	<341	-											
^{241}Am	29.51	0.18	28.38	1.69	5.95	-3.83	-0.04	-0.67	0.96	1.13	4.38	**A**	5.99	**A**	**A**

Sample 05

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	11.56	0.04	10.95	0.55	5.02	-5.28	-0.53	-1.11	0.95	0.61	1.42	**A**	5.03	**A**	**A**
^{60}Co	16.60	0.13	15.48	0.96	6.20	-6.75	-0.67	-1.16	0.93	1.12	2.50	**A**	6.25	**A**	**A**
^{65}Zn	18.28	0.19	16.09	0.87	5.41	-11.98	-1.20	-2.46	0.88	2.19	2.30	**A**	5.51	**A**	**A**
^{109}Cd	42.97	0.21	41.78	4.02	9.62	-2.77	-0.28	-0.30	0.97	1.19	10.39	**A**	9.63	**A**	**A**
^{134}Cs	18.03	0.14	16.54	0.87	5.26	-8.26	-0.83	-1.69	0.92	1.49	2.27	**A**	5.31	**A**	**A**
^{137}Cs	15.00	0.07	14.48	0.69	4.77	-3.47	-0.35	-0.75	0.97	0.52	1.79	**A**	4.79	**A**	**A**
^{210}Pb	62.87	0.95	<383	-											
^{241}Am	29.51	0.18	27.44	1.72	6.27	-7.01	-0.06	-1.20	0.93	2.07	4.46	**A**	6.30	**A**	**A**

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

Sample 04

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria: Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	3.73	0.02	3.96	0.24	6.06	6.17	0.62	0.96	1.06	0.23	0.62	**A**	6.08	**A**	**A**
^{60}Co	5.55	0.06	5.86	0.38	6.48	5.59	0.56	0.81	1.06	0.31	0.99	**A**	6.58	**A**	**A**
^{65}Zn	5.14	0.10	5.36	0.39	7.28	4.28	0.43	0.55	1.04	0.22	1.04	**A**	7.51	**A**	**A**
^{109}Cd	16.34	0.11	19.08	2.46	12.89	16.77	1.68	1.11	1.17	2.74	6.35	**A**	12.91	**A**	**A**
^{134}Cs	11.65	0.07	11.47	0.63	5.49	-1.55	-0.15	-0.28	0.98	0.18	1.63	**A**	5.52	**A**	**A**
^{137}Cs	16.59	0.04	16.67	0.78	4.68	0.48	0.05	0.10	1.00	0.08	2.01	**A**	4.68	**A**	**A**
^{210}Pb	9.45	0.47													
^{241}Am	3.66	0.09	3.30	0.73	22.12	-9.84	-0.09	-0.49	0.90	0.36	1.90	**A**	22.25	**N**	**W**

A: Acceptable **W: Warning** **N: Not Acceptable**

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

Sample 02 *Reference date: 01October 2006*

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	6.94	0.02	7.12	0.13	1.83	2.59	0.26	1.37	1.03	0.18	0.34	**A**	1.85	**A**	**A**
^{60}Co	9.96	0.06	10.16	0.13	1.28	2.01	0.20	1.39	1.02	0.20	0.37	**A**	1.42	**A**	**A**
^{65}Zn	10.97	0.10	10.82	0.26	2.40	-1.37	-0.14	-0.54	0.99	0.15	0.72	**A**	2.56	**A**	**A**
^{109}Cd	25.79	0.11	24.43	1.09	4.46	-5.27	-0.53	-1.24	0.95	1.36	2.83	**A**	4.48	**A**	**A**
^{134}Cs	10.82	0.07	10.38	0.12	1.16	-4.07	-0.41	-3.19	0.96	0.44	0.36	**N**	1.32	**A**	**W**
^{137}Cs	9.48	0.04	9.97	0.17	1.71	5.17	0.52	2.82	1.05	0.49	0.45	**N**	1.74	**A**	**W**
^{210}Pb	37.73	0.47	31.85	2.30	7.22	-15.58	-1.56	-2.50	0.84	5.88	6.06	**A**	7.33	**A**	**A**
^{241}Am	17.71	0.09	17.69	0.29	1.64	-0.11	0.00	-0.07	1.00	0.02	0.78	**A**	1.71	**A**	**A**

Sample 06

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	6.94	0.02	7.23	0.14	1.94	4.18	0.42	2.05	1.04	0.29	0.36	**A**	1.96	**A**	**A**
^{60}Co	9.96	0.06	10.17	0.13	1.28	2.11	0.21	1.46	1.02	0.21	0.37	**A**	1.42	**A**	**A**
^{65}Zn	10.97	0.10	10.68	0.26	2.43	-2.64	-0.26	-1.05	0.97	0.29	0.72	**A**	2.59	**A**	**A**
^{109}Cd	25.79	0.11	23.94	1.09	4.55	-7.17	-0.72	-1.69	0.93	1.85	2.83	**A**	4.57	**A**	**A**
^{134}Cs	10.82	0.07	10.29	0.12	1.17	-4.90	-0.49	-3.84	0.95	0.53	0.36	**N**	1.32	**A**	**W**
^{137}Cs	9.48	0.04	10.08	0.17	1.69	6.33	0.63	3.46	1.06	0.60	0.45	**N**	1.73	**A**	**W**
^{210}Pb	37.73	0.47	42.70	2.73	6.39	13.17	1.32	1.79	1.13	4.97	7.15	**A**	6.52	**A**	**A**
^{241}Am	17.71	0.09	18.57	0.30	1.62	4.86	0.04	2.75	1.05	0.86	0.81	**N**	1.69	**A**	**W**

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

Sample 03

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	11.56	0.04	11.22	0.18	1.60	-2.94	-0.30	-1.84	0.97	0.34	0.48	**A**	1.64	**A**	**A**
^{60}Co	16.60	0.13	15.75	0.17	1.08	-5.12	-0.54	-4.03	0.95	0.85	0.54	**N**	1.32	**A**	**W**
^{65}Zn	18.28	0.19	16.77	0.33	1.97	-8.26	-0.90	-3.96	0.92	1.51	0.99	**N**	2.23	**A**	**W**
^{109}Cd	42.97	0.21	38.69	1.55	4.01	-9.96	-1.11	-2.74	0.90	4.28	4.04	**N**	4.04	**A**	**W**
^{134}Cs	18.03	0.14	16.39	0.15	0.92	-9.10	-1.00	-8.07	0.91	1.64	0.52	**N**	1.19	**A**	**W**
^{137}Cs	15.00	0.07	15.59	0.23	1.48	3.93	0.38	2.45	1.04	0.59	0.62	**A**	1.55	**A**	**A**
^{210}Pb	62.87	0.95	64.60	3.70	5.73	2.75	0.27	0.45	1.03	1.73	9.85	**A**	5.92	**A**	**A**
^{241}Am	29.51	0.18	28.41	0.41	1.44	-3.73	-0.04	-2.46	0.96	1.10	1.15	**A**	1.56	**A**	**A**

Sample 05

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	11.56	0.04	11.41	0.19	1.67	-1.30	-0.13	-0.77	0.99	0.15	0.50	**A**	1.70	**A**	**A**
^{60}Co	16.60	0.13	15.87	0.18	1.13	-4.40	-0.44	-3.33	0.96	0.73	0.57	**N**	1.36	**A**	**W**
^{65}Zn	18.28	0.19	16.85	0.36	2.14	-7.82	-0.78	-3.50	0.92	1.43	1.05	**N**	2.38	**A**	**W**
^{109}Cd	42.97	0.21	39.66	1.59	4.01	-7.70	-0.77	-2.06	0.92	3.31	4.14	**A**	4.04	**A**	**A**
^{134}Cs	18.03	0.14	16.60	0.17	1.02	-7.93	-0.79	-6.55	0.92	1.43	0.56	**N**	1.28	**A**	**W**
^{137}Cs	15.00	0.07	15.65	0.24	1.53	4.33	0.43	2.60	1.04	0.65	0.65	**N**	1.60	**A**	**W**
^{210}Pb	62.87	0.95	58.96	3.59	6.09	-6.22	-0.62	-1.05	0.94	3.91	9.58	**A**	6.27	**A**	**A**
^{241}Am	29.51	0.18	28.30	0.42	1.48	-4.10	-0.04	-2.65	0.96	1.21	1.18	**N**	1.60	**A**	**W**

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

Sample 04

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria: Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	3.73	0.02	3.83	0.10	2.61	2.68	0.27	0.98	1.03	0.10	0.26	**A**	2.67	**A**	**A**
^{60}Co	5.55	0.06	5.51	0.10	1.81	-0.72	-0.07	-0.34	0.99	0.04	0.30	**A**	2.13	**A**	**A**
^{65}Zn	5.14	0.10	5.19	0.19	3.66	0.97	0.10	0.23	1.01	0.05	0.55	**A**	4.11	**A**	**A**
^{109}Cd	16.34	0.11	15.13	0.85	5.62	-7.41	-0.74	-1.41	0.93	1.21	2.21	**A**	5.66	**A**	**A**
^{134}Cs	11.65	0.07	11.40	0.12	1.05	-2.15	-0.21	-1.81	0.98	0.25	0.36	**A**	1.20	**A**	**A**
^{137}Cs	16.59	0.04	17.54	0.24	1.37	5.73	0.57	3.92	1.06	0.95	0.63	**N**	1.38	**A**	**W**
^{210}Pb	9.45	0.47	6.64	1.40	21.08	-29.74	-2.97	-1.90	0.70	2.81	3.81	**A**	21.67	**A**	**A**
^{241}Am	3.66	0.09	3.61	0.12	3.32	-1.37	-0.01	-0.33	0.99	0.05	0.39	**A**	4.12	**A**	**A**

Acceptable **W: Warning** **N: Not Acceptable**

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

Sample 02 *Reference date: 01October 2006*

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria: Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	6.94	0.02	7.16	0.47	6.56	3.17	0.32	0.47	1.03	0.22	1.21	**A**	6.57	**A**	**A**
^{60}Co	9.96	0.06	9.47	0.61	6.44	-4.92	-0.49	-0.80	0.95	0.49	1.58	**A**	6.47	**A**	**A**
^{65}Zn	10.97	0.10	10.10	0.68	6.73	-7.93	-0.79	-1.27	0.92	0.87	1.77	**A**	6.79	**A**	**A**
^{109}Cd	25.79	0.11	26.40	2.91	11.02	2.37	0.24	0.21	1.02	0.61	7.51	**A**	11.03	**A**	**A**
^{134}Cs	10.82	0.07	9.78	0.63	6.44	-9.61	-0.96	-1.64	0.90	1.04	1.63	**A**	6.47	**A**	**A**
^{137}Cs	9.48	0.04	9.06	0.59	6.51	-4.43	-0.44	-0.71	0.96	0.42	1.52	**A**	6.52	**A**	**A**
^{210}Pb	37.73	0.47	42.10	3.35	7.96	11.58	1.16	1.29	1.12	4.37	8.73	**A**	8.06	**A**	**A**
^{241}Am	17.71	0.09	17.40	1.23	7.07	-1.75	-0.02	-0.25	0.98	0.31	3.18	**A**	7.09	**A**	**A**

Sample 06

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria: Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	6.94	0.02	7.19	0.47	6.54	3.60	0.36	0.53	1.04	0.25	1.21	**A**	6.54	**A**	**A**
^{60}Co	9.96	0.06	10.20	0.66	6.47	2.41	0.24	0.36	1.02	0.24	1.71	**A**	6.50	**A**	**A**
^{65}Zn	10.97	0.10	10.70	0.73	6.82	-2.46	-0.25	-0.37	0.98	0.27	1.90	**A**	6.88	**A**	**A**
^{109}Cd	25.79	0.11	25.40	2.24	8.82	-1.51	-0.15	-0.17	0.98	0.39	5.79	**A**	8.83	**A**	**A**
^{134}Cs	10.82	0.07	10.00	0.65	6.50	-7.58	-0.76	-1.25	0.92	0.82	1.69	**A**	6.53	**A**	**A**
^{137}Cs	9.48	0.04	9.70	0.63	6.49	2.32	0.23	0.35	1.02	0.22	1.63	**A**	6.51	**A**	**A**
^{210}Pb	37.73	0.47	36.40	3.80	10.44	-3.53	-0.35	-0.35	0.96	1.33	9.88	**A**	10.51	**A**	**A**
^{241}Am	17.71	0.09	18.00	1.28	7.11	1.64	0.01	0.23	1.02	0.29	3.31	**A**	7.13	**A**	**A**

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

Sample 03

Analyte	IAEA Value	IAEA Unc.	Laboratory Value	Laboratory Unc.		R. bias	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness			Precision		Final score
	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	[%]	[%]				A1	A2	Score	P	Score	
^{54}Mn	11.56	0.04	11.00	0.71	6.45	-4.84	-0.51	-0.79	0.95	0.56	1.83	**A**	6.46	**A**	**A**
^{60}Co	16.60	0.13	15.30	0.97	6.34	-7.83	-0.85	-1.33	0.92	1.30	2.52	**A**	6.38	**A**	**A**
^{65}Zn	18.28	0.19	17.00	1.09	6.41	-7.00	-0.75	-1.16	0.93	1.28	2.86	**A**	6.50	**A**	**A**
^{109}Cd	42.97	0.21	40.60	2.85	7.02	-5.52	-0.58	-0.83	0.94	2.37	7.37	**A**	7.04	**A**	**A**
^{134}Cs	18.03	0.14	15.00	0.90	6.00	-16.81	-2.02	-3.33	0.83	3.03	2.35	**N**	6.05	**A**	**N**
^{137}Cs	15.00	0.07	14.20	0.92	6.48	-5.33	-0.56	-0.87	0.95	0.80	2.38	**A**	6.50	**A**	**A**
^{210}Pb	62.87	0.95	56.90	4.46	7.84	-9.50	-1.05	-1.31	0.91	5.97	11.76	**A**	7.98	**A**	**A**
^{241}Am	29.51	0.18	27.10	1.91	7.05	-8.17	-0.08	-1.26	0.92	2.41	4.95	**A**	7.07	**A**	**A**

Sample 05

Analyte	IAEA Value	IAEA Unc.	Laboratory Value	Laboratory Unc.		R. bias	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness			Precision		Final score
	[Bq/kg]	[Bq/kg]	[Bq/kg]	[Bq/kg]	[%]	[%]				A1	A2	Score	P	Score	
^{54}Mn	11.56	0.04	11.10	0.72	6.49	-3.98	-0.40	-0.64	0.96	0.46	1.86	**A**	6.50	**A**	**A**
^{60}Co	16.60	0.13	15.00	0.96	6.40	-9.64	-0.96	-1.65	0.90	1.60	2.50	**A**	6.44	**A**	**A**
^{65}Zn	18.28	0.19	16.50	1.08	6.55	-9.74	-0.97	-1.62	0.90	1.78	2.83	**A**	6.63	**A**	**A**
^{109}Cd	42.97	0.21	39.20	2.76	7.04	-8.77	-0.88	-1.36	0.91	3.77	7.14	**A**	7.06	**A**	**A**
^{134}Cs	18.03	0.14	15.00	0.96	6.40	-16.81	-1.68	-3.12	0.83	3.03	2.50	**N**	6.44	**A**	**N**
^{137}Cs	15.00	0.07	14.70	0.95	6.46	-2.00	-0.20	-0.31	0.98	0.30	2.46	**A**	6.48	**A**	**A**
^{210}Pb	62.87	0.95	57.30	4.51	7.87	-8.86	-0.89	-1.21	0.91	5.57	11.89	**A**	8.01	**A**	**A**
^{241}Am	29.51	0.18	27.00	1.90	7.04	-8.51	-0.08	-1.32	0.91	2.51	4.92	**A**	7.06	**A**	**A**

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

Sample 04

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria: Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	3.73	0.02	3.81	0.26	6.82	2.14	0.21	0.31	1.02	0.08	0.67	**A**	6.85	**A**	**A**
^{60}Co	5.55	0.06	5.31	0.35	6.59	-4.32	-0.43	-0.68	0.96	0.24	0.92	**A**	6.69	**A**	**A**
^{65}Zn	5.14	0.10	5.17	0.38	7.35	0.58	0.06	0.08	1.01	0.03	1.01	**A**	7.58	**A**	**A**
^{109}Cd	16.34	0.11	16.20	1.70	10.49	-0.86	-0.09	-0.08	0.99	0.14	4.39	**A**	10.51	**A**	**A**
^{134}Cs	11.65	0.07	10.40	0.67	6.44	-10.73	-1.07	-1.86	0.89	1.25	1.74	**A**	6.47	**A**	**A**
^{137}Cs	16.59	0.04	16.20	1.04	6.42	-2.35	-0.24	-0.37	0.98	0.39	2.68	**A**	6.42	**A**	**A**
^{210}Pb	9.45	0.47	10.80	2.24	20.74	14.29	1.43	0.59	1.14	1.35	5.91	**A**	21.34	**A**	**A**
^{241}Am	3.66	0.09	3.36	0.26	7.74	-8.20	-0.07	-1.09	0.92	0.30	0.71	**A**	8.11	**A**	**A**

Acceptable **W: Warning** **N: Not Acceptable**

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

Sample 02 *Reference date: 01October 2006*

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	6.94	0.02	6.91	1.04	15.06	-0.48	-0.05	-0.03	1.00	0.03	2.68	A	15.06	N	W
^{60}Co	9.96	0.06	10.27	1.53	14.90	3.11	0.31	0.20	1.03	0.31	3.95	A	14.91	A	A
^{65}Zn	10.97	0.10	9.96	1.39	13.96	-9.21	-0.92	-0.72	0.91	1.01	3.59	A	13.98	A	A
^{109}Cd	25.79	0.11	23.33	3.97	17.02	-9.54	-0.95	-0.62	0.90	2.46	10.25	A	17.02	N	W
^{134}Cs	10.82	0.07	9.16	1.47	16.05	-15.34	-1.53	-1.13	0.85	1.66	3.80	A	16.06	N	N
^{137}Cs	9.48	0.04	10.14	1.38	13.61	6.96	0.70	0.48	1.07	0.66	3.56	A	13.61	A	A
^{210}Pb	37.73	0.47	-	-											
^{241}Am	17.71	0.09	21.46	3.28	15.28	21.17	0.19	1.14	1.21	3.75	8.47	A	15.29	N	N

Sample 06

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	6.94	0.02	6.86	1.23	17.93	-1.15	-0.12	-0.07	0.99	0.08	3.17	A	17.93	N	W
^{60}Co	9.96	0.06	9.94	1.79	18.01	-0.20	-0.02	-0.01	1.00	0.02	4.62	A	18.02	N	W
^{65}Zn	10.97	0.10	9.75	1.76	18.05	-11.12	-1.11	-0.69	0.89	1.22	4.55	A	18.07	N	W
^{109}Cd	25.79	0.11	16.89	3.16	18.71	-34.51	-3.45	-2.81	0.65	8.90	8.16	N	18.71	N	N
^{134}Cs	10.82	0.07	9.13	1.61	17.63	-15.62	-1.56	-1.05	0.84	1.69	4.16	A	17.65	N	N
^{137}Cs	9.48	0.04	10.04	1.81	18.03	5.91	0.59	0.31	1.06	0.56	4.67	A	18.03	N	W
^{210}Pb	37.73	0.47	-	-											
^{241}Am	17.71	0.09	22.29	3.12	14.00	25.86	0.24	1.47	1.26	4.58	8.05	A	14.01	A	A

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

Sample 03

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	11.56	0.04	10.48	1.39	13.26	-9.34	-1.03	-0.78	0.91	1.08	3.59	**A**	13.27	**A**	**A**
^{60}Co	16.60	0.13	16.20	2.82	17.41	-2.41	-0.25	-0.14	0.98	0.40	7.28	**A**	17.42	**N**	**W**
^{65}Zn	18.28	0.19	16.29	2.78	17.07	-10.89	-1.22	-0.71	0.89	1.99	7.19	**A**	17.10	**N**	**W**
^{109}Cd	42.97	0.21	33.37	5.78	17.32	-22.34	-2.88	-1.66	0.78	9.60	14.92	**A**	17.33	**N**	**N**
^{134}Cs	18.03	0.14	14.19	2.55	17.97	-21.30	-2.71	-1.50	0.79	3.84	6.59	**A**	17.99	**N**	**N**
^{137}Cs	15.00	0.07	15.55	3.11	20.00	3.67	0.35	0.18	1.04	0.55	8.03	**A**	20.01	**N**	**W**
^{210}Pb	62.87	0.95	-	-											
^{241}Am	29.51	0.18	35.67	5.97	16.74	20.87	0.16	1.03	1.21	6.16	15.41	**A**	16.75	**N**	**N**

Sample 05

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	11.56	0.04	9.63	1.93	20.04	-16.70	-1.67	-1.00	0.83	1.93	4.98	**A**	20.04	**N**	**N**
^{60}Co	16.60	0.13	15.99	2.80	17.51	-3.67	-0.37	-0.22	0.96	0.61	7.23	**A**	17.53	**N**	**W**
^{65}Zn	18.28	0.19	16.63	2.49	14.97	-9.03	-0.90	-0.66	0.91	1.65	6.44	**A**	15.01	**N**	**W**
^{109}Cd	42.97	0.21	24.78	4.46	18.00	-42.33	-4.23	-4.07	0.58	18.19	11.52	**N**	18.01	**N**	**N**
^{134}Cs	18.03	0.14	14.49	2.67	18.43	-19.63	-1.96	-1.32	0.80	3.54	6.90	**A**	18.44	**N**	**N**
^{137}Cs	15.00	0.07	15.19	2.43	16.00	1.27	0.13	0.08	1.01	0.19	6.27	**A**	16.00	**N**	**W**
^{210}Pb	62.87	0.95	-	-											
^{241}Am	29.51	0.18	31.68	5.63	17.77	7.35	0.07	0.39	1.07	2.17	14.53	**A**	17.78	**N**	**W**

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

Sample 04

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria: Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	3.73	0.02	3.60	0.64	17.81	-3.49	-0.35	-0.20	0.97	0.13	1.65	**A**	17.81	**N**	**W**
^{60}Co	5.55	0.06	5.53	0.88	15.99	-0.36	-0.04	-0.02	1.00	0.02	2.29	**A**	16.02	**N**	**W**
^{65}Zn	5.14	0.10	4.63	0.74	16.00	-9.92	-0.99	-0.68	0.90	0.51	1.93	**A**	16.11	**N**	**W**
^{109}Cd	16.34	0.11	13.92	2.23	16.02	-14.81	-1.48	-1.08	0.85	2.42	5.76	**A**	16.03	**A**	**A**
^{134}Cs	11.65	0.07	9.69	1.74	17.96	-16.82	-1.68	-1.13	0.83	1.96	4.49	**A**	17.97	**N**	**N**
^{137}Cs	16.59	0.04	16.64	3.16	18.99	0.30	0.03	0.02	1.00	0.05	8.15	**A**	18.99	**N**	**W**
^{210}Pb	9.45	0.47	-	-											
^{241}Am	3.66	0.09	3.69	0.68	18.43	0.82	0.01	0.04	1.01	0.03	1.77	**A**	18.59	**N**	**W**

Acceptable **W: Warning** **N: Not Acceptable**

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

Sample 02 *Reference date: 01October 2006*

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria: Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	6.94	0.02	5.63	0.43	7.64	-18.88	-1.89	-3.04	0.81	1.31	1.11	**N**	7.64	**A**	**N**
^{60}Co	9.96	0.06	7.81	0.49	6.27	-21.59	-2.16	-4.35	0.78	2.15	1.27	**N**	6.30	**A**	**N**
^{65}Zn	10.97	0.10	7.72	0.83	10.75	-29.63	-2.96	-3.89	0.70	3.25	2.16	**N**	10.79	**A**	**N**
^{109}Cd	25.79	0.11	ND	-											
^{134}Cs	10.82	0.07	8.69	0.41	4.72	-19.69	-1.97	-5.13	0.80	2.13	1.07	**N**	4.76	**A**	**N**
^{137}Cs	9.48	0.04	8.01	0.52	6.45	-15.51	-1.55	-2.84	0.84	1.47	1.34	**N**	6.46	**A**	**N**
^{210}Pb	37.73	0.47	ND	-											
^{241}Am	17.71	0.09	<5.14	-											

Sample 06

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria: Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	6.94	0.02	5.71	0.42	7.36	-17.72	-1.77	-2.93	0.82	1.23	1.08	**N**	7.36	**A**	**N**
^{60}Co	9.96	0.06	7.74	0.49	6.33	-22.29	-2.23	-4.49	0.78	2.22	1.27	**N**	6.36	**A**	**N**
^{65}Zn	10.97	0.10	7.96	0.81	10.18	-27.44	-2.74	-3.69	0.73	3.01	2.10	**N**	10.21	**A**	**N**
^{109}Cd	25.79	0.11	ND	-											
^{134}Cs	10.82	0.07	9.07	0.42	4.63	-16.17	-1.62	-4.11	0.84	1.75	1.10	**N**	4.67	**A**	**N**
^{137}Cs	9.48	0.04	7.71	0.49	6.36	-18.67	-1.87	-3.60	0.81	1.77	1.27	**N**	6.37	**A**	**N**
^{210}Pb	37.73	0.47	ND	-											
^{241}Am	17.71	0.09	<5.32	-											

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

Sample 03

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	11.56	0.04	8.13	0.53	6.52	-29.67	-4.22	-6.45	0.70	3.43	1.37	**N**	6.53	**A**	**N**
^{60}Co	16.60	0.13	12.00	0.67	5.58	-27.71	-3.83	-6.75	0.72	4.60	1.76	**N**	5.63	**A**	**N**
^{65}Zn	18.28	0.19	11.48	1.01	8.80	-37.20	-5.92	-6.61	0.63	6.80	2.65	**N**	8.86	**A**	**N**
^{109}Cd	42.97	0.21	ND	-											
^{134}Cs	18.03	0.14	13.52	0.54	3.99	-25.01	-3.34	-8.10	0.75	4.51	1.44	**N**	4.07	**A**	**N**
^{137}Cs	15.00	0.07	12.10	0.67	5.54	-19.33	-2.40	-4.30	0.81	2.90	1.74	**N**	5.56	**A**	**N**
^{210}Pb	62.87	0.95	ND	-											
^{241}Am	29.51	0.18	<5.8	-											

Sample 05

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	11.56	0.04	8.88	0.55	6.19	-23.18	-2.32	-4.86	0.77	2.68	1.42	**N**	6.20	**A**	**N**
^{60}Co	16.60	0.13	12.27	0.68	5.54	-26.08	-2.61	-6.26	0.74	4.33	1.78	**N**	5.59	**A**	**N**
^{65}Zn	18.28	0.19	12.08	1.04	8.61	-33.92	-3.39	-5.86	0.66	6.20	2.73	**N**	8.67	**A**	**N**
^{109}Cd	42.97	0.21	ND	-											
^{134}Cs	18.03	0.14	13.68	0.57	4.17	-24.13	-2.41	-7.42	0.76	4.35	1.51	**N**	4.24	**A**	**N**
^{137}Cs	15.00	0.07	12.22	0.67	5.48	-18.53	-1.85	-4.13	0.81	2.78	1.74	**N**	5.50	**A**	**N**
^{210}Pb	62.87	0.95	ND	-											
^{241}Am	29.51	0.18	<5.7	-											

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

Sample 04

Analyte	IAEA Value [Bq/kg]	IAEA Unc. [Bq/kg]	Laboratory Value [Bq/kg]	Laboratory Unc. [Bq/kg]	Laboratory Unc. [%]	R. bias [%]	Z-score	U-score	Lab./IAEA	Acceptance criteria: Trueness A1	Trueness A2	Trueness Score	Precision P	Precision Score	Final score
^{54}Mn	3.73	0.02	2.95	0.30	10.18	-21.02	-2.10	-2.61	0.79	0.78	0.78	N	10.20	A	N
^{60}Co	5.55	0.06	4.05	0.30	7.41	-27.03	-2.70	-4.90	0.73	1.50	0.79	N	7.49	A	N
^{65}Zn	5.14	0.10	3.46	0.58	16.76	-32.68	-3.27	-2.86	0.67	1.68	1.52	N	16.87	N	N
^{109}Cd	16.34	0.11													
^{134}Cs	11.65	0.07	8.55	0.40	4.68	-26.61	-2.66	-7.64	0.73	3.10	1.05	N	4.71	A	N
^{137}Cs	16.59	0.04	13.26	0.66	4.98	-20.07	-2.01	-5.04	0.80	3.33	1.71	N	4.98	A	N
^{210}Pb	9.45	0.47	ND	-											
^{241}Am	3.66	0.09	<4.77	-											

Acceptable **W: Warning** **N: Not Acceptable**

The IAEA-CU-2006-08 proficiency test on the determination of gamma emitting radionuclides in sea water

Appendix C: Information provided by the laboratories

The technical information provided by the participants on the analytical procedures used in their own laboratories is compiled in this Appendix and coded with the same laboratory code used in the data evaluation. The participants can benefit from the information exchange without revealing the laboratories identity.

Information provided by laboratory No. 01

The IAEA-CU-2006-08 proficiency test on the determination of gamma emitting radionuclides in sea water

Method Validation and Combined standard Uncertainty Estimation Form (F-03)

Please provide us with the following information related to method validation:
1- Did you perform method validation?

Standard methods are used (ASTM E181-98 and ISO 10703:97), but validation was performed for the used corrections (True summing and self absorption) in combination with the rest of the analysis routine.

2- If yes, kindly submit the obtained validation parameters such as: Minimum detection limit, Repeatability limit, Reproducibility limit…

For the current counting setup, activity values for sample #1 except for Cs-137 (MDA $\simeq$ 0.24 Bq/kg) can be taken as MDA values. Repeatability parameters : For the true summing correction $\pm$ 5 %. For self attenuation correction $\pm$ 3%.

3- Please describe your approach for evaluation of uncertainty components and give the formula used for calculation of the expanded uncertainty

All possible sources of uncertainty are first taken into account, the effect of each element on the overall uncertainty is then assessed and elements of minor effects are neglected.
Expanded Uncertainty = Coverage factor * combined standard uncertainty

4- You are kindly asked to list the sources of uncertainties included in the estimation of the combined standard uncertainty

The uncertainty in the peak area. The uncertainty in the counting time, ≈ 1% (experimentally determined according to ASTM E181-98*(2003).* The uncertainty in the yield, obtained from PTB RA 16/4, 1993 or from αβγ-Table, Radionuclide Handbook for Laboratory workers in Spectrometry, Radiation Protection and Medicine. V. 3.8.0.a, Wolfgang Wah. The uncertainty in the efficiency calculation, which includes the uncertainty in the calibration standard, the uncertainty in the decay correction for the standard including uncertainty in the half life (as listed in PTB RA 16/4, 1993 or αβγ-Table, Radionuclide Handbook for Laboratory workers in Spectrometry, and counting time, the uncertainty in the peak areas of the radionuclides in the standard and the uncertainty in the mathematical curve fitting of the measured efficiency values to a dual curve (empirical + linear). The uncertainty in the sample weight = $\pm$ 0.2 g. The uncertainty in the cascade summing correction factor (when applied) ≈ 5% (experimentally determined). The uncertainty in the self attenuation correction factor ≈ 3% (experimentally determined). The uncertainty in the radionuclide decay correction factor (this correction factor includes the uncertainty in the correction factor for the radionuclide decay from reference date to the counting start, and the uncertainty in the correction factor for the radionuclide decay during counting).

5- Did your laboratory obtain a formal accreditation? Do you apply a QAS?

Yes, by UKAS since 2004 and by the national accreditation body since 2005.
QAS is applied in the lab. It includes monitoring counting systems' parameters, analysts proficiency testing through the use of CRMs, multiple samples, back samples and at least two PT runs/yr using samples of 4 different matrix forms (soil, water, vegetation and glass fibre air filters).
6- How many samples your laboratories analyze per year? 400 – 600 samples

Information provided by laboratory No. 01

The IAEA-CU-2006-08 proficiency test on the determination of gamma emitting radionuclides in sea water

Method and Quality Control Procedure Description Form (F-04)

1. DESCRIPTION OF SAMPLE PREPARATION AND DIGESTION METHOD (if applicable)

Describe how the sample was prepared and presented to the apparatus (digestion method).
As instructed, samples were homogenised by shaking for 2 minutes.

2. DESCRIPTION OF MEASUREMENT TECHNIQUE AND CALIBRATION METHOD

Describe your system and the efficiency and energy calibration procedures, which sources were used for efficiency calibration? Which corrections were applied?
Detector type : P-Type coaxial HPGe Detector.
Relative Efficiency : 20%, FWHM = 1.9 keV, peak:Compton ratio = 56:1.
Energy and efficiency calibrations are performed using a ten radionuclide mixed gamma standard.
True summing corrections were applied to the resulting efficiency curve for correction of summing by Co-60 and Y-88 present in the standard.

3. DESCRIPTION OF QUALITY CONTROL PROCEDURE

Use of blank, CRM, Control samples, duplicate, replicate, spike sample and control charts. Kindly report quality control data, how you validate your efficiency calibration? How you check the trueness of your results?

Efficiency curve validation is done using a Eu-152 standard of the same matrix and density as the standard. This also helps in checking the trueness of the true summing correction method applied.

As an example of QC Data, attached are the results of the last PT the lab participated in (radionuclides only). Detailed system parameter control charts are available at the lab.

Information provided by laboratory No. 02

The IAEA-CU-2006-08 proficiency test on the determination of gamma emitting radionuclides in sea water

Method Validation and Combined Standard Uncertainty Estimation Form (F-03)

Please provide us with the following information related to method validation:
1- Did you perform method validation?

Yes

2- If yes, kindly submit the obtained validation parameters such as: Minimum detection limit, Repeatability limit, Reproducibility limit…

Please find attachment No. 1.

3- Please describe your approach for evaluation of uncertainty components and give the formula used for calculation of the expanded uncertainty

The uncertainty components are the following:
- Uncertainty of sample preparation: sample homogeneity, weight, volume and geometry.
- Uncertainty of measurement: uncertainty in area counts, emission probability, detector efficiency, attenuation and coincidence summing corrections.

The combined standard uncertainty is then multiplied by coverage factor (k), to get the expanded uncertainty. Please find attachment No. 2 for equation.

4- You are kindly asked to list the sources of uncertainties included in the estimation of the combined standard uncertainty

Please find in attachment No. 2.

5- Did your laboratory obtain a formal accreditation? Do you apply a QAS?

6- How many samples your laboratory analyze per year?

Information provided by laboratory No. 02

The IAEA-CU-2006-08 proficiency test on the determination of gamma emitting radionuclides in sea water

Method and Quality Control Procedure Description Form (F-04)

1. DESCRIPTION OF SAMPLE PREPARATION AND DIGESTION METHOD (if applicable)

Describe how the sample was prepared and presented to the apparatus (digestion method).

- The sample was already prepared and homogenised.
- The sub-sample was filled by using our own geometry.
- The calibration standard source density approximately equals the sub-samples.

2. DESCRIPTION OF MEASUREMENT TECHNIQUE AND CALIBRATION METHOD

Describe your system and the efficiency and energy calibration procedures, which sources were used for efficiency calibration? Which corrections were applied?

- Gamma spectrometry system with HPGe detector (40% R.E.) was used to measure the samples.
- Mixed gamma source from CMI was used to establish the calibration files (energy, shape and efficincy).
- Genie 2000 software was used to perform the primary evaluation of the spectra, after that we used reference material (IAEA-375) to check the results.

3. DESCRIPTION OF QUALITY CONTROL PROCEDURE

Use of blank, CRM, Control samples, duplicate, replicate, spike sample and control charts. Kindly report quality control data, how you validate your efficiency calibration? How you check the trueness of your results?

- The background was measured in weekly bases to establish control charts using the total integral counts and counts per second for energy lines.
- The (IAEA-375) reference material was measured to compare the analysed value with the reference value and to calculate the validation parameters.
- Measure the standard which used for efficiency calibration to check the energy and efficiency calibration.
- Please find control charts (attachment No. 3)

Information provided by laboratory No. 03

The IAEA-CU-2006-08 proficiency test on the determination of gamma emitting radionuclides in sea water

Method Validation and Combined standard Uncertainty Estimation Form (F-03)

Please provide us with the following information related to method validation:

1- Did you perform method validation?

Existing method was previously validated for a typical routine count time of 6000 seconds.

2- If yes, kindly submit the obtained validation parameters such as: Minimum detection limit, Repeatability limit, Reproducibility limit…

For this study the typical detection levels for a 120,000 second count were:
Pb-210, 6.6 Bq/kg
Am-241, 0.4 Bq/kg
Cd-109, 4.0 Bq/kg
Co-60, 0.2 Bq/kg
Cs-134, 0.2 Bq/kg
Cs-137, 0.23 Bq/kg
Mn-54, 0.22 Bq/kg
Zn-65, 0.5 Bq/kg
The samples were counted on two different HPGe n-type detection systems. A few of the samples were re-counted on the same system and showed good agreement/reproducibility. Results available upon request.

3- Please describe your approach for evaluation of uncertainty components and give the formula used for calculation of the expanded uncertainty.

There are several factors that are considered in the uncertainty component. The reported uncertainty is the total systematic uncertainty which includes error evaluations associated with the components outlined in question 4.

The overall uncertainty is the square root of each individual uncertainty component squared.

4- You are kindly asked to list the sources of uncertainties included in the estimation of the combined standard uncertainty.

Sources of uncertainty

1) Uncertainty due to isotope half-life
2) Uncertainty associated with use of the balance for weight measurements
3) Raw Counting uncertainties (peak areas, background subtractions, etc…)
4) Efficiency process uncertainties that encompass nuclide certificate uncertainties, etc…

Estimated combined standard uncertainty is around 6.5%

5- Did your laboratory obtain a formal accreditation? Do you apply a QAS?

The laboratory has received formal accreditation from the National authority.

6- How many samples your laboratory analyze per year?

Information provided by laboratory No. 03

The IAEA-CU-2006-08 proficiency test on the determination of gamma emitting radionuclides in sea water

Method and Quality Control Procedure Description Form (F-04)

1. DESCRIPTION OF SAMPLE PREPARATION AND DIGESTION METHOD (if applicable)

Describe how the sample was prepared and presented to the apparatus (digestion method).

- The balance was tared using an empty Marinelli beaker.
- The samples were stirred for 5 minutes shaken and approximately 500mL was transferred to the marinelli beaker and re-weighed.
- The net sample weight in the Marinelli was recorded
- The sample was then placed on an n-type HPGe detection system and counted for 120,000 seconds. The exception was sample #1. Since the radionuclides with the exception of Cs-137 were not detected the sample was recounted for 180,000 seconds.

2. DESCRIPTION OF MEASUREMENT TECHNIQUE AND CALIBRATION METHOD

Describe your system and the efficiency and energy calibration procedures, which sources were used for efficiency calibration? Which corrections were applied?

The HPGe systems are efficiency and energy calibrated per procedure No.21-02, Calibration of the Gamma Spectrometer." There are several sources of varying geometry used for the efficiency calibration. Some of the geometries used for calibration include, a 500mL Marinelli beaker with a density of 1.0 g/cm^3 (used to simulate water), a 500mL Marinelli beaker with a density of 2.7 g/cm^3 (used for soils), a 500 mL Marinelli beaker with a density of 0.4 g/cm^3 (used to simulate paper), a point source, a 1inch air filter, a 2 inch air filter, a charcoal cartridge used in air sampling, and a 20mL liquid scintillation vial. The efficiency calibration used for this study included the 500mL Marinelli beaker geometry with a density of 1.0 g/cm^3. Since the sample was in a standard geometry there were no corrections applied other than the ones discussed in Form F-03, Method Validation and Combined standard Uncertainty Estimation Form.

3. DESCRIPTION OF QUALITY CONTROL PROCEDURE

Use of blank, CRM, Control samples, duplicate, replicate, spike sample and control charts. Kindly report quality control data, how you validate your efficiency calibration? How you check the trueness of your results?

There were no duplicate, replicate, or sample spikes run with this batch of samples since there was no sample preparation used. To evaluate/validate the consistency of the efficiency calibration a known spike (quality control check) is ran to ensure that the actual values are within the required limits. Also, there is a laboratory control sample (LCS) spiked with a known concentration ran with each sample. The quality control sample requirement is +/- 25%. The quality control checks and laboratory control samples for these samples were all within the required limits. To correct for background, a 60,000 second background count was subtracted from the sample results.

Information provided by laboratory No. 04

The IAEA-CU-2006-08 proficiency test on the determination of gamma emitting radionuclides in sea water

Method Validation and Combined standard Uncertainty Estimation Form (F-03)

Please provide us with the following information related to method validation:
1- Did you perform method validation?

No Method of validation used

2- If yes, kindly submit the obtained validation parameters such as: Minimum detection limit, Repeatability limit, Reproducibility limit…

Repeatability used

3- Please describe your approach for evaluation of uncertainty components and give the formula used for calculation of the expanded uncertainty.

Square root for activity was taken

4- You are kindly asked to list the sources of uncertainties included in the estimation of the combined standard uncertainty.

Act=n/t / (eff*I*w) this means source of uncertainties are net count, time, efficiency, Intensity, and weight of sample

5- Did your laboratory obtain a formal accreditation? Do you apply a QAS?

No

6- How many samples your laboratory analyze per year?

Around 300-500 sample per year

Information provided by laboratory No. 04

The IAEA-CU-2006-08 proficiency test on the determination of gamma emitting radionuclides in sea water

Method and Quality Control Procedure Description Form (F-04)

1. DESCRIPTION OF SAMPLE PREPARATION AND DIGESTION METHOD (if applicable)

Describe how the sample was prepared and presented to the apparatus (digestion method).

No preparation have done, sample was measure as it in Marinelli beaker

2. DESCRIPTION OF MEASUREMENT TECHNIQUE AND CALIBRATION METHOD

Describe your system and the efficiency and energy calibration procedures, which sources were used for efficiency calibration? Which corrections were applied?

1 Liter Marinelli beaker (130G) , Multinuclide distributed in 1.0 g/cc epoxy matrix

3. DESCRIPTION OF QUALITY CONTROL PROCEDURE

Use of blank, CRM, Control samples, duplicate, replicate, spike sample and control charts. Kindly report quality control data, how you validate your efficiency calibration? How you check the trueness of your results?

Duplicate method using

Information provided by laboratory No. 05

The IAEA-CU-2006-08 proficiency test on the determination of gamma emitting radionuclides in sea water

Method Validation and Combined standard Uncertainty Estimation Form (F-03)

Please provide us with the following information related to method validation:
1- Did you perform method validation?

Yes

2- If yes, kindly submit the obtained validation parameters such as: Minimum detection limit, Repeatability limit, Reproducibility limit…

MDL

3- Please describe your approach for evaluation of uncertainty components and give the formula used for calculation of the expanded uncertainty.

Uncertainty values calculated by software. We use 'Interwinner" by Ortec.

4- You are kindly asked to list the sources of uncertainties included in the estimation of the combined standard uncertainty.

Concentration levels in our standards are much higher than those in measured samples.

5- Did your laboratory obtain a formal accreditation? Do you apply a QAS?

No, but we are looking to get ISO 17025.

6- How many samples your laboratory analyze per year?

30

Information provided by laboratory No. 05

The IAEA-CU-2006-08 proficiency test on the determination of gamma emitting radionuclides in sea water

Method and Quality Control Procedure Description Form (F-04)

1. DESCRIPTION OF SAMPLE PREPARATION AND DIGESTION METHOD (if applicable)

Describe how the sample was prepared and presented to the apparatus (digestion method).

We homogenized the sample by shaking for two minutes.
The contents were then transferred to a Marinelli Beaker.

2. DESCRIPTION OF MEASUREMENT TECHNIQUE AND CALIBRATION METHOD

Describe your system and the efficiency and energy calibration procedures, which sources were used for efficiency calibration? Which corrections were applied?

We have a HPG system with Ortec Trump MCA. We use several sources for energy calibration and efficiency calibration; such as Co-60, Cs-137, Na-22. We do not have very low energy sources for calibration purposes.

3. DESCRIPTION OF QUALITY CONTROL PROCEDURE

Use of blank, CRM, Control samples, duplicate, replicate, spike sample and control charts. Kindly report quality control data, how you validate your efficiency calibration? How you check the trueness of your results?

We repeat each sample measurement. We measure for 1 day to get better statistics. If we have duplicate samples, we measure both to check. We join RMCC project and MAPEP test which allow us to check our results against some spiked samples.