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Worldwide Open Proficiency Test: Determination of Naturally Occurring Radionuclides in Phosphogypsum and Water

IAEA-CU-2008-03

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Worldwide Open Proficiency Test: Determination of Naturally Occurring Radionuclides in Phosphogypsum and Water

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FOREWORD

Phosphogypsum is generated as a by-product of the phosphoric acid based fertilizer industry. The discharge of phosphogypsum on earth surface deposits is a potential source of enhanced natural radiation and heavy metals, and the resulting environmental impact should be considered carefully to ensure safety and compliance with environmental regulations.

A reliable determination of naturally occurring radionuclides in phosphogypsum is necessary to comply with the radiation protection and environmental regulations.

The IAEA assists its Member States laboratories to maintain their readiness by producing reference materials, by developing standardized analytical methods, and by conducting interlaboratory comparisons and proficiency tests as tools for quality control.

To fulfil this obligation and ensure a reliable worldwide, rapid and consistent response, the IAEA Terrestrial Environment Laboratory in Seibersdorf, Austria organises interlaboratory comparisons and proficiency tests.

This summary report presents the results of the worldwide proficiency test IAEA-CU-2008-03 on the determination of naturally occurring radionuclides in phosphogypsum and spiked water. Methodologies, data evaluation approach, summary evaluation of each nuclide and individual evaluation reports for each laboratory are also described.

This proficiency test was designed to identify analytical problems, to support IAEA Member States laboratories to improve the quality of their analytical results, to maintain their accreditation and to provide a regular forum for discussion and technology transfer in this area. The number of samples, their matrix interferences and the concentration levels of the analytes were designed in a way to enable identification of potential analytical problems.

Three National Metrology Institutes (NMI) and six expert laboratories took part in the characterization campaign of the IAEA-434 RM phosphogypsum; namely: ERISS, Australia (A. Bollhöfer), PTB, Germany (H. Wershofen), HAA, Hungary (S. Tarjan), KINS, Republic of Korea (S. Kim and Y.J. Kim), KRISS, Republic of Korea (S.H. Lee), LNE-LNHB, France (M. Moune), IJS, Slovenia (M. Korun), AECS, Syrian Arab Republic (M.S. Al-Masri), in addition to the IAEA Terrestrial Environment Laboratory (Austria). The IAEA is appreciative for the contribution of these institutes which was at no cost to the IAEA.

The IAEA officer responsible for this publication was A. Shakhashiro of the IAEA Environment Laboratories.

CONTENTS

1. INTRODUCTION

A reliable determination of naturally occurring radionuclides in phosphogypsum is necessary to comply with the radiation protection and environmental regulations.

This proficiency test (PT) is one of the series of the world wide proficiency tests organised every year by the IAEA Terrestrial Environment Laboratory. This series of PTs is designed to identify analytical problems, to support Member State laboratories to maintain their accreditation and to provide a forum for discussions regarding the analysis of naturally occurring radionuclides. The range of sample types available for analysis has been mainly at environmental levels.

In this PT, the test item set consisted of six samples: one phosphogypsum (the IAEA-434 reference material) and five water samples spiked with natural radionuclides. The main task of the participating laboratories was to identify and traceably quantify the activity levels of radionuclides present in these matrices. 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 international standards of radioactivity.

In this PT, 1800 test items (reference materials) were prepared and distributed to 300 laboratories from 76 countries in November 2008. The deadline for receiving the results from the participants was set at 15 May 2009.

The participating laboratories were requested to analyse Ra-226, U-234 and U-238 in water samples 01 and 02, and gross alpha/beta in water samples 03, 04 and 05. In the phosphogypsum sample number 06 the participants were asked to analyse Pb-210, Ra-226, Th-230, U-234 and U-238. 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 laboratories which responded to this proficiency test and contributed their efforts to the present work are highly appreciated and acknowledged.

Three National Metrology Institutes (NMI) and six expert laboratories took part in the characterization campaign of the IAEA-434 RM phosphogypsum, namely: ERISS (Australia), PTB (Germany), HAA (Hungary), KINS (Republic of Korea), KRISS (Republic of Korea), LNE-LNHB (France), IJS (Slovenia), AECS (Syrian Arab Republic) and the IAEA Environment Laboratory (Austria).

The summary evaluation of this proficiency test demonstrated that 63% of the overall reported analytical results resulted in acceptable performance and fulfilled the evaluation criteria applied in this PT.

Figure 1 reports the summary of the analytical data evaluation of this proficiency test.

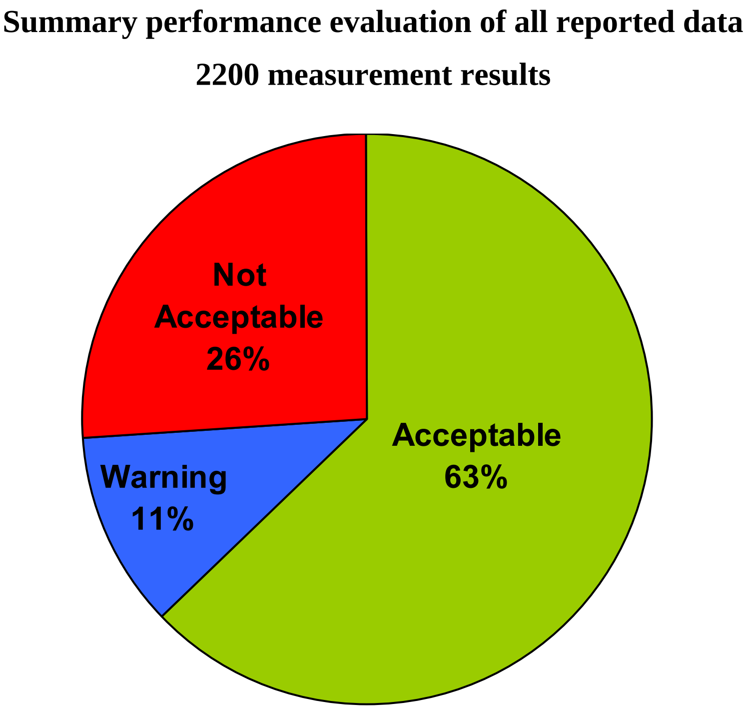

Figure 1. Summary of the analytical performance evaluation of the participating laboratories.

2. MATERIALS AND METHODS

2.1. Proficiency test objectives

The measurement of phosphogypsum and water samples containing a mixture of radionuclides with an unknown (to the participants) composition was aimed at (i) Assessment of the analytical performance of the participating laboratories in determining natural radionuclides in phosphogypsum and water matrices, (ii) testing the international comparability of radiological measurements and (iii) encouraging the participating laboratories in finding remedial actions where shortcomings in analytical performance are detected.

2.2. Participants

A total of 210 laboratories reported their results to the IAEA (157 from Europe, 25 from Asia, 11 from North America, 10 from Latin America, 5 from Africa and 2 from Australia). Figures 2 and 3 show the geographical distribution of the countries of the participants. A full listing of participants is given in Appendix IV.

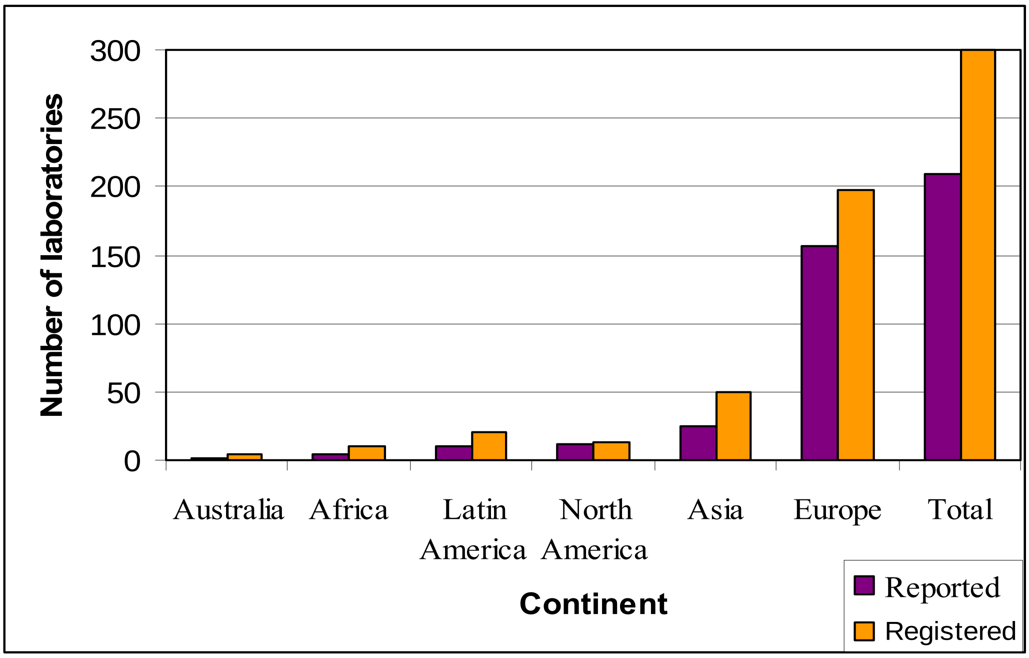

Figure 2. Geographical distribution of the participants.

2.3. Preparation of the proficiency test materials

The following proficiency test design was applied:

- Three spiked water samples (100 ml) for determination of gross alpha/beta,
- Two spiked water samples (500 ml) for determination of Ra-226, U-234 and U-238,
- One phosphogypsum sample (250 g) for determination of Pb-210, Ra-226, Th-230, U-234 and U-238.

Figures 4 and 5 show the PT material sets.

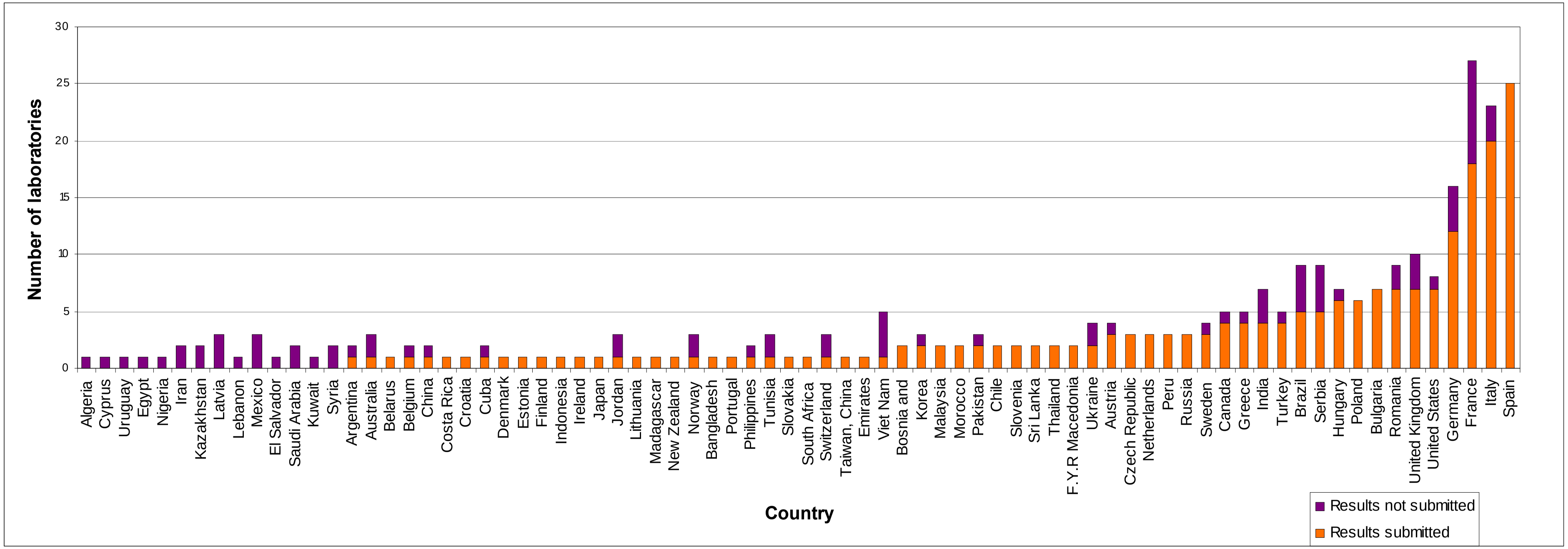

Figure 3. Participation distribution per country.

Figure 4. Distribution of the PT sets**.**

Figure 5. A set of the PT material.

2.3.1. Preparation of the spiked water samples 01 and 02

Three hundreds litres of tap water outsourced in one batch from Seibersdorf laboratories, were used to prepare all spiked water samples. The blank water was acidified and then analysed for the radionuclides of interest. It was found that the activity value of each measurand was below the detection limit of the analytical method which is far below the spiked activity value.

The water samples 01 and 02 were gravimetrically prepared in two batches. A portion of 170 kg of the blank water prepared above was spiked with an appropriate amount of a mixture of certified single radionuclide solutions of Ra-226, U-234 and U-238 traceable to the international standard of radioactivity. Table 1 shows the identification of the certified solutions of each radionuclide used in spiking the water samples in this PT.

For homogenising the spiked water a pump with multiple outlets was used to mix the water in a tank of 600 litre. The homogenised spiked water was bottled in 500 ml portions in appropriate plastic bottles. The total mass of the bottle with the label was registered for further control. Three water sample portions at 100 g were analysed by gamma spectrometry. The relative standard deviation of each analyte was calculated. It was found that the relative standard deviations of all analytes were below the method repeatability relative standard deviation, which demonstrates satisfactory homogeneity of the water sample.

Table 2 lists the target values and the associated combined uncertainty in the water samples.

TABLE 1. IDENTIFICATION OF THE CERTIFIED SOLUTIONS OF EACH RADIONUCLIDE USED IN SPIKING THE WATER SAMPLES IN THIS PT

Nuclide	Source manufacturer
Ra-226	AMERSHAM - RAY 44
U-234	NIST 4321C and ISOTRAK UEP 10020
U-238	NIST 4321C
Th-230	NIST 4342A
Sr-90	NIST 4234A

TABLE 2. TARGET VALUES AND RESPECTIVE STANDARD COMBINED UNCERTAINTIES OF THE MEASURANDS OF INTEREST IN WATER SAMPLES

	Radionuclides	Activity Concentration [Bq kg^{-1}]	Standard Uncertainty [Bq kg^{-1}]	LAP [%]	MAB [%]
Sample 01	U-234	0.56	0.02	15	15
	U-238	0.36	0.01	15	15
	Ra-226	0.69	0.04	20	20
Sample 02	U-234	1.20	0.04	15	15
	U-238	1.25	0.04	15	15
	Ra-226	1.93	0.09	20	20
Sample 03	Gross alpha	<0.2		Not applicable	
	Gross beta	<0.2			
Sample 04	Gross alpha	3.93	0.08		
	Gross beta	15.7	0.3		
Sample 05	Gross alpha	7.68	0.15		
	Gross beta	30.7	0.6		

For all measurement results the reference date is 01 December 2008, the combined standard measurement result uncertainty is expressed at 1σ level.

2.3.2. *Preparation of the spiked water samples 03, 04 and 05*

Sample 03 was the blank acidified water which was used for preparation of the spiked water samples.

Water samples 04 and 05 for gross alpha/beta measurements were gravimetrically prepared in two batches. Two portions of 40kg of the blank water were spiked with an appropriate amount of a mixture of certified single radionuclide solutions of Th-230 and Sr-90 traceable to the international standard of radioactivity.

The homogeneity test results provided experimental evidence that a satisfactory level of within and between bottles homogeneity was attained.

The water samples 03, 04 and 05 were filled in bottles of 100ml and weighed on an appropriate balance and the mass was recorded for further control.

2.3.3. *Verification of the target activity values and homogeneity test*

The final target activity value in water samples for each radionuclide was calculated from the certified activity values assigned to each radionuclide, taking into account the successive gravimetric 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.

To confirm the assigned target values and to test the homogeneity of the test items, two bottles from each water sample were analyzed at ARPA Lombardia, Department of Milano Laboratory, Italy. The measurement results obtained by the laboratory were in good agreement with the assigned target values and demonstrated that the homogeneity of the water samples was fit for the purpose of this proficiency test.

2.3.4. Analytical procedure applied in analysis of water samples

The ARPA Lombardia laboratory reported the following summary of the applied analytical procedure for the determination of gross alpha-beta, Ra-226, U-234 and U-238 in water samples.

2.3.4.1. Analytical procedure for gross alpha-beta measurements

A test portion of water sample (8g) was weighed into a scintillation vial. Quicksafe 400 (Zinsser) scintillation cocktail (12ml) was added and the sample was measured by liquid scintillation counting.

Calibration (determination of the counting efficiency and determination of the discrimination parameter) was performed using U-236 and Sr-90/Y-90 sources.

The standard method had to be modified as the sample acidity was out of the acceptable range (the method acceptable pH is 1.7 ± 0.3, actual sample pH was 0.3). New calibrations had to be performed in similar pH conditions to take into account the increase of spill-over due to the higher acidity.

2.3.4.2. Analytical procedure for Ra-226, U-234, U-238

Uranium isotopes were extracted from a weighed amount of sample (100g), previously acidified by 14 M nitric acid (5ml), by a selective scintillation cocktail (double extraction, 10 + 10 ml of cocktail).

The cocktail was then degassed with Ar and measured by liquid scintillation counting.

The scintillation cocktail was homemade and prepared by dissolving bis-etylhexyl orthophosphoric acid (HDEHP), naphthalene and fluorescent substance (PBBO) in p-xylene.

Calibration was performed using a U-236 source.

Radium-226 was measured through Rn-222 and short lived progeny at secular equilibrium. A test portion of water sample (10g) was weighed into a scintillation vial. Optiscint (Perkin Elmer) scintillation cocktail (10ml) was added to the sample (this cocktail is not miscible with aqueous samples).

2.3.4.3. Counting method

Samples (20 ml Teflon coated vials) were measured by a Quantulus 1220 LS counter applying alpha-beta discrimination optimized for the specific sample-cocktail mixture. Quench is kept under strict control by SQP(E) measurement and always has the same value.

Radium-226 measurement was performed after secular equilibrium between Ra-226 and Rn-222 and its short lived progeny was attained (1 month). The target values of the water samples with the respective uncertainties are presented in Table 2.

2.3.5. Preparation and characterization of sample 06 (IAEA-434 Phosphogypsum)

The IAEA-434 RM was collected from a processing plant located in Gdansk (Poland) in 2003. The matrix composition is: $CaSO_4*2H_2O$ (96%), P_2O_5 (1-2%), F Total (1.2%), SiO_2 (1%), Al_2O_3 (0.2%).

The milled material was homogenised in one lot in a clean atmosphere at a temperature of 20±2 °C and a relative humidity of 55%. The used homogeniser was a clone Ploughshare-Mixer of 1000 litre capacity.

Bottling of IAEA-434 was done under normal laboratory conditions; 1000 bottles was filled in one day taking all precautions to avoid segregation. The bottles were labeled arranged into plastic boxes and sterilized using gamma ray irradiation with a total dose of 25 kGy using a Co-60 source.

The bottle size was 900 ml with wide secure-sealed cover to preserve the integrity of the reference material in the bottle. The amount of the material in each bottle was 250 g.

2.3.5.1. Homogeneity study of the IAEA-434

Ten bottles covering the whole bottling range were randomly selected; three independent test portions at 12.5 g from each bottle were analyzed using gamma spectrometry for Pb-210, Ra-226, Th-230, U-234 and U-238. The homogeneity of Ra-226 was also tested by analyzing three test portions of one gram from five bottles using alpha spectrometry technique. The analysis of homogeneity study was performed under repeatability conditions to minimize variations.

The outcome of the homogeneity study demonstrated that the uncertainties due to between and within bottles heterogeneity u_{bb} were generally very small and the material could be considered sufficiently homogeneous for the tested radionuclides at the range of mass used.

2.3.5.2. Characterization and assignment of target values of the measurands of IAEA-434

The material was initially characterized at the Terrestrial Environment Laboratory in Seibersdorf during the feasibility study phase. Then the characterization of the material took place within the interlaboratory comparison piloted by the Terrestrial Environment Laboratory in cooperation with the Consultative Committee on Ionization Radiation (CCRI) of the International Bureau des Poids et Mesure (PIBM). The results reported in this comparison were used to derive the property values of the measurands of interest.

Test portion mass for the analysis was proposed to be al least 1 gram for radiochemical analysis and 50 grams for gamma spectroscopy analysis. To assess the digestion difficulty of the phosphogypsum, and to assist users of the IAEA-434 in selecting the dissolution technique, the Terrestrial Environment Laboratory performed several dissolution experiments, the most effective one was based on using of HNO_3 and HF acids.

As an example for the measurement of gamma emitting nuclides in the IAEA-434 the gamma-spectrum of phosphogypsum is shown on the Figure 6. and the low energy part is detailed on Figure 7. The sample was closed into a metal (radon tight) sample container of 250 cm^3. The spectrum was collected after 30 days when the Ra-226 Rn-222 equilibrium reached. A special low background n-type HPGe detector 30% relative efficiency with CARBON-EPOXI window was used for the spectrum collection. The shielding was made of 7 cm low background lead and 3 mm of cupper.

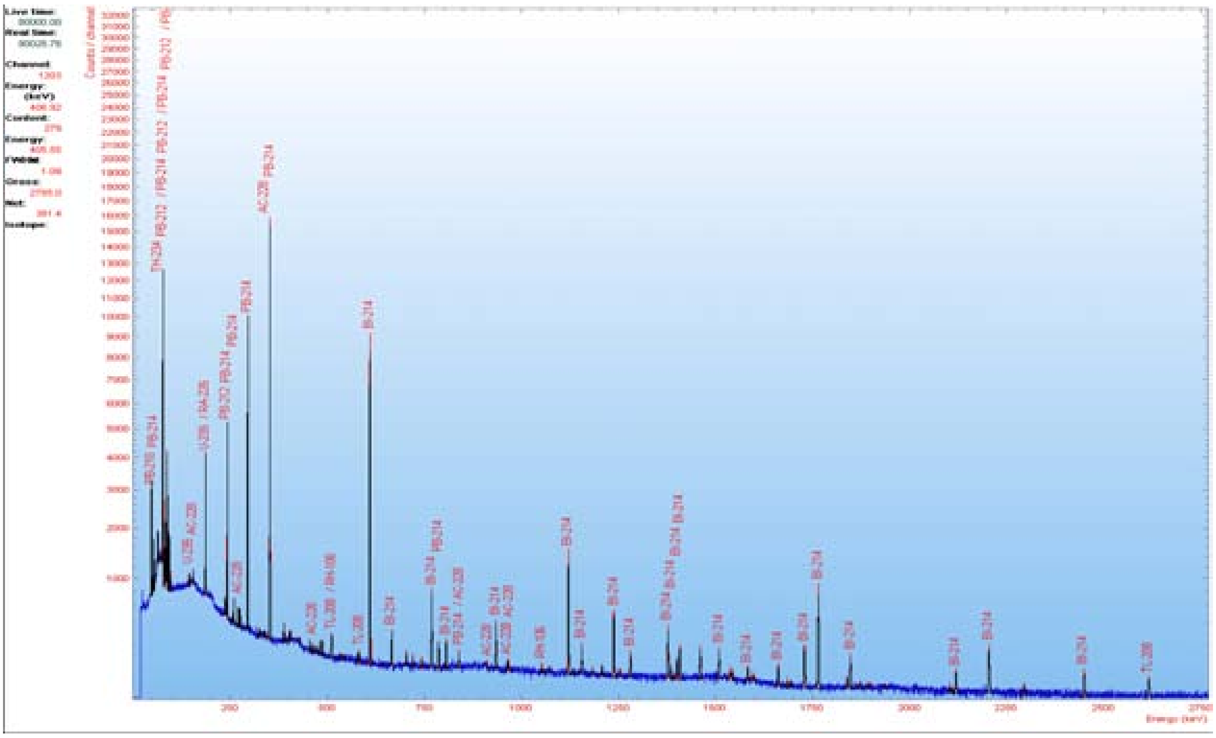

Figure 6. Gamma spectrum of the phosphogypsum IAEA-434.

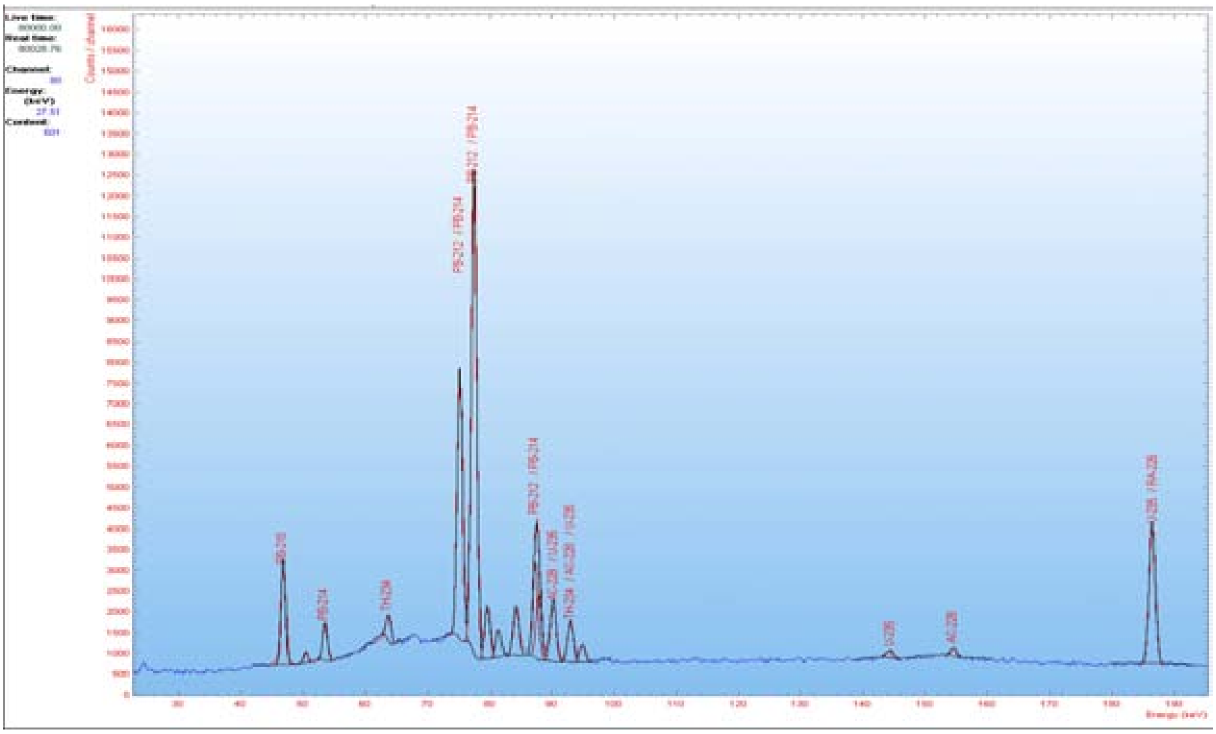

Figure 7. Low energy part of the gamma spectrum the phosphogypsum IAEA-434.

The property values of all radionuclides of the IAEA-434 were established on the basis of a robust approach proposed by David L. Duewer [1] and the Mixture Model Median (MM-median) of the analytical results reported by the expert laboratories was calculated. The MM-median is a direct analogue of the median. It is the location which divides the Mixture Model Probability Density Function (MM-PDF) into two sections of equal area. The MM-median is closely related to the median. It is robust to outliers and also accounts for the reported uncertainty of each measurement result.

To estimate the standard uncertainty associated with the property value the MM-median based Standard Deviation S(MM-median) was calculated from the span of the central 50% of the MM-PDF density function [1].

The calculated parameters of the homogeneity study are listed in Table 3. It can be noticed that the uncertainty associated with the between-bottles heterogeneity is reasonably small.

TABLE 3. BETWEEN-BOTTLES UNCERTAINTIES ASSOCIATED WITH THE HETEROGENEITY OF THE IAEA-434 PHOSPHOGYPSUM MATERIAL

Nuclide	Standard uncertainty associated with the between-bottles heterogeneity [%]
Pb-210	0.76
Ra-226	0.45
Th-230	0.36
U-234	0.41
U-238	0.33

2.3.5.3. Determination of Pb-210, U and Th isotopes in phosphogypsum

Ten bottles of phosphogypsum were selected, and then five subsamples were randomly taken from each bottle. About 0.5 g sample portions were weighed into microwave containers. For checking chemical recovery, Pb^{2+} carrier (30 mg), U-232 and Th-239 (its daughter Ra-225) were added. The samples were digested in a microwave oven using the following program: 150°C for 15 min and at 190°C for 25 min. The sample solutions were then transferred to plastic centrifuge tubes and centrifuged for 10 min. The supernatants were transferred to Teflon beakers. The residues were transferred back into the microwave containers with 3 ml HNO_3, and 2 ml of 40 % HF was added. The residue was digested in a microwave oven using the same program as mentioned above. The solutions were combined with supernatants and 0.1g H_3BO_3 was added and then evaporated with three portions of 5ml of 65% HNO_3 to remove HF. The residue was dissolved in 30 ml of 2 M HCl.

2.3.5.4. Sequential separation of Pb-210, U, Th and Ra-226 using Sr resin, TEVA and UTEVA

After sample digestion, the solutions were loaded on Sr. Resin columns, preconditioned in advance with 100 ml 2M HCl The columns were rinsed with 100 ml of 2 M HCl and 25 ml 6 M HNO_3 to remove the non-retained ions. The effluent and washing solutions were combined into a beaker and used for analysis of uranium and thorium. Polonium was eluted with 60 ml 6 M HNO_3, and then lead was eluted with 60 ml 6 M HCl. Polonium fractions were carefully evaporated to dryness. The residues were taken up with 10 ml 0.5 M HCl, and the pH of the solution was adjusted to 2 using 6 M NaOH. Polonium was auto-deposited onto a silver disc at 90°C for 90 min with stirring of the solution. Polonium was measured by alpha spectrometry. A ^{210}Pb source was prepared as lead oxalate and measured by liquid scintillation counting [2].

The effluents and the washing solutions from Sr Resin columns were combined and then evaporated to dryness. The residue was dissolved in 20 ml 3 M HNO_3 and then loaded on TEVA columns which were preconditioned in advance with 20 ml of 3 M HNO_3. The columns were washed with 10 ml of 3 M HNO_3. The washing solution was combined with the effluent from the TEVA column for analysis of uranium. After additional washing with 20 ml of 3 M HNO_3, 20 ml 8 M HCl was used to elute Th. The effluent and the first washing solution obtained from the TEVA column were directly loaded onto UTEVA column which was preconditioned in advance with 20 ml of 3 M HNO_3. The column was washed with 20 ml of 3 M HNO_3, 5ml 9 M HCl and followed by 15 ml 6 M HCl to remove traces of Po and Th remaining on the column. Finally, the uranium on the UTEVA column was eluted with 6 ml H_2O.

The effluent (30 ml of 3 M HNO_3) and the washing solution (20 ml of 3 M HNO_3) from UTEVA column were combined in a 200 ml volume of beaker. 4 ml of concentrated H_2SO_4 and 20 ml of 20% Na_2SO_4 were added, and then 5 ml of Pb^{2+} carrier (10 mg ml^{-1}) was slowly added while stirring to form $Pb(Ra)SO_4$ co-precipitation. The precipitation was allowed to settle for 3-4 hours and centrifuged at 3000 rpm for 10min. The precipitation was dissolved in 10 ml of 0.2 M DTPA (diehtylenetriaminepentaacetic acid).

2.3.5.5. Source preparation and measurement

The Pb fraction was evaporated 3 times with 2 ml of HNO3. The residue was dissolved in 20 ml 1 M HNO_3, 0.400 g oxalic acid was added to warm the solution and adjust the pH to 3–5 with $NH_{3(aq)}$ to precipitate Pb-oxalate. The Pb-oxalate precipitate was filtered through a pre-weighed filter paper (∅ 24 mm). The filter was washed three times with 1 ml water and 2 ml of ethanol, dried in oven at 40-50 °C, cooled in a desiccator and weighted to determine the mass of lead-oxalate and the chemical recovery gravimetrically. The lead-oxalate precipitate was transferred together with the filter into liquid scintillation vial, dissolved in 1 ml 6 M HNO_3 and mixed it with 14 ml 'INSTA-GEL PLUS' liquid scintillation cocktail. Pb-210 was determined by liquid scintillation spectrometry.

U and Th fractions were three times evaporated with few ml of 65% HNO_3, respectively. The residues were dissolved in 10 ml of 10 $(NH_4)_2SO_4$ plating solution with pH 2 and transferred into electro-deposition cell. U and Th were electrodeposited onto stainless steel discs at 0.97A for 90 min, respectively and then measured by alpha-spectrometry. An example of alpha-spectrum for uranium isotopes is given in Figure 8.

4 ml mixed solution of 5 parts of 20% Na_2SO_4 with 1 part of acetic acid was added to 10 ml of 0.2 M DTPA dissolved $Pb(Ra)SO_4$ precipitation and 0.4 ml the Ba seeding solution was

added, and then allowed to sit for 30 min. The colloidal suspension of Ba(Ra)SO_4 was filtered through a pre-wetted polypropylene filter (Pall, 0.1µm pore size, 25mm dia.) and measured by alpha-spectrometry.

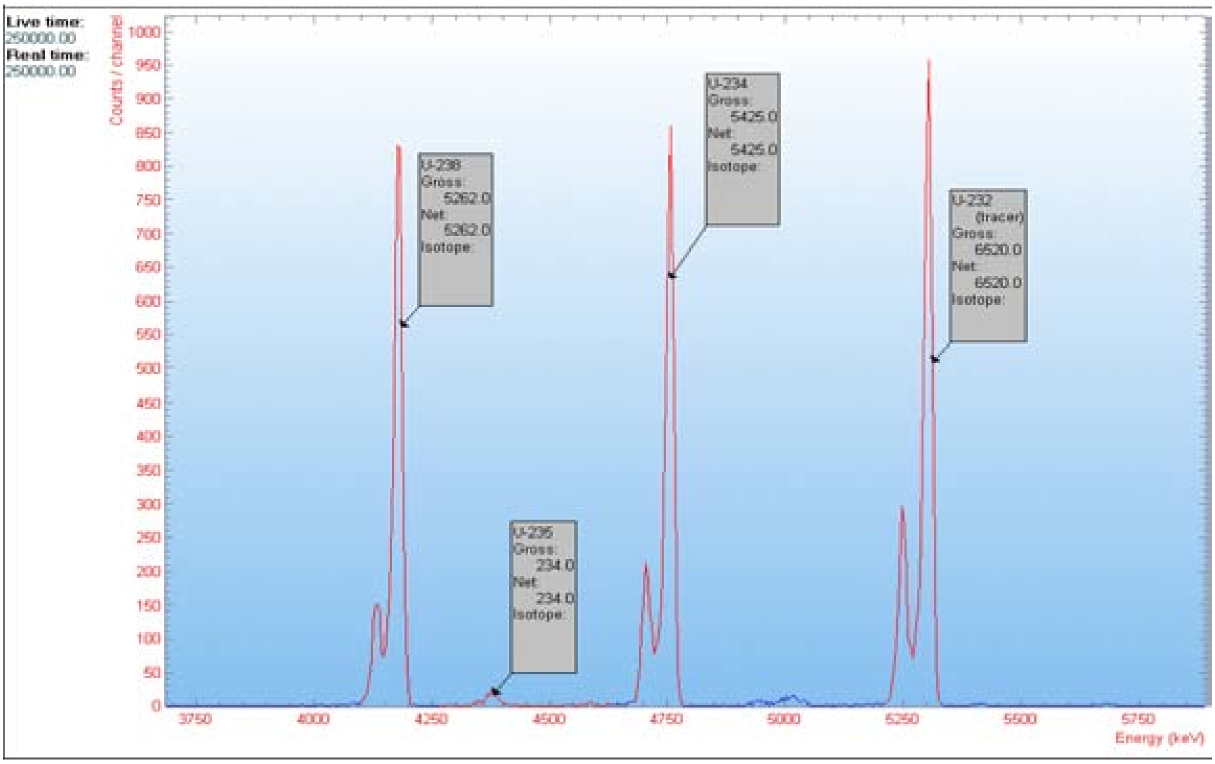

Figure 8. The alpha spectra of uranium isotopes.

Table 4 shows the target values of the massic activities and associated standard combined uncertainties of the measurands of interest.

TABLE 4. TARGET VALUES AND RESPECTIVE STANDARD COMBINED UNCERTAINTIES FOR SAMPLE 06 (IAEA-434 PHOSPHOGYPSUM)

Nuclide	Recommended massic activities [Bq kg^{-1} dry mass]	Standard combined uncertainty* [Bq kg^{-1} dry mass]	LAP (%)	MAB (%)
Pb-210	680	58	15	15
Ra-226	780	62	20	20
Th-230	211	9	15	15
U-234	120	9	15	15
U-238	120	11	15	15

*Uncertainty is expressed as a Mixture model median based standard deviation S(MM-median) [1]. Reference date: 01 December 2008.

3. PERFORMANCE CRITERIA

Several rating systems have been developed for determining a laboratory's performance and the meaning of the results of the different scoring systems are not always comparable. Among various statistics, z-scores and u-scores are most often used. The drawback of z-scores is that the uncertainty of the participant's measurement result is not taken into account for the evaluation of performance. In the case of u-scores, the evaluation includes uncertainties of the participant measurements and the 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 IAEA Laboratory, Seibersdorf takes into consideration the trueness and the precision of the reported data and it includes in the evaluation both the total combined uncertainty associated with the target value of proficiency testing samples and the total 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 uncertainty statement given by the participating laboratories, and 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: z-score, IAEA Laboratory, Seibersdorf result ratio and relative bias are calculated as complementary information for the participating laboratories.

3.1.Relative bias

The first stage in producing a score for a result Value $_{\text{reported}}$ (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 reported value and the target value is calculated and expressed as a percentage:

$$\text{Bias}_{relative} = \frac{\text{Value}_{\text{reported}} - \text{Value}_{\text{target}}}{\text{Value}_{\text{target}}} \times 100\% \quad (1)$$

3.2. The z-score value

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

$$z_{Score} = \frac{\text{Value}_{\text{reported}} - \text{Value}_{\text{target}}}{\sigma} \quad (2)$$

On the basis of the "fitness for purpose" principle, the target standard deviation (σ) is:

$$0.10 \times \text{Value}_{\text{target}}$$

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

3.3. The u-score value

The value of the u_{test} was calculated according to the following equation [3]

$$u_{test} = \frac{\left|\text{Value}_{\text{target}} - \text{Value}_{\text{reported}}\right|}{\sqrt{u^2_{\text{target}} + u^2_{\text{reported}}}} \quad (3)$$

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

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

3.4. Evaluation procedure for samples 01, 02 and 06

The proficiency test results were evaluated against the acceptance criteria for trueness and precision and assigned the status “Acceptable”, “Warning” or “Not Acceptable” accordingly [4].

3.4.1. Trueness

The participant result is assigned “Acceptable” status for trueness if:

$$A1 \leq A2$$

where:

$$\text{A1} = \left|\text{Value}_{\text{target}} - \text{Value}_{\text{reported}}\right|$$

$$\text{A2} = 2.58 \times \sqrt{u^2_{\text{target}} + u^2_{\text{reported}}}$$

3.4.2. Assessment of claimed uncertainty

To evaluate the claimed measurement result uncertainty an estimator P is calculated for each reported uncertainty, according to the following formula:

$$\text{P} = \sqrt{\left(\frac{u_{\text{target}}}{\text{Value}_{\text{target}}}\right)^2 + \left(\frac{u_{\text{reported}}}{\text{Value}_{\text{reported}}}\right)^2} \times 100\%$$

P directly depends on the measurement result 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 the claimed uncertainty when $P \leq \text{LAP}$. The LAP values used in the evaluation of all radionuclides are listed in Table 2.

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 final score will be "acceptable with warning". "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 result close to the assigned property value is reported, but the associated uncertainty is large. If R. Bias > MAB, the result will be "not acceptable". The MAB values used in the evaluation of all radionuclides are listed in Table 2.

3.5. Evaluation procedure for gross alpha/beta results in water sample 03

For evaluation of the analytical measurement results of gross alpha/beta in the blank water sample 03 a factor F was calculated as the following:

$$F = Value_{reported.} - 2 * uncertainty_{reported.}$$

The participant result was assigned "acceptable" score if:

$$F \leq 0.2$$

The participant result was assigned "warning" score if:

$$0.2 < F \leq 0.3$$

The participant result was assigned "not acceptable" score if:

$$F > 0.3$$

3.6. Evaluation procedure for gross alpha/beta results in water samples 04 and 05

For evaluation of the analytical results of gross alpha/beta in the spiked water samples 04 and 05 the relative bias ($\text{Bias}_{\text{Relative})}$ was calculated according to 3.1 and a factor R was calculated as the following:

$$R = \text{Value}_{\text{reported}} / \text{uncertainty}_{\text{reported}}$$

The participant result was assigned "acceptable" score if:

R> 2 and Bias Relative ≤ 50%, for gross alpha

R> 2 and Bias Relative ≤ 30%, for gross beta

The participant result was assigned "acceptable with warning" score if:

R>2 and 50% < $\text{Bias}_{\text{Relative}}$ ≤ 75%, for gross alpha

R>2 and 50% < $\text{Bias}_{\text{Relative}}$ ≤ 60%, for gross beta

The participant result was assigned "not acceptable" score if:

R<=2 or Bias Relative >75%, for gross alpha

R<=2 or Bias Relative >60%, for gross beta

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 fits specific requirements.

4. RESULTS AND DISCUSSION

4.1. General

In this PT, 2200 measurement results were reported to the IAEA from 210 laboratories in 76 countries.

One month after the deadline for reporting results, each participant obtained an individual evaluation report using a dedicated on-line application to give a rapid feed back on the performance of the laboratories.

The participants’ data along with the statistical performance evaluation were compiled and presented in two types of tables: tables of summary of the reported technical information in the PT questionnaire regarding the applied analytical technique sorted by laboratory code are shown in Appendix I, and the tables of the performance evaluation results sorted by analyte are reported in Appendix II.

The number of reported results and obtained evaluation as acceptable/warning/not acceptable of each laboratory is presented graphically in Figure 9. This way of presenting results evaluation allows the participating laboratories to compare their results to those reported by other laboratories and to benchmark their performance level with peers. In addition, all participating laboratories could share the technical information provided in the Appendix I to identify the commonly applied analytical procedures, the listed information could also be used to find out the weak or strong points in the analytical procedure adopted by each laboratory when comparing the laboratory evaluation results with other participating laboratories.

To have an overview of the participants’ performance for each specific radionuclide, each radionuclide was studied individually. Table 5 shows the distribution of results scored as acceptable/warning/not acceptable for each evaluated radionuclide and for each sample.

To have an overall view of the analytical performance of the laboratories population in this PT, the Z-score charts of evaluated analytes are presented in Appendix III and finally the list of participating laboratories is presented in Appendix IV.

The overall evaluation showed that 26% of all reported results failed to meet the PT criteria. It was noticed that the percentage of acceptable results for natural radionuclides is slightly lower (around 10%) than the observed level for the artificial ones. This fact might indicate the need to develop and improve the analysts’ skills in analysing natural radionuclides in environmental samples at low level of activity. The main reasons of not acceptable performance are discussed later in this chapter.

To compare the performance level of each laboratory a normalized average analytical performance and the percentage of “Not Acceptable” scores were calculated in the following way:

$$\text{Normalized average performance (\%)} = ((A+W)/ NRR)*100$$

$$\text{Percentage of “Not Acceptable scores” (\%)} = (N/NRR)*100$$

Where:

A: number of obtained “Acceptable” scores

W: number of obtained “Warning” scores

N: number of obtained “Not Acceptable” scores

NRR: Total number of reported results.

The results of the calculation are shown in Table 6 in ascending order according to the normalized average performance value.

TABLE 5. SUMMARY EVALUATION OF ALL NUCLIDES SORTED BY SAMPLE

	Radionuclide	No. of reported results	Percentage of "Acceptable" results (%)	Percentage of "Warning" results (%)	Percentage of "Not Acceptable" results (%)
Sample 01	Ra-226	125	48	8	44
	U-234	107	66	7	26
	U-238	125	56	10	34
Sample 02	Ra-226	136	54	7	39
	U-234	108	63	10	27
	U-238	129	56	9	36
Sample 03	Gross alpha	124	88	2	10
	Gross beta	125	82	6	13
Sample 04	Gross alpha	136	60	21	19
	Gross beta	143	75	18	7
Sample 05	Gross alpha	138	67	15	18
	Gross beta	142	83	10	7
Sample 06	Pb-210	137	62	9	28
	Ra-226	169	59	20	21
	Th-230	98	39	13	48
	U-234	104	56	9	35
	U-238	150	51	9	40

This approach of presenting the level of performance of all laboratories allows each participant to compare its own performance level with the level of peers. In addition, participants could look for the level of the performance of each laboratory in Table 6 and find out the summary of the analytical method which was applied in this laboratory in Appendix I, hence giving a platform for information exchange and potential improvement of the analytical performance of those laboratories who encountered difficulties.

TABLE 6. SUMMARY INDIVIDUAL EVALUATION SORTED BY THE AVERAGE OF PERFORMANCE SCORE

Laboratory code	Number of reported results	Number. of “Acceptable” results	Number of “Warning” results	Number of “Not Acceptable” results	Normalized Average performance (%)	Percentage of “Not Acceptable” (%)
2	8	4	4	0	100	0
35	2	1	1	0	100	0
33	12	7	5	0	100	0
36	5	3	2	0	100	0
92	17	11	6	0	100	0
7	3	2	1	0	100	0
48	3	2	1	0	100	0
58	6	4	2	0	100	0
132	6	4	2	0	100	0
28	11	8	3	0	100	0
204	16	12	4	0	100	0
232	4	3	1	0	100	0
165	15	12	3	0	100	0
126	13	11	2	0	100	0
86	7	6	1	0	100	0
119	15	13	2	0	100	0
241	9	8	1	0	100	0
253	9	8	1	0	100	0
21	12	11	1	0	100	0
11	13	12	1	0	100	0
196	14	13	1	0	100	0
186	17	16	1	0	100	0
5	6	6	0	0	100	0
15	7	7	0	0	100	0
46	7	7	0	0	100	0
50	16	16	0	0	100	0
64	17	17	0	0	100	0
70	8	8	0	0	100	0
105	9	9	0	0	100	0
136	8	8	0	0	100	0
149	4	4	0	0	100	0
154	5	5	0	0	100	0
162	4	4	0	0	100	0
169	6	6	0	0	100	0
190	3	3	0	0	100	0
195	9	9	0	0	100	0
202	14	14	0	0	100	0
208	3	3	0	0	100	0
209	6	6	0	0	100	0
213	3	3	0	0	100	0
214	3	3	0	0	100	0
216	3	3	0	0	100	0
217	3	3	0	0	100	0

Laboratory code	Number of reported results	Number. of “Acceptable” results	Number of “Warning” results	Number of “Not Acceptable” results	Normalized Average performance (%)	Percentage of “Not Acceptable” (%)
218	3	3	0	0	100	0
220	2	2	0	0	100	0
221	3	3	0	0	100	0
224	3	3	0	0	100	0
227	3	3	0	0	100	0
277	11	11	0	0	100	0
286	15	15	0	0	100	0
22	16	15	0	1	93.8	6
167	16	15	0	1	93.8	6
267	16	15	0	1	93.8	6
276	17	13	3	1	94.1	6
59	17	16	0	1	94.1	6
80	17	16	0	1	94.1	6
8	14	12	1	1	92.9	7
84	14	13	0	1	92.9	7
201	15	12	2	1	93.3	7
20	15	13	1	1	93.3	7
38	13	7	5	1	92.3	8
1	13	9	3	1	92.3	8
288	13	12	0	1	92.3	8
263	11	7	3	1	90.9	9
261	11	9	1	1	90.9	9
44	10	8	1	1	90	10
296	10	8	1	1	90	10
69	10	9	0	1	90	10
163	10	9	0	1	90	10
62	17	12	3	2	88.2	12
72	17	14	1	2	88.2	12
133	17	14	1	2	88.2	12
236	17	14	1	2	88.2	12
274	17	14	1	2	88.2	12
114	17	15	0	2	88.2	12
193	15	12	1	2	86.7	13
82	15	13	0	2	86.7	13
131	8	0	7	1	87.5	13
51	16	14	0	2	87.5	13
206	8	7	0	1	87.5	13
67	14	10	2	2	85.7	14
112	7	6	0	1	85.7	14
158	13	9	2	2	84.6	15
234	13	9	2	2	84.6	15
91	13	10	1	2	84.6	15
238	13	10	1	2	84.6	15
26	6	2	3	1	83.3	17
125	12	4	6	2	83.3	17

Laboratory code	Number of reported results	Number. of “Acceptable” results	Number of “Warning” results	Number of “Not Acceptable” results	Normalized Average performance (%)	Percentage of “Not Acceptable” (%)
111	6	5	0	1	83.3	17
255	6	5	0	1	83.3	17
299	11	7	2	2	81.8	18
77	11	9	0	2	81.8	18
273	17	9	5	3	82.4	18
54	17	12	2	3	82.4	18
161	17	12	2	3	82.4	18
194	17	12	2	3	82.4	18
93	17	13	1	3	82.4	18
278	17	13	1	3	82.4	18
9	5	2	2	1	80	20
68	10	5	3	2	80	20
120	5	3	1	1	80	20
96	10	7	1	2	80	20
43	15	11	1	3	80	20
164	10	8	0	2	80	20
181	10	8	0	2	80	20
3	9	6	1	2	77.8	22
102	9	7	0	2	77.8	22
32	13	6	4	3	76.9	23
95	17	8	5	4	76.5	24
294	17	12	1	4	76.5	24
37	17	13	0	4	76.5	24
203	12	5	4	3	75	25
252	8	5	1	2	75	25
4	12	8	1	3	75	25
156	16	12	0	4	75	25
265	8	6	0	2	75	25
298	16	12	0	4	75	25
138	11	6	2	3	72.7	27
107	11	8	0	3	72.7	27
250	11	8	0	3	72.7	27
187	15	9	2	4	73.3	27
103	15	10	1	4	73.3	27
94	17	10	2	5	70.6	29
45	17	11	1	5	70.6	29
260	17	11	1	5	70.6	29
297	17	12	0	5	70.6	29
200	14	7	3	4	71.4	29
113	14	8	2	4	71.4	29
244	7	4	1	2	71.4	29
110	10	3	4	3	70	30
49	10	5	2	3	70	30
56	10	5	2	3	70	30
197	10	6	1	3	70	30

Laboratory code	Number of reported results	Number. of “Acceptable” results	Number of “Warning” results	Number of “Not Acceptable” results	Normalized Average performance (%)	Percentage of “Not Acceptable” (%)
18	9	3	3	3	66.7	33
52	3	1	1	1	66.7	33
89	3	1	1	1	66.7	33
166	3	1	1	1	66.7	33
85	12	5	3	4	66.7	33
42	15	7	3	5	66.7	33
23	12	6	2	4	66.7	33
134	12	6	2	4	66.7	33
207	6	3	1	2	66.7	33
98	3	2	0	1	66.7	33
143	6	4	0	2	66.7	33
219	6	4	0	2	66.7	33
6	17	8	3	6	64.7	35
13	17	8	3	6	64.7	35
14	17	8	3	6	64.7	35
188	11	3	4	4	63.6	36
177	14	8	1	5	64.3	36
275	13	7	1	5	61.5	38
140	8	3	2	3	62.5	38
282	16	7	3	6	62.5	38
137	8	4	1	3	62.5	38
73	10	5	1	4	60	40
266	17	8	2	7	58.8	41
47	14	3	5	6	57.1	43
176	7	3	1	3	57.1	43
259	9	4	1	4	55.6	44
81	16	8	1	7	56.3	44
271	16	8	1	7	56.3	44
53	13	6	1	6	53.8	46
101	17	9	0	8	52.9	47
97	15	7	1	7	53.3	47
173	15	8	0	7	53.3	47
229	4	1	1	2	50	50
60	12	4	2	6	50	50
74	8	3	1	4	50	50
264	16	6	2	8	50	50
31	2	1	0	1	50	50
66	2	1	0	1	50	50
168	2	1	0	1	50	50
283	8	4	0	4	50	50
104	7	2	1	4	42.9	57
78	14	5	1	8	42.9	57
157	14	5	1	8	42.9	57
79	5	2	0	3	40	60
128	13	3	2	8	38.5	62

Laboratory code	Number of reported results	Number. of “Acceptable” results	Number of “Warning” results	Number of “Not Acceptable” results	Normalized Average performance (%)	Percentage of “Not Acceptable” (%)
39	16	4	2	10	37.5	63
57	14	4	1	9	35.7	64
144	17	3	3	11	35.3	65
109	3	0	1	2	33.3	67
118	3	0	1	2	33.3	67
147	6	1	1	4	33.3	67
99	9	2	1	6	33.3	67
145	9	2	1	6	33.3	67
24	3	1	0	2	33.3	67
34	6	2	0	4	33.3	67
106	9	3	0	6	33.3	67
124	9	3	0	6	33.3	67
222	3	1	0	2	33.3	67
19	10	3	0	7	30	70
40	10	3	0	7	30	70
235	7	1	1	5	28.6	71
29	7	2	0	5	28.6	71
65	4	0	1	3	25	75
191	17	1	3	13	23.5	76
151	9	2	0	7	22.2	78
160	15	2	1	12	20	80
117	5	1	0	4	20	80
150	10	2	0	8	20	80
108	12	1	1	10	16.7	83
178	7	1	0	6	14.3	86
30	17	2	0	15	11.8	88
63	9	1	0	8	11.1	89
27	1	0	0	1	0	100
129	2	0	0	2	0	100
205	1	0	0	1	0	100
272	4	0	0	4	0	100

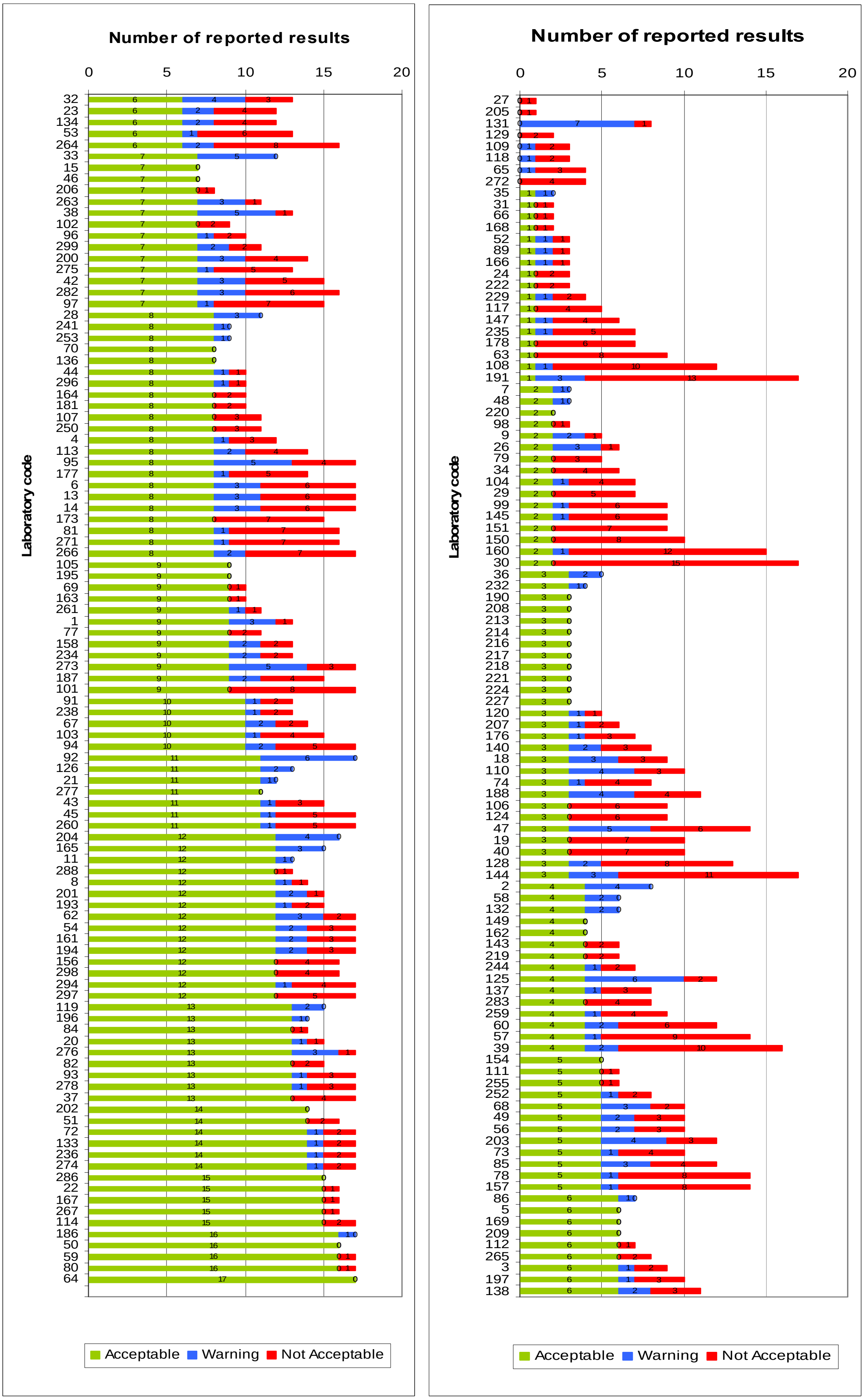

Figure 9. Performance evaluation results sorted by the number of acceptable results obtained.

4.2. General recommendations to the participating laboratories

The participating laboratories could be classified into four groups based on the number on unacceptable results as listed in Table 6. This type of classification (summarized in Table 7) gives a general overview on the level of performance in this PT and could be helpful for the participants to compare their own level of performance to peer laboratories.

4.2.1. Laboratories group A

Fifty laboratories reported their results without any "not acceptable" score. Table 7 lists the codes of these laboratories. In this group, three participants (codes 64, 92 and 186) reported the results of all requested analytes (17 results) without any "not acceptable" result.

It is recommended to this group of laboratories to maintain the statistical control of the analytical process and to monitor it. This group of laboratories reported satisfactory analytical results for the scope and evaluation criteria of this PT.

TABLE 7. LABORATORIES GROUPS ACCORDING TO THE ANALYTICAL PERFORMANCE

Group	Laboratory code
Group A	2, 5, 7, 11, 15, 21, 28, 33, 35, 36, 46, 48, 50, 58, 64, 70, 86, 92, 105, 119, 126, 132, 136, 149, 154, 162, 165, 169, 186, 190, 195, 196, 202, 204, 208, 209, 213, 214, 216, 217, 218, 220, 221, 224, 232, 241, 253, 277, 286
Group B	1, 8, 9, 20, 22, 26, 31, 38, 44, 52, 59, 66, 69, 80, 84, 98, 111, 112, 120, 131, 163, 166, 167, 168, 201, 206, 255, 261, 263, 267, 276, 288, 296
	3, 24, 51, 62, 67, 68, 72, 77, 82, 91, 96, 102, 109, 114, 118, 125, 129, 133, 143, 158, 164, 181, 193, 207, 219, 222, 229, 234, 236, 238, 244, 252, 265, 274, 299
Group C	4, 18, 32, 43, 49, 54, 56, 65, 79, 93, 107, 110, 137, 138, 140, 161, 176, 194, 197, 203, 250, 273, 278
	23, 34, 37, 73, 74, 85, 95, 103, 104, 113, 117, 134, 147, 156, 187, 188, 200, 259, 272, 283, 294, 298
Group D	6, 13, 14, 19, 29, 30, 39, 40, 42, 45, 47, 53, 57, 60, 63, 78, 81, 94, 97, 99, 101, 106, 108, 124, 128, 144, 145, 150, 151, 157, 160, 173, 177, 178, 191, 235, 260, 264, 266, 271, 275, 282, 297

4.2.2. Laboratories group B

Thirty three and thirty six laboratories had only one or two "not acceptable" results respectively.

The not acceptable performance mainly due to Ra-226 in water samples, Th-230 and Pb-210 in phosphogypsum.

The quality of reported results, by this group of laboratories, fits the criteria of this PT However, further investigation should be undertaken to investigate the root cause of the specific nuclide shortcoming and corrective action should be applied to rectify the situation.

4.2.3. Laboratories groups C & D

In group C twenty three and twenty two laboratories scored three or four “not acceptable” results respectively.

Group D comprises forty three laboratories which had five or more not acceptable results.

The probable reasons behind the not acceptable performance are discussed in the following paragraphs. The root cause of not acceptable performance should be investigated and corrective actions to be implemented.

Certain laboratories reported unrealistically high values (may be wrong units or gross error) which could be due to inappropriate quality control mechanism to verify the validity of reported results and to avoid issuing analysis report with unreliable analytical results which might be used in decision making and could lead to detrimental consequences. The analyst should have the appropriate tools and procedure to make sure that the reported results are valid and accurate.

4.3. Recommendations and lessons learned

Based on the performance evaluation results certain recommendations to enhance the analytical performance of the participating laboratories could be suggested. It was not possible to find a clear correlation between the years of experience and the level of performance. There were many cases where the laboratory declared an insufficient experience but its results were good. It is evident that the skills and experience of the analyst performing the analysis at the time of the PT samples analysis is the crucial factor in obtaining acceptable results. Proper equipment, human and material resources are of course important factors in obtaining reliable and good quality results.

Method validation and robustness studies of the analytical procedure could assist the analyst to know more in depth its strong and weak points, where more attention should be given and what are the critical points in the procedure. When a laboratory reports 5-10 not acceptable analytical results it means that it has not the appropriate tools to verify the quality of the outcome of the analytical system, there should be a dedicated mechanism and tools which help the analyst to assess the quality of the results produced. If the analyst does not have control of the analytical system, erroneous results could be reported without these being detected.

It is quite normal to make mistakes in an analytical laboratory, the analytical system is a very complex one, it even interacts extensively with human factors and even with the specific conditions of the laboratory. However, the main objective of each laboratory should focus, after detection of the shortcoming, on finding out the root cause of the analytical problem and to put the needed actions to remediate the problem and obtain satisfactory results.

The IAEA Terrestrial Environment Laboratory would appreciate to get feedback from those participants who where able to benefit from this PT in finding the root cause of any analytical problems and were able to improve their performance in determining natural radionuclides. In addition, the learned lessons provided by the participants could be later on shared amongst the participants without revealing the identity of the originator.

4.3.1. Recommendations regarding Ra-226 determination

Forty eight laboratories reported their results for Ra-226 in phosphogypsum. Only 19% of these did not fulfil the PT criteria. This is considered a good level of performance taking into consideration the difficulty of the matrix and unavailability of appropriate reference material.

Most of the laboratories used gamma spectrometry with HPGe detector; different efficiency calibration procedures were applied. Analysts were innovative in adopting the appropriate method for calibration of gamma spectrometer and in performing the needed corrections.

The PT participants reported in the questionnaire a wide range of analytical methods taken from the open literature such as ASTM E 181-98(2003), CIEMAT PR-X2-04, DOE RA-06-RC, IAEA-TRS-295, IAEA-TECDOC-1401, ISO 10703:2007, NEN5623 (Dutch), NF M 60-803, NF M 60-805-5 and DOE EML HASL-300. Many laboratories used computational calibration such as Monte Carlo for efficiency calibration. A few laboratories used spiked milk powder for calibration; others used some matrix reference materials such as IAEA-Soil-6 and IAEA-RGU ore. One laboratory reported the use of a well detector where a sample portion of only 2 grams was used in the analysis of the phosphogypsum; the reported results were “acceptable”, which indicates the suitability of the material for measurement using a small sample portion in well detectors.

Many laboratories applied radiochemical separation and alpha spectrometry measurement. Technical details of successful application of digestion procedure, radiochemical separation and auto-plating including were reported by the participating laboratories and summarized in Appendix I.

The shortcomings shown in the performance level of the participating laboratories in gamma measurements of Ra-226 could be attributed to several factors. These factors are related to the gamma spectrometry procedure utilised by each laboratory. Some of these factors are the use of inappropriate calibration standards or procedure, sample geometry, interference from other gamma lines, and properties of the sample container used.

In general, there are two approaches used for Ra-226 determination by gamma spectrometry. These are the use of the 186 keV line from Ra-226, and use of gamma lines from the short-lived progeny Pb-214 and Bi-214. In the former case, the contribution of U-235 to the peak area needs to be allowed for, and if an inappropriate correction is applied, this may lead to shortcomings in performance.

In the latter case, the sample container used needs to be Rn-222 tight. Many laboratories reported the use of plastic containers for gamma spectrometry measurements. The analysts in this case assumed the tightness of such containers. However, in practice most plastic containers are not Rn-222 tight and they allow the emanation of the noble gas (in some cases even through the walls of the container). Special containers should be used and validated for Ra-222 tightness and not only air tightness. Note that a problem with Rn-222 tightness of the container could lead to a bias in either direction, depending on the relative loss of Rn-222 from the calibration and test containers. In addition, one issue should be considered which is the time required to establish secular equilibrium between Ra-226 and its daughters; most laboratories using this approach use a delay period of at least 3 weeks.

For water samples the performance level was poorer than for phosphogypsum due to the low activity level and the necessity to use complex radiochemical procedures in comparison with phosphogypsum. It is intended that a future IAEA proficiency test will provide follow-up testing in the area of natural radioactivity in water samples.

4.3.2. Recommendations regarding Pb-210 determination

Thirty seven laboratories reported their results for Pb-210 in sample 06 phosphogypsum, 19% of them were not acceptable. This level of performance is comparable to the level of performance in the 2007 PT for the determination of Pb-210 in soil samples [5]. By comparison, the results evaluation of a PT in 2005 resulted in 59% of not acceptable reported results for the same analyte in soil [6]. This suggests a general improvement in the analytical performance of the population of laboratories interested in Pb-210 determination in solid matrix.

In this PT the majority of laboratories measured the Pb-210 at 46.52 keV using n type wide energy range HPGe detector and applying a calibration procedure and corrections.

Equally successful determinations were reported by several laboratories using radiochemical procedures such as the separation of Pb-210 after the addition of a stable carrier according to the method of chromate precipitation followed by lead chloride precipitation, then mixing the source with scintillation cocktail and performing the measurement using a Liquid Scintillation Spectrometer.

Many laboratories that used radiochemical procedure failed in proper implementation of the procedure which resulted in not acceptable results, the exact technical reason for the shortcoming should be investigated. Little information was reported in the questionnaire on the chemical recovery correction. The main reason for not acceptable results could be attributed to a non validated radiochemical procedure or to incomplete digestion procedure.

Some laboratories stated that they used gamma detectors with energy range from 200 keV which might be not suitable for Pb-210 measurement; also some laboratories extrapolated the efficiency calibration to cover the Pb-210 energy which resulted in not acceptable results. The most frequent reasons for failure in Pb-210 are discussed in more details in [7].

4.3.3. Recommendations regarding U-234, U-238 determination

Thirty four and forty three laboratories reported their results for U-234 and U-238 respectively. Various methods were used successfully in this PT. Alpha spectrometry with various extraction and purification procedures was used successfully. Acceptable results were also reported using ICP-MS and INAA at a very small sample portion 0.2 g, which indicates the high level of the material homogeneity.

The uranium content of the water samples was around one Bq kg^{-1} only. In this case the low activity level was the main cause of analytical difficulty during the analysis.

To obtain a good quality of gamma spectrum it would have required a special low background detector and a well controlled quality of the laboratory air to avoid the effect of Rn-222 on the analysis, “Rn-free” laboratory air would be the best option. The enrichment of the radon progeny in the detector shielding could lead to an uncontrolled (random) positive bias which is comparable to the activity level in the sample.

Using a chemical separation and alpha spectrometry the radiochemical purity of the applied reagent and tools may be the crucial and critical point for both of uranium and radium determinations. The analysis and statistical monitoring of the "blank" sample could help to recognize false positive result or positive bias. In particular, this factor is important due to the similarity of the chemical behaviour of Ba compounds which contains a traces amount of Ra.

4.3.4. Recommendations regarding gross alph/beta determination

The gross alpha/beta measurements are considered to be primarily screening determinations, therefore, this PT was aimed at testing the ability of a laboratory to determine whether radioactivity is present or not, and if a laboratory can detect the presence of radioactivity accurately. Also the PT aimed at testing if a laboratory could by an erroneous analytical result trigger a false alarm which might entrain wrong decisions and waste of resources. For this reason the acceptance criteria were fairly wide for alpha/beta measurements.

The participants were not informed in advance about the nuclides used in spiking the water samples. This was in the design of the PT to check the effect of calibration with different nuclides on the final results. Also to simulate the real situation in a laboratory where in a real sample the radionuclides present will not be known, and hence a calibrated instrument used successfully in this PT cannot be expected to give similarly accurate and precise measurement results on real and routine gross alpha/beta determination.

Different radionuclides were successfully used in calibration such as: K-40, Sr-90/Y-90, Cs-137, U-236, U-238, Am-241 and Pu-242.

4.3.5. Recommendations regarding Ra-226, U-234 and U-238 determination

Gamma spectrometry is not the best suited method for the measurement of Ra-226 and uranium isotopes in water as the expected concentration is usually low (less than 1 Bq kg^{-1} in drinking waters) and the background contribution quite high when compared to the expected values. Furthermore, U-238 lacks direct gamma emissions and can be measured only assuming radioactive equilibrium with daughter nuclide Th-234 (useful gamma emissions at 63.3 keV and 92.4-92.8 keV); U-234 lacks gamma emissions and no reliable assumptions can usually be made on its equilibrium with parent and progeny nuclides (it is well known that U-234 is not even in secular equilibrium with U-238, due to different chemical-physical behaviour of the two uranium isotopes in aquifers [8] [9] [10]); Ra-226 has a direct gamma emission at 186.2 keV strongly interfering with both U-235 gamma emission and background contribution and, as outlined in par. 4.3.1, its measurements by Rn-222 and daughter nuclides needs specific care in order to avoid radon losses and assure radioactive equilibrium.

However, gamma spectrometry is often used as it is a well established and widely diffused technique (furthermore, high efficiency detectors with low background are more and more often available). In such a case, special care has to be taken to assess background contribution e.g. by repeated background measurements and a thorough statistical analysis of results (in low level measurements the variability of repeated measurements can be higher than the counting - Poisson - uncertainty of single measurement, and the background contribution and uncertainty can be best assessed as average and standard deviation of repeated measurements). Sample containers must be filled to the top as any air headspace can cause uneven radon dispersion (and consequently affect the actual geometrical efficiency). The use of updated and internationally agreed Nuclear Data Tables is strongly supported (e.g. [11, 12]) in order to avoid mistakes due to the use of out-of-date gamma ray intensities.

Measurements by liquid scintillation counting, both in homogeneous and in non homogeneous phase, rely on progeny nuclides at equilibrium and must be performed using radon tight containers (e.g. polytetrafluoroethylene (PTFE), polyethylene-PTFE coated or high density polyethylene vials); furthermore, radon extraction yield cannot usually be directly measured and must be assessed on the basis of the results of method validation, that should include a thorough evaluation of both repeatability and robustness. Counting can be performed considering alpha or alpha + beta window: in the last case, blank contribution has to be carefully checked to account for possible reagent contamination (e.g. K-40 is often present at detectable levels in commercial liquid scintillation cocktails) and for fluctuations well beyond the variability expected on the basis of counting (Poisson) statistic.

Measurements based on emanometry are widely used; in this case a critical point is the evaluation of Rn-222 extraction yield from the radium solution since internal yield tracers are not available and the recovery strongly depends on degassing procedure (gas flow, bubble size, etc.). A particular effort must be put in method validation, with special regard to repeatability assessment.

Ra-226 can be measured by direct alpha counting of Ba(Ra)SO4, precipitated and deposited on filter; in this case Rn-222 and short lived progeny contribution to alpha counting is a critical point as radon can be trapped in sulphate crystals in variable amounts thus affecting actual counting rate. Again, method validation and repeatability assessment are key points.

The radium co-precipitation with barium sulphate is often used as a preliminary step for concentration and purification, and can be applied in all the above reported methods. In such cases, the assessment of chemical yield is necessary and it is usually performed gravimetrically by weighing the recovered Ba(Ra)SO4; yield overestimates can occur when similar elements (e.g. calcium) are co-precipitated. The use of radioactive tracer (e.g. Ba-133 that can be measured by gamma spectrometry) overcomes this problem to some extent, but the question of variation in recovery between Ra and Ba remains.

The determination of chemical yield is also a limiting factor for the determination of radium isotopes by alpha spectrometry. In this case most commonly used best tracer is Ra-225 (direct progeny of Th-229), and it is the best tracer available as it is an isotope of the same element (radium). However, in general alpha spectrometry techniques are more cumbersome than other approaches, and require a high operator skill.

Uranium measurement by alpha spectrometry is a well established procedure but not the easiest one. Special care should be taken in order to avoid cross contamination that can occur when the same laboratory materials and deposition device (beakers, deposition cells, etc.) are used for the analysis of waters, soils etc. Use of disposable materials is strongly recommended as far as possible.

Uranium can be measured by liquid scintillation counting following extraction by homemade scintillation cocktail containing specific complexing agents (e.g. HDEHP) or by specifically designed commercial cocktails (e.g. URAEX® by Ordela, Inc.). As internal yield tracers can hardly be used due to poor spectral resolution, the evaluation of overall efficiency and repeatability are key points of method validation.

For all the above reported methods, traceability of radioactive sources used for calibration or as internal yield tracers must be assured at any time. Liquid solutions of tracer nuclides are often provided without any indication about expiry date, which (if present) actually refers to the sealed, untouched source. Once opened (and diluted), internal procedures should be applied for their management (dilution included) possibly including periodical check of actual concentration

4.4. Technical information provided by the participants

Appendix I contains the summary evaluation of each laboratory along with the summary of the reported technical information. For each laboratory, the years of claimed experience in analysis and summary of analytical procedure and counting method is summarized.

5. CONCLUSIONS

The IAEA-CU-2008-03 proficiency test was successfully completed with a high level of reporting-back of the analytical results (72% of the registered laboratories reported their results to the IAEA). Most participants were able to quantify certain number of radionuclides of interest in phosphogypsum and water. 26% of all reported results did not pass the PT acceptance criteria.

This PT provides the possibility to improve the world-wide comparability and reliability of the determination of natural radionuclides in environmental matrices.

This PT shows the need for further improvement of the analytical performance for determination of natural radionuclides in aqueous samples at low level of radioactivity for some laboratories. The performance level of such determinations was the lowest in this PT. A second PT on the same radionuclides is recommended to assess any improvement in the analytical performance based on the lessons learned in this PT.

APPENDIX I: SUMMARY OF THE REPORTED TECHNICAL INFORMATION SORTED BY LABORATORY CODE

The summary technical information on the analytical procedures applied in the laboratories of the PT participants is presented as reported by the participants without editing.

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the IAEA or any of its staff members thereof.

In these tables, laboratory information is presented in ascending order of the laboratory code. The blank cells indicate that no technical information was provided. The listed years of experience is as reported by the participants according to their judgment.

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
1	1–3 years	Counting time 3962 min. HPGe-detector. Efficiency calibration using separate single-line standard solutions and additionally a certified multi-gamma source.	Sample (mass 93 g) was measured in sealed cylindrical container (diameter 37 mm, height 26 mm) on top of the detector end-cap. Spectrum was analysed by in-house software GAMMA-99 taking into account sample self-absorption, true coincidence summing and background corrections
2	> 3 years	Not reported	Not reported
3	1–3 years	Detector efficiency calibration curve obtained from standard reference materials. Counting time-80 000s	Gamma spectrometry for normalized disc geometry.
4	> 3 years	Gamma spectrometry: Calibration: Mixed Nuclides: Ba-133, Cs-137 measure: Ra-226 (p-type Ge) and Mixed Nuclides: Pb-210, Am-241 Measurement: Pb-210, Th-230 (n-type Ge) Ra-226 correction for U-235	Gamma spectrometry: Geometry: 250ml Marinelli, Ra-226, Pb-210, Th-230 (Th-230: P=0,38%) Alpha-Spectrometry: U-234, U-238, Determination with different Extractions: HNO_3,HCL internal tracer U-232.
5	> 3 years	Not reported	Not reported
6	> 3 years	Gamma	Direct Count
7	1–3 years	Two counting systems were used. The first one consists of: HPGe coaxial detector with 42% efficiency and the second one consists of: LEGe detector For the efficiency calibration of cylindrical geometry (f: 6 cm, height: 1.2cm) the reference materials RGU-1 provided by IAEA- was used.	Following the drying instruction the moisture content was determined. Six samples of Phosphogypsum were prepared (using 5% charcoal additive) and the mean value of them was reported in the specific proficiency test.
8	> 3 years	The sample was measured by means of 70% HPGe-detector. The counting time was 24 h.	A standard box is filled with 260 ml of the sample. For the determination of Ra-226 the box was sealed with epoxide glow and remains for 25 days until equilibrium.
9	> 3 years	Low background gamma-ray spectrometry technique was used: - HPGe detector, 30 % relative efficiency). Amounts of 97.85 g, 74.43 g and 66.05 g of phosphogypsum sample were investigated. Counting time: between 3.33 h and 24.53 h (3 runs for each geometry). Efficiency calibration: appropriate reference materials of certified U and Th concentrations, or certified Ra-226 specific activity were used (IAEA-S17 phosphate rock, IAEA-314 stream sediment, IAEA-312 soil, IAEA-Soil6, IAEA-306 marine sediment).	Ra-226 was determined by measuring the gamma-emitting decay products of Rn-222. The samples were kept tightly closed in plastic boxes for about one month prior the counting to avoid losses of the gaseous Rn-222, in order to establish radioactive equilibrium with Ra-226. To determine Ra-226, the following gamma-rays were considered: 295.2 keV and 352,0 keV of Pb-214; 609.3 keV and 1120.3 keV of Bi-214. - U-238 was determined by using 63.3 keV and 92.8 keV (doublet) gamma-rays of Th-234. Pb-210 was determined by using 46.5 keV gamma-ray, assuming a radioactive equilibrium with Ra-226. - The natural background contribution was extracted.
11	> 3 years	HPGe gamma spectroscopy for Ra-226 progeny. In-house geometry calibration using NIST SRM.	Sample sealed in airtight aluminium can and radium progeny allowed reaching equilibrium. Ra-226 determined from gamma peaks of progeny.
13	> 3 years	Germanium HPGe gamma spectrometry detector Energy and efficiency calibration	Direct measurement of sample aliquot in sealed geometry after 1 month of delay to

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		was performed with gamma emitters standard solution (QCY-48)	ensure secular equilibrium Ra-226 activity obtained through Pb-241 and Bi-214
14	1─3 years	The plastic container is calibrated with a multisource standard solution	35g of phosphogypsum were added to a plastic container and were measured with a HPGe 22% relative efficiency for gamma radioactivity.
15	> 3 years	The energy and efficiency calibration were performed with mixed calibration standard sources MBSS2 from the Czech Metrological Institute. The analysis procedure takes into account background corrections and corrections for self-absorption.	The sample was mixed before transferring the content in our counting container. Sample mass was measured with calibrated analytical balance. After gamma spectrometry measurement and analysis the sample was drayed overnight. The dry-to-wet correction was performed.
18	> 3 years	Not reported	Not reported
19	> 3 years	Instrument calibrated using Gamma Vision software following counting of a geometry spiked with traceable mixed gamma source.	Sample counted using HPGE detector in 90 mm diameter calibrated geometry
20	NULL	SRM in Marinelli beaker of the same geometry used.	Sample sealed in Marinelli beaker and after 20 days gamma-spectrum measured by high resolution gamma-spectrometry. All corrections applied (matrix, decay, efficiency, summation effects etc.)
21	> 3 years	Not reported	Not reported
22	> 3 years	Measurement of isotopes was carried out by spectrometry using intrinsic germanium detector. The detector efficiency calibration was determined using a standard calibration source with known quantities of gamma isotopes (Am-241 to Co-60). Peak analysis of isotopes was done using Genie-200 peak-analysis software (Canberra Company).	The sample was transferred into a container of 50 mm of diameter.
23	1─3 years	Multinuclide standard Cd-109, Am-241, Pb-210, Co-57 (low energy) Ba-133, Ce-139, Co-57, Sr-85, Cs-137, Mn-54, Zn-65, Co-60, Y-88 (high energy)	100-ml-beaker filled with 60 g sample, correction of the 186-keV peak with U-235-activity (alpha-spectrometry) to get Ra-226-activity, n-type HPGe-detector Software INTERWINNER 6.0
24	> 3 years	Not reported	Not reported
26	> 3 years	NULL	Not reported
27	> 3 years	The counting was performed for 16 hours each for sample and for standards. Two standards IAEA-RGU-1 and IAEA-RGTh-1 were used. The method was validated by analysing QAP-SOil-0003 from US DoE.	The sample was analysed using relative method that is counting sample and standards in the same geometry.
28	1─3 years	U-238, U-235 and U-234: External calibration with a five point calibration Th-230, Ra-226, Pb-210: multi-nuclide standard, self absorption correction, interference correction for Ra-226 with ICP-MS results for U-235.	U-238, U-235, U-234: Addition of In as internal standard to one gram of the sample, dissolution in 4.5 M nitric acid, dilution with 2% nitric acid, measurement with ICP-MS Th-230, Ra-226, Pb-210: Transfer of the sample in 0.25 L plastic beaker, sample mass and density were recorded, measurement with gamma spectrometry.
29	> 3 years	Not reported	Not reported

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
30	1–3 years	Pb-210, U-234, 238, Th-230; Am-241, Cu-244 and Pu-239 standard sealed source are used for energy calibration. For combined recovery and efficiency calibration, the internal standard, Po-209, U-236, and T-229 are used: Ra-226 standard solution follow the same procedure is used for detector calibration; Low background gas proportional counter.	Pb-210: Each sample is done in triplicate. Transfer to a beaker 1 grams of phosphogypsum sample. Po-209 was used as tracer. The sample was consecutively digested with conc. nitric acid, perchloric acid and hydrochloric acid. Auto deposition the solution on a 99.99% purity silver disc and counted under an ORTEC Ultra.
31	> 3 years	Efficiency calibration: Mathematical approach Software: CANBERRA GENIE2000; Counting Time: 200000 s	High Resolution gamma ray spectroscopy. Sample preparation: (i) weighing and sealing of the sample in polyethylene Marinelli Beacker. Mass Density determination. (ii) Dry-to-wet ratio determination (iii) counting
32		Not reported	Not reported
33	> 3 years	Gamma lines at 46.54, 67.67 and 63.30 keV have been used for the measurement of Pb-210, Th-230 and U-238, respectively, the latter assumed in radioactive equilibrium with its daughter Th-234. The final measurement result reported for Ra-226 has been evaluated by weighting the concentration values obtained from Pb-214 peaks at 295.22 and 351.93 keV with the inverse of their uncertainty variances. The calibration of the gamma spectrometry system employed has been carried out using standard sources with the same detection geometry as the measured samples prepared from different matrices, with bulk densities between 600 and 1900 kg/m3, spiked with known amounts of solution containing a mixture of ten certified gamma-emitting radionuclides.	An aliquot of the phosphogypsum sample was bottled in a hermetically sealed 250-ml cylindrical PVC can of 8 cm diameter and counted for 75 h, using a HPGe coaxial detector with a 20% relative efficiency, about four weeks after bottling to ensure that radioactive equilibrium between Ra-226, Rn-222 and its short-lived decay products was reached. After the measurement was performed, a subsample of about 50 mg was dried at 105 °C for 24 h to determine dry-to-wet ratio of the phosphogypsum.
34	> 3 years	Efficiency calibration was performed with MGS-6 Multi-gamma ray standards produced by Canberra, with mathematical correction on density. Energy calibration was performed with point sources (Co-60, Co-57, Cs-137).	Bottle was mixed and then carefully opened, and the phosphogypsum transferred into the measurement vessel (metal canister 100 g). Determined mass of PG in canister was record. For analysis of spectra used software GENIE 2000.
35	> 3 years	Not reported	Not reported
36	> 3 years	Energy calibration. Efficiency calibration using multi-nuclide standard. Method: High resolution Ge spectrometry Software: Genie 2000	Preparation of sample 06: 1/Determination the sample container mass and the sample mass in the 450ml container. 2/Counting - 367700s. 3/Three samples of about 5 ml each, drying overnight, determining of dry sample mass and dry-to-wet ratio.
37	> 3 years	Count on a Xtra 50% Canberra.	75g put in a "house" geometry (plastic beaker 110mL), closed, and wait for at least 28 days before counting.
38	> 3 years	Uranium isotopes were determined by alpha spectrometry. Sources were prepared by electro-deposition, following the procedure described by Hallstadius and initially	Determination of uranium isotopes: Three 0.6-g aliquots of the sample were transferred to Teflon beakers and a mixture of HNO3, HCl and HF acids were added several times

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		developed by Talvitie. Uranium determination by alpha spectrometry: Energy and efficiency calibrations of the spectrometer were carried out using a certified electroplated source that contains a mixture of three radionuclides: U-233, Pu-239 and Am-241. Samples were counted for 500000. seconds Determination of Ra-226 and Pb-210 by gamma spectrometry: Canberra BEGe detector was used. Efficiency calibration standards were prepared from a certified solution with a mixture of gamma emitters (50-1800 keV). Ra-226 and Pb-210 were determined by gamma spectrometry, using a BEGe detector. Ra-226 was determined from its daughter, Bi-214, while Pb-210 was directly measured from its gamma line. 50-g of the phosphogypsum sample was transferred to a plastic container and this was hermetically sealed to avoid Rn losses. Measurement was carried out 24 days later, in order to ensure secular equilibrium between Ra and its descendents.	for the acid digestion of the samples, followed by a few ml of H3BO3. Resulting solutions were evaporated to dryness and finally dissolved in 50 ml of HCl 10M prior to uranium separation by ion exchange(Bio Rad AG1-X10 resin) and extraction (UTEVA columns) chromatography Separation by ion exchange chromatography: Columns were conditioned with 50 ml of 10M HCl -Washing with 50 ml of HCl 10M. -Elute uranium with 40 ml of deionised water Purification by extraction chromatography (UTEVA columns): -Solutions were evaporated to dryness on a hot plate and dissolved in 10 ml of 3M HNO3. - Columns were conditioned with 5ml of 3M HNO3. - Samples were loaded on to the columns - Washing with 5 ml of 9M HCl and 25 ml of 5M HCl. -Elute uranium with 25 ml of 0.02M HCl Determination of gamma emitters.
39	> 3 years	Ra-226 - Calibration was carried out using Eu-152 standard in same geometry and graph was drawn between energy and efficiency. Built in calibration and efficiency graph was used to estimate Activity.Ra-226 was determined by taking the mean activity of two separate photo peak of its daughter Bi-214 at 609keV and 1764keV U-234, U-238 and Th-230- Estimation by Alpha spectrometry. Calibration by multi-nuclide alpha standard.	Ra226 - The aliquot of sample was taken in plastic bottle and hermetically sealed and kept for a period of 1 month for equilibration so that Ra-226 is in equilibrium with its daughters.2g of sample was dried in oven and moisture content was determined. U-234, U-238 and Th-230 - Sample dissolution with HF, HNO3 and HCLO4 followed by ferric hydroxide precipitation, separation by anion exchange method and solvent extraction with di-iso propyl ether, electro-deposition.
40	> 3 years	Calibration and counting method is carried out on the algorithm realized in the program of processing of spectra GENIE 2000 Canberra Industries	Detector HPGe Coaxial Relative Efficiency 35% Energy range: 50-10000 keV Method of efficiency calibration: Multi-nuclide standard
42		A known activity Pb-210 standard solution which is in secular equilibrium with the progeny was used for calibration. After sequential separation of Bi-210 and Pb-210, tailing factor and counting efficiency were calculated. The double energy window method is used to determine the Pb-210 activity concentration. This way the contribution of the ingrowing Bi-210 to the Pb-210 region can be corrected. All counting procedure performed by LSC.	Determination of Pb-210 by liquid scintillation counting after sequential separation with extraction chromatography using Sr-spect resin. The separated Pb-210 was precipitated as oxalate and chemical recovery was determined by gravimetrically.
43	1–3 years	counting method: gamma spectrometry and calibration method: mathematical efficiency calibration	direct counting (gamma spectrometry)
44	> 3 years	CSN 11.2004	CSN 11.2003

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
45	> 3 years	Several procedures were applied depending on radionuclide: a) For alpha spectrometry the tracer acts like standard for calculating recovery and the content of the sample. b) For gamma spectrometry Standard matrix measured in the same geometry as of our sample. The samples were completely dissolved in a microwaves oven-hot plate and diluted in 0.1 N HNO3 medium. For Th-230 the sample was dissolved and Th-229 was added as tracer. After a radiochemical procedure the Th-230 was electroplated onto a stainless-steel disc and measured by alpha spectrometry Pb-210/Po-210 6 Aliquots of the sample were digested in HNO3/HCl/HF acids and heated 90?C in a hot plate (3 Aliquots) and microwave-oven (3 Aliquots). Po-209 was used as tracer for both auto-deposition taking into account than the first one is quantitative (100 %). Both radionuclides were measured by alpha spectrometry after two auto-deposition on silver discs following the Fleer method (Citric/Bi/HCl media).	Ra-226 (Two techniques were applied: a) Direct gamma spectrometry b) Radiochemical analysis a) The sample is dried at 85 C. Lately, it is placed in a Petri disc and hermetically closed. After 3 weeks, it is counted by gamma spectrometry with HPGe detector. 226Ra is measured by means of its daughters 214Pb (352 keV) and 214Bi (1120 keV). b) Radium is co-precipitated in Ba Sulphate and after several precipitation for purifying the precipitated the Radium is measured in a Solid Scintillation Counter. U-238,U-234 (Two techniques were applied: a) alpha spectrometry and b) Laser-Phosphorimetry) a) The samples were dried and digested with HNO3/HCl/HF acids. U-232 tracer was added to calculate the recovery. The dissolved sample was pre-concentrated in Fe(OH)3. The Fe was extracted in ether before the Uranium separation. The aqueous phase was concentrated and finally the sample in 8N HCl was passed through a column with resin AG 1x8. The uranium is eluted in 0.5 N HCl and electroplated on stainless steel disc (2.5 cm of diameter) (1 Aliquot) b)
46	> 3 years	The energy and efficiency calibration were performed with mixed calibration standard sources MBSS2 from the Czech Metrological Institute. The analysis procedure takes into account background corrections and corrections for self-absorption.	The sample was mixed before transferring the content in our counting container. Sample mass was measured with calibrated analytical balance. After gamma spectrometry measurement and analysis the sample was drayed overnight. The dry-to-wet correction was performed.
47	> 3 years	Not reported	Not reported
48	< 1 year	Calibrated vs NIST standard reference materials.	Dry sample and seal known mass in plastic counting dish. Age 3 weeks. Count.
49	1—3 years	Calibration with gamma spectrometry system with HPGe detector	sample transferred in cylindrical container (180 ml)
50	> 3 years	Gamma spectrometry: n-type Ge detector; calibration whit liquid standard sources (46 keV - 1836 keV); TCC correction; background correction; self-absorption correction (NIST database); 5 h measurement time. Alpha spectrometry: calibration whit multi-alpha standard source; vacuum chamber whit 450 mm2 Si detector; 7 d measurement time.	Pb-210, Ra-226: Gamma spectrometry in 100 ml bottle; self-absorption correction. U-234, U-238: Alpha spectrometry after microwave digestion, phosphate precipitation, UTEVA Eichrom resin separation and electro-deposition; U-232 tracer.
51	> 3 years	Not reported	Not reported
52		Calibration Standard Solution (4M HCl)from nuclitec GmbH/Germany, Type QCYB10989, containing reference nuclides: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Mn-54, Y-88, Zn-65 and Co-60; Canberra HPGe-Gamma-	1) sample preparation in either Gas-tight aluminium flask with about 100g sample or polystyrene dish with about 1/10 of material 2) Gamma spectrometry with HPGe-spectrometer incl. calculation software

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		Spectrometer incl. Genie software	
53	> 3 years	Method of efficiency calibration: Calibration is done with a commercial mixture with a certificate of traceability of activity. The commercial mixture is from CIEMAT with reference number MRC2007-017 in the same geometry (Marinelli beaker_250 ml). Detector: Type: Ge Detector - XtRa (Extended Range) Applied corrections: 1. Radioactive decay corrections. 2. Coincidence summing. 3. Background. Time of measurement: 20 hours	Not applicable because the measurement is made by following these steps: 1. The Marinelli beaker used in the measurement (250 ml) is weighted. 2. The container with the sample is shaken. 4. After that, the container with the sample is opened and the sample is poured into the Marinelli beaker, and then it is weighted. 5. The cover is sealed. 6. About two months should be waited before the measurement in the Counting System. In order to evaluate the humidity, 5 grams were taken from the soil sample and dried.
54	> 3 years	A semi-empirical full energy peak efficiency calibration protocol was developed at the counting geometry to properly quantify radionuclide activity in the sample. This model combines both experimental measurements and Monte Carlo (MC) simulations taking into consideration the sample bulk density and its chemical composition. The mathematical calibration software tool for MC simulation is Virtual Gamma Spectroscopy Laboratory (VGSL) developed under the auspices of the Comprehensive Nuclear Test Ban Treaty Organization. The Gamma spectrometer is calibrated for energy and peak shape as required and at least on an annual basis. The certified standards traceable to NIST are used for calibrations. The energy range for a mixed calibration standard is from 46.5 keV to 1836 keV. A check source of similar geometry containing 4 radionuclides is run with each batch of samples. A combined point source containing Am-241 and Co-60 is used for QC check prior to the start of each batch and at least weekly.	A broad energy germanium detector (BEGe) from Canberra with a high resolution at low energies (e.g., a resolution of 0.58keV at 122keV) was used to determine the concentration of Ra-226 in the phosphogypsum sample. This resolution allows the required separation and deconvolution of 186.2keV peak from Ra-226 from the neighbouring 185.7keV peak from U-235. The collected spectrum was analyzed using the radionuclide analysis software Aatami, which is an advanced gamma-spectrum analysis tool for the assessment of monitoring information. The energy distances between the gamma-peaks and peak resolution are fixed in this case with peak centroids at 185.7keV and 186.2keV and a FWHM of 0.77keV. Any external information obtained from outside the multiplet aids greatly in deconvolution. In this case, when the 143.7keV gamma-ray intensity of 235U is available, the related information such as efficiency, gamma-yield, and peak area can be used as a reference for deconvolution.
56	NULL	1) Gamma spectrometer CANBERRA 3106D, Detector REVERSE CANBERRA GR2020-7500SL. 2)Efficiency was calibrated using multinuclide standard .	The sample was measured using germanium detector. Secular equilibrium was reached. The Ra-226 activity was calculated from the measured Bi-214 and Pb-214.
57	1—3 years	Ra-226 standard solution for calibration Counting method: live time - 1000 m. Replicates: 4 per sample	Secular equilibrium by 4 weeks Direct gamma spectrometry HpGe on filter Analysis: 609 keV peak.
58	1–3 years	Not reported	Not reported
59	> 3 years	Preparation of NIST-traceable mixed gamma calibration standards into standard counting geometries in aq. soln. Averaged efficiencies from multiple counts to typically <1% counting uncertainty, separated in time.	Non-destructive counting of sample material in standardized geometries on shielded HPGe detectors.
60	> 3 years	Not reported	Not reported

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Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
62	> 3 years	Not reported	Not reported
63	> 3 years	Calibration of Gamma spectrometry system has been done by standard Eu-152(100 Bq). Eu2O mixed in 250g Al2O3 in pot geometry for the solid samples. The efficiencies of the detector HPGe for different energies & solid samples have been determined. The samples IAEA-06 was transferred into the pot geometry for the measurement of gamma emitting radionuclides by Gamma spectrometry method. Ra-226 is measured by 186.2 keV gamma energy samples. U-238 is measured by Pb-214 (242.0 keV, 295.2 keV & 351.9 keV) .	The radioactivity of IAEA-06 sample was measured by using a low-level gamma counting system, a high resolution HPGe coaxial detector coupled with a multichannel analyzer (MCA) and associate microprocessors. The effective volume of the detector was 83.469 cm^3 and energy resolution of the 1.33 MeV energy peak for Co-60 at 1.69 KeV at full width half maximum (FWHM) with a relative efficiency of 19.6%. The bias applied to the HPGe detector used in the present experiment was +3200 Volts. Ra-226 was measured by Ra-226 (186.2 keV) for IAEA-06. U-238 was measured by Pb-214 (242.0 keV, 295.2 keV & 351.9 keV). Th-230.(228Ra) was measured by Ac-228 (969.11 keV).
64	> 3 years	Samples are measured by high resolution gamma spectrometry, energy range 50-2000 keV, relative efficiency at 1.33 MeV: 30% . Measurements are performed after the secular equilibrium between Ra-226 and Rn-222 and its short live daughters is attained (1 month). Calibration was performed by repeated measurements of Ra-226 sources in the same conditions. Ra-226 activity value is based on Bi-214 and Pb-214 concentration.	A radon tight container (volume about 100 mL) was completely filled with the sample and sealed with a flange cap.
65		Not reported	Not reported
66	> 3 years	Spectrometer was calibrated with a sediment standard (reference material) of type CBSS2 from the Czech Metrological Institute. The geometry of the reference material was as same as the geometry of the sample and both were counted for 80000 s. Sample was counted 5 times. Genie 2000 software was used to acquire spectra and to perform efficiency calibration. The spectrometer used is the InSpector 2000 (Canberra Industries)with a HPGe detector of relative efficiency of 25.4% connected to the multichannel analyzer with 8192 channels. The resolution at 1332.5 keV (Co-60) is 1.80 keV.	Ra-226 activity was determined as a weighted mean activity from 295 and 351 keV peaks of Pb-214 and from 609, 1120 and 1764 keV peaks of Bi-214. U-238 activity was determined from the natural activity ratio U-235/U-238=0.04603. U-235 activity was determined from the 186 keV peak after subtraction of the Ra-226 contribution . The sample was counted 5 times and the final activity is expressed as the mean activity of the 5 measurements.
67	> 3 years	The sample is measured in a Gamma-ray Spectrometer calibrated with a QCY-48 mixed standard.	The sample is sieved and placed in a petri box. This box is sealed and measured 30 days after preparation.
68	> 3 years	Energy and efficiency calibration with a similar matrix spiked with a QCY48 reference source in the same geometry. For Pb-210 another matrix in 90 mm Petri geometry was spiked with a Pb-210 reference source. The counting system was	Direct measurement of the sample in a efficiency calibrated geometry.

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Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		an HpGe type N.	
69	1—3 years	The sample is counted in a semiconductor for 92 hours. A certified mono-energetic multi-element source, at the same geometry of the sample, is used to the detector calibration.	Sample, wrapped in plastic film, is located inside a 0.5L bottle or 90mm Petri plate (volume fixed), depending on density, composition and quantity of sample.
70	1—3 years	Calibration source: gamma cocktail. Counting system: GeHp 25% efficiency.	214Pb and 214Bi equilibrium with 226Ra
72	1—3 years	Full energy peak efficiency calibration with traceable reference materials (Mixed source including Pb-210, Am-241, Cd-109, Co-57, Te-123m, Cr-51, Sn-113, Sr-85, Cs-137, Y-88 and Co-57in sand matrix and Pb-210 solution in acidified water). The detectors used were an n-type % 70 relative efficiency HPGe detector, a p-type % 150 relative efficiency HPGe detector and a p-type % 120 relative efficiency HpGe detector. The sample was put into a cylindrical container having a diameter of 8.5 cm and 4 cm height. Counting periods were 3 day and 10 day.	This method uses high purity gamma ray spectrometers calibrated with reference calibration sources traceable to a primary standard laboratory. Relevant self attenuation corrections are applied using both commercial software and in-laboratory calculations.
73		calibration with Ba- Ra 226- sulfate, weight control	Leaching with Na-carbonate, preparing of Ba chromate weight control Measuring alpha in Low-level Beta counter
74	< 1 year	Not reported	Not reported
77		Not reported	Not reported
78	> 3 years	Calibration source - the same type Marinelli beaker (0.5 g/cm^3)with Amersham QCY.48 cocktail (60-1836 keV)	EG&G Ortec HPGe detector GEM-15190-P, energy range 40-1940 keV in 4k channels; 0.25 kg sample in Marinelli beaker, 240 ks counting time; Maestro software for spectra acquisition, ANGES software for spectra analysis, Excel spreadsheet for activity calculations.
79	1–3 years	Not reported	Not reported
80	1–3 years	The sample is counted in GeHP detector (type N). The calibration is made with a sample of known activity and with same density of the phosphogypsum.	The sample is conditioned in adapted geometry before counting in gamma spectrometry.
81	> 3 years	Efficiency calibration was done based on reference sources which contain natural radionuclides: U-series for well type detector; U, Th-series and K-40 for BEGe detector.	Samples of material were measured by means of gamma spectrometry with 2 detectors: well type and Broad Energy Germanium (BEGe). The measuring geometry: 2,5 ml glass vial for well type detector; 50 ml plastic beaker for second detector.
82	> 3 years	calibration with multi peak gamma emitting standard solution. counting with HPGe spectrometer and subsequent spectrum analysis	packaging of samples in proper geometry
84	> 3 years	Samples are transferred to a standard geometry container for counting on the gamma detectors. High purity germanium (HPGe) gamma detectors are used to detect isotopes with gamma ray energies between	Activity concentration was determined using commercially available gamma spectral analysis software. A sample matrix which can be mounted in one of the standard geometries was analyzed for the isotopes

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Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		40 and 2000 Kev.	included in the radionuclide reference library. Detection limits were affected by the sample size.
85	NULL	Not reported	Not reported
86	> 3 years	Ge(Hp). Mixed radionuclide gamma-ray reference solution Amersham QCY.48. Software: Gamma Vision A66-BI Version 2.40 ORTEC	Not reported
89	> 3 years	Point and other geometry standard sources and standard radioactive materials HPGe detectors, Pb or Fe shielded	Not reported
91	> 3 years	Calibration with standard source (Am-241,Ba-113, Eu-152) in cylindrical geometry of 100 ml -counting in cylindrical geometry of 100 ml for 80000s with background subtraction	In accord to UNI 10797:1999 without sealing the beaker. U-238 was determined by activity of Th-234. Ra-226 was determined by line at 186.22 keV with subtraction of U-235 at 185.72 keV.
92	> 3 years	Calibration: Pb-210, Am-241, Cs-137, K-40, Eu-152, Ba-133 from CIEMAT (SPAIN) and PTB (GERMANY), and GEANT4 Monte Carlo code. Counting: Canberra Well Type Detector Gcw3023	The method is based on the calibration of the germanium well type-detector using Monte Carlo simulation via GEANT4 code, and different experimental standards in order to optimize the MC simulation. The procedure is going to be submitted to a journal to be published.
93		Efficiency and energy calibrations with certified mixed gamma standard. Also use of Labsocs (Monte Carlo calculations)	Measurement of sample with HPGe detector. Use of Canberra Genie2000 software
94	1–3 years	The spectrometers were calibrated using multi-gamma reference sources in different counting geometry. The samples are usually counted for 16 hours	The sample is weighted, put in calibrated jar and counted for 16 hours by means of a gamma spectrometer (HPGe 40%, type n) The results are corrected (if needed) for self-absorption
95	< 1 year	Measurement and calculation of phosphogypsum activity is carried out on a semi-conductor detector (25 % efficiency), preliminary calibrated with use RGSS (referent gamma spectrometric source) and with volumetric source in 125 ml plastic box. Measurement of S6 samples is carried out in 125 ml plastic box. Gamma spectrometer energy range is 30 to 3000 KeV. Calibration of a semi-conductor detector for gamma emitting RN is carried out with use RGSS (referent gamma spectrometric source) and with volumetric sources.	Uranium selection in phosphogypsum is consisted of several operations: Dissolution an aliquot of phosphogypsum (1-3 g) Neutralization of solution by ammonia for hydroxide formation Selection and dissolution of a hydroxide precipitate in hydrochloric acid Drainage of the solution through anion-exchange resin Electro-deposition of uranium and measurement of activity. Thorium was determined similarly, but in this case a nitrate solution was passed through anion-exchange resin.
96	> 3 years	Detector-type and model: Broad Energy Germanium detector (BEGe), Canberra BE 3830-7500SL-2002CPLS. Energy range calibrated: 46-1836 keV Method of efficiency calibration: Multinuclide standard (Amersham QCY.58). Counting time of the samples was 85595 seconds (1 day). Sample counting was carried out 30 days after seal the sample counting container.	The sample was thoroughly mixed before transferring the content to our sample counting container. The dimensions of the sample counting container were 60mm diameter, 50 mm height (40 mm sample height). The mass of the analysed sample was 67.43g. Dry weigh: 66.56g. Dry-to-wet ratio: 0.987
97	> 3 years	Calibration was performed for gamma ray	The sub-samples were taken and a

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Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		energies from 60 keV to 1836 keV against a certified NIST traceable mixed gamma-ray solution (NPL). The gamma ray spectrum was collected overnight and all significant peaks identified. Peak significance was based on the second derivative and counting statistics of the potential peak (<55%). (coverage factor The spectrum was interpreted with the aid of a commercially available software package.	sediment/sand geometry was assumed, which matches one of the calibrated geometries for gamma-spectrometry. Activities of individual radionuclides were calculated based on all identified peaks, taken an energy tolerance of maximum 3 keV. Activities are reported as Bq/g original material. Uncertainty is quoted on a 95% confidence level. Measurements were made on intrinsic high purity germanium gamma ray detectors with relative efficiencies of 18% to 25%.
98	< 1 year	Efficiency calibration (total and peak absorption) by means of standards in Marinelli beaker (Co-57, Co-60, Cs-137, Am-241, Eu-152, Y-88, Ba-133 Cd-109, Ce-139, Sn-113, Sr-85) coincidence summing corrections, self-absorption corrections (1. Hubbell J. H., Photon Mass Attenuation and Energy-absorption Coefficients from 1 kev to 20 MeV, Int. J. Appl. Radiat. Isot., 33, pp. 1269-1290, 1982).	Gamma spectrometry - HPGe detector (PGT) and a multichannel analyser, sample was counted in 450 ml radon tight plastic Marinelli beaker.
99	> 3 years	I worked the sample with the system gamma spectrometry and detector of Ge(Hp)-BE 3820 . I used a source cocktail for calibration.	Not reported
101	> 3 years	Not reported	Not reported
102	1–3 years	Not reported	Not reported
103	> 3 years	Energy calibration with Pb-210, Ba-133, Cs-137 and Co-60. Efficiency curve obtained with Pb-210, Am-241, Ba-133, Cs-137 and K-40 tracers added in aqueous matrix. The Genie-2000 interactive peak tool was used to get the net counts in the spectra.	Sample measured in a well-defining geometry by gamma spectrometry followed of a transmission with punctual sources exercise to obtain the self-absorption correction factor.
104	1–3 years	Not reported	Gamma spectrometry with HPGe (30%)
105	> 3 years	A commercially prepared 8 nuclide mixture in a 0.5 L. Marinelli with soil is used for geometry calibration. We use an HPGe detector. This particular sample media was lighter than expected and it was hard to find a geometry that we had that would fit best. We will see what happens to our results from this study to gain more knowledge.	Sample placed in a 0.5 L. Marinelli, sealed and stored for at least 30 days for radium 226 daughters to reach equilibrium. Counted on an HPGe for 12 hours. Bi-214 is analyzed for and assumed to equal Ra-226.
106	> 3 years	The procedure is the same as the water.	The sample of phosphorgypsum were put in the Marinelli baker, measured and left for 28 days to reach the radioactive equilibrium between Ra-226 and Pb-214 and Bi-214, and then counting.
107	> 3 years	A mixed 10 radionuclide gamma standard with water equivalent solid matrix is used for calibration of spectrometer. True summing correction is applied for Co-60 and Y-88 lines. Sample is counted for 60000 seconds without pre-treatment other than homogenization.	Gamma spectrometry using coaxial HPGe detector with 35% rel. efficiency without sample pre-treatment. True summing and sample self attenuation corrections are applied when needed. Genie-2k V.3.1 with gamma analysis and interactive peak fitting is used for spectral analysis.

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Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
108	1–3 years	For determination of natural radionuclides in spiked water and phosphogypsum (Sample 01, 02 and 06), the samples were kept for a month to let the parents and the daughters radionuclides reached the homogeneity. All measurements were done in 2 times counting with the gamma spectroscopy systems where the relative efficiency of 30% and resolution of 1.8 KeV (FWHM) at 1.33 MeV and the analysis of photo peaks were carried out using Genie-2000 software. The systems were calibrated with multinuclide standard solution, respectively in the same geometry with the samples.	For determination of natural radionuclides in spiked water and phosphogypsum (Sample 01, 02 and 06), the samples were kept for a month to let the parents and the daughters radionuclides reached the homogeneity. All measurements were done in 2 times counting with the gamma spectroscopy systems where the relative efficiency of 30% and resolution of 1.8 KeV (FWHM) at 1.33 MeV and the analysis of photo peaks were carried out using Genie-2000 software. The systems were calibrated with multinuclide standard solution, respectively in the same geometry with the samples.
109	> 3 years	It was used a mathematical calibration taking into consideration the known detector properties and matrix composition. An old p-type HPGe detector with 25 % of efficiency was used for the analytical determinations.	The sample, once received was deposited and sealed in a plastic container flask of 500 mL volume. After having lapsed the necessary time for the establishment of secular equilibrium (almost one month), the Ra-226 activity concentration was estimated by the 609 keV photo peak of Bi-214. The sample of the mass was corrected to dry mass, a 4% mass reduction was determined.
110	> 3 years	Gamma spectrometry: Calibration with SRM in the same geometry the measurement. Use of the 186 keV for Ra-226 by consideration the interference with U-235. U-238: By using of 1001 keV of Pa-234m and the naturally relation U-235/U-238 . Using the 67 keV for Th-230 and 46 keV for Pb-210.	Directly measurement after drying
111	> 3 years	Calibration with reference material (uranium tailings UTS4 from CANMET) in the same counting vessel HPGe gamma spectrometry Ra 226 = (Lead 214 + Bismuth 214)/2 at equilibrium U 238 is supposed to be at equilibrium with Th 234 and U 234.	Direct counting in a normalised vessel (Petri dish)
112	> 3 years	42% HPGe in very low background lab (underground). Counting geometries: 35 ml, 60 ml, 200 ml, 250 ml gas-tight plastic bottles. Eff calibration from NIST-traceable standard solutions (mixed gamma, Ra-226, Cs-137, Pb-210) prepared and counted in the same counting geometries. Calibration in various sample matrixes; water, sediment, sugar, grass. Validation of method by regular/yearly participation in international/national intercomparisons. Cross-validation of Ra-226 analysis with in-house LSC-counting/spectrometry.	Not reported
113	1–3 years	The High Resolution Gamma Spectrometry System used is composed by the Detector Model: BE 3820-7500SL: BEGe Detect orand the DSA-1000: Digital Spectrum Analyzer. The software used is S501Genie 2000 Spectroscopy Software, S505 Genie	The bottle of the phosphogypsum sample is weighted, then it is gamma spectrometry measured for 300 000 sec. A quantity of 20 g phosphogypsum is dried for 24 hours For used the ISOCS Calibration Software it was necessary to determine the bottle dimensions.

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Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		2000 Quality Assurance Software, S506 Genie 2000 Interactive Peak Fit, S573 Genie 2000 ISOCS In situ Calibration Software. Detector energy range: 8 keV- 1900 keV. The energy calibration and efficiency calibration is performed with the following radionuclides: Cd-109: 16.29 kBq with 1.4%, Ce-139: 0.713 kBq with 1.1%, Co-57: 0.633 kBq with 1.1%, Co-60: 3.166 kBq with 1.1%, Cs-137: 2.412 kBq with 1.2%, Sn-113: 2.830 kBq with 1.9%, Sr-85 3.851 kBq with 1.5%, Y-88 5.954 with 1.2%, Hg-203 2.258 kBq with 2.3%. The counting time was of 300 000 sec.	The ISOCS measurement process includes the following steps: -An MCNP-characterized germanium detector at the factory -Acquiring spectral data from the sample -Specifying the dimensions and physical composition of the measured object -Generating an efficiency calibration file appropriate for the specified counting configuration -Using this efficiency results to analyze the acquired spectra. The activity of U-238 is determined from its daughter Th-234 at 63.29 keV. The Ra-226 activity is determined from the 186.1 keV, using the interferating correction with U235 peaks at 143.76KeV, 163.3 keV and 185.7KeV. The Pb-210 activity is determined at 46.5 keV , the Th-230 is determined at 67.7 KeV, also the U-234 is determined at 120.9 KeV.
114	> 3 years	Counting sources obtained as a result of radiochemical separation procedures (Pb, Ra, U, Th) were measured using "TRI-CARB 3170 TR/SL" ("PerkinElmer") Liquid Scintillation Analyzer with Pulse Shape Analysis and Multichannel Analyzer. Calculations of radionuclides activities were fulfilled in compliance with the algorithm realized in software, including the optimized convolution of the spectrum into groups and modeling the spectrum by set of single library spectra corrected to sample quenching parameter.Calibration-standard solutions of isotopes Ra ,U ,Pu ,Th, Am, Cm, Po, Cs, Sr, Ba etc. from Khlopin Radium Institute and D.I.Mendeleev VNIIM. Counting sources was prepared by the mixing of the separated organic fraction (U) with 15 ml of "Insta-Fluor "scintillation cocktail in 20 ml polyethylene counting vial and measured using Liquid Scintillation Spectrometer. Th-230 separation was carried out from 5 g of phosphogypsum using Th-230 standard solution as the tracer of the radiochemical recovery and the method of liquid-liquid extraction (2 parallel analysis) using "THOREX" as the extractive reagent from 2M sulphuric acid medium. Counting sources was prepared by the mixing of the separated organic fraction(Th)with 15 ml of "Insta-Fluor" scintillation cocktail in 20 ml polyethylene counting vial and measured using Liquid Scintillation Spectrometer.	LEACHING/DISSOLUTION METHOD: Drying of 5 g phosphogypsum at 85 C; Ashing at 500 C; Treatment with sodium carbonate (25%), HCl (6M), HF+nitric acid. Ra-226 separation was carried out from 5 g of phosphogypsum using Ba-133 standard solution as the tracer of the radiochemical recovery and the method of the chromate precipitation with iron hydroxide purification. Counting sources obtained as a result of radiochemical separation procedures was mixed in 20 ml polyethylene counting vial with 10 ml of "ULTIMA GOLD AB" scintillation cocktail and measured using Liquid Scintillation Spectrometer. Pb-210 separation was carried out from 5 g of phosphogypsum after the addition of the stable carriers using the method of the chromate precipitation followed by lead chloride precipitation. Radiochemical recovery was determined using gravimetric method. Counting sources obtained as a result of radiochemical separation procedures was mixed in 20 ml polyethylene counting vial with 10 ml of "ULTIMA GOLD AB" scintillation cocktail and measured using Liquid Scintillation Spectrometer. U isotopes separation was carried out from 5 g of phosphogypsum using U-232 standard solution as the tracer of the radiochemical recovery and the method of liquid-liquid extraction using "URAEX" as the extractive reagent from 0.5M sulphuric acid medium.
117	> 3 years	Using Eu-152 and Ba-133 Sources, Efficiency of a radionuclide(Energy) were determined by graphical method.	Gamma ray spectrometry using HpGe, 15% relative efficiency, 186Kev for Ra-226, 93Kev of Th-234 for estimation of U-238.
118	> 3 years	The detection system was calibrated for	For gamma-spectrometric measurements, the

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Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		energy and efficiency using a multi-nuclide aqueous solution The spectrum analysis was performed using the software Gamma2000 Silena v. 2.0.	samples were transferred to 450-mL Marinelli beakers and weighed. Samples were sealed and stored for at least 30 days. Measurements were carried out using gamma-spectrometry by means of an n-type coaxial HPGe The calibration quality control was carried out by means of a soil standard sample (IAEA-375), whose concentrations of the main natural radionuclides have been certified by the International Atomic Energy Agency (IAEA).
119	NULL	Canberra ISOCS calibration, in-house verification for geometry of measurement, Geometry cylindrical Volume 260 ml 400000 sec.	HPGe detector, ISOCS calibrated, matrix and density are included
120	> 3 years	Energy calibration; efficiency calibration using multinuclide standard; Genie 2000 (Canberra)	Determination of sample volume using measuring cylinder 500ml and determination of sample mass using Marinelli beaker 450ml, sample moisture and mass correction.
124	> 3 years	Test was performed using a HPGe semiconductor detector and a MCA spectrometer. Calibration and analysis are performed with the Ortec Gamma-Vision software.	Sample was closed in a proper "Marinelli" beaker and after its was counted.
125	1–3 years	Not reported	Not reported
126	> 3 years	For Gamma-spectrometry We used mixed source to calibrate. For alpha ray spectrometry We used Am-241 standard source to calibrate.	For Ra-226 and Pb-210 We placed sample into the sample container (diameter 6.2 cm and height 4.5 cm) without any treatment. Ra-226 and Pb-210 was measured by Gamma-spectrometry. For U-238 and U-234 Uranium was separated using solvent extraction (TBP-Xylene) and electrodeposited on a stainless disk. The disk was measured by alpha ray spectrometry.
128	> 3 years		
129	> 3 years	Pb-210: The Pb-210 concentration was determined through its decay product, Bi-210, by measuring the gross beta activity of the Pb-210CrO4 precipitate. The chemical yield was determined by gravimetric analysis and for the measurement a low background gas flow proportional detector was used. U-238: Gamma spectrometry for U-238determination was performed by using a Canberra gamma X hyper pure Ge detector and associated electronics, with a resolution of 0.88 keV and 1.90 keV for Co-57 and Co-60, respectively. The analysis of the data was made by Winner Gamma program.	Pb-210: The samples were dissolved in mineral acids, HNO3conc. and HF 40%, and H2O2 30%, in a microwave digester and submitted to the radiochemical procedure for the determination of Pb-210. This procedure consists of an initial precipitation of Ra and Pb with 3M H2SO4, dissolution of the precipitate with nitrilo-tri-acetic acid at basic pH and precipitation of PbCrO4 with 30% sodium chromate. U-238: Approximately 150 mg of samples and reference materials were accurately weighed and sealed in pre-cleaned double polyethylene bags, for 16 hours of irradiation under a thermal neutron flux in a nuclear reactor. U-238 activity was determined after one-week decay in a counting time of 2 hours in samples and reference materials.
130	1–3 years	Not reported	Not reported

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Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
131	> 3 years	After homogenizing the material by shaking the container, a 50 g aliquot was weighted and afterwards pressed as a pellet with a diameter of 60 mm and a height of 10 mm. The pellet was transferred into a round plastic container with a diameter of 65 mm and placed on a coaxial p-type HpGe-detector with 35% rel. efficiency and measured for 60000s. The determinations of the radioactivity of Pb-210 and Ra-226 were made by this method. Method of efficiency-calibration: multinuclide standard. Alpha spectrometry: Method of efficiency-calibration: multinuclide standard	The determinations of the radioactivity of U-234 and U-238 were made by alpha spectrometric method. The separation of the Actinides was made by peroxide fusion, followed by a liquid/liquid separation with methyltrioctylammoniumnitrate in xylol. Afterwards the "Messanleitungen z. Ueberwachung der Radioaktivitaet in der Umwelt; code: H-U/Pu/am-AWASS-01-01 was used.
132	1–3 years	Not reported	Not reported
133	> 3 years	The efficiency calibration was obtained through a calibration curve from a standard reference material. Several reference materials were used to test the calibration like DH-1A, UTS-1 from Natural Resources Canada and IAEA-326, IAEA-327. Self-absorption corrections were applied according to method developed in references above. Gamma peak were analyzed with software Genie 2k.	The samples were milled and dried when necessary. Afterwards, the samples were sealed in a cylindrical container for 30 days to assure secular equilibrium between Ra-226 and daughters. Gamma-ray measurements were performed using an extended range (XtRa) coaxial HPGe detector. Ra-226 activities were determined via the 352 keV emission of Pb-214. This energy was chosen because the high emission probability (35.1(4)%) and the negligible summing effects.
134		Not reported	Not reported
136	> 3 years	CRM: IAEA RG Set, HPGe gamma detector (Canberra BEGe 50%) (some problem in low energy) Use 35cc snap cap plastic vial. Counted after aging for ingrowth during about 1 month.	Not reported
137	> 3 years	Not reported	Not reported
138	> 3 years	The calibration of the HPGe detector (CANBERRA, 15% relative efficiency connected to Genie PC (CANBERRA) software) involves the determination of the peak-to-total ratio. The detector was calibrated and the efficiency curve was fitted using several suitable absolutely calibrated quasi-point sources. The full-energy peak efficiency curve for the detector was determined using the Kay Win software.	To determine the uranium elemental concentration in the samples (5 aliquots) the neutron activation analysis, specifically the k0-standardization method, was applied. The samples, around 200 mg, were irradiated simultaneously with neutron flux monitor Al-Au (0.1%) IRMM-530RA foil cut into 5 mm diameter and 0.1 mm thick. The usual neutron activation analysis and gamma spectroscopy comprised 8 hours of irradiation time and suitable decay and measurement time to determine 238U by 239Np, medium half-life. The gamma spectroscopy was performed on an HPGe detector with 15% efficiency and for the spectra analysis - peak area evaluation - the Hyper Lab program was used. For the calculation of elemental concentrations a software package called KayWin was applied.

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Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
140	> 3 years	The High Resolution Gamma Spectrometry System used is composed by the BEGe Detector and the DSA-1000-Canberra. The energy and the efficiency calibration are performed by using radionuclides mixed gamma standard or by ISOCS calibration method, and it is verified using various reference material IAEA. Our system contains: a Broad Germanium (BeGe) Detector; software Genie 2000 Applied correction : decay correction, self attenuation and background correction, random summing. The dry mass of measured phosphogypsum was of 87.8g. The counting time was of 270 000 sec.	The phosphogypsum sample was homogenized by shaking for two minutes, then it was transferred to the measuring container (140ml), and then it was weighted and left for 28 days to reach the radioactive equilibrium between Ra-226 and daughters Bi-214 and Pb-214 and between U-238 and Th-234. The gamma spectroscopy technique was used to determine the concentration of U-238 , Ra-226, Th-230, Pb-210. The activity of U-238 was determined both indirectly from the 63.29 keV (3.7%) photon emitted by its decay product Th-234 The activity of U-235 was determined by using its peaks at 143.8 and 163.3 keV. The Ra-226 activity was determined directly from the 186.1 keV. The Pb-210 activity was determined directly from the 46.52 keV.
143	> 3 years	Not reported	Not reported
144	> 3 years	IAEA soil6 was used as the standard sources for efficiency calibrate.	The samples in the origin containers were measured directly without any processing. The detector is Ortec HPGe DSPEC jr 2.0 the counting time is 80,000 sec.
145	> 3 years	calibration source: spiked milk powder 100cm^3 p-type 25% coaxial HPGe detector Canberra	unattended sample was measured
147	> 3 years	Phosphogypsum sample and agar were counted for 60000sec. (six times) in a Ge detector Canberra GX3020, previously calibrated with standard of Eu-152 75.3 Bq/g. Note:Pb-210,Th-230, U-234 was not possible to quantify because we do not have standard to calibrate the detector in this energy range.	Sub-sample of Phosphogypsum sample was weighted in a Petri dish. Agar was used as a background
149		Calibration method - Gennie 2000 Efficiency calibration procedure using multinuclide cocktail type MBSS2 - Czech Metrological Institute; (Pb-210;Am-241;Cd-109;Ce-139;C0-57;Co-60;Cs-137;Sn-113;Sr-85;Y-88;Hg-203) Counting system - Canberra InSpector+Hp Ge detector Canberra GX-3018	The analytical procedure involves: peak location via nuclide library; peak area determination via sum/nonlinear LSQ set up; Area correction; Efficiency correction; Nuclide identification plus interference correction; Detection limits determination (Currie MDA); Line activity evaluation using weighted mean activities;
150	1─3 years	Not reported	Not reported
151	> 3 years	Calibration of the gamma spectrometer was performed by using the standards prepared in our laboratory. Calibration standard (powder of milk) were prepared using the standardized radioactive solution of a common mixture of gamma emitting radionuclides purchased at the Czech Metrological Institute.	Phosphogypsum was measured on a HPGe spectrometer (37% Relative efficiency at 1.33 MeV Co-60 and 1.66 kev Resolution at 1.33 MeV Co-60) in cylindrical geometry (cca 46 g). Dry-to-wet ratio was determined in accordance to recommendation for sample handling.
154	> 3 years	Not reported	Not reported
156	> 3 years	Monte-Carlo-Eff.-Determination (Genie3.0) P-Type 70% pure germanium detector	Direct Measurement in 125 ml Nalgene

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
157	> 3 years	Counting method - gamma-spectrometry (HPGe detector p-type) Calibration - water solution with mixed radionuclides	Samples are (if necessary) drying, crushing, sieving, and hermetically sealed in cylindrical vessels. Samples are measured after equilibration between Ra-226 and Rn-222.
158	< 1 year	Multigamma Standards (Eckert & Ziegler Analytics) BEGe detector (BE5030) Genie2K software	Drying and weighing.
160	1–3 years	Calibration made by the National Institute Calibration source: 152-Eu (A = 2750 Bq/2008) Counting system: Detector Oxford HPGe is used in combination with a multichannel analyzer.	After spectrum analyzing the various peaks are attributed to each corresponding gamma radiation radionuclides. Radionuclide concentrations in samples is calculated using the detector energy efficiency, previously calculated (15%).
161	> 3 years	U-238, Ra-226 and Pb-210 in water samples: Homogenize the samples, then transfer to our cylinder-shape container (diameter is 70cm,and the height is also 70cm), finally measure directly after more than 20 days later.	U-234 and Th-230: The solid samples were spiked with U-236-Th-229 tracer. After digestion, the remaining solids were dissolved by deionised water. The nuclides were copreciptated with Fe(OH)3 from the large volume water and then separated from each other buy using anion exchange columns. The thin sources were made by electrodeposition, and were recorded by an alpha spectrometer.
162	> 3 years	Efficiency calibration: cocktail Type:MBSS, Czech Metrological Institute Reference date:02.02.2009	Software: Genie 2000 Canberra, HPGe detector GX3018, 1.8keV(FWHM)at 1.33MeV; Geometry: Marinelli beaker 450cm3, Density:0.5g/cm3;Moisture content:1.6% Counting time:604 800s
163		Not reported	Not reported
164	> 3 years	LabSOCS efficiency calibration. Measurement with gamma spectrometry (HPGe) from Canberra.	Weighing of sample aliquot. Determination of dry-to-wet ratio after measurement.
165	> 3 years	Energy calibration of alpha and gamma spectrometers on standard laboratory sources.	Ra-226 determination: measurement in Marinelli geometry on gamma spectrometer. Determination of uranium isotopes - sample dissolution in acids, alpha source preparation from the uranium fraction by coprecipitation with NdF3, alpha spectrometry.
166	NULL	Efficiency calibration by mathematical approach. MCNP calculations coupled with gamma radionuclides standards measurements. Software Genie 2000.	Gamma spectra measurement with the use of HPGE detector
167	1–3 years	Canberra GX4020 semiconductor detector with 42% relative efficiency	Pb-210, Ra-226, U-238 - Gamma spectrometry. HPGe semiconductor detector (Canberra GX4020) with 42% relative efficiency is used. In the efficiency calibration procedure reference solutions containing artificial radionuclides are used. Self-absorption correction factors Cs are calculated using method proposed by K.Debertin and Monte Carlo calculations; the uncertainty level being 1?2%. U-234 - Sample is mineralized. Radiochemical

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
			preparation, analytical procedure and counting method - see U-234 in water.
168	1–3 years	Energy and FWHM calibration using Am-241, Eu-155, Ba-13, Sb-125, Co-60 and Cs-137. Efficiency calibration using IAEA-RGU-1 and IAEA-RGTh-1.	All samples were measured by a Canberra HPGe GC2520 (resolution 2.0 kEV at 1.33 MeV, relative efficiency 25%). Live time 24h. Analysis was performed by GANAAS software.
169	> 3 years		
173	> 3 years	A known activity Pb-210 standard solution which is in secular equilibrium with the progeny was used for calibration. After sequential separation of Bi-210 and Pb-210, tailing factor and counting efficiency were calculated. The double energy window method is used to determine the Pb-210 activity concentration. This way the contribution of the ingrowing Bi-210 to the Pb-210 region can be corrected. All counting procedure performed by LSC.	Determination of Pb-210 by liquid scintillation counting after sequential separation with extraction chromatography using Sr-spect resin. The separated Pb-210 was precipitated as oxalate and chemical recovery was determined by gravimetrically.
176	> 3 years	System calibration was done with IAEA RGU std of the same geometry.	Gamma spectrometry measurements were carried out using a HPGe detector. Sample wt used was 112g. Before counting the samples were kept sealed for 3 wk for Ra-226 and it's to daughters to come to secular equilibrium. The activities were calculated using the count rate of 609 keV peak of Bi-214
177	> 3 years	Gamma spectrometry: Calibration: with QCY48 multinuclide water-equivalent standard solution. Counting method: 35% rel. eff. n-type HPGe coaxial detector. The sample was put in routinely used geometries, measuring time being 80000s.Analysed by GENIE-2000 from CANBERRA. Alpha spectrometry: Efficiency of the detector system is calculated from the spectrum of Amersham standard source with known activity of Am241. Passive ion implanted planar silicon (PIPS) detector, CANBERRA; multichannel analyser. Acquisition time per sample : 300000 s. Qualitatively and quantitatively analysis by the Genie-2000 with Alpha Analyst Software included / CANBERRA.	Alpha spectrometry: Sample preparation: Radiochemical tracer (U-232) is added to the sample and repeated evaporations of cc. HF, cc. HNO3 and cc. HNO3 + H2O2 are performed and the sample is dissolved in cc. HNO3. The insoluble salts are separated by filtration or centrifugation. Separation method: The clear sample solution is loaded into a previously conditioned anion exchange column (Dovex 1) and passed through by gravity flow. Uranium ions are passing through the column. The column is then washed with HNO3 solution. The sample is carried on to uranium determination. Thorium is then eluted by HCl solution. The sample is carried on to thorium determination. Source preparation for uranium determination: The sample is dried and HNO3 dissolved sample is performed. The uranium is reduced to tetravalent state by the addition of Fe(II) ions. Uranium ions are then precipitated with lanthan-fluoride and filtrated to a membrane serving hereafter as sample for alpha spectrometry. for thorium determination: After the sample has been dried, repeated evaporations of cc. HNO3 performed and the sample is dissolved in HNO3. Thorium ions are then

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
			precipitated with lanthan-fluoride and filtrated to a membrane serving hereafter as sample for alpha spectrometry.
178	> 3 years	The efficiency calibration of HPGe detector was performed using a 2 soil and 1 grass matrix spiked with the standard radioactive solution type ER X no. 250208-1148020 issued by Czech Metrological institute. Experimental results were then fitted by power function of fourth order and efficiency calibration curve was obtained. Energy calibration was performed using a set of standard radioactive sources and software GENIE 2000. Counting was also performed using software GENIE 2000.	The sample provided by IAEA was mixed and transferred into the small plastic container, and then weighted. After the measurement, the sample was dried for about 20 hours and then weighted again in order to determine dry to wet ratio. The sample was placed directly on the window of the detector.
181	NULL	Calibration by multinuclide standard; corresponding density, same geometry. Using GX2519-RD-ULB, p-type, XtRa Ge detector, with carbon epoxy window in 10 cm lead shielding. Counting time is 80000 sec.	1. Homogenizing and settling down samples in original bottle. 2. Transferring of about 80 g to the PE vessel (35 mm x diameter 67mm). 3. Closing by tape and waiting for equilibrium between Ra-226 and Rn-222. 4. Determination of dry weight by drying of about 3 g of sample 85+/- 2 centigrade, during 15 hours.
186	> 3 years	For calibration was used: 1 method - multinuclide standard; 2 method - for U: U-232 tracer; for Th: Th-234 tracer.	Two methods were used. 1. Gamma spectrometry. The 2 g samples were packed to hermetically sealed holders. The holders were stored for at least 21 days to ensure that Ra-226 and its daughter products were in equilibrium and measurement by gamma-spectrometry with well-type HPGe detector (GWL type, Ortec). 2. Alpha spectrometry. For U: the 2 g samples were dissolved in HNO3 acid and U-232 tracer were added, than were performed solvent extraction isotopes U with TBP (30%) in toluene and re-extraction U, electrodeposition on stainless steel plate and measured with surface barried detector. For Th: the 2 g samples were dissolved in HNO3 acid and Th-234 tracer were added. Several times ferric hydroxide precipitate were performed for extraction of radionuclides, separated isotopes Th with anionite AB-17 and electrodeposition on stainless steel plate and measured with surface barrier detector. Chemical yield was determined by measurement stainless steel plate with X-ray HPGe gamma-spectrometry (GMX-type detector, Ortec).
187	> 3 years	Standard. Making use of calibration factors.	Compare a measurement with a measurement on sample with RGU-1 in it.
188	> 3 years	Our system contains: a Broad Germanium (BeGe) Detector Canberra DSA 2000 digital MCA; software Genie 2000. The energy and the efficiency calibration are performed by	The background was measured monthly.

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		using a radionuclide mixed gamma standard or by ISOCS calibration method, and it is verified by using various reference material IAEA.	
190	1–3 years	Calibrated using EPA sourced aqueous standard. Radon trapped and stored in a ZnS coated Lucas cell. Counted by alpha scintillation using bare PMT/amp/MCA.	Pre-digestion of phosphogypsum in HF followed by conc nitric acid digestion, taking to dryness, bringing back into solution in 5 % nitric acid. Ra-226 analysis of solution by radon emanation, measurement of alpha emitting daughters in a Lucas cell on a bare PMT, and recording counts on a MCA. Mathieu, G.G. et al. 1988. System for measurement of Rn-222 at low levels in natural waters. Health Physics 55:989-992.
191	1–3 years	Gamma spectrometry with 30% detection efficiency - Measurement of a blank sample prior to sample measurement - Counting time > 6 h - - Software calculation for singlet peaks - Hand deconvolution for multiplet peaks.	- Fill in a 200 cc plastic container - Weigh out the sample - Seal the container for 3 weeks to reach radioactive equilibrium. Non gamma emitters determined from gamma emitter progenies (Bi-Pb-214 for Ra-226, Th-234 for U-238).
193	1–3 years	Not reported	Not reported
194		The calibration for gamma spectrometry was done by a multigamma standard solution provided by Amersham. The gamma counter is a HPGe detector (CANBERRA 30%). For alpha analysis, U-234 and U-238 were measured by a silicon detector (EG&G ORTEC. The tracer used was U-232.	Ra-226 and Pb-210 in phosphogypsum were measured by gamma spectrometry. The gamma ray 186 keV of Ra-226 and the gamma ray 609 keV of Bi-214 (after sealing)and 46.5 keV for Pb-210 were used for measuring Ra-226 and Pb-210. The value of Pb-210 was also checked by alpha spectrometry using Po-210. The geometry of counting was a cylindrical. Auto-absorption correction was applied. U-234 and U-238 were measured by alpha spectrometry after radiochemical separation using TBP and anionique exchange resin and electro-deposition
195	< 1 year	Detector-Type and Model: HPGe-P 56% - EG&G Ortec Energy range: 50 keV - 2000 keV Method of efficiency calibration: Multinuclide standard Summing effect corrections have been applied, according to published data (Debertin K. and Schoetzig U., PTB-Ra-24, 1990).	The sample was homogenised, waiting the powder for settling down, before opening the bottle. An aliquot of the sample (about 140 g) was transferred inside the routine-used cylindrical container (58 mm diameter, 170 ml volume). After the measurement the dry-to-wet ratio was determined.
196		Not reported	Not reported
197	> 3 years	Instrument calibration with reference source: IAEA-RGU, IAEA-RGTh, IAEA-RGK and National Multiradionuclide Source. The counting efficiency shall be determined under the same conditions as the samples. The energies of the emitted gamma rays shall be distributed over the entire energy range.	Transfer of homogenized and dried sample in an apposite container. Measure of the sample by Germanium Detector (HpGe). Analyses and spectrum processing using right software (Gamma Vision) and in-house method.
200	1–3 years	Calibration method: Set of sources (Pb-210, Am-241, Ra-226, Cs-137) provided by CIEMAT. Gamma spectrometry with a low background BEGE detector of 50% relative	Homogenization and splitting in two beakers.

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		efficiency.	
201	1–3 years	Not reported	Not reported
202	> 3 years	Ra-226: Liquid scintillation Uranium: Alpha spectrometry	Ra-226: Dissolution of 1 g of sample, precipitation as BaSO4, dissolution with EDTA, growth of Rn-222 in scintillation vial, separation organic face. Uranium: Method 1) Anionic resin, Method 2) Extraction with TBP.
203	> 3 years	Not reported	Not reported
204	> 3 years	Ra-226: HPGE detector: high energy, low background Calibration: Eu-152 Pb-210: Broad energy detector, high efficiency	Ra-226: Measurement of radon daughters after establishment of equilibrium U-234/238: Neutron activation analysis (measured as U-235, natural isotopic ratio assumed) Pb-210: broad energy detector (46.54 keV)
205	NULL	The counting was performed for 16 hours each for sample and for standards. Two standards IAEA-RGU-1 and were used IAEA-RGTh-1. The method was validated by analyzing QAP-SOil-0003 from US DoE.	The sample was analysed using relative method, which is counting sample and standards in the same geometry.
206	> 3 years	Not reported	Not reported
207	> 3 years	Not reported	Not reported
208	> 3 years	Not reported	Not reported
209	> 3 years	Not reported	Not reported
213		Not reported	Not reported
214	1–3 years	Not reported	Not reported
216	< 1 year	Not reported	Not reported
217	> 3 years	Not reported	gamma analysis is not made at the environmental laboratory
218	> 3 years	Not reported	Not reported
219	< 1 year	Not reported	Not reported
220	> 3 years	Not reported	Not reported
221	> 3 years	Not reported	Not reported
222	1–3 years	Not reported	Not reported
224	> 3 years	Not reported	Not reported
227	1–3 years	Not reported	Not reported
229	> 3 years	Not reported	Not reported
232	> 3 years	Not reported	Not reported
234	> 3 years	Detector calibrated using mixed gamma certified reference solution. "Gammavision" software used to calculate results.	Packed into standard geometry and gamma spectrometry analysis done. Ra-226 peak corrected for U-235 at same energy via the U-235 144keV peak
235	1–3 years	Calibrations described on certificate.	Samples analyses direction within Marinelli Geometries. Corrections made for water matrix
236	> 3 years	Calibration with Eu-Sb liquid standard Counting with HPGe Coaxial detector	Preparation of standard geometry, counting, and analysis of spectrum using Genie 2000

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
238	> 3 years	Energies and efficiencies calibration with a cocktail of gamma emitters QCY48 Method: Gamma Spectrometry Counting System: ReGE Program: Spectran-AT	the sample in the suitable geometry is analysed by gamma spectrometry with a ReGe detector.
241	> 3 years	Not reported	Not reported
244	> 3 years	Not reported	Not reported
250	1–3 years	Reference materials Verified methods	HPGe gamma spectrometry Self-absorption corrections
252	> 3 years	The efficiency calibration was performed using a cocktail provided by the Metrology Laboratory consisting of several isotopes to span the energy range of interest. The system was calibrated for the same geometry of the sample. The efficiency calibration was performed using a cocktail provided by the Metrology Laboratory consisting of several isotopes to span the energy range of interest. The system was calibrated for the same geometry of the sample. The counting system consist of a 25% GX Canberra HPGe. The Pb-210 was determined in the low energy range and corrected for the sample self-absorption.	The sample (175 g) was weighed in a 7 cm plastic vial routinely used at our laboratory as gamma counting geometry. The plastic vial was wrapped with Aluminium foil to wait for Radon ingrowth. We waited more than 30 days before gamma counting. The plastic vial containing the sample was placed directly on the 25% efficiency GX Canberra HPGe detector and counted for 60000 seconds.
253	> 3 years	Gamma-spectrometry, HPGe detector. Software: Gamma Trac. Efficiency calibration: multinuclide standard.	Sample preparation: 0,5 l Marinelli container.
255	> 3 years	Measurements were performed with 40% HPGe gamma spectrometer "Canberra". Spectra were evaluated with Canberra Genie 2000 v3.1. Gamma spectrometer was calibrated with cocktail mixture (Am-241, Cd-109, Ce-139, Co-57, Co-60, Cs-137, Sn-113, Sr-85, Y-88, Hg-203) with 0.46 g/cm3 density.	25 g of dried sample were transferred to 50 ml plastic box. The cover of the box was tied to the box with silicone glue. After 28 days activity was measured.
259	NULL	HPGe: With liquid solutions containing multiple radionuclides. PIPS: Energy calibration with four different radionuclides. A Petri dish was filled with the sample and set aside for 3-4 weeks to allow re equilibrium between Ra-226 and the short-lived Rn-222 daughters. Ra-226 and Pb-210 were determined with HPGe. Ra-226 via Bi-214 and Pb-214. Self-absorption in the sample was corrected for using a point source	. U and Th: 1,024 gram sample was dissolved in 1.5 litre of slightly acidic water and Th-229 and U-232 added. The organics in the sample were destroyed with H2O2 and MnO4- and U and Th co-precipitated with MnO2. MnO2 was collected by decantation and centrifugation, and dissolved with HCl and H2O2. The silicates in the sample were dissolved with HNO3 + HF. U and Th were then separated using UTEVA and their activities determined with alpha spectrometry.
260	> 3 years	Counting on High Purity Germanium, N-type (40%). Counting time 60.000 seconds. Analysis with Gamma Vision. Calibration is performed with a nuclide mixture (QCY-48 from PTB (Germany)in the same geometry. Afterwards correction for density and composition difference was done.	A 250 ml counting box was filled with 135.68 grams of Phosphogypsum. Dry weight was 93.7 %.
261	> 3 years	The sample was analyzed by gamma	The moisture content was calculated by

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		spectrometry HPGE; the calibration of the gamma spectrometry detector was carried out with a multinuclide standard source.	determination of loss of weight, at 85 degree Celsius in oven, overnight; then a quantity of sample was sifted; then a net quantity of 30.46 grams of sample was poured in a little cylindrical container (with the same geometry of the calibration standard source) and analyzed by gamma spectrometry HPGE, twice, with a counting time of 120000 seconds and 200000 seconds.
263	1–3 years	Gamma-spectrometry HPGe, peaked background correction, decay correction, multiplet deconvolution; calibration with multipeaks source. Alpha spectrometry with PIPs detectors and inductively coupled plasma-mass spectrometry (ICP-MS).	Rapid measurement with no treatments; only to determinate Ra-226, Pb-210 activities. The other nuclides were determined by alpha spectrometry and ICP-MS systems.
264	> 3 years	-Energy calibration with eu-152 standard source; -efficiency calibration with mix qy44-amersham in Marinelli 0.5l; -counting method: high-resolution gamma spectrometer with hpge detector with be window, counting time=24h; background subtract; bottle 0.5l geometry.	direct measurement in Marinelli 0.5l geometry dry-to-wet ratio determination for an aliquot of 5 g at 85 degree Celsius overnight
265	> 3 years	Not reported	Not reported
266	> 3 years	System calibrated with certified mixed standard radionuclides calibration checked using IAEA 326 and Soil-6	Sample prepared in a 200mL Marinelli Beaker Sealed and wait >1 month for secular equilibrium Sample counted using gamma spectrometry Spectra peak area marked, subtracted background, calculated manually
267	1–3 years	The same for Gamma emitting RN in water plus material self attenuation correction.	Geometrical configuration used: cylinder (diam.65 mm)100 mL.
271	> 3 years	efficiency calibration(Mixed source) chemical preparation Alpha PIPS detector chemical yield	Ra-226: 500 ml in MB, HPGe detector, counting time 80000 s Activity Ra-226 calculated from Pb-214 and Bi-214. U-238,U-234 Alpha spectrometry, electrodeposited source using U-232 tracer
272	1–3 years	Not reported	Not reported
273	> 3 years	Gamma Spectrometer, Canberra Model, HPGe Detector, 45% Efficiency.	Mixed Gamma as calibration source
274		U alpha spectrometry Ra alpha spectrometry calibration with internal tracer Th-alpha spectrometry calibration with internal tracer Pb-gross beta calibration with reference source	U - Fe coprecipitation, TOPO-column separation, electrodeposition Ra- BaSO4 coprecipitation, TOPO and cation column separation, electrodeposition Th- Fe coprecipitation, TOPO-column separation, electrodeposition Pb Leaching, PbS precipitation, anion column separation, PbSO4 deposition
275	> 3 years	Gamma spectrometry (Ra-226) Alpha spectrometry (Th-230) ICP-MS (U-isotopes)	Dissolution in weak HNO3 + HF on residue. Th-230: Ion-exchange and electrodeposition. Th-229 spike. Ra-226: MnO2+PbSO4 ppt + LSC U-isotopes: ICP-MS directly on dissolved sample.
276	> 3 years	Spectrometers are calibrated using a calibration standard produced in the same way that the measured sample from a liquid	The method used is the direct introduction of phosphogypsum (or sediments, soil, ash...)in a plastic container which is sealed and stored

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		QCY48 certified solution. Calibration spectra is collected until the number of counts in each peak is higher than 10000. Spectra are analyzed by Gamma Vision software.	25 days to reach radioactive equilibrium, if natural radionuclides are searched. And then, the container is directly measured on the top of a Ge(Hp)spectrometer from Canberra with EG&G Ortec electronics. Measuring time depends on the activity contents; in routine measurements 24 hours. The same time is chosen for background measurement done with blank samples.
277	> 3 years	Not reported	Not reported
278	> 3 years	Not reported	The measurement technique is based on the use of germanium detectors coupled to a computerized analytical system. The detectors are calibrated for efficiency using a mixed radionuclide standard that covers an energy range of approximately 120-2000 keV. Efficiencies at lower energies are determined on an individual basis. Stored spectra are analysed using the software FITZPEAKS for photo peak identification and subsequent quantification.
282	> 3 years	Alpha spectrometry calibration by Pu-239 standard and Th recovery was assumed.	Ra-226: Gamma counting in 35% P-type HPGe detector in pre-calibrated 130 g cylindrical geometry plastic bottle. Th & U isotopes: 20-25 g sample added U-232 tracer. Acid leaching. Hydroxide precipitation. Anion exchange chromatography with 8N HNO3. Elute with 8 N HCL for Th. Washing of 8N HNO3 for U and again anion ex. separation for U with 8 N HCL. elute with 0.1 N HCL.Electroplating of U and Th separately and counted in PIPS alpha spectrometer.
283	> 3 years	gamma spectrometer with mix standard sources alpha spectrometry using U-232 tracer and standard calibration of 4 radionuclides.	for Ra-226 and Pb-226 by gamma spectrometer for U-234 and 238 by radiochemical analysis
286	> 3 years	High resolution gamma spectrometer was used for the determination of Ra-226. Alpha spectrometry was used for the determination of uranium.	Samples are mixed with a epoxy resin and set in a calibrated geometry. The samples are allowed to sit for 30 days to allow for ingrowth of radon decay products (for Ra-226). Samples for uranium determined by digesting the sample (microwave digestion/hotplate), separation using UTEVA resin.
288	> 3 years	Canberra gamma-spectrometry system, HPGe detector, the system is calibrated with multinuclide standard in standard Marinelli 0.45 L, 1.0 g/cm^3 density.	Measuring time: 259200 seconds.
294		Calibration source is prepared with spiking of artificial soil (mostly SiO2) as method is usually used for sediments or soils.	embedding of sample in epoxy resin in standard size container and waiting for ingrowth radon daughters.
296	1–3 years	The spectrometers are calibrated with traceable radionuclide activity standards	Ca. 55 g of the sample was gravimetrically transferred into a polypropylene container.

Appendix I: Summary of the reported technical information sorted by laboratory code

Lab code	Years of experience	Counting method	Summary of the applied analytical procedure
		supplied by PTB. Direct gamma measurements on two different spectrometers from January to April 2009, but needed to be interrupted for routine measurements several times. Finally, sum spectra from each spectrometer were formed and evaluated for the final results. Self-attenuation correction was applied by use of the GESPECOR code.	
297	> 3 years	Gamma-spectrometer DSA-1000 "Canberra", detector GX5019 with Be window (0,5mm thick. Calibration on CRM CBSS_2 (Cert.No:9031-OL-06/08)	Th-230 and U-234 on ICP-MS 1. mineralization 2. Selective allocation on anion-exchange columns 3. Measuring on ICP-MS Ra-226, Pb-210 and U-238 on gamma-spectrometry 1. 3 aliquots the dried up sample is transferred to hermetic closed measuring vessel. 2. Vessels are stored within 14 days for achievement of balance Ra-226 with daughter radionuclides. After that measurements on gamma-spectrometer are carried out.
298	> 3 years	The sample was measured in eight germanium detectors; the reported result is obtained as a non weighted average over the results individual results. The detectors are calibrated biannually with calibrated solution.	The sample material was pressed in a plastic canister with the diameter of 90 mm to the height of 35 mm. The sample was sealed to minimize the exhalation of radon. The activity of U-238, Th-230 and Pb-210 were obtained from the count rate in the 63 keV, 68 keV and 46 keV peaks respectively. The Ra-226 concentration was obtained from the count rates of the 242, 295, 352, 609 1120 and 1765 keV peak, belonging to radon daughters. The radon exhalation was taken into account on the basis of the calculated disequilibrium between Ra-226 and Rn-222.
299	> 3 years	Not reported	Not reported

APPENDIX II: PERFORMANCE EVALUATION TABLES SORTED BY ANALYTE

All results listed in this Appendix are expressed in Bq kg^{-1} units at a reference date set to 01 December 2008.

The abbreviations used in the Table header are explained below:

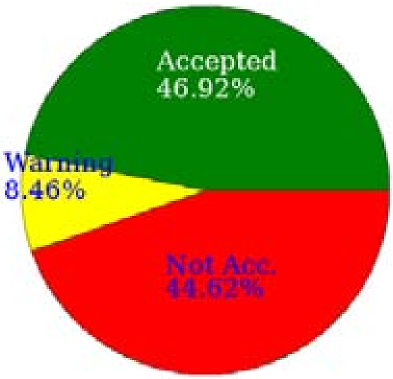
Rep. Value:	Reported measurement result value for the analyte of interest in Bq kg^{-1}.
Rep. Unc.	Reported standard measurement result uncertainty in Bq kg^{-1}.
Unc. [%]	Reported standard measurement result uncertainty in percentage.
Rel. Bias	Relative bias calculated according to formula (1) in paragraph 3.1.
A1 and A2	Evaluation estimators for trueness please see 3.5 in the report body.
True	Evaluation score for Trueness please see 3.5 in the report body.
P	Evaluation estimator for precision please sees 3.5 in the report body.
Prec.	Evaluation score for Precision, please see 3.5 in the report body.
F	Evaluation estimator for evaluation of the blank sample 03.
A	Acceptable: The reported measurement result fulfils the PT criteria.
W	Acceptable with Warning: Although the relative bias of the reported measurement result meets the PT criteria, but a flag was raised due to either underestimated or overestimated measurement result uncertainty.
N	Not Acceptable: The reported measurement result did not fulfil the PT criteria.

The evaluation results are presented in ascending order of the laboratory code.

Performance evaluation of Ra-226 measurement results

Spiked water sample 1

Target Value: 0.69 ± 0.04 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
1	0.74	0.11	14.9	7.3	0.05	0.3	A	15.96	A	A
2	0.74	0.04	4.7	7.7	0.05	0.14	A	7.47	A	A
3	0.52	0.01	2.9	-24.2	0.17	0.11	N	6.47	A	N
6	947	143	15.1	13714	946.3	368.9	N	16.17	A	N
8	0.73	0.04	4.8	5.8	0.04	0.14	A	7.52	A	A
9	0.49	0.12	25.3	-28.3	0.19	0.34	A	25.91	N	N
11	0.89	0.11	12.4	29.0	0.2	0.3	A	13.65	A	A
13	0.68	0.16	23.2	-1.3	0.01	0.42	A	23.91	N	W
14	0.53	0.02	3.8	-23.2	0.16	0.12	N	6.92	A	N
19	<1.63									
20	0.7	0.05	7.3	1.6	0.01	0.17	A	9.3	A	A
21	0.77	0.05	6.5	12.2	0.08	0.17	A	8.68	A	A
24	4.5	0.5	11.1	552.2	3.81	1.29	N	12.53	A	N
28	0.8	0.2	25.0	15.9	0.11	0.53	A	25.66	N	W
29	<0.35									
30	0.38	0.04	10.9	-45.5	0.31	0.15	N	12.35	A	N
32	0.79	0.09	11.3	13.8	0.1	0.25	A	12.73	A	A
33	0.7	0.02	2.9	1.5	0.01	0.12	A	6.46	A	A
34	1.72	0.14	8.0	149.3	1.03	0.37	N	9.9	A	N
36	<1.09									
37	0.63	0.07	11.3	-9.3	0.06	0.21	A	12.67	A	A
39	0.95	0.17	17.9	37.7	0.26	0.45	A	18.81	A	A
40	2.78	1.72	61.9	302.9	2.09	4.44	A	62.14	N	N
42	0.74	0.08	10.8	7.3	0.05	0.23	A	12.27	A	A
43	0.58	0.03	5.2	-15.9	0.11	0.13	A	7.77	A	A
44	1.6	0.5	31.3	131.9	0.91	1.29	A	31.78	N	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
45	0.92	0.12	13.0	33.3	0.23	0.33	A	14.27	A	A
47	0.45	0.03	6.2	-35.4	0.24	0.13	N	8.46	A	N
48	0.68	0.03	5.0	-2.2	0.01	0.14	A	7.68	A	A
49	0.41	0.04	9.8	-40.6	0.28	0.15	N	11.35	A	N
50	0.63	0.07	11.8	-8.7	0.06	0.22	A	13.1	A	A
51	0.74	0.01	1.4	7.3	0.05	0.11	A	5.95	A	A
53	0.6	0.04	6.7	-13.0	0.09	0.15	A	8.83	A	A
54	0.69	0.03	4.4	0.0	0	0.13	A	7.25	A	A
56	3.07	1.35	44.0	344.5	2.38	3.48	A	44.4	N	N
59	0.69	0.04	6.2	0.3	0	0.15	A	8.5	A	A
62	0.73	0.2	27.4	5.8	0.04	0.53	A	28	N	W
63	6.2	3.56	57.4	798.6	5.51	9.19	A	57.71	N	N
64	0.72	0.05	7.0	4.2	0.03	0.17	A	9.05	A	A
67	0.68	0.04	6.5	-1.2	0.01	0.15	A	8.67	A	A
68	0.41	0	1.0	-41.3	0.28	0.1	N	5.88	A	N
72	0.76	0.08	10.5	10.4	0.07	0.23	A	11.99	A	A
73	0.51	0.09	18.4	-26.1	0.18	0.26	A	19.32	A	A
74	1.21	0.24	19.8	75.4	0.52	0.63	A	20.66	N	N
77	0.71	0.08	11.2	2.5	0.02	0.23	A	12.59	A	A
78	0.74	0.16	21.6	7.3	0.05	0.43	A	22.39	N	W
80	0.71	0.08	11.5	3.3	0.02	0.24	A	12.88	A	A
81	0.53	0.04	7.5	-22.9	0.16	0.15	N	9.49	A	N
82	0.61	0.06	9.2	-11.3	0.08	0.18	A	10.83	A	A
85	0	0		-100.	0.69	0.1	N			
91	<1.5									
92	0.64	0.02	3.1	-7.3	0.05	0.12	A	6.59	A	A
93	0.55	0.02	3.9	-21.0	0.14	0.12	N	6.96	A	N
94	0.63	0.06	9.2	-8.3	0.06	0.18	A	10.84	A	A
95	0.39	0.06	14.1	-43.5	0.3	0.18	N	15.25	A	N
96	0.7	0.22	31.4	1.5	0.01	0.58	A	31.96	N	W
99	1.82	0.17	9.3	164.2	1.13	0.45	N	10.98	A	N
101	0.38	0.03	7.9	-44.9	0.31	0.13	N	9.79	A	N
102	0.54	0.11	20.4	-21.7	0.15	0.3	A	21.18	N	N
104	0.92	0.4	43.5	33.3	0.23	1.04	A	43.86	N	N
105	0.66	0.03	4.6	-4.4	0.03	0.13	A	7.37	A	A
106	0.34	0.02	6.5	-50.6	0.35	0.12	N	8.67	A	N
107	2.97	0.35	11.8	330.4	2.28	0.91	N	13.13	A	N
108	4.35	0.29	6.7	530.4	3.66	0.76	N	8.89	A	N
109	1.4	0.5	35.7	102.9	0.71	1.29	A	36.18	N	N
110	1.2	0.21	17.5	73.9	0.51	0.55	A	18.44	A	A

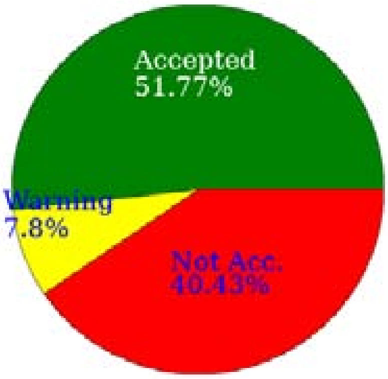
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
113	0.51	0.09	17.7	-26.1	0.18	0.25	A	18.57	A	A
114	0.6	0.05	8.3	-13.0	0.09	0.17	A	10.15	A	A
117	2.61	0.03	1.2	278.3	1.92	0.13	N	5.91	A	N
119	0.73	0.05	7.0	5.9	0.04	0.17	A	9.07	A	A
124	1.21	0.1	8.3	75.4	0.52	0.28	N	10.09	A	N
125	0.9	0.3	33.3	30.4	0.21	0.78	A	33.83	N	N
128	0.76	0.23	30.3	10.1	0.07	0.6	A	30.81	N	W
133	0.71	0.02	2.8	2.9	0.02	0.12	A	6.45	A	A
134	0.39	0.1	25.8	-43.9	0.3	0.28	N	26.46	N	N
138	3.85	0.5	13.0	458.0	3.16	1.29	N	14.22	A	N
140	0.7	0.3	42.9	1.5	0.01	0.78	A	43.25	N	W
144	3.92	1.13	28.9	468.4	3.23	2.93	N	29.49	N	N
145	17.08	2.76	16.2	2375	16.39	7.12	N	17.17	A	N
147	1.28	7.63	596.1	85.5	0.59	19.69	A	596.1	N	N
150	0.49	0.03	6.9	-29.0	0.2	0.14	N	9.04	A	N
151	2.5	0.4	16.0	262.3	1.81	1.04	N	17.02	A	N
156	1	0.1	10.0	44.9	0.31	0.28	N	11.56	A	N
157	0.06	0.01	7.9	-90.9	0.63	0.1	N	9.83	A	N
160	<2									
161	0.85	0.08	9.4	23.2	0.16	0.23	A	11.05	A	A
163	0.7	0.03	3.9	1.5	0.01	0.12	A	6.96	A	A
165	0.8	0.03	3.8	15.9	0.11	0.13	A	6.9	A	A
167	0.72	0.04	4.9	3.9	0.03	0.14	A	7.58	A	A
173	0.66	0.07	10.6	-4.4	0.03	0.21	A	12.09	A	A
178	2.6	0.2	7.7	276.8	1.91	0.53	N	9.63	A	N
181	1.49	0.58	38.9	115.9	0.8	1.5	A	39.36	N	N
186	0.75	0.08	10.7	8.7	0.06	0.23	A	12.14	A	A
187	0.6	0.3	50.0	-13.0	0.09	0.78	A	50.33	N	W
188	2.52			265.2						
190	0.64	0.05	8.3	-7.0	0.05	0.17	A	10.09	A	A
191	1.36	0.54	39.7	97.1	0.67	1.4	A	40.13	N	N
193	0.81	0.1	12.4	17.4	0.12	0.28	A	13.64	A	A
194	0.08	0.11	137.5	-88.4	0.61	0.3	N	137.6	N	N
195	0.6	0.1	16.7	-13.0	0.09	0.28	A	17.65	A	A
197	0.79	0.14	17.7	14.5	0.1	0.38	A	18.65	A	A
200	1.14	0.16	14.0	65.2	0.45	0.43	N	15.19	A	N
202	0.74	0.09	12.2	7.3	0.05	0.25	A	13.47	A	A
203	0.01	0	40.2	-98.5	0.68	0.1	N	40.61	N	N
204	0.59	0.02	3.4	-14.6	0.1	0.12	A	6.72	A	A
234	0.67	0.15	22.4	-2.9	0.02	0.4	A	23.13	N	W

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
236	1.54	0.46	29.9	123.2	0.85	1.19	A	30.43	N	N
250	1.62	0.15	9.26	135	0.93	0.40	N	10.92	A	N
253	0.71	0.07	10.35	4	0.03	0.22	A	11.86	A	A
259	0.88	0.04	4.55	28	0.19	0.15	N	7.37	A	N
260	0.60	0.07	11.67	-13	0.09	0.21	A	13.03	A	A
263	0.61	0.07	11.48	-12	0.08	0.21	A	12.86	A	A
264	3.76	2.44	64.95	445	3.07	6.30	A	65.21	N	N
266	0.63	0.06	9.52	-9	0.06	0.19	A	11.15	A	A
267	0.62	0.08	13.04	-10	0.07	0.23	A	14.27	A	A
271	0.42	0.06	14.42	-39	0.27	0.19	N	15.54	A	N
272	5.85	1.92	32.82	748	5.16	4.95	N	33.33	N	N
273	0.66	0.10	15.91	-4	0.03	0.29	A	16.93	A	A
274	0.65	0.06	8.94	-6	0.04	0.18	A	10.65	A	A
275	0.59	0.10	16.95	-14	0.10	0.28	A	17.91	A	A
276	0.59	0.06	10.37	-14	0.10	0.19	A	11.88	A	A
277	0.69	0.02	3.07	-1	0.00	0.12	A	6.56	A	A
278	0.43	0.03	6.98	-38	0.26	0.13	N	9.07	A	N
282	0.40	0.05	12.72	-42	0.29	0.17	N	13.98	A	N
286	0.69	0.04	5.97	0	0.00	0.15	A	8.32	A	A
288	0.73	0.12	16.44	6	0.04	0.33	A	17.43	A	A
294	775.0	59.00	7.61	11221	774.3	152.2	N	9.57	A	N
296	0.70	0.30	42.86	1	0.01	0.78	A	43.25	N	W
297	0.10	0.10	100.0	-86	0.59	0.28	N	100.1	N	N
298	0.79	0.05	6.33	14	0.10	0.17	A	8.58	A	A

Performance evaluation of Ra-226 measurement results

Spiked water sample 2

Target Value: 1.93 ± 0.09 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
1	2.06	0.31	15.05	6.7	0.13	0.83	A	15.75	A	A
2	2.13	0.08	3.75	10.6	0.20	0.31	A	5.98	A	A
3	1.77	0.05	2.83	-8.5	0.16	0.27	A	5.45	A	A
6	2030	340.0	16.75	10508	2028	877	N	17.39	A	N
8	2.10	0.07	3.33	8.8	0.17	0.29	A	5.73	A	A
9	1.55	0.15	9.68	-19.6	0.38	0.45	A	10.74	A	A
11	2.00	0.11	5.50	3.6	0.07	0.37	A	7.21	A	A
13	1.66	0.16	9.78	-14.2	0.27	0.48	A	10.84	A	A
14	1.53	0.03	1.96	-20.7	0.40	0.24	N	5.06	A	N
19	3.93	1.72	43.77	103.6	2.00	4.44	A	44.01	N	N
20	1.79	0.21	11.66	-7.1	0.14	0.59	A	12.55	A	A
21	2.09	0.12	5.54	8.5	0.16	0.38	A	7.24	A	A
22	1.56	0.16	10.38	-19.1	0.37	0.48	A	11.38	A	A
24	8.30	0.40	4.82	330.0	6.37	1.06	N	6.71	A	N
28	2.20	0.50	22.73	14.0	0.27	1.31	A	23.20	N	W
29	0.65	0.28	43.08	-66.3	1.28	0.76	N	43.33	N	N
30	1.06	0.07	6.82	-45.2	0.87	0.30	N	8.26	A	N
32	2.20	0.30	13.64	14.0	0.27	0.81	A	14.41	A	A
33	2.07	0.06	2.90	7.3	0.14	0.28	A	5.49	A	A
34	2.20	0.20	9.09	14.0	0.27	0.57	A	10.22	A	A
36	2.57	0.32	12.45	33.2	0.64	0.86	A	13.30	A	A
37	1.49	0.15	10.35	-22.9	0.44	0.46	A	11.35	A	A
39	2.30	0.23	10.00	19.2	0.37	0.64	A	11.03	A	A
40	4.21	2.34	55.58	118.1	2.28	6.04	A	55.78	N	N
42	1.91	0.04	2.09	-1.0	0.02	0.25	A	5.11	A	A
43	1.58	0.08	5.06	-18.1	0.35	0.31	N	6.88	A	W

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
44	2.60	0.50	19.23	34.7	0.67	1.31	A	19.79	A	A
45	2.09	0.23	11.00	8.3	0.16	0.64	A	11.95	A	A
47	1.16	0.04	3.53	-39.9	0.77	0.26	N	5.85	A	N
48	1.90	0.10	5.00	-1.6	0.03	0.34	A	6.84	A	A
49	1.26	0.07	5.56	-34.7	0.67	0.29	N	7.25	A	N
50	1.75	0.10	5.93	-9.1	0.18	0.35	A	7.54	A	A
51	2.01	0.03	1.49	4.2	0.08	0.24	A	4.90	A	A
53	1.53	0.07	4.58	-20.7	0.40	0.29	N	6.53	A	N
54	1.60	0.05	3.13	-17.1	0.33	0.27	N	5.61	A	W
56	8.47	1.65	19.50	338.7	6.54	4.27	N	20.05	N	N
57	17.20	2.10	12.21	791.1	15.27	5.42	N	13.07	A	N
59	1.98	0.07	3.54	2.6	0.05	0.29	A	5.85	A	A
62	2.10	0.40	19.05	8.8	0.17	1.06	A	19.61	A	A
63	1.47	1.13	76.87	-23.8	0.46	2.92	A	77.01	N	N
64	2.07	0.13	6.28	7.3	0.14	0.41	A	7.82	A	A
65	1.20	17.00	1416	-37.8	0.73	43.8	A	1416	N	N
67	2.03	0.09	4.64	5.1	0.10	0.34	A	6.57	A	A
68	1.11	0.01	0.45	-42.4	0.82	0.23	N	4.68	A	N
72	2.13	0.18	8.45	10.3	0.20	0.52	A	9.66	A	A
73	0.51	0.11	21.57	-73.5	1.42	0.37	N	22.07	N	N
74	1.33	0.24	18.05	-31.0	0.60	0.66	A	18.64	A	A
77	2.02	0.09	4.26	4.6	0.09	0.32	A	6.32	A	A
78	1.26	0.19	15.08	-34.7	0.67	0.54	N	15.78	A	N
80	2.10	0.23	10.95	8.8	0.17	0.64	A	11.90	A	A
81	1.90	0.13	6.75	-1.7	0.03	0.40	A	8.20	A	A
82	2.05	0.18	8.78	6.2	0.12	0.52	A	9.94	A	A
85	1.58	0.09	5.63	-18.0	0.35	0.33	N	7.31	A	W
91	2.20	0.40	18.18	14.0	0.27	1.06	A	18.77	A	A
92	1.67	0.04	2.40	-13.4	0.26	0.25	N	5.24	A	W
93	1.63	0.06	3.43	-15.3	0.30	0.27	N	5.79	A	W
94	1.47	0.17	11.36	-23.8	0.46	0.49	A	12.28	A	A
95	1.05	0.10	10.00	-45.6	0.88	0.36	N	11.03	A	N
96	1.09	0.23	21.10	-43.5	0.84	0.64	N	21.61	N	N
99	1.16	0.17	14.69	-40.0	0.77	0.50	N	15.42	A	N
101	1.75	0.08	4.57	-9.3	0.18	0.31	A	6.53	A	A
104	2.49	0.40	16.06	29.0	0.56	1.06	A	16.73	A	A
105	1.74	0.04	2.30	-9.8	0.19	0.25	A	5.20	A	A
106	0.97	0.05	5.15	-49.7	0.96	0.27	N	6.95	A	N
107	2.95	0.72	24.41	52.9	1.02	1.87	A	24.85	N	N
108	6.76	1.01	14.94	250.2	4.83	2.62	N	15.65	A	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
109	1.70	0.50	29.41	-11.9	0.23	1.31	A	29.78	N	W
110	2.85	0.48	16.84	47.7	0.92	1.26	A	17.48	A	A
111	1.80	0.32	17.78	-6.7	0.13	0.86	A	18.38	A	A
113	1.89	0.20	10.58	-2.1	0.04	0.57	A	11.56	A	A
114	1.72	0.12	6.98	-10.8	0.21	0.39	A	8.39	A	A
119	2.05	0.12	5.85	6.2	0.12	0.39	A	7.48	A	A
120	2.75	0.18	6.55	42.5	0.82	0.52	N	8.04	A	N
124	2.08	0.18	8.65	7.8	0.15	0.52	A	9.83	A	A
125	1.20	0.30	25.00	-37.8	0.73	0.81	A	25.43	N	N
126	2.10	0.66	31.43	8.8	0.17	1.72	A	31.77	N	W
128	0.61	0.20	32.79	-68.3	1.32	0.57	N	33.12	N	N
133	2.02	0.03	1.49	4.7	0.09	0.24	A	4.89	A	A
134	0.87	0.01	1.36	-54.9	1.06	0.23	N	4.86	A	N
138	3.03	0.50	16.50	57.0	1.10	1.31	A	17.15	A	A
140	1.50	0.70	46.67	-22.2	0.43	1.82	A	46.90	N	N
144	8.11	4.82	59.40	320.3	6.18	12.4	A	59.58	N	N
145	5.69	0.80	14.13	194.8	3.76	2.09	N	14.88	A	N
147	2.43	7.65	314.8	25.9	0.50	19.7	A	314.8	N	N
150	1.20	0.09	7.08	-37.8	0.73	0.32	N	8.48	A	N
151	5.70	0.60	10.53	195.3	3.77	1.57	N	11.51	A	N
156	2.56	0.10	3.91	32.6	0.63	0.35	N	6.08	A	N
157	0.18	0.01	6.49	-90.4	1.74	0.23	N	7.99	A	N
160	<2									
161	1.83	0.19	10.38	-5.2	0.10	0.54	A	11.38	A	A
163	2.03	0.08	3.79	5.2	0.10	0.31	A	6.01	A	A
165	1.96	0.07	3.57	1.6	0.03	0.29	A	5.87	A	A
167	2.00	0.10	5.00	3.6	0.07	0.35	A	6.84	A	A
173	1.86	0.04	2.15	-3.6	0.07	0.25	A	5.14	A	A
178	1.30	0.10	7.69	-32.6	0.63	0.35	N	9.00	A	N
181	4.91	0.71	14.46	154.4	2.98	1.85	N	15.19	A	N
186	2.14	0.20	9.35	10.9	0.21	0.57	A	10.44	A	A
187	2.00	0.14	7.00	3.6	0.07	0.43	A	8.41	A	A
188	2.71			40.4						
190	1.72	0.06	3.50	-11.1	0.21	0.28	A	5.83	A	A
191	1.27	0.56	44.09	-34.2	0.66	1.46	A	44.34	N	N
193	1.94	0.29	14.95	0.5	0.01	0.78	A	15.66	A	A
194	1.26	0.25	19.84	-34.7	0.67	0.69	A	20.38	N	N
195	2.01	0.15	7.46	4.2	0.08	0.45	A	8.80	A	A
197	2.34	0.19	8.12	21.2	0.41	0.54	A	9.36	A	A
200	3.25	0.23	7.08	68.4	1.32	0.64	N	8.48	A	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
201	2.90	0.20	6.90	50.3	0.97	0.57	N	8.33	A	N
202	2.03	0.11	5.42	5.2	0.10	0.37	A	7.15	A	A
203	0.01	0.00	36.36	-99.5	1.92	0.23	N	36.66	N	N
204	1.59	0.03	1.89	-17.6	0.34	0.24	N	5.03	A	W
229	2.00	0.40	20.00	3.6	0.07	1.06	A	20.54	N	W
234	2.35	0.30	12.77	21.8	0.42	0.81	A	13.59	A	A
235	2.70	1.50	55.56	39.9	0.77	3.88	A	55.75	N	N
236	0.80	0.22	27.50	-58.6	1.13	0.61	N	27.89	N	N
241	1.84	0.05	2.50	-4.7	0.09	0.26	A	5.29	A	A
244	7.89	3.00	38.02	308.8	5.96	7.74	A	38.31	N	N
250	2.7	0.25	9.26	39.9	0.77	0.69	N	10.37	A	N
253	1.95	0.2	10	1.0	0.02	0.55	A	11.03	A	A
259	2.45	0.12	4.9	26.9	0.52	0.39	N	6.76	A	N
260	1.87	0.14	7.49	-3.1	0.06	0.43	A	8.82	A	A
263	1.7	0.2	11.76	-11.9	0.23	0.57	A	12.66	A	A
264	6.04	2.3	38.08	213.1	4.11	5.94	A	38.37	N	N
266	1.3	0.1	7.69	-32.6	0.63	0.35	N	9.00	A	N
267	1.77	0.13	7.5	-8.1	0.16	0.41	A	8.83	A	A
271	1	0.1	10	-48.2	0.93	0.35	N	11.03	A	N
273	2.04	0.29	14.46	5.7	0.11	0.80	A	15.19	A	A
274	1.75	0.15	8.57	-9.3	0.18	0.45	A	9.76	A	A
275	1.71	0.2	11.7	-11.4	0.22	0.57	A	12.59	A	A
276	1.76	0.06	3.56	-8.7	0.17	0.28	A	5.87	A	A
277	1.95	0.06	2.92	1.0	0.02	0.27	A	5.50	A	A
278	1.41	0.06	4.26	-26.9	0.52	0.28	N	6.31	A	N
282	2.22	0.26	11.71	15.0	0.29	0.71	A	12.61	A	A
286	1.99	0.11	5.53	3.1	0.06	0.37	A	7.23	A	A
288	2.16	0.3	13.89	11.9	0.23	0.81	A	14.65	A	A
294	2400	120	5	12425	2398	309	N	6.84	A	N
296	2.5	0.7	28	29.5	0.57	1.82	A	28.39	N	N
297	1.85	0.22	11.89	-4.2	0.08	0.61	A	12.77	A	A
298	2.26	0.12	5.31	17.1	0.33	0.39	A	7.07	A	A

Performance evaluation of Ra-226 measurement results

Phosphogypsum IAEA-434 sample 6

Target Value: 780.0 ± 31.0 [Bq kg^{-1}]

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
1	848.0	51.0	6.0	9	68.0	154.0	A	7.2	A	A
3	679.1	8.7	1.3	-13	100.9	83.1	N	4.2	A	W
4	851.0	130.0	15.3	9	71.0	344.8	A	15.8	A	A
6	656.0	15.5	2.4	-16	124.0	89.4	N	4.6	A	W
7	819.0	11.0	1.3	5	39.0	84.9	A	4.2	A	A
8	720.0	40.0	5.6	-8	60.0	130.6	A	6.8	A	A
9	701.0	50.0	7.1	-10	79.0	151.8	A	8.2	A	A
11	880.0	15.0	1.7	13	100.0	88.9	N	4.3	A	W
13	604.8	10.6	1.8	-22	175.2	84.5	N	4.3	A	N
14	747.0	34.0	4.6	-4	33.0	118.7	A	6.0	A	A
15	693.0	51.0	7.4	-11	87.0	154.0	A	8.4	A	A
18	825.1	17.4	2.1	6	45.1	91.7	A	4.5	A	A
19	123.0	3.0	2.4	-84	657.0	80.4	N	4.7	A	N
20	785.0	39.0	5.0	1	5.0	128.5	A	6.4	A	A
22	643.3	46.8	7.3	-18	136.7	144.8	A	8.3	A	A
23	929.0	44.0	4.7	19	149.0	138.9	N	6.2	A	W
24	779.0	57.0	7.3	0	1.0	167.4	A	8.3	A	A
27	1012	68.0	6.7	30	232.0	192.8	N	7.8	A	N
28	722.0	38.0	5.3	-7	58.0	126.5	A	6.6	A	A
29	733.0	23.0	3.1	-6	47.0	99.6	A	5.1	A	A
30	359.2	0.6	0.2	-54	420.8	80.0	N	4.0	A	N
31	1066	94.0	8.8	37	286.0	255.4	N	9.7	A	N
32	980.0	45.0	4.6	26	200.0	141.0	N	6.1	A	N
33	664.0	13.0	2.0	-15	116.0	86.7	N	4.4	A	W
34	684.0	43.6	6.4	-12	96.0	138.0	A	7.5	A	A
36	821.0	49.0	6.0	5	41.0	149.6	A	7.2	A	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
37	623.0	16.0	2.6	-20	157.0	90.0	N	4.7	A	N
38	573.6	7.8	1.4	-26	206.4	82.5	N	4.2	A	N
39	666.4	19.3	2.9	-15	113.6	94.3	N	4.9	A	W
40	993.7	36.6	3.7	27	213.7	123.8	N	5.4	A	N
43	812.0	66.6	8.2	4	32.0	189.5	A	9.1	A	A
44	677.0	13.0	1.9	-13	103.0	86.7	N	4.4	A	W
45	456.0	38.0	8.3	-42	324.0	126.5	N	9.2	A	N
46	722.0	46.0	6.4	-7	58.0	143.1	A	7.5	A	A
47	491.0	47.1	9.6	-37	289.0	145.5	N	10.4	A	N
48	625.0	31.0	5.0	-20	155.0	113.1	N	6.4	A	W
49	724.9	41.0	5.7	-7	55.1	132.6	A	6.9	A	A
50	845.5	64.9	7.7	8	65.5	185.6	A	8.6	A	A
51	775.0	7.0	0.9	-1	5.0	82.0	A	4.1	A	A
52	890.0	108.0	12.1	14	110.0	289.9	A	12.8	A	A
53	595.0	14.3	2.4	-24	185.0	88.1	N	4.6	A	N
54	718.5	52.6	7.3	-8	61.5	157.5	A	8.3	A	A
56	674.4	13.0	1.9	-14	105.6	86.7	N	4.4	A	W
57	2594	206.7	8.0	233	1814	539.3	N	8.9	A	N
59	741.0	14.0	1.9	-5	39.0	87.8	A	4.4	A	A
62	770.0	200.0	26.0	-1	10.0	522.2	A	26.3	N	W
63	610.0	24.8	4.1	-22	170.0	102.4	N	5.7	A	N
64	840.0	63.0	7.5	8	60.0	181.2	A	8.5	A	A
65	670.0	9.0	1.3	-14	110.0	83.3	N	4.2	A	W
66	722.6	7.1	1.0	-7	57.4	82.1	A	4.1	A	A
67	660.0	14.0	2.1	-15	120.0	87.8	N	4.5	A	W
68	673.0	13.0	1.9	-14	107.0	86.7	N	4.4	A	W
69	699.0	14.0	2.0	-10	81.0	87.8	A	4.5	A	A
70	708.0	14.0	2.0	-9	72.0	87.8	A	4.4	A	A
72	668.0	35.0	5.2	-14	112.0	120.6	A	6.6	A	A
73	437.0	80.4	18.4	-44	343.0	222.3	N	18.8	A	N
74	652.0	32.0	4.9	-16	128.0	115.0	N	6.3	A	W
77	752.0	13.0	1.7	-4	28.0	86.7	A	4.3	A	A
78	576.0	31.0	5.4	-26	204.0	113.1	N	6.7	A	N
80	1030	36.0	3.5	32	250.0	122.6	N	5.3	A	N
81	690.0	10.0	1.5	-12	90.0	84.0	N	4.2	A	W
82	785.0	14.0	1.8	1	5.0	87.8	A	4.4	A	A
85	1097	190.2	17.3	41	317.1	497.3	A	17.8	A	A
86	690.0	40.0	5.8	-12	90.0	130.6	A	7.0	A	A
89	820.0	160.0	19.5	5	40.0	420.5	A	19.9	A	A
91	881.0	20.0	2.3	13	101.0	95.2	N	4.6	A	W

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
92	784.0	20.0	2.6	1	4.0	95.2	A	4.7	A	A
93	1040	51.8	5.0	33	260.0	155.8	N	6.4	A	N
94	734.2	35.1	4.8	-6	45.8	120.8	A	6.2	A	A
95	574.0	68.9	12.0	-26	206.0	194.9	N	12.6	A	N
96	610.0	50.0	8.2	-22	170.0	151.8	N	9.1	A	N
97	1070	150.0	14.0	37	290.0	395.2	A	14.6	A	A
98	808.0	50.0	6.2	4	28.0	151.8	A	7.4	A	A
99	624.0	12.6	2.0	-20	156.0	86.4	N	4.5	A	N
101	720.0	40.0	5.6	-8	60.0	130.6	A	6.8	A	A
103	781.0	33.0	4.2	0	1.0	116.8	A	5.8	A	A
104	775.0	10.0	1.3	-1	5.0	84.0	A	4.2	A	A
105	693.2	13.7	2.0	-11	86.8	87.4	A	4.4	A	A
106	751.0	15.0	2.0	-4	29.0	88.9	A	4.5	A	A
107	666.4	35.2	5.3	-15	113.6	121.0	A	6.6	A	A
108	1592	111.1	7.0	104	812.0	297.6	N	8.0	A	N
109	551.0	17.0	3.1	-29	229.0	91.2	N	5.0	A	N
110	904.0	75.0	8.3	16	124.0	209.4	A	9.2	A	A
111	780.0	110.0	14.1	0	0.0	294.9	A	14.7	A	A
112	556.0	36.0	6.5	-29	224.0	122.6	N	7.6	A	N
113	715.9	38.9	5.4	-8	64.1	128.3	A	6.7	A	A
114	670.0	60.0	9.0	-14	110.0	174.2	A	9.8	A	A
117	827.1	0.0	0.0	6	47.1	80.0	A	4.0	A	A
118	640.0	5.0	0.8	-18	140.0	81.0	N	4.1	A	W
119	806.0	65.0	8.1	3	26.0	185.8	A	9.0	A	A
120	785.0	25.0	3.2	1	5.0	102.8	A	5.1	A	A
125	644.1	15.4	2.4	-17	135.9	89.3	N	4.6	A	W
126	664.0	22.0	3.3	-15	116.0	98.1	N	5.2	A	W
128	630.6	28.0	4.4	-19	149.4	107.8	N	6.0	A	W
131	912.3	21.0	2.3	17	132.3	96.6	N	4.6	A	W
133	862.0	41.0	4.8	11	82.0	132.6	A	6.2	A	A
136	717.0	18.0	2.5	-8	63.0	92.5	A	4.7	A	A
140	731.1	84.0	11.5	-6	48.9	231.0	A	12.2	A	A
144	834.7	3.4	0.4	7	54.7	80.5	A	4.0	A	A
145	1161.0	37.0	3.2	49	381.0	124.5	N	5.1	A	N
147	1024	138.0	13.5	31	244.0	364.9	A	14.1	A	A
149	789.0	16.0	2.0	1	9.0	90.0	A	4.5	A	A
150	0.6	0.1	8.3	-100	779.4	80.0	N	9.2	A	N
151	921.0	115.0	12.5	18	141.0	307.3	A	13.1	A	A
156	0.7	0.1	8.5	-100	779.3	80.0	N	9.3	A	N
157	691.0	46.0	6.7	-11	89.0	143.1	A	7.8	A	A

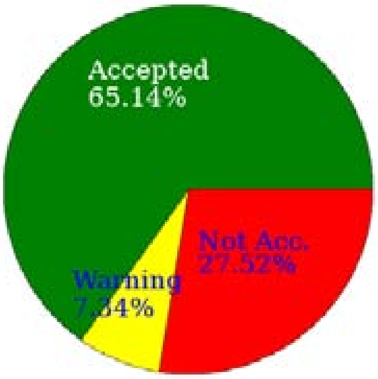
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
158	706.0	41.0	5.8	-9	74.0	132.6	A	7.0	A	A
160	671.6	2.5	0.4	-14	108.4	80.2	N	4.0	A	W
161	645.6	17.3	2.7	-17	134.4	91.6	N	4.8	A	W
162	797.0	20.0	2.5	2	17.0	95.2	A	4.7	A	A
163	767.0	38.0	5.0	-2	13.0	126.5	A	6.4	A	A
164	602.0	63.0	10.5	-23	178.0	181.2	A	11.2	A	A
165	695.0	10.0	1.4	-11	85.0	84.0	N	4.2	A	W
166	690.0	69.0	10.0	-12	90.0	195.2	A	10.8	A	A
167	763.0	35.0	4.6	-2	17.0	120.6	A	6.1	A	A
168	756.0	3.0	0.4	-3	24.0	80.4	A	4.0	A	A
176	687.0	7.0	1.0	-12	93.0	82.0	N	4.1	A	W
177	930.0	45.0	4.8	19	150.0	141.0	N	6.3	A	W
178	620.0	40.0	6.5	-21	160.0	130.6	N	7.6	A	N
181	784.0	51.0	6.5	1	4.0	154.0	A	7.6	A	A
186	671.0	81.0	12.1	-14	109.0	223.8	A	12.7	A	A
187	790.0	47.0	6.0	1	10.0	145.3	A	7.2	A	A
188	635.5	14.3	2.2	-19	144.5	88.0	N	4.6	A	W
190	671.0	61.0	9.1	-14	109.0	176.5	A	9.9	A	A
191	488.0	25.0	5.1	-37	292.0	102.8	N	6.5	A	N
194	813.6	82.4	10.1	4	33.6	227.0	A	10.9	A	A
195	740.0	120.0	16.2	-5	40.0	319.8	A	16.7	A	A
197	772.0	8.0	1.0	-1	8.0	82.6	A	4.1	A	A
200	713.4	12.1	1.7	-9	66.6	85.9	A	4.3	A	A
201	808.0	62.0	7.7	4	28.0	178.8	A	8.6	A	A
202	778.0	35.0	4.5	0	2.0	120.6	A	6.0	A	A
204	782.0	17.0	2.2	0	2.0	91.2	A	4.5	A	A
205	1012	72.0	7.1	30	232.0	202.3	N	8.2	A	N
206	515.0	31.0	6.0	-34	265.0	113.1	N	7.2	A	N
229	840.0	10.0	1.2	8	60.0	84.0	A	4.2	A	A
234	646.0	40.0	6.2	-17	134.0	130.6	N	7.4	A	W
235	618.0	37.0	6.0	-21	162.0	124.5	N	7.2	A	N
236	749.0	11.0	1.5	-4	31.0	84.9	A	4.2	A	A
238	679.0	19.8	2.9	-13	101.0	94.9	N	4.9	A	W
241	632.0	22.0	3.5	-19	148.0	98.1	N	5.3	A	W
250	870	62	7.1	11.5	90	178.8	A	8.2	A	A
252	762	58	7.6	-2.3	18	169.7	A	8.6	A	A
253	770	40	5.2	-1.3	10	130.6	A	6.5	A	A
255	644.6	60	9.3	-17.4	135.4	174.2	A	10.1	A	A
259	630	40	6.4	-19.2	150	130.6	N	7.5	A	W
260	650	50	7.7	-16.7	130	151.8	A	8.7	A	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
261	748	95	12.7	-4.1	32	257.8	A	13.3	A	A
263	660	88	13.3	-15.4	120	240.7	A	13.9	A	A
264	745	45	6.0	-4.5	35	141.0	A	7.2	A	A
265	847	65	7.7	8.6	67	185.8	A	8.6	A	A
266	666	58	8.7	-14.6	114	169.7	A	9.6	A	A
267	849	35	4.1	8.9	69	120.6	A	5.7	A	A
271	812.1	63.4	7.8	4.1	32.1	182.0	A	8.8	A	A
272	1186	63.5	5.4	52.1	406.2	182.3	N	6.7	A	N
273	800.1	75.4	9.4	2.6	20.1	210.3	A	10.2	A	A
274	696	63	9.1	-10.8	84	181.2	A	9.9	A	A
275	630	40	6.4	-19.2	150	130.6	N	7.5	A	W
276	672.4	14.4	2.1	-13.8	107.6	88.2	N	4.5	A	W
277	751	22	2.9	-3.7	29	98.1	A	4.9	A	A
278	467	10	2.1	-40.1	313	84.0	N	4.5	A	N
282	1211	50	4.1	55.3	431	151.8	N	5.7	A	N
283	755	41	5.4	-3.2	25	132.6	A	6.7	A	A
286	802	40	5.0	2.8	22	130.6	A	6.4	A	A
288	803	20	2.5	3.0	23	95.2	A	4.7	A	A
294	776	20	2.6	-0.5	4	95.2	A	4.7	A	A
296	814	25	3.1	4.4	34	102.8	A	5.0	A	A
297	610	20	3.3	-21.8	170	95.2	N	5.2	A	N
298	810	20	2.5	3.9	30	95.2	A	4.7	A	A
299	770.8	44.9	5.8	-1.2	9.2	140.7	A	7.1	A	A

Performance evaluation of U-234 measurement results

Spiked water sample 1

Target Value: 0.56 ± 0.02 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
1	0.6	0.09	15.0	7.1	0.04	0.24	A	15.42	N	W
4	0.57	0.03	5.3	1.8	0.01	0.09	A	6.36	A	A
6	1.46	0.31	21.4	160.7	0.9	0.81	N	21.73	N	N
8	0.51	0.02	3.5	-8.9	0.05	0.07	A	5.02	A	A
11	0.56	0.06	10.7	0.0	0	0.16	A	11.29	A	A
13	0.5	0.08	16.0	-10.9	0.06	0.21	A	16.43	N	W
14	0.47	0.02	4.3	-16.1	0.09	0.07	N	5.56	A	N
19	0.68	0.04	5.9	21.4	0.12	0.12	N	6.88	A	N
20	0.59	0.07	12.8	4.6	0.03	0.2	A	13.29	A	A
21	0.64	0.07	10.7	13.6	0.08	0.18	A	11.27	A	A
22	0.54	0.04	6.9	-3.6	0.02	0.11	A	7.73	A	A
23	0.49	0.04	8.1	-12.5	0.07	0.11	A	8.85	A	A
28	0.59	0.07	11.9	5.4	0.03	0.19	A	12.39	A	A
29	<6.5									
30	0.26	0.06	22.8	-54.5	0.31	0.16	N	23.02	N	N
32	0.56	0.09	15.0	0.9	0	0.23	A	15.46	N	W
37	0.59	0.03	5.7	5.7	0.03	0.1	A	6.69	A	A
38	0.53	0.02	3.4	-5.2	0.03	0.07	A	4.92	A	A
39	0.77	0.06	7.8	37.5	0.21	0.16	N	8.57	A	N
42	0.37	0.06	16.0	-34.1	0.19	0.16	N	16.38	N	N
43	0.57	0.04	7.0	1.8	0.01	0.12	A	7.87	A	A
45	0.51	0.03	5.5	-9.6	0.05	0.09	A	6.59	A	A
47	0.55	0.09	16.0	-2.5	0.01	0.23	A	16.44	N	W
50	0.56	0.04	6.4	0.4	0	0.11	A	7.33	A	A
51	0.44	0.03	6.8	-21.4	0.12	0.09	N	7.7	A	N
54	0.78	0.01	1.8	39.1	0.22	0.06	N	4	A	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
57	1.5	0.1	6.7	167.9	0.94	0.26	N	7.56	A	N
59	0.48	0.03	7.1	-14.1	0.08	0.1	A	7.92	A	A
60	1.46	0.14	9.6	161.4	0.9	0.36	N	10.21	A	N
62	0.38	0.01	2.6	-32.1	0.18	0.06	N	4.44	A	N
64	0.56	0.07	11.5	0.9	0	0.18	A	12.05	A	A
67	0.51	0.02	3.3	-8.9	0.05	0.07	A	4.89	A	A
72	0.59	0.03	4.8	5.4	0.03	0.09	A	5.94	A	A
73	0.53	0.01	2.1	-5.2	0.03	0.06	A	4.13	A	A
77	0.64	0.06	8.8	14.3	0.08	0.15	A	9.45	A	A
78	0.01	0	25.0	-98.2	0.55	0.05	N	25.25	N	N
80	0.61	0.04	6.6	8.9	0.05	0.12	A	7.47	A	A
81	0.58	0.06	10.7	3.4	0.02	0.17	A	11.29	A	A
82	0.54	0.06	11.6	-4.1	0.02	0.17	A	12.09	A	A
84	0.56	0.03	6.1	-0.4	0	0.1	A	7.05	A	A
92	0.59	0.01	1.7	5.4	0.03	0.06	A	3.95	A	A
93	0.56	0.03	4.8	-0.4	0	0.09	A	6.01	A	A
94	0.66	0.02	3.5	17.3	0.1	0.08	N	5	A	N
95	0.48	0.03	6.1	-14.8	0.08	0.09	A	7.05	A	A
96	0.56	0.02	3.2	0.7	0	0.07	A	4.79	A	A
97	0.47	0.04	8.5	-16.1	0.09	0.12	A	9.23	A	A
101	0.76	0.05	6.6	35.7	0.2	0.14	N	7.49	A	N
103	0.53	0.02	3.2	-5.5	0.03	0.07	A	4.8	A	A
110	0.52	0.1	19.2	-7.1	0.04	0.26	A	19.56	N	W
112	0.57	0.02	3.5	1.6	0.01	0.07	A	5.01	A	A
114	0.48	0.04	8.3	-14.3	0.08	0.12	A	9.07	A	A
119	0.59	0.04	7.2	4.8	0.03	0.12	A	8	A	A
126	0.57	0.02	2.8	1.1	0.01	0.07	A	4.55	A	A
128	0.13	0.3	230.8	-76.8	0.43	0.78	A	230.8	N	N
131	0.58	0.09	15.5	3.6	0.02	0.24	A	15.92	N	W
133	0.56	0.02	3.6	0.0	0	0.07	A	5.05	A	A
134	0.57	0.02	3.5	2.5	0.01	0.07	A	4.99	A	A
137	0.49	0.02	4.1	-12.5	0.07	0.07	A	5.42	A	A
144	2.12	0.54	25.2	279.3	1.56	1.38	N	25.49	N	N
150	0.3	0.03	8.3	-46.4	0.26	0.08	N	9.07	A	N
156	0.58	0.03	5.2	3.6	0.02	0.09	A	6.29	A	A
157	0.35	0.03	9.8	-38.0	0.21	0.1	N	10.43	A	N
158	0.528	0.02	3.60	-5.7	0.03	0.07	A	5.1	A	A
160	0.06	0.02	39.3	-89.1	0.5	0.08	N	39.51	N	N
161	0.57	0.02	3.5	1.8	0.01	0.07	A	5.01	A	A
163	0.52	0.06	11.5	-7.1	0.04	0.16	A	12.08	A	A

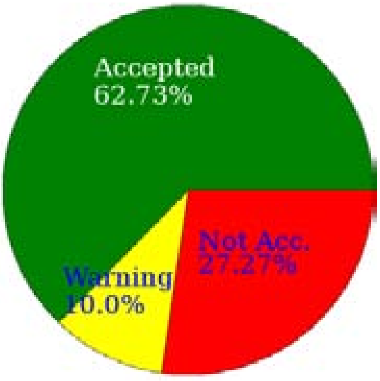
Lab code	**Rep. Value**	**Rep. Unc.**	**Unc. [%]**	**Rel. Bias**	**A1**	**A2**	**True**	**P**	**Prec**	**Final Score**
164	0.4	0.04	9.0	-28.2	0.16	0.11	N	9.64	A	N
165	0.54	0.03	5.6	-3.6	0.02	0.09	A	6.6	A	A
167	0.64	0.02	3.8	13.4	0.07	0.08	A	5.2	A	A
173	0.38	0.06	16.5	-32.9	0.18	0.17	N	16.87	N	N
177	0.53	0.03	5.7	-5.4	0.03	0.09	A	6.69	A	A
181	0.49	0.04	9.1	-11.8	0.07	0.13	A	9.78	A	A
186	0.48	0.05	10.4	-14.3	0.08	0.14	A	11.01	A	A
187	0.25	0.01	2.8	-55.2	0.31	0.05	N	4.53	A	N
188	26.4			4614						
191	2.46	0.09	3.7	339.3	1.9	0.24	N	5.11	A	N
193	0.55	0.05	9.1	-1.8	0.01	0.14	A	9.77	A	A
194	0.49	0.04	8.2	-12.5	0.07	0.12	A	8.91	A	A
196	0.64	0.04	7.1	13.6	0.08	0.13	A	7.93	A	A
201	0.62	0.03	4.7	10.4	0.06	0.09	A	5.9	A	A
202	0.59	0.05	8.5	5.4	0.03	0.14	A	9.2	A	A
203	0.58	0.05	8.0	3.3	0.02	0.13	A	8.77	A	A
204	0.5	0.02	4.0	-10.4	0.06	0.07	A	5.35	A	A
232	0.62	0	0.2	10.2	0.06	0.05	N	3.58	A	W
236	0.51	0.01	2.0	-8.9	0.05	0.06	A	4.07	A	A
238	0.54	0.05	8.4	-3.6	0.02	0.13	A	9.17	A	A
241	0.57	0.03	5.6	2.0	0.01	0.1	A	6.65	A	A
250	0.47	0.04	9.5	-15.2	0.09	0.13	A	10.12	A	A
255	0.55	0.05	9.4	-1.1	0.01	0.14	A	10.04	A	A
259	0.47	0.04	8.5	-16.1	0.09	0.12	A	9.23	A	A
260	0.53	0.03	5.7	-5.4	0.03	0.09	A	6.69	A	A
263	0.49	0.08	16.3	-12.5	0.07	0.21	A	16.71	N	W
264	124.5	86.93	69.8	22132	123.9	224.2	A	69.91	N	N
266	0.57	0.03	5.3	1.3	0.01	0.09	A	6.38	A	A
267	0.58	0.04	6.6	3.6	0.02	0.11	A	7.46	A	A
271	1.11	0.02	1.8	98.2	0.55	0.07	N	4	A	N
273	0.52	0.07	14.4	-7.1	0.04	0.2	A	14.86	A	A
274	0.53	0.05	9.1	-5.7	0.03	0.13	A	9.77	A	A
275	0.54	0.05	9.3	-3.6	0.02	0.14	A	9.92	A	A
276	0.56	0.02	3.7	-0.3	0	0.07	A	5.12	A	A
277	0.61	0.02	3.3	9.5	0.05	0.07	A	4.84	A	A
278	0.55	0.06	10.9	-1.8	0.01	0.16	A	11.48	A	A
282	0.69	0.09	13.0	23.2	0.13	0.24	A	13.52	A	A
283	1.35	0.18	13.3	141.1	0.79	0.47	N	13.8	A	N
286	0.56	0.03	6.1	-0.5	0	0.1	A	7.07	A	A
294	0.53	0.05	8.6	-4.6	0.03	0.13	A	9.33	A	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
296	0.57	0.01	2.1	2.3	0.01	0.06	A	4.14	A	A
297	0.7	0.03	4.3	25.0	0.14	0.09	N	5.58	A	N
298	0.61	0.04	6.6	8.9	0.05	0.12	A	7.47	A	A

Performance evaluation of U-234 measurement results

Spiked water sample 2

Target Value: 1.2 ± 0.04 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
1	1.21	0.18	14.88	1	0.01	0.48	A	15.24	N	W
4	1.05	0.07	6.67	-13	0.15	0.21	A	7.45	A	A
6	1.36	0.40	29.56	13	0.16	1.04	A	29.75	N	W
8	1.16	0.04	3.53	-3	0.04	0.15	A	4.86	A	A
11	1.20	0.11	9.17	0	0.00	0.30	A	9.75	A	A
13	0.87	0.13	15.11	-28	0.33	0.35	A	15.47	N	N
14	1.38	0.03	2.17	15	0.18	0.13	N	3.98	A	W
19	1.40	0.10	7.14	17	0.20	0.28	A	7.88	A	A
20	1.18	0.13	10.70	-2	0.02	0.34	A	11.20	A	A
21	1.24	0.11	9.14	3	0.04	0.31	A	9.73	A	A
22	1.16	0.05	4.15	-4	0.04	0.16	A	5.32	A	A
23	0.97	0.07	7.44	-19	0.23	0.21	N	8.15	A	N
28	1.20	0.10	8.33	0	0.00	0.28	A	8.98	A	A
29	13.80	5.30	38.41	1050	12.60	13.67	A	38.55	N	N
30	1.12	0.07	6.61	-7	0.08	0.22	A	7.40	A	A
32	1.15	0.17	14.78	-4	0.05	0.45	A	15.15	N	W
37	1.11	0.05	4.50	-8	0.09	0.17	A	5.60	A	A
38	1.03	0.04	4.15	-14	0.17	0.15	N	5.33	A	W
39	1.86	0.15	8.06	55	0.66	0.40	N	8.73	A	N
42	1.17	0.15	12.82	-3	0.03	0.40	A	13.25	A	A
43	1.14	0.05	4.39	-5	0.06	0.17	A	5.51	A	A
45	0.70	0.06	7.85	-42	0.50	0.18	N	8.52	A	N
47	1.08	0.17	15.28	-10	0.12	0.44	A	15.64	N	W
50	1.21	0.07	5.95	1	0.01	0.21	A	6.82	A	A
51	1.07	0.07	6.54	-11	0.13	0.21	A	7.34	A	A
54	1.71	0.06	3.51	43	0.51	0.19	N	4.84	A	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
57	0.90	0.10	11.11	-25	0.30	0.28	N	11.60	A	N
59	1.15	0.05	4.35	-4	0.05	0.17	A	5.48	A	A
60	0.93	0.09	9.97	-22	0.27	0.26	N	10.52	A	N
62	1.20	0.01	0.83	0	0.00	0.11	A	3.44	A	A
64	1.10	0.10	8.79	-8	0.10	0.27	A	9.40	A	A
72	1.20	0.07	5.74	0	0.00	0.21	A	6.64	A	A
73	0.54	0.02	2.99	-55	0.66	0.11	N	4.48	A	N
77	1.34	0.14	10.28	12	0.14	0.37	A	10.81	A	A
78	0.01	0.00	25.50	-99	1.19	0.10	N	25.72	N	N
80	1.27	0.07	5.52	6	0.07	0.21	A	6.45	A	A
81	0.27	0.03	11.48	-78	0.93	0.13	N	11.96	A	N
82	1.06	0.06	5.65	-12	0.14	0.19	A	6.56	A	A
84	1.18	0.06	5.22	-2	0.02	0.19	A	6.19	A	A
92	1.21	0.02	1.65	1	0.01	0.12	A	3.72	A	A
93	1.15	0.06	4.87	-4	0.05	0.18	A	5.90	A	A
94	1.40	0.05	3.29	17	0.20	0.16	N	4.68	A	N
95	1.10	0.07	5.98	-8	0.10	0.20	A	6.84	A	A
96	1.20	0.03	2.50	0	0.00	0.13	A	4.17	A	A
97	0.85	0.00	0.12	-29	0.34	0.10	N	3.34	A	N
101	1.29	0.07	5.43	8	0.09	0.21	A	6.37	A	A
102	1.32	0.10	7.34	10	0.12	0.27	A	8.06	A	A
103	1.17	0.04	2.99	-2	0.03	0.14	A	4.48	A	A
110	1.01	0.20	19.80	-16	0.19	0.53	A	20.08	N	N
112	1.16	0.04	3.36	-3	0.04	0.14	A	4.73	A	A
114	1.03	0.10	9.71	-14	0.17	0.28	A	10.27	A	A
119	1.22	0.07	5.99	2	0.02	0.21	A	6.86	A	A
126	1.11	0.03	2.34	-8	0.09	0.12	A	4.07	A	A
128	0.16	0.20	125.0	-87	1.04	0.53	N	125.0	N	N
131	1.15	0.18	15.65	-4	0.05	0.48	A	16.00	N	W
133	1.12	0.03	2.68	-7	0.08	0.13	A	4.28	A	A
134	1.09	0.05	4.59	-9	0.11	0.16	A	5.67	A	A
137	1.00	0.03	3.00	-17	0.20	0.13	N	4.48	A	N
144	0.81	0.23	28.57	-33	0.39	0.60	A	28.77	N	N
150	1.00	0.08	7.90	-17	0.20	0.23	A	8.57	A	A
156	1.17	0.04	3.42	-3	0.03	0.15	A	4.77	A	A
157	0.61	0.06	9.03	-49	0.59	0.18	N	9.63	A	N
158	1.14	0.03	2.63	-5	0.06	0.13	A	4.25	A	A
160	0.02	0.01	40.00	-98	1.18	0.11	N	40.14	N	N
161	1.08	0.16	14.81	-10	0.12	0.43	A	15.19	N	W
163	1.20	0.11	9.17	0	0.00	0.30	A	9.75	A	A

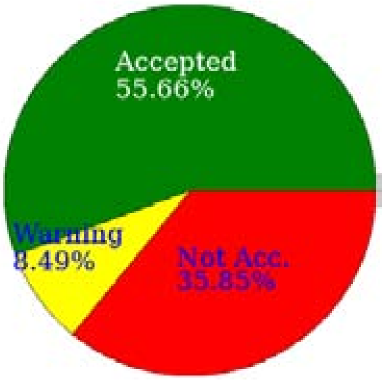
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
164	1.04	0.09	8.65	-13	0.16	0.25	A	9.27	A	A
165	1.11	0.05	4.50	-8	0.09	0.17	A	5.60	A	A
167	1.18	0.04	3.55	-1	0.02	0.15	A	4.87	A	A
173	0.42	0.06	14.69	-65	0.78	0.19	N	15.07	N	N
177	1.47	0.07	4.76	23	0.27	0.21	N	5.81	A	N
181	1.13	0.09	7.96	-6	0.07	0.25	A	8.63	A	A
186	1.02	0.10	9.80	-15	0.18	0.28	A	10.36	A	A
187	0.58	0.02	3.11	-52	0.62	0.11	N	4.56	A	N
188	22.30			1758						
191	2.33	0.07	3.00	94	1.13	0.21	N	4.49	A	N
193	1.16	0.09	7.76	-3	0.04	0.25	A	8.44	A	A
194	1.17	0.11	9.40	-3	0.03	0.30	A	9.98	A	A
196	1.19	0.10	8.26	-1	0.01	0.27	A	8.91	A	A
201	1.16	0.06	4.73	-3	0.04	0.18	A	5.79	A	A
202	1.21	0.05	4.13	1	0.01	0.17	A	5.31	A	A
203	1.20	0.14	11.54	0	0.00	0.37	A	12.01	A	A
204	1.11	0.03	2.70	-8	0.09	0.13	A	4.29	A	A
232	1.24	0.00	0.07	3	0.04	0.10	A	3.33	A	A
236	1.16	0.06	5.17	-3	0.04	0.19	A	6.15	A	A
238	1.10	0.06	5.46	-8	0.10	0.19	A	6.40	A	A
241	1.06	0.05	4.34	-12	0.14	0.16	A	5.47	A	A
250	1.11	0.1	9.01	-7.5	0.09	0.28	A	9.61	A	A
255	1.11	0.11	9.93	-7.7	0.09	0.3	A	10.47	A	A
259	1.27	0.1	7.87	5.8	0.07	0.28	A	8.55	A	A
260	0.95	0.04	4.21	-20.8	0.25	0.15	N	5.37	A	N
263	1.06	0.16	15.09	-11.7	0.14	0.43	A	15.46	N	W
264	95.02	61.76	65	7818	93.82	159	A	65.08	N	N
266	0.72	0.04	5.11	-39.7	0.48	0.14	N	6.1	A	N
267	1.19	0.08	6.88	-0.8	0.01	0.24	A	7.65	A	A
271	1.46	0.03	2.05	21.7	0.26	0.13	N	3.92	A	N
273	1.1	0.17	15.45	-8.3	0.1	0.45	A	15.81	N	W
274	1.14	0.11	9.65	-5.0	0.06	0.3	A	10.21	A	A
275	1	0.05	5	-16.7	0.2	0.17	N	6.01	A	N
276	1.16	0.04	3.4	-3.0	0.04	0.15	A	4.76	A	A
277	1.19	0.04	2.94	-0.8	0.01	0.14	A	4.45	A	A
278	1.16	0.1	8.62	-3.3	0.04	0.28	A	9.24	A	A
282	1.38	0.24	17.39	15.0	0.18	0.63	A	17.71	N	W
283	0.25	0.03	12	-79.2	0.95	0.13	N	12.45	A	N
286	1.13	0.07	5.84	-5.8	0.07	0.2	A	6.72	A	A
294	1.13	0.08	7.24	-5.6	0.07	0.24	A	7.97	A	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
296	1.17	0.03	2.56	-2.5	0.03	0.13	A	4.21	A	A
297	1.32	0.07	5.3	10.0	0.12	0.21	A	6.26	A	A
298	1.2	0.07	5.83	0.0	0	0.21	A	6.72	A	A

Performance evaluation of U-234 measurement results

Phosphogypsum IAEA-434 sample 6

Target Value: 120.0 ± 4.5 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
4	102.0	27.0	26.5	-15	18.0	70.6	A	26.7	N	N
6	130.0	10.5	8.0	8	10.0	29.4	A	8.9	A	A
8	96.0	10.0	10.4	-20	24.0	28.3	A	11.1	A	A
13	97.6	13.7	14.0	-19	22.4	37.2	A	14.5	A	A
14	120.0	20.0	16.7	0	0.0	52.9	A	17.1	N	W
19	86.5	4.8	5.6	-28	33.5	17.0	N	6.7	A	N
22	120.6	4.4	3.7	1	0.6	16.2	A	5.2	A	A
23	88.1	5.0	5.7	-27	31.9	17.4	N	6.8	A	N
28	123.0	18.0	14.6	3	3.0	47.9	A	15.1	N	W
29	<650									
30	1151	2.6	0.2	859	1031	13.4	N	3.8	A	N
37	0.8	0.0	5.4	-99	119.2	11.6	N	6.6	A	N
38	106.1	3.0	2.8	-12	13.9	13.9	N	4.7	A	W
39	179.6	10.3	5.8	50	59.6	29.1	N	6.9	A	N
42	17.2	2.8	16.4	-86	102.8	13.7	N	16.9	N	N
45	113.5	4.4	3.9	-5	6.5	16.2	A	5.4	A	A
47	86.2	15.8	18.3	-28	33.8	42.4	A	18.7	N	N
50	134.5	9.0	6.7	12	14.5	26.0	A	7.7	A	A
51	109.0	4.0	3.7	-9	11.0	15.5	A	5.3	A	A
54	183.9	5.3	2.9	53	63.9	17.9	N	4.7	A	N
57	10.5	1.5	14.3	-91	109.5	12.2	N	14.8	A	N
59	120.0	3.0	2.5	0	0.0	14.0	A	4.5	A	A
60	14.7	1.4	9.6	-88	105.4	12.2	N	10.3	A	N
62	140.0	10.0	7.1	17	20.0	28.3	A	8.1	A	A
64	120.0	11.0	9.2	0	0.0	30.7	A	9.9	A	A
67	91.0	3.0	3.3	-24	29.0	14.0	N	5.0	A	N

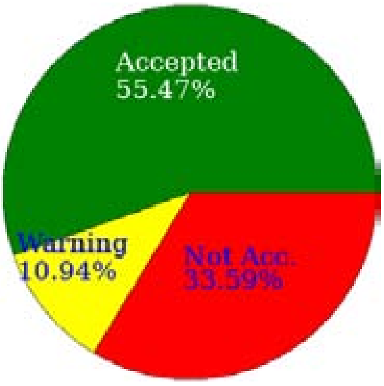
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
72	168.0	55.0	32.7	40	48.0	142.4	A	33.0	N	N
73	108.0	3.4	3.1	-10	12.0	14.5	A	4.9	A	A
74	2191	280.0	12.8	1726	2071	722.5	N	13.3	A	N
77	135.0	14.0	10.4	13	15.0	37.9	A	11.0	A	A
80	110.0	6.6	6.0	-8	10.0	20.6	A	7.1	A	A
84	108.0	6.1	5.7	-10	12.0	19.6	A	6.8	A	A
85	152.2	10.1	6.6	27	32.2	28.5	N	7.6	A	N
89	118.0	24.0	20.3	-2	2.0	63.0	A	20.7	N	W
92	128.0	2.0	1.6	7	8.0	12.7	A	4.1	A	A
93	116.0	7.0	6.0	-3	4.0	21.5	A	7.1	A	A
94	132.7	21.7	16.4	11	12.7	57.2	A	16.8	N	W
95	112.7	6.8	6.0	-6	7.3	21.0	A	7.1	A	A
96	123.0	4.0	3.3	3	3.0	15.5	A	5.0	A	A
97	49.0	8.0	16.3	-59	71.0	23.7	N	16.8	N	N
99	249.7	5.5	2.2	108	129.7	18.4	N	4.4	A	N
101	159.0	9.0	5.7	33	39.0	26.0	N	6.8	A	N
103	121.0	2.0	1.7	1	1.0	12.7	A	4.1	A	A
106	136.0	15.0	11.0	13	16.0	40.4	A	11.7	A	A
108	2071	197.0	9.5	1626	1951	508.4	N	10.2	A	N
111	120.0	14.0	11.7	0	0.0	37.9	A	12.3	A	A
112	121.9	4.0	3.3	2	1.9	15.5	A	5.0	A	A
113	118.8	15.0	12.6	-1	1.2	40.4	A	13.2	A	A
114	110.0	10.0	9.1	-8	10.0	28.3	A	9.8	A	A
119	121.0	15.0	12.4	1	1.0	40.4	A	13.0	A	A
126	113.0	2.4	2.1	-6	7.0	13.1	A	4.3	A	A
128	49.2	11.0	22.4	-59	70.8	30.7	N	22.7	N	N
131	126.0	20.2	16.0	5	6.0	53.4	A	16.5	N	W
133	122.0	4.0	3.3	2	2.0	15.5	A	5.0	A	A
137	100.0	2.0	2.0	-17	20.0	12.7	N	4.3	A	N
144	0.9	0.5	50.3	-99	119.1	11.7	N	50.4	N	N
145	5295	810.0	15.3	4313	5175	2089	N	15.8	N	N
150	0.1	0.0	42.0	-100	119.9	11.6	N	42.2	N	N
151	5885	875.0	14.9	4804	5765	2257	N	15.3	N	N
156	114.0	6.0	5.3	-5	6.0	19.4	A	6.5	A	A
158	125.0	4.0	3.2	4	5.0	15.5	A	4.9	A	A
160	248.1	0.4	0.2	107	128.1	11.7	N	3.8	A	N
161	71.3	2.6	3.7	-41	48.7	13.4	N	5.2	A	N
165	123.0	6.0	4.9	3	3.0	19.4	A	6.2	A	A
167	125.0	10.0	8.0	4	5.0	28.3	A	8.8	A	A
173	17.1	2.8	16.1	-86	102.9	13.6	N	16.5	N	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
176	687.0	7.0	1.0	473	567.0	21.5	N	3.9	A	N
177	155.0	8.0	5.2	29	35.0	23.7	N	6.4	A	N
178	3230	300.0	9.3	2592	3110	774.1	N	10.0	A	N
181	124.8	5.2	4.2	4	4.8	17.7	A	5.6	A	A
186	115.0	15.0	13.0	-4	5.0	40.4	A	13.6	A	A
187	118.7	6.0	5.1	-1	1.3	19.4	A	6.3	A	A
188	5344	1157	21.7	4354	5224	2985	N	22.0	N	N
191	120.0	3.0	2.5	0	0.0	14.0	A	4.5	A	A
193	104.0	8.0	7.7	-13	16.0	23.7	A	8.6	A	A
194	106.3	7.8	7.3	-11	13.7	23.1	A	8.2	A	A
196	141.5	12.8	9.0	18	21.5	34.9	A	9.8	A	A
201	121.0	2.0	1.7	1	1.0	12.7	A	4.1	A	A
202	116.1	4.9	4.2	-3	3.9	17.2	A	5.7	A	A
204	136.0	4.0	2.9	13	16.0	15.5	N	4.8	A	W
234	104.4	4.2	4.0	-13	15.6	15.9	A	5.5	A	A
236	128.5	5.2	4.1	7	8.5	17.7	A	5.5	A	A
238	81.2	4.9	6.0	-32	38.8	17.2	N	7.1	A	N
241	122.0	6.0	4.9	2	2.0	19.4	A	6.2	A	A
250	156	15	9.62	30	36	40.4	A	10.3	A	A
260	101	6	5.94	-16	19	19.4	A	7.0	A	A
261	120	17	14.17	0	0	45.4	A	14.7	A	A
263	130	15	11.54	8	10	40.4	A	12.1	A	A
264	5094	3131	61.47	4145	4973	8079	A	61.6	N	N
266	90.5	4.7	5.19	-25	29.5	16.8	N	6.4	A	N
267	140	5	3.57	17	20	17.4	N	5.2	A	N
271	132.2	4.9	3.68	10	12.2	17.1	A	5.3	A	A
273	118.1	20.7	17.53	-2	1.9	54.7	A	17.9	N	W
274	124	12	9.68	3	4	33.1	A	10.4	A	A
275	116	7	6.03	-3	4	21.5	A	7.1	A	A
276	120.2	4.1	3.4	0	0.2	15.7	A	5.1	A	A
277	131	3.3	2.52	9	11	14.4	A	4.5	A	A
278	121	8	6.61	1	1	23.7	A	7.6	A	A
282	124.2	12.1	9.74	4	4.2	33.3	A	10.4	A	A
283	92	10	10.87	-23	28	28.3	A	11.5	A	A
286	116.6	7.8	6.69	-3	3.4	23.2	A	7.7	A	A
294	57	3.5	6.14	-53	63	14.7	N	7.2	A	N
296	122	3	2.46	2	2	14.0	A	4.5	A	A
297	150	15	10	25	30	40.4	A	10.7	A	A
299	113.7	23.5	20.64	-5	6.3	61.6	A	21.0	N	W

Performance evaluation of U-238 measurement results

Spiked water sample 1

Target Value: 0.36 ± 0.01 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
1	0.39	0.06	15.38	8	0.03	0.16	A	15.63	N	W
4	0.47	0.03	6.38	31	0.11	0.08	N	6.96	A	N
6	0.84	0.22	26.07	133	0.48	0.57	A	26.22	N	N
8	0.34	0.01	3.82	-6	0.02	0.04	A	4.73	A	A
11	0.36	0.04	11.11	0	0.00	0.11	A	11.45	A	A
13	0.36	0.06	16.85	-1	0.00	0.16	A	17.08	N	W
14	0.61	0.02	3.28	69	0.25	0.06	N	4.30	A	N
19	0.46	0.03	6.52	28	0.10	0.08	N	7.09	A	N
20	0.38	0.03	6.79	6	0.02	0.07	A	7.33	A	A
21	0.49	0.06	11.48	36	0.13	0.15	A	11.81	A	A
22	0.34	0.03	8.41	-4	0.02	0.08	A	8.85	A	A
23	0.32	0.03	8.59	-11	0.04	0.08	A	9.03	A	A
28	0.37	0.01	2.70	3	0.01	0.04	A	3.88	A	A
29	<0.5									
30	0.23	0.03	13.30	-35	0.13	0.08	N	13.59	A	N
32	0.36	0.05	15.04	0	0.00	0.14	A	15.30	N	W
34	2.11	0.65	30.90	487	1.75	1.68	N	31.03	N	N
36	<1.61									
37	0.39	0.03	6.38	9	0.03	0.07	A	6.96	A	A
38	0.33	0.01	2.99	-7	0.03	0.04	A	4.08	A	A
39	0.54	0.04	7.41	50	0.18	0.11	N	7.91	A	N
40	1.68	1.29	76.79	367	1.32	3.33	A	76.84	N	N
42	0.21	0.04	17.76	-41	0.15	0.10	N	17.97	N	N
43	0.35	0.03	8.57	-3	0.01	0.08	A	9.01	A	A
45	0.37	0.02	6.15	4	0.01	0.06	A	6.75	A	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
47	0.36	0.06	17.20	0	0.00	0.16	A	17.43	N	W
50	0.36	0.02	6.59	1	0.00	0.07	A	7.15	A	A
51	0.28	0.02	7.14	-22	0.08	0.06	N	7.66	A	N
53	0.23	0.02	8.70	-36	0.13	0.06	N	9.13	A	N
54	0.39	0.00	0.26	8	0.03	0.03	N	2.79	A	W
57	0.90	0.10	11.11	150	0.54	0.26	N	11.45	A	N
59	0.32	0.03	8.18	-12	0.04	0.07	A	8.64	A	A
60	0.84	0.08	9.51	134	0.48	0.21	N	9.91	A	N
62	0.38	0.01	2.63	6	0.02	0.04	A	3.83	A	A
63	10.59	7.15	67.52	2842	10.23	18.4	A	67.57	N	N
64	0.37	0.04	12.23	2	0.01	0.12	A	12.54	A	A
65	0.70	6.00	857.1	94	0.34	15.4	A	857.1	N	N
67	0.32	0.01	3.46	-12	0.04	0.04	N	4.44	A	W
72	0.36	0.02	4.42	1	0.00	0.05	A	5.22	A	A
73	0.34	0.01	2.52	-6	0.02	0.03	A	3.75	A	A
74	6.95	1.20	17.27	1831	6.59	3.10	N	17.49	N	N
77	0.42	0.04	9.57	16	0.06	0.11	A	9.96	A	A
78	0.01	0.00	25.00	-97	0.35	0.03	N	25.15	N	N
80	0.39	0.03	6.41	8	0.03	0.07	A	6.99	A	A
81	0.60	0.06	10.67	67	0.24	0.17	N	11.02	A	N
82	0.38	0.05	11.98	7	0.02	0.12	A	12.30	A	A
84	0.32	0.02	7.18	-12	0.04	0.06	A	7.70	A	A
91	0.35	0.03	8.57	-3	0.01	0.08	A	9.01	A	A
92	0.40	0.01	2.50	11	0.04	0.04	N	3.74	A	W
93	0.38	0.02	6.08	5	0.02	0.06	A	6.69	A	A
94	0.39	0.02	4.16	7	0.03	0.05	A	5.00	A	A
95	0.31	0.02	6.07	-13	0.05	0.06	A	6.68	A	A
96	0.37	0.01	3.80	2	0.01	0.04	A	4.71	A	A
97	0.32	0.03	9.38	-11	0.04	0.08	A	9.78	A	A
101	0.44	0.02	5.20	23	0.08	0.06	N	5.90	A	N
103	0.35	0.01	3.39	-2	0.01	0.04	A	4.38	A	A
104	12.40	3.50	28.23	3344	12.04	9.03	N	28.36	N	N
106	6.56	1.96	29.88	1722	6.20	5.06	N	30.01	N	N
108	5.91	0.49	8.29	1542	5.55	1.26	N	8.74	A	N
110	0.36	0.07	19.44	0	0.00	0.18	A	19.64	N	W
112	0.36	0.01	3.56	1	0.01	0.04	A	4.52	A	A
113	0.60	0.08	13.33	67	0.24	0.21	N	13.62	A	N
114	0.39	0.04	10.26	8	0.03	0.11	A	10.63	A	A
119	0.39	0.03	7.73	8	0.03	0.08	A	8.22	A	A
126	0.34	0.01	3.53	-6	0.02	0.04	A	4.49	A	A

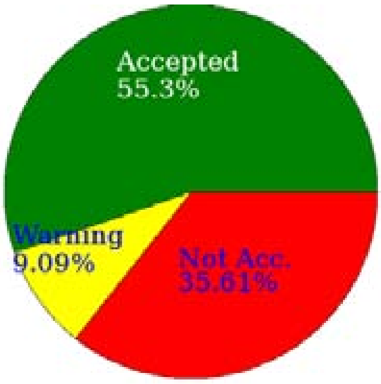
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
128	1.30	0.17	13.08	261	0.94	0.44	N	13.37	A	N
131	0.38	0.06	15.79	6	0.02	0.16	A	16.03	N	W
133	0.36	0.01	2.78	0	0.00	0.04	A	3.93	A	A
134	0.39	0.01	3.89	7	0.03	0.05	A	4.78	A	A
137	0.35	0.02	5.71	-3	0.01	0.06	A	6.35	A	A
138	0.38	0.02	5.26	6	0.02	0.06	A	5.95	A	A
140	1.46	0.70	47.95	306	1.10	1.81	A	48.03	N	N
144	1.20	0.32	26.65	233	0.84	0.82	N	26.79	N	N
147	0.67	0.86	128.3	86	0.31	2.22	A	128.3	N	N
150	0.29	0.03	10.00	-19	0.07	0.08	A	10.38	A	A
151	7.20	1.70	23.61	1900	6.84	4.39	N	23.77	N	N
156	0.37	0.03	8.11	3	0.01	0.08	A	8.57	A	A
157	0.22	0.02	9.91	-38	0.14	0.06	N	10.29	A	N
158	0.362	0.01	3.87	0.6	0.00	0.04	A	4.8	A	A
160	0.01	0.01	40.00	-96	0.34	0.03	N	40.10	N	N
161	0.37	0.02	5.41	3	0.01	0.06	A	6.08	A	A
163	0.34	0.01	3.24	-6	0.02	0.04	A	4.26	A	A
164	0.26	0.02	9.30	-28	0.10	0.07	N	9.71	A	N
165	0.35	0.02	5.71	-3	0.01	0.06	A	6.35	A	A
167	0.45	0.02	3.82	24	0.09	0.05	N	4.72	A	N
173	0.22	0.04	17.65	-39	0.14	0.10	N	17.86	N	N
177	0.35	0.02	5.71	-3	0.01	0.06	A	6.35	A	A
181	0.32	0.04	10.87	-11	0.04	0.09	A	11.22	A	A
186	0.34	0.03	8.82	-6	0.02	0.08	A	9.25	A	A
187	0.16	0.01	3.07	-55	0.20	0.03	N	4.14	A	N
188	0.52			44						
191	4.58	4.09	89.30	1172	4.22	10.5	A	89.34	N	N
193	0.38	0.04	10.53	6	0.02	0.11	A	10.89	A	A
194	0.32	0.03	9.38	-11	0.04	0.08	A	9.78	A	A
196	0.38	0.03	7.65	5	0.02	0.08	A	8.14	A	A
200	0.35	0.08	21.97	-4	0.01	0.20	A	22.14	N	W
201	0.38	0.02	4.75	5	0.02	0.05	A	5.50	A	A
202	0.39	0.03	7.69	8	0.03	0.08	A	8.18	A	A
203	0.33	0.01	2.18	-8	0.03	0.03	A	3.53	A	A
204	0.36	0.02	4.75	-1	0.00	0.05	A	5.50	A	A
232	0.36	0.00	0.25	1	0.00	0.03	A	2.79	A	A
235	0.86	0.61	70.93	139	0.50	1.57	A	70.98	N	N
236	0.32	0.01	3.10	-10	0.04	0.04	N	4.16	A	W
238	0.35	0.04	10.29	-3	0.01	0.10	A	10.65	A	A
241	0.36	0.02	6.67	0	0.00	0.07	A	7.22	A	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
250	0.31	0.03	10.9	-13	0.05	0.09	A	11.25	A	A
255	0.36	0.04	10.56	0	0	0.1	A	10.91	A	A
259	0.3	0.02	8.11	-18	0.06	0.07	A	8.57	A	A
260	0.35	0.02	5.13	-3	0.01	0.05	A	5.83	A	A
263	0.31	0.07	22.58	-14	0.05	0.18	A	22.75	N	W
264	3.76	2.44	64.95	944	3.4	6.3	A	65.01	N	N
266	0.43	0.02	5.52	21	0.08	0.07	N	6.18	A	N
267	0.38	0.03	6.67	4	0.02	0.07	A	7.22	A	A
271	0.73	0.02	2.33	103	0.37	0.05	N	3.62	A	N
272	0.96	0.23	23.96	167	0.6	0.59	N	24.12	N	N
273	0.34	0.05	14.88	-7	0.02	0.13	A	15.14	N	W
274	0.34	0.03	9.06	-5	0.02	0.08	A	9.48	A	A
275	0.36	0.02	5.56	0	0	0.06	A	6.21	A	A
276	0.37	0.01	3.8	2	0.01	0.04	A	4.71	A	A
277	0.39	0.01	3.85	8	0.03	0.05	A	4.74	A	A
278	0.36	0.05	13.89	0	0	0.13	A	14.16	A	A
282	0.47	0.06	12.77	31	0.11	0.16	A	13.06	A	A
283	2.74	0.25	9.12	661	2.38	0.65	N	9.54	A	N
286	0.35	0.02	6.23	-2	0.01	0.06	A	6.82	A	A
294	0.37	0.04	9.43	3	0.01	0.09	A	9.83	A	A
296	0.36	0.01	2.19	1	0.01	0.03	A	3.54	A	A
297	0.33	0.01	3.03	-8	0.03	0.04	A	4.11	A	A
298	0.39	0.03	7.69	8	0.03	0.08	A	8.18	A	A

Performance evaluation of U-238 measurement results

Spiked water sample 2

Target Value: 1.25 ± 0.04 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
1	1.23	0.18	14.63	-2	0.02	0.48	A	14.98	A	A
3	1.38	0.18	12.86	10	0.13	0.47	A	13.26	A	A
4	1.17	0.05	4.27	-6	0.08	0.17	A	5.34	A	A
6	1.23	0.30	24.07	-2	0.02	0.77	A	24.28	N	W
8	1.17	0.04	3.59	-6	0.08	0.15	A	4.81	A	A
11	1.20	0.11	9.17	-4	0.05	0.30	A	9.71	A	A
13	0.91	0.14	15.14	-28	0.34	0.37	A	15.47	N	N
14	1.59	0.03	1.89	27	0.34	0.13	N	3.71	A	N
19	1.40	0.10	7.14	12	0.15	0.28	A	7.83	A	A
20	1.19	0.02	1.34	-5	0.06	0.11	A	3.47	A	A
21	1.22	0.11	9.14	-3	0.03	0.30	A	9.68	A	A
22	1.18	0.05	4.17	-6	0.07	0.16	A	5.26	A	A
23	1.00	0.07	7.40	-20	0.25	0.22	N	8.06	A	N
28	1.19	0.04	3.36	-5	0.06	0.15	A	4.64	A	A
29	0.73	0.22	30.14	-42	0.52	0.58	A	30.31	N	N
30	1.05	0.07	6.79	-16	0.20	0.21	A	7.50	A	A
32	1.15	0.17	14.78	-8	0.10	0.45	A	15.12	N	W
34	2.33	0.69	29.39	87	1.08	1.77	A	29.57	N	N
36	<1.62									
37	1.13	0.05	4.51	-10	0.12	0.17	A	5.53	A	A
38	1.06	0.04	4.13	-15	0.19	0.15	N	5.23	A	W
39	1.86	0.15	8.06	49	0.61	0.40	N	8.68	A	N
40	2.11	1.57	74.41	69	0.86	4.05	A	74.48	N	N
42	1.10	0.15	13.61	-12	0.15	0.40	A	13.98	A	A
43	1.05	0.05	4.76	-16	0.20	0.17	N	5.74	A	N
45	0.70	0.06	7.89	-44	0.55	0.18	N	8.52	A	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
47	1.06	0.16	15.28	-15	0.19	0.43	A	15.61	N	N
49	1.96	0.44	22.45	57	0.71	1.14	A	22.68	N	N
50	1.25	0.07	5.98	0	0.00	0.22	A	6.78	A	A
51	1.08	0.07	6.48	-14	0.17	0.21	A	7.23	A	A
53	0.87	0.06	6.90	-30	0.38	0.19	N	7.60	A	N
54	1.24	0.00	0.16	-1	0.01	0.10	A	3.20	A	A
57	0.60	0.10	16.67	-52	0.65	0.28	N	16.97	N	N
59	1.18	0.05	4.24	-6	0.07	0.17	A	5.31	A	A
60	0.55	0.06	10.01	-56	0.70	0.18	N	10.51	A	N
62	1.20	0.01	0.83	-4	0.05	0.11	A	3.31	A	A
63	6.75	5.47	81.04	440	5.50	14.1	A	81.10	N	N
64	1.15	0.10	8.81	-8	0.10	0.28	A	9.38	A	A
65	1.70	6.00	352.9	36	0.45	15.4	A	352.9	N	N
72	1.19	0.07	5.81	-5	0.06	0.21	A	6.63	A	A
73	0.34	0.01	3.54	-73	0.91	0.11	N	4.77	A	N
74	9.00	1.70	18.89	620	7.75	4.39	N	19.16	N	N
77	1.30	0.13	10.31	4	0.05	0.36	A	10.79	A	A
78	0.01	0.00	25.00	-99	1.24	0.10	N	25.20	N	N
80	1.23	0.07	5.53	-2	0.02	0.20	A	6.39	A	A
81	0.38	0.04	11.26	-69	0.87	0.15	N	11.70	A	N
82	1.30	0.15	11.54	4	0.05	0.40	A	11.97	A	A
84	1.23	0.06	5.15	-2	0.02	0.19	A	6.07	A	A
91	1.12	0.11	9.82	-10	0.13	0.30	A	10.33	A	A
92	1.24	0.02	1.61	-1	0.01	0.12	A	3.58	A	A
93	1.17	0.05	4.51	-6	0.08	0.17	A	5.53	A	A
94	1.32	0.04	3.26	6	0.07	0.15	A	4.57	A	A
95	1.12	0.07	6.00	-11	0.13	0.20	A	6.80	A	A
96	1.18	0.03	2.54	-6	0.07	0.13	A	4.09	A	A
97	0.87	0.03	3.45	-30	0.38	0.13	N	4.70	A	N
101	1.32	0.07	5.30	6	0.07	0.21	A	6.19	A	A
102	1.34	0.10	7.33	7	0.09	0.27	A	8.00	A	A
103	1.18	0.04	3.04	-5	0.07	0.14	A	4.42	A	A
104	8.10	1.80	22.22	548	6.85	4.65	N	22.45	N	N
106	9.07	2.52	27.78	626	7.82	6.50	N	27.97	N	N
108	8.19	0.74	9.04	555	6.94	1.91	N	9.59	A	N
110	0.98	0.20	20.41	-22	0.27	0.53	A	20.66	N	N
112	1.19	0.04	3.36	-5	0.06	0.15	A	4.64	A	A
113	1.70	0.18	10.59	36	0.45	0.48	A	11.06	A	A
114	1.15	0.10	8.70	-8	0.10	0.28	A	9.27	A	A
119	1.25	0.07	5.93	0	0.00	0.22	A	6.74	A	A

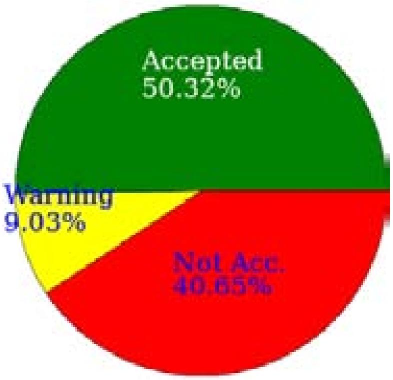
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
126	1.13	0.03	2.30	-10	0.12	0.12	A	3.94	A	A
128	1.30	0.14	10.77	4	0.05	0.38	A	11.23	A	A
131	1.20	0.19	15.83	-4	0.05	0.50	A	16.15	N	W
133	1.16	0.03	2.59	-7	0.09	0.13	A	4.11	A	A
134	1.07	0.05	4.67	-15	0.18	0.16	N	5.66	A	W
137	1.11	0.03	2.70	-11	0.14	0.13	N	4.19	A	W
138	1.21	0.10	8.28	-3	0.04	0.28	A	8.88	A	A
140	3.65	1.40	38.36	192	2.40	3.61	A	38.49	N	N
144	0.86	0.27	31.86	-31	0.39	0.71	A	32.02	N	N
147	1.21	0.84	69.42	-3	0.04	2.17	A	69.50	N	W
150	1.00	0.04	3.50	-20	0.25	0.14	N	4.74	A	N
151	7.10	1.10	15.49	468	5.85	2.84	N	15.82	N	N
156	1.17	0.04	3.42	-6	0.08	0.15	A	4.68	A	A
157	0.66	0.06	9.05	-47	0.59	0.19	N	9.60	A	N
158	1.13	0.03	2.65	-10	0.12	0.13	A	4.16	A	A
160	0.10	0.04	39.80	-92	1.15	0.14	N	39.92	N	N
161	1.11	0.07	6.31	-11	0.14	0.21	A	7.07	A	A
163	1.29	0.03	2.25	3	0.04	0.13	A	3.91	A	A
164	1.08	0.09	8.33	-14	0.17	0.25	A	8.93	A	A
165	1.16	0.05	4.31	-7	0.09	0.17	A	5.37	A	A
167	1.21	0.04	3.48	-3	0.04	0.15	A	4.73	A	A
173	0.37	0.06	14.97	-70	0.88	0.18	N	15.31	N	N
177	1.56	0.08	5.13	25	0.31	0.23	N	6.04	A	N
178	7.00	0.60	8.57	460	5.75	1.55	N	9.15	A	N
181	1.18	0.09	7.63	-6	0.07	0.25	A	8.27	A	A
186	1.06	0.10	9.43	-15	0.19	0.28	A	9.96	A	A
187	0.59	0.02	3.21	-53	0.66	0.11	N	4.54	A	N
188	1.48			18						
191	7.60	4.50	59.21	508	6.35	11.6	A	59.30	N	N
193	1.08	0.10	9.26	-14	0.17	0.28	A	9.80	A	A
194	1.18	0.11	9.32	-6	0.07	0.30	A	9.86	A	A
196	1.18	0.10	8.28	-5	0.07	0.27	A	8.87	A	A
200	1.26	0.23	18.25	1	0.01	0.60	A	18.53	N	W
201	1.21	0.06	4.71	-3	0.04	0.18	A	5.70	A	A
202	1.15	0.05	4.35	-8	0.10	0.17	A	5.40	A	A
203	1.12	0.02	1.65	-11	0.13	0.11	N	3.60	A	W
204	1.09	0.03	2.75	-13	0.16	0.13	N	4.22	A	W
232	1.19	0.00	0.08	-5	0.06	0.10	A	3.20	A	A
235	1.53	0.54	35.29	22	0.28	1.40	A	35.44	N	N
236	1.18	0.06	5.08	-6	0.07	0.19	A	6.01	A	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
238	1.20	0.06	5.18	-4	0.05	0.19	A	6.08	A	A
241	1.10	0.05	4.27	-12	0.15	0.16	A	5.34	A	A
250	1.19	0.11	9.24	-5	0.06	0.3	A	9.78	A	A
255	1.18	0.12	10.2	-6	0.07	0.33	A	10.69	A	A
259	1.3	0.11	8.46	4	0.05	0.3	A	9.05	A	A
260	0.97	0.04	4.12	-22	0.28	0.15	N	5.22	A	N
263	1.05	0.17	16.19	-16	0.2	0.45	A	16.5	N	N
264	6.04	2.3	38.08	383	4.79	5.94	A	38.22	N	N
266	0.72	0.04	5.15	-42	0.53	0.14	N	6.06	A	N
267	1.19	0.08	6.88	-5	0.06	0.24	A	7.59	A	A
271	1.49	0.02	1.34	19	0.24	0.12	N	3.47	A	N
273	1.15	0.18	15.65	-8	0.1	0.48	A	15.98	N	W
274	1.16	0.11	9.48	-7	0.09	0.3	A	10.01	A	A
275	1	0.02	2	-20	0.25	0.12	N	3.77	A	N
276	1.2	0.04	3.39	-4	0.05	0.15	A	4.67	A	A
277	1.21	0.04	2.89	-3	0.04	0.14	A	4.31	A	A
278	1.17	0.1	8.55	-6	0.08	0.28	A	9.13	A	A
282	1.5	0.26	17.33	20	0.25	0.68	A	17.63	N	N
283	0.39	0.04	10.26	-69	0.86	0.15	N	10.74	A	N
286	1.15	0.07	5.81	-8	0.1	0.2	A	6.63	A	A
288	1.74	0.39	22.41	39	0.49	1.01	A	22.64	N	N
294	1.18	0.09	7.22	-6	0.07	0.24	A	7.89	A	A
296	1.19	0.03	2.52	-5	0.06	0.13	A	4.07	A	A
297	1.16	0.03	2.59	-7	0.09	0.13	A	4.11	A	A
298	1.26	0.07	5.56	1	0.01	0.21	A	6.41	A	A

Performance evaluation of U-238 measurement results

Phosphogypsum IAEA-434 sample 6

Target Value: 120.0 ± 5.5 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
1	96.0	10.00	10.42	-20	24.00	29.44	A	11.38	A	A
3	97.9	3.80	3.88	-18	22.10	17.25	N	6.01	A	N
4	104.0	27.00	25.96	-13	16.00	71.09	A	26.36	N	W
6	132.0	10.60	8.03	10	12.00	30.81	A	9.25	A	A
7	138.0	8.00	5.80	15	18.00	25.05	A	7.39	A	A
8	101.0	11.00	10.89	-16	19.00	31.73	A	11.82	A	A
9	131.0	20.00	15.27	9	11.00	53.52	A	15.94	N	W
13	89.2	12.92	14.49	-26	30.83	36.23	A	15.20	N	N
14	130.0	20.00	15.38	8	10.00	53.52	A	16.05	N	W
18	174.9	15.10	8.63	46	54.90	41.46	N	9.77	A	N
19	81.9	4.50	5.49	-32	38.10	18.33	N	7.16	A	N
20	144.0	32.00	22.22	20	24.00	83.77	A	22.69	N	N
22	115.9	4.30	3.71	-3	4.10	18.01	A	5.90	A	A
23	85.8	4.90	5.71	-29	34.20	19.00	N	7.32	A	N
28	117.0	4.00	3.42	-3	3.00	17.55	A	5.72	A	A
29	147.0	47.00	31.97	23	27.00	122.0	A	32.30	N	N
30	1056	1.34	0.13	781	936.7	14.61	N	4.59	A	N
32	150.0	10.00	6.67	25	30.00	29.44	N	8.09	A	N
33	119.0	14.00	11.76	-1	1.00	38.81	A	12.63	A	A
34	437.7	43.25	9.88	265	317.7	112.4	N	10.89	A	N
36	121.0	18.00	14.88	1	1.00	48.56	A	15.57	N	W
37	0.8	0.04	5.34	-99	119.2	14.19	N	7.03	A	N
38	103.1	2.89	2.80	-14	16.93	16.03	N	5.37	A	W
39	169.5	10.04	5.92	41	49.52	29.54	N	7.49	A	N
40	21.7	3.25	14.97	-82	98.29	16.48	N	15.66	N	N
42	17.1	2.81	16.42	-86	102.8	15.93	N	17.05	N	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
43	79.9	35.10	43.93	-33	40.10	91.66	A	44.17	N	N
45	111.1	4.30	3.87	-7	8.90	18.01	A	6.00	A	A
47	83.1	15.00	18.05	-31	36.90	41.22	A	18.62	N	N
49	135.8	15.90	11.71	13	15.80	43.41	A	12.57	A	A
50	127.9	8.60	6.72	7	7.90	26.34	A	8.14	A	A
51	106.0	3.00	2.83	-12	14.00	16.16	A	5.39	A	A
52	140.0	51.00	36.43	17	20.00	132.3	A	36.72	N	N
53	116.2	3.80	3.27	-3	3.80	17.25	A	5.63	A	A
54	128.6	0.52	0.40	7	8.58	14.25	A	4.60	A	A
57	6.4	0.90	14.06	-95	113.6	14.38	N	14.79	A	N
59	122.0	3.00	2.46	2	2.00	16.16	A	5.20	A	A
60	6.0	0.59	9.87	-95	114.0	14.27	N	10.88	A	N
62	140.0	10.00	7.14	17	20.00	29.44	A	8.49	A	A
63	350.0	12.40	3.54	192	230.0	35.00	N	5.79	A	N
64	130.0	12.00	9.23	8	10.00	34.06	A	10.31	A	A
66	611.9	19.20	3.14	410	491.9	51.53	N	5.55	A	N
67	84.0	3.00	3.57	-30	36.00	16.16	N	5.81	A	N
69	83.8	7.10	8.47	-30	36.20	23.17	N	9.63	A	N
72	113.0	22.00	19.47	-6	7.00	58.51	A	20.00	N	W
73	104.0	3.29	3.16	-13	16.00	16.53	A	5.57	A	A
74	128.0	11.00	8.59	7	8.00	31.73	A	9.74	A	A
77	128.0	14.00	10.94	7	8.00	38.81	A	11.86	A	A
78	100.0	13.00	13.00	-17	20.00	36.42	A	13.78	A	A
80	120.0	7.20	6.00	0	0.00	23.38	A	7.55	A	A
81	228.0	23.00	10.09	90	108.0	61.01	N	11.08	A	N
82	97.0	5.20	5.36	-19	23.00	19.53	N	7.05	A	N
84	107.0	6.06	5.66	-11	13.00	21.11	A	7.29	A	A
85	153.4	10.16	6.62	28	33.39	29.81	N	8.05	A	N
91	114.0	6.00	5.26	-5	6.00	21.00	A	6.98	A	A
92	128.0	2.00	1.56	7	8.00	15.10	A	4.84	A	A
93	116.0	7.00	6.03	-3	4.00	22.97	A	7.58	A	A
94	130.6	21.30	16.31	9	10.60	56.76	A	16.94	N	W
95	110.5	6.63	6.00	-8	9.49	22.23	A	7.55	A	A
96	118.0	3.00	2.54	-2	2.00	16.16	A	5.24	A	A
97	47.0	4.00	8.51	-61	73.00	17.55	N	9.67	A	N
98	142.0	40.00	28.17	18	22.00	104.1	A	28.54	N	N
99	249.7	5.54	2.22	108	129.6	20.14	N	5.09	A	N
101	147.0	8.00	5.44	23	27.00	25.05	N	7.12	A	N
103	118.0	2.00	1.69	-2	2.00	15.10	A	4.89	A	A
104	118.0	18.00	15.25	-2	2.00	48.56	A	15.93	N	W

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
106	171.0	34.00	19.88	43	51.00	88.86	A	20.40	N	N
107	222.5	13.50	6.07	85	102.5	37.61	N	7.60	A	N
108	1772	125.1	7.06	1377	1652	323.1	N	8.42	A	N
110	140.0	21.00	15.00	17	20.00	56.01	A	15.68	N	N
111	120.0	14.00	11.67	0	0.00	38.81	A	12.53	A	A
112	112.8	4.00	3.55	-6	7.20	17.55	A	5.79	A	A
113	118.3	12.06	10.19	-1	1.68	34.20	A	11.18	A	A
114	111.0	10.00	9.01	-8	9.00	29.44	A	10.11	A	A
117	39.4	0.12	0.30	-67	80.59	14.19	N	4.59	A	N
118	230.0	6.00	2.61	92	110.0	21.00	N	5.27	A	N
119	129.0	11.00	8.53	8	9.00	31.73	A	9.68	A	A
120	124.0	5.00	4.03	3	4.00	19.18	A	6.10	A	A
125	94.1	12.00	12.75	-22	25.90	34.06	A	13.55	A	A
126	114.0	2.42	2.12	-5	6.00	15.50	A	5.05	A	A
128	50.6	4.00	7.91	-58	69.40	17.55	N	9.14	A	N
129	68.0	16.00	23.53	-43	52.00	43.65	N	23.97	N	N
131	122.0	19.60	16.07	2	2.00	52.52	A	16.71	N	W
133	116.0	4.00	3.45	-3	4.00	17.55	A	5.74	A	A
137	96.0	2.00	2.08	-20	24.00	15.10	N	5.03	A	N
138	119.0	5.00	4.20	-1	1.00	19.18	A	6.22	A	A
140	137.3	34.80	25.35	14	17.30	90.90	A	25.76	N	W
144	37.8	0.34	0.90	-69	82.20	14.22	N	4.67	A	N
145	1990	132.0	6.63	1558	1870	340.8	N	8.06	A	N
147	478.0	49.10	10.27	298	358.0	127.4	N	11.25	A	N
149	117.0	4.00	3.42	-3	3.00	17.55	A	5.72	A	A
150	0.1	0.00	1.00	-100	119.9	14.19	N	4.69	A	N
151	161.0	25.00	15.53	34	41.00	66.04	A	16.19	N	N
156	112.0	6.00	5.36	-7	8.00	21.00	A	7.05	A	A
158	127.0	4.00	3.15	6	7.00	17.55	A	5.56	A	A
160	248.1	0.37	0.15	107	128.0	14.22	N	4.59	A	N
161	71.3	6.58	9.24	-41	48.75	22.13	N	10.31	A	N
162	117.0	4.00	3.42	-3	3.00	17.55	A	5.72	A	A
163	122.0	14.00	11.48	2	2.00	38.81	A	12.36	A	A
165	119.0	6.00	5.04	-1	1.00	21.00	A	6.81	A	A
166	150.0	37.00	24.67	25	30.00	96.51	A	25.09	N	N
167	127.0	10.00	7.87	6	7.00	29.44	A	9.11	A	A
168	140.0	4.00	2.86	17	20.00	17.55	N	5.40	A	N
173	17.7	2.82	15.98	-85	102.3	15.95	N	16.62	N	N
176	687.0	7.00	1.02	473	567.0	22.97	N	4.70	A	N
177	153.0	8.00	5.23	28	33.00	25.05	N	6.95	A	N

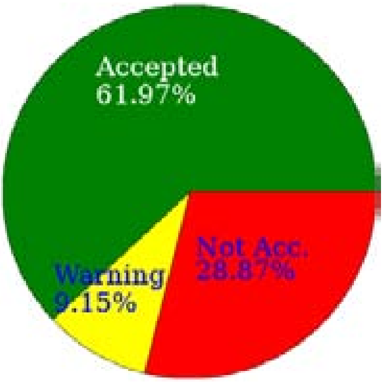
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
178	103.0	9.00	8.74	-14	17.00	27.21	A	9.87	A	A
181	121.9	5.10	4.18	2	1.90	19.35	A	6.21	A	A
186	113.0	14.00	12.39	-6	7.00	38.81	A	13.21	A	A
187	120.0	7.00	5.83	0	0.00	22.97	A	7.42	A	A
188	137.9	10.65	7.72	15	17.90	30.92	A	8.98	A	A
191	113.0	18.00	15.93	-6	7.00	48.56	A	16.58	N	W
193	104.0	10.00	9.62	-13	16.00	29.44	A	10.65	A	A
194	112.5	8.09	7.19	-6	7.47	25.24	A	8.53	A	A
196	126.4	11.65	9.21	5	6.44	33.24	A	10.29	A	A
197	240.0	50.00	20.83	100	120.0	129.7	A	21.33	N	N
200	109.7	13.50	12.31	-9	10.30	37.61	A	13.13	A	A
201	119.0	2.00	1.68	-1	1.00	15.10	A	4.88	A	A
202	116.4	4.90	4.21	-3	3.60	19.00	A	6.22	A	A
204	135.0	4.00	2.96	13	15.00	17.55	A	5.46	A	A
234	99.8	4.10	4.11	-17	20.20	17.70	N	6.16	A	N
235	103.0	50.00	48.54	-14	17.00	129.7	A	48.76	N	W
236	119.1	3.50	2.94	-1	0.90	16.82	A	5.44	A	A
238	86.2	4.70	5.45	-28	33.80	18.67	N	7.12	A	N
241	129.0	6.00	4.65	8	9.00	21.00	A	6.53	A	A
250	155	17	11.0	29	35	46.1	A	11.89	A	A
255	97.9	15	15.3	-18	22.1	41.22	A	15.99	N	N
260	98	6	6.1	-18	22	21	N	7.65	A	N
261	102	16	15.7	-15	18	43.65	A	16.34	N	N
263	124	13	10.5	3	4	36.42	A	11.44	A	A
264	138	17.2	12.5	15	18	46.59	A	13.28	A	A
266	95	4.9	5.2	-21	25	19	N	6.9	A	N
267	130	5	3.9	8	10	19.18	A	5.98	A	A
271	127.4	7.03	5.5	6	7.4	23.03	A	7.17	A	A
272	722	35	4.8	502	602	90.44	N	6.63	A	N
273	106.9	18.8	17.6	-11	13.1	50.54	A	18.17	N	W
274	121	11	9.1	1	1	31.73	A	10.18	A	A
275	112	7	6.3	-7	8	22.97	A	7.75	A	A
276	118.6	4.0	3.4	-1	1.4	17.61	A	5.71	A	A
277	127	3.2	2.5	6	7	16.42	A	5.23	A	A
278	119	8	6.7	-1	1	25.05	A	8.14	A	A
282	123	12	9.8	3	3	34.06	A	10.78	A	A
283	96	10	10.4	-20	24	29.44	A	11.38	A	A
286	123.2	8.2	6.7	3	3.2	25.47	A	8.08	A	A
288	123	6	4.9	3	3	21	A	6.69	A	A
294	56	3.5	6.3	-53	64	16.82	N	7.75	A	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
296	126	3	2.4	5	6	16.16	A	5.16	A	A
297	110	11	10.0	-8	10	31.73	A	11	A	A
298	120	10	8.3	0	0	29.44	A	9.51	A	A
299	113.7	23.5	20.6	-5	6.31	62.17	A	21.14	N	W

Performance evaluation of Pb-210 measurement results

Phosphogypsum IAEA-434 sample 6

Target Value: 680.0 ± 29.0 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True.	P	Prec.	Final Score
1	577	87	15.1	-15	103	237	A	15.67	N	N
3	637	7	1.1	-6	44	77	A	4.39	A	A
4	629	35	5.6	-8	51	117	A	7.01	A	A
6	549	20	3.6	-19	131	91	N	5.59	A	N
7	765	15	2.0	13	85	84	N	4.69	A	W
9	692	104	15.0	2	12	279	A	15.62	N	W
13	538	45	8.3	-21	142	138	N	9.37	A	N
14	768	33	4.3	13	88	113	A	6.05	A	A
18	781	23	2.9	15	101	95	N	5.18	A	W
19	403	24	6.0	-41	277	97	N	7.32	A	N
20	645	114	17.7	-5	35	303	A	18.18	N	W
22	705	49	7.0	4	25	147	A	8.18	A	A
23	662	29	4.4	-3	18	106	A	6.11	A	A
28	632	34	5.4	-7	48	115	A	6.87	A	A
29	844	67	7.9	24	164	188	A	9.01	A	A
30	243851	3576	1.5	358504	2437	9226	N	4.51	A	N
31	842	98	11.6	24	162	264	A	12.4	A	A
32	670	30	4.5	-1	10	108	A	6.18	A	A
33	639	34	5.3	-6	41	115	A	6.82	A	A
36	650	36	5.5	-4	30	119	A	6.99	A	A
37	764	91	11.9	12	84	246	A	12.65	A	A
38	597	42	7.1	-12	83	133	A	8.29	A	A
40	47	13	27.3	-93	633	82	N	27.64	N	N
42	848	40	4.7	25	168	127	N	6.36	A	N
43	670	68	10.1	-1	10	190	A	10.97	A	A
44	765	60	7.8	13	85	172	A	8.93	A	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True.	P	Prec.	Final Score
45	555	12	2.2	-18	125	81	N	4.78	A	N
47	714	43	6.0	5	34	133	A	7.32	A	A
49	741	51	6.8	9	61	150	A	8.04	A	A
50	657	58	8.8	-3	23	166	A	9.73	A	A
52	720	131	18.2	6	40	346	A	18.69	N	W
53	826	12	1.4	22	146	81	N	4.5	A	N
54	803	58	7.2	18	123	167	A	8.36	A	A
56	541	173	32.0	-21	139	452	A	32.27	N	N
59	601	23	3.8	-12	79	95	A	5.73	A	A
62	650	200	30.8	-4	30	521	A	31.06	N	W
64	737	88	11.9	8	57	239	A	12.68	A	A
67	591	49	8.3	-13	89	147	A	9.32	A	A
68	649	25	3.9	-5	31	99	A	5.75	A	A
69	660	28	4.2	-3	20	104	A	6.02	A	A
70	661	30	4.5	-3	19	108	A	6.23	A	A
72	746	52	7.0	10	66	154	A	8.17	A	A
74	858	95	11.1	26	178	256	A	11.87	A	A
77	545	10	1.8	-20	135	79	N	4.64	A	N
80	622	27	4.3	-9	58	102	A	6.09	A	A
81	671	32	4.8	-1	9	111	A	6.4	A	A
82	530	130	24.5	-22	150	344	A	24.9	N	N
84	90	7	7.9	-87	590	77	N	8.94	A	N
85	1394	208	14.9	105	714	542	N	15.52	N	N
89	810	30	3.7	19	130	108	N	5.65	A	N
91	517	81	15.7	-24	163	222	A	16.24	N	N
92	778	17	2.2	14	98	87	N	4.79	A	W
93	792	43	5.4	16	112	133	A	6.85	A	A
94	536	52	9.8	-21	144	154	A	10.64	A	A
95	515	62	12.0	-24	165	176	A	12.74	A	A
96	740	60	8.1	9	60	172	A	9.16	A	A
97	659	89	13.5	-3	21	242	A	14.16	A	A
98	775	90	11.6	14	95	244	A	12.37	A	A
99	594	10	1.8	-13	86	80	N	4.61	A	W
101	780	50	6.4	15	100	149	A	7.7	A	A
103	808	43	5.3	19	128	134	A	6.82	A	A
104	315	33	10.5	-54	365	113	N	11.31	A	N
106	759	33	4.4	12	79	113	A	6.09	A	A
107	637	70	11.0	-6	43	196	A	11.83	A	A
108	163	0	0.2	-76	516	75	N	4.27	A	N
110	751	112	14.9	10	71	299	A	15.51	N	W

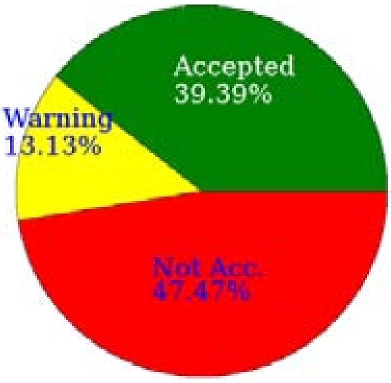
Lab code	**Rep. Value**	**Rep. Unc.**	**Unc. [%]**	**Rel. Bias**	**A1**	**A2**	**True.**	**P**	**Prec.**	**Final Score**
111	720	72	10.0	6	40	201	A	10.87	A	A
113	709	43	6.1	4	29	134	A	7.42	A	A
114	720	70	9.7	6	40	196	A	10.62	A	A
118	490	5	1.0	-28	190	76	N	4.39	A	N
119	680	65	9.6	0	0	183	A	10.47	A	A
120	646	47	7.3	-5	34	143	A	8.43	A	A
124	495	33	6.7	-27	185	114	N	7.96	A	N
125	653	255	39.1	-4	27	662	A	39.28	N	W
126	707	10	1.4	4	27	79	A	4.48	A	A
128	738	71	9.6	9	58	198	A	10.52	A	A
129	445	40	9.0	-35	235	128	N	9.95	A	N
131	533	125	23.4	-22	147	331	A	23.78	N	N
133	633	39	6.2	-7	47	126	A	7.49	A	A
136	764	30	3.9	12	84	108	A	5.8	A	A
137	600	40	6.7	-12	80	127	A	7.91	A	A
140	716	45	6.3	5	36	139	A	7.64	A	A
144	2	2	117.8	-100	678	75	N	117.6	N	N
145	603	55	9.1	-11	77	161	A	10.09	A	A
149	650	20	3.1	-4	30	91	A	5.26	A	A
151	748	83	11.1	10	68	226	A	11.89	A	A
156	1	0	10.7	-100	679	75	N	11.53	A	N
157	452	79	17.5	-34	228	217	N	17.99	N	N
158	648	28	4.3	-5	32	104	A	6.07	A	A
160	576	10	1.8	-15	104	79	N	4.62	A	N
161	687	36	5.2	1	7	118	A	6.71	A	A
162	639	20	3.1	-6	41	91	A	5.29	A	A
163	696	12	1.7	2	16	81	A	4.6	A	A
164	703	99	14.1	3	23	267	A	14.71	A	A
166	640	96	15.0	-6	40	258	A	15.59	N	W
167	738	35	4.7	9	58	118	A	6.38	A	A
173	820	35	4.3	21	140	118	N	6.03	A	N
177	665	60	9.0	-2	15	172	A	9.98	A	A
178	450	30	6.7	-34	230	108	N	7.91	A	N
181	628	21	3.4	-8	53	92	A	5.42	A	A
186	670	60	9.0	-1	10	172	A	9.92	A	A
187	730	15	2.1	7	50	84	A	4.73	A	A
188	4747	357	7.5	598	4067	924	N	8.64	A	N
191	256	45	17.6	-62	424	138	N	18.09	N	N
194	673	110	16.4	-1	8	294	A	16.93	N	W
196	739	58	7.9	9	59	168	A	8.98	A	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True.	P	Prec.	Final Score
197	870	40	4.6	28	190	128	N	6.27	A	N
200	389	7	1.9	-43	290	77	N	4.65	A	N
204	696	50	7.2	2	16	149	A	8.35	A	A
206	713	85	11.9	5	33	231	A	12.66	A	A
229	795	15	1.9	17	115	84	N	4.66	A	N
234	527	15	2.9	-23	153	84	N	5.13	A	N
235	668	36	5.4	-2	12	120	A	6.87	A	A
236	787	35	4.5	16	107	118	A	6.16	A	A
238	686	41	6.0	1	6	130	A	7.34	A	A
250	681	49	7	0	1	146	A	8.36	A	A
252	1276	105	8	88	596	281	N	9.27	A	N
259	840	50	6	24	160	149	N	7.32	A	N
260	870	180	21	28	190	470	A	21.12	N	N
261	627	82	13	-8	53	224	A	13.76	A	A
263	540	51	9	-21	140	151	A	10.36	A	A
264	742	609	82	9	62	1574	A	82.26	N	W
265	585	54	9	-14	95	158	A	10.17	A	A
266	744	91	12	9	64	245	A	12.90	A	A
267	662	23	3	-3	18	95	A	5.50	A	A
273	614	31	5	-10	67	109	A	6.59	A	A
274	681	62	9	0	1	176	A	10.05	A	A
276	572	28	5	-16	108	103	N	6.47	A	N
277	799	40	5	18	119	127	A	6.58	A	A
278	660	70	11	-3	20	195	A	11.43	A	A
283	804	50	6	18	124	149	A	7.54	A	A
288	640	21	3	-6	40	92	A	5.38	A	A
294	651	26	4	-4	29	100	A	5.84	A	A
296	682	17	2	0	2	86	A	4.94	A	A
297	670	23	3	-1	10	95	A	5.47	A	A
298	750	30	4	10	70	107	A	5.85	A	A
299	449	53	12	-34	231	154	N	12.45	A	N

Performance evaluation of Th-230 measurement results

Phosphogypsum IAEA-434 sample 6

Target Value: 211.0 ± 4.5 [Bq kg^{-1}]



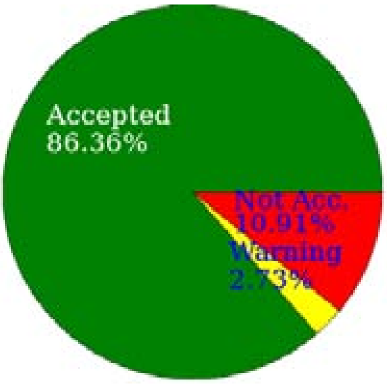
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
1	273	25	9	29	62.0	65.5	A	9.4	A	A
4	298	50	17	41	87.0	129.5	A	16.9	N	N
6	258	16	6	22	47.0	43.4	N	6.6	A	N
8	108	5	4	-49	103.0	16.4	N	4.7	A	N
13	263	43	16	25	52.3	110.3	A	16.3	N	N
14	115	20	17	-46	96.0	52.9	N	17.5	N	N
19	196	6	3	-7	15.0	19.4	A	3.7	A	A
22	132	3	3	-37	78.7	14.6	N	3.3	A	N
23	188	29	15	-11	23.0	75.7	A	15.6	N	W
28	256	35	14	21	45.0	91.0	A	13.8	A	A
29	290	88	30	37	79.0	227.3	A	30.4	N	N
30	1207	5	0	472	995.5	17.4	N	2.2	A	N
32	270	45	17	28	59.0	116.7	A	16.8	N	N
33	232	42	18	10	21.0	109.0	A	18.2	N	W
36	185	56	30	-12	26.0	145.0	A	30.4	N	W
37	1	0	6	-100	210.2	11.6	N	5.9	A	N
39	347	16	5	64	136.0	44.1	N	5.2	A	N
43	339	63	19	61	128.0	163.2	A	18.7	N	N
45	164	31	19	-22	47.0	80.8	A	19.0	N	N
51	235	9	4	11	24.0	26.0	A	4.4	A	A
54	257	33	13	22	45.6	87.0	A	13.2	A	A
59	248	3	1	18	37.0	14.0	N	2.5	A	N
62	320	100	31	52	109.0	258.3	A	31.3	N	N
64	220	19	9	4	9.0	50.4	A	8.9	A	A
69	271	32	12	28	60.0	83.4	A	12.0	A	A
72	319	56	18	51	108.0	145.0	A	17.7	N	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
73	183	4	2	-13	28.0	15.0	N	2.9	A	W
77	245	11	4	16	34.0	30.7	N	5.0	A	N
80	232	10	4	10	21.0	28.3	A	4.8	A	A
81	264	35	13	25	53.0	91.0	A	13.4	A	A
84	232	11	5	10	21.0	31.3	A	5.3	A	A
85	241	54	22	14	29.6	138.8	A	22.4	N	W
91	517	151	29	145	306.0	389.8	A	29.3	N	N
92	207	4	2	-2	4.0	15.5	A	2.9	A	A
93	320	31	10	52	109.0	80.8	N	9.9	A	N
94	164	34	21	-22	46.6	88.2	A	20.7	N	N
95	112	9	8	-47	98.9	25.9	N	8.3	A	N
97	167	25	15	-21	44.0	65.5	A	15.1	N	N
99	264	16	6	25	52.9	43.1	N	6.5	A	N
101	370	80	22	75	159.0	206.7	A	21.7	N	N
103	222	10	5	5	11.0	28.3	A	5.0	A	A
106	265	58	22	26	54.0	150.1	A	22.0	N	N
108	381	3	1	80	169.8	13.7	N	2.3	A	N
110	200	50	25	-5	11.0	129.5	A	25.1	N	W
111	410	58	14	94	199.0	150.1	N	14.3	A	N
113	322	28	9	53	110.8	71.9	N	8.8	A	N
114	120	11	9	-43	91.0	30.7	N	9.4	A	N
119	240	45	19	14	29.0	116.7	A	18.9	N	W
120	230	39	17	9	19.0	101.3	A	17.1	N	W
125	234	26	11	11	22.5	67.6	A	11.3	A	A
133	244	12	5	16	33.0	33.1	A	5.4	A	A
137	195	6	3	-8	16.0	19.4	A	3.7	A	A
140	261	35	13	24	49.7	91.3	A	13.6	A	A
144	40	2	4	-81	170.8	12.3	N	4.4	A	N
145	1992	563	28	844	1780	1452	N	28.4	N	N
149	235	27	11	11	24.0	70.6	A	11.7	A	A
150	0	0	13	-100	210.7	11.6	N	13.6	A	N
151	250	70	28	18	39.0	181.0	A	28.1	N	N
158	210	10	5	0	1.0	28.3	A	5.2	A	A
160	251	6	2	19	39.8	19.2	N	3.2	A	N
161	312	15	5	48	100.5	39.2	N	5.1	A	N
162	227	23	10	8	16.0	60.5	A	10.4	A	A
163	314	33	11	49	103.0	85.9	N	10.7	A	N
176	687	7	1	226	476.0	21.5	N	2.4	A	N
177	230	18	8	9	19.0	47.9	A	8.1	A	A
186	211	35	17	0	0.0	91.0	A	16.7	N	W

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	A1	A2	True	P	Prec	Final Score
187	206	7	3	-2	4.7	20.6	A	3.8	A	A
188	242	37	15	15	31.0	96.6	A	15.5	N	W
191	419	170	41	99	208.0	438.8	A	40.6	N	N
193	119	13	11	-44	92.0	35.5	N	11.1	A	N
194	234	10	4	11	23.1	29.2	A	4.9	A	A
196	210	15	7	0	0.8	39.8	A	7.3	A	A
200	311	28	9	47	100.1	72.9	N	9.2	A	N
201	196	9	5	-7	15.0	26.0	A	5.1	A	A
202	200	12	6	-5	11.0	33.1	A	6.4	A	A
229	450	130	29	113	239.0	335.6	A	29.0	N	N
234	230	12	5	9	19.0	33.1	A	5.6	A	A
235	320	65	20	52	109.0	168.1	A	20.4	N	N
236	235	10	4	11	24.0	28.3	A	4.8	A	A
250	158	19	12	-25	53	50.4	N	12.2	A	N
259	270	16	6	28	59	42.9	N	6.3	A	N
260	204	14	7	-3	7	37.9	A	7.2	A	A
261	182	82	45	-14	29	211.9	A	45.1	N	W
263	222	30	14	5	11	78.3	A	13.7	A	A
266	271.2	9.1	3	29	60.2	26.2	N	4.0	A	N
271	211.0	6.3	3	0	0.02	19.9	A	3.7	A	A
273	219.1	17	8	4	8.1	45.4	A	8.1	A	A
274	216	20	9	2	5	52.9	A	9.5	A	A
275	219	15	7	4	8	40.4	A	7.2	A	A
276	237	6.5	3	12	26	20.4	N	3.5	A	W
277	227	9.6	4	8	16	27.4	A	4.7	A	A
278	195	18	9	-8	16	47.9	A	9.5	A	A
282	129	30	23	-39	82	78.3	N	23.4	N	N
288	247	25	10	17	36	65.5	A	10.3	A	A
294	204	37	18	-3	7	96.2	A	18.3	N	W
297	207	20	10	-2	4	52.9	A	9.9	A	A
298	270	40	15	28	59	103.9	A	15.0	A	A
299	113.7	23.5	21	-46	97.31	61.6	N	20.7	N	N

Performance evaluation gross alpha measurement results

Water Sample 3 (Blank water)



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	F	Final Score
1	0.14	0.05	35.71	0.04	A
2	0.06	0.02	25.40	0.02	A
3	<0.032				A
4	0.09	0.02	22.22	0.05	A
5	0.16	0.07	45.63	0.02	A
6	0.08	0.04	51.85	0	A
11	0.20	0.50	250.00	-0.8	A
13	0.10	0.01	9.52	0.08	A
14	0.07	0.06	85.71	-0.05	A
15	0.10	0.02	22.11	0.06	A
18	0.63	0.06	9.52	0.51	N
20	<0.30				A
21	0.15	0.03	19.48	0.09	A
22	0.09	0.02	24.14	0.05	A
23	0.15	0.03	21.33	0.09	A
26	0.11	0.06	54.55	-0.01	A
30	18370.0	480.00	2.61	17410	N
32	0.11	0.06	54.55	-0.01	A
33	0.08	0.02	20.00	0.04	A
37	0.18	0.07	38.89	0.04	A
38	0.23	0.12	50.22	-0.01	A
39	0.09			0.09	A
40	1.13	1.00	88.50	-0.87	A
42	0.39	0.08	19.95	0.23	W
43	0.24	0.05	20.83	0.14	A
44	0.12	0.04	33.33	0.04	A
45	0.31	0.10	31.17	0.11	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	F	Final Score
46	0.11	0.02	14.55	0.07	A
50	0.14	0.05	37.76	0.04	A
51	0.11	0.01	6.19	0.09	A
53	0.07	0.01	22.73	0.05	A
54	0.16	0.05	31.25	0.06	A
56	0.07	0.01	18.57	0.05	A
57	0.00			0	A
58	0.01	0.09	843.81	-0.17	A
59	0.18	0.04	23.37	0.1	A
60	0.00	0.05		-0.1	A
62	0.16	0.09	56.25	-0.02	A
63	0.04	0.01	23.81	0.02	A
64	0.05	0.14	276.00	-0.23	A
67	0.11	0.01	11.93	0.09	A
68	0.05	0.05	100.00	-0.05	A
69	0.10	0.03	29.52	0.04	A
70	0.13	0.02	15.38	0.09	A
72	0.23	0.05	21.74	0.13	A
78	0.20	0.05	25.00	0.1	A
79	18.87	1.43	7.58	16.01	N
80	0.12	0.02	16.67	0.08	A
81	0.02	0.02	100.00	-0.02	A
82	<0.0895				A
84	0.07	0.04	51.67	-0.01	A
85	0.12	0.09	75.00	-0.06	A
86	0.07	0.01	18.46	0.05	A
91	<0.3				A
92	0.05	0.01	14.81	0.03	A
93	0.16	0.02	10.63	0.12	A
94	0.50	0.08	16.13	0.34	N
95	0.01	0.01	50.00	-0.01	A
97	0.70	0.20	28.57	0.3	W
101	<1.4				A
102	0.44	0.05	11.36	0.34	N
103	3.42	0.04	1.17	3.34	N
105	0.13	0.05	38.46	0.03	A
107	0.16	0.06	39.24	0.04	A
113	0.13	0.05	38.46	0.03	A
114	0.13	0.02	15.38	0.09	A
124	0.00	0.00	418.18	0	A

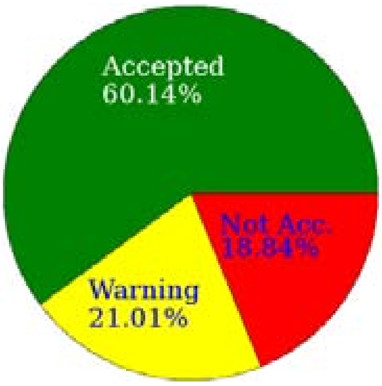
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	F	Final Score
125	0.09	0.02	22.22	0.05	A
128	0.02	0.00	12.50	0.02	A
132	0.16	0.12	70.73	-0.08	A
133	0.10	0.02	20.00	0.06	A
134	0.01	0.10	1000.00	-0.19	A
136	0.21	0.07	33.33	0.07	A
138	2.18	0.23	10.55	1.72	N
143	0.00			0	A
144	0.09	0.03	34.78	0.03	A
156	0.14	0.02	14.29	0.1	A
157	1.65	0.13	7.82	1.39	N
160	0.10	0.03	29.81	0.04	A
161	0.11	0.16	145.45	-0.21	A
165	<0.5				A
167	0.17	0.04	23.53	0.09	A
169	0.09	0.04	44.44	0.01	A
173	0.20	0.05	26.13	0.1	A
176	0.54	0.31	57.41	-0.08	A
186	0.09	0.08	88.89	-0.07	A
188	0.04			0.04	A
191	0.78	0.15	19.23	0.48	N
193	0.07	0.10	142.86	-0.13	A
194	0.00	0.00		0	A
195	<1				A
196	0.49	0.10	19.96	0.29	W
200	0.19	0.01	6.91	0.17	A
201	0.07	0.04	57.14	-0.01	A
203	0.01	0.00	20.00	0.01	A
204	0.03	0.15	506.67	-0.27	A
206	0.10	0.20	200.00	-0.3	A
207	<0.047				A
209	0.09			0.09	A
219	<0.09				A
222	<0.55				A
234	0.04	0.09	209.76	-0.14	A
236	0.03			0.03	A
244	0.22	0.11	50.00	0	A
252	0.07	0.01	9.46	0.05	A
253	0.10	0.01	15.79	0.08	A
260	0.48	0.08	16.67	0.32	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	F	Final Score
261	0.20			0.2	A
264	0.04	0.00	11.14	0.04	A
265	0.03	0.00	16.00	0.03	A
266	0.06	0.00	1.69	0.06	A
267	0.19	0.01	5.26	0.17	A
271	0.41	0.15	37.11	0.11	A
273	2.63	0.74	28.14	1.15	N
274	0.06	0.01	20.63	0.04	A
276	0.19	0.03	17.19	0.13	A
278	0.23	0.19	82.61	-0.15	A
282	0.04	0.01	17.50	0.02	A
286	0.27	0.15	55.56	-0.03	A
288	0.28	0.15	53.57	-0.02	A
294	0.09	0.02	24.18	0.05	A
297	0.20	0.40	200.00	-0.6	A
298	26.50	3.50	13.21	19.5	N
299	0.18	0.03	17.30	0.12	A

Performance evaluation of gross alpha measurement results

Spiked water sample 4

Target Value: 3.93 ± 0.08 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
1	2.87	0.43	14.98	-26.97	A
2	1.06	0.11	10.60	-73.10	W
3	2.81	0.05	1.78	-28.50	A
4	2.91	0.46	15.81	-25.95	A
5	2.73	0.38	14.04	-30.41	A
6	4.05	0.46	11.26	3.05	A
8	1.55	0.20	12.90	-60.56	W
11	4.00	0.50	12.50	1.78	A
13	2.34	0.07	3.12	-40.46	A
14	3.60	0.10	2.78	-8.40	A
15	4.30	0.51	11.93	9.41	A
18	3.48	0.27	7.76	-11.45	A
20	4.07	0.66	16.22	3.56	A
21	3.01	0.44	14.62	-23.41	A
22	2.25	0.30	13.32	-42.70	A
23	2.31	0.14	6.06	-41.22	A
26	1.04	0.20	19.23	-73.54	W
30	12430	410.00	3.30	316184	N
32	3.50	1.00	28.57	-10.94	A
33	1.87	0.08	4.28	-52.42	W
37	3.29	0.31	9.42	-16.28	A
38	1.93	0.15	7.77	-50.89	W
39	0.15	0.06	40.00	-96.18	N
40	2.80	1.00	35.71	-28.75	A
42	2.20	0.18	8.11	-44.12	A
43	3.26	0.34	10.43	-17.05	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
44	2.94	0.06	2.04	-25.19	A
45	3.17	0.66	20.82	-19.34	A
46	4.45	0.52	11.64	13.23	A
47	1.13	0.10	9.03	-71.25	W
49	1.88	0.55	29.26	-52.16	W
50	2.90	0.42	14.48	-26.21	A
51	2.70	0.10	3.70	-31.30	A
53	0.75	0.04	4.67	-80.92	N
54	2.57	0.59	22.96	-34.61	A
56	1.39	0.04	2.59	-64.68	W
57	2.50	0.10	4.00	-36.39	A
58	2.88	0.06	2.24	-26.80	A
59	3.18	0.34	10.69	-19.08	A
60	2.94	0.09	2.92	-25.11	A
62	3.40	0.90	26.47	-13.49	A
63	0.15	0.02	15.58	-96.08	N
64	3.03	0.24	7.92	-22.90	A
67	3.18	0.14	4.40	-19.08	A
68	1.80	0.10	5.56	-54.20	W
69	2.54	0.11	4.33	-35.37	A
70	2.87	0.10	3.48	-26.97	A
72	2.63	0.37	14.07	-33.08	A
78	3.74	0.27	7.22	-4.83	A
80	2.66	0.21	7.89	-32.32	A
81	0.02	0.02	100.00	-99.49	N
82	2.47	0.22	8.91	-37.15	A
84	2.86	0.20	7.03	-27.23	A
85	0.57	0.35	61.40	-85.50	N
86	1.90	0.20	10.53	-51.65	W
91	2.50	0.70	28.00	-36.39	A
92	1.17	0.02	2.06	-70.36	W
93	3.20	0.07	2.34	-18.58	A
94	3.30	0.24	7.42	-15.95	A
95	1.63	0.10	6.03	-58.63	W
97	2.60	0.25	9.62	-33.84	A
101	0.25	0.05	20.00	-93.64	N
102	3.66	0.14	3.83	-6.87	A
103	1.19	0.02	1.68	-69.72	W
105	3.14	0.10	3.18	-20.10	A
107	2.64	0.28	10.55	-32.93	A

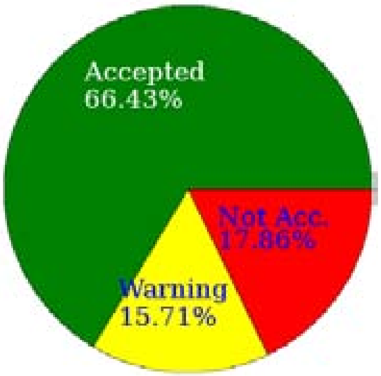
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
113	0.27	0.07	25.93	-93.13	N
114	3.10	0.30	9.68	-21.12	A
119	1.77	0.15	8.47	-54.96	W
124	0.00	0.00	268.78	-100.00	N
125	1.50	0.10	6.67	-61.83	W
126	2.68	0.83	30.97	-31.81	A
128	0.04	0.01	11.36	-98.88	N
132	1.22	0.07	5.86	-68.96	W
133	1.00	0.20	20.00	-74.55	W
134	0.61	0.15	24.59	-84.48	N
136	4.10	0.30	7.32	4.33	A
138	1.72	0.20	11.63	-56.23	W
143	0.16	0.03	18.75	-95.93	N
144	1.25	0.10	8.14	-68.12	W
154	2.56	0.37	14.45	-34.83	A
156	2.90	0.20	6.90	-26.21	A
157	5.19	0.31	5.89	32.09	A
158	0.99	0.23	23.23	-74.81	W
160	0.24	0.07	29.75	-93.84	N
161	3.83	0.53	13.84	-2.54	A
164	2.55	0.53	20.78	-35.11	A
165	1.44	0.04	2.78	-63.36	W
167	3.41	0.12	3.52	-13.23	A
169	2.87	0.21	7.32	-26.97	A
173	2.85	0.57	20.00	-27.48	A
176	5.60	1.10	19.64	42.49	A
177	5.33	0.56	10.51	35.62	A
186	3.50	0.51	14.57	-10.94	A
187	3.09	0.27	8.74	-21.37	A
188	0.04		710.53	-99.03	N
191	1.86	0.23	12.37	-52.67	W
193	1.63	0.28	17.18	-58.52	W
194	0.40	0.20	50.00	-89.82	N
195	2.80	0.60	21.43	-28.75	A
196	2.95	0.26	8.91	-24.86	A
197	1.10	0.04	3.64	-72.01	W
200	3.30	0.08	2.48	-15.95	A
201	1.89	0.11	5.82	-51.91	W
202	2.51	0.18	7.17	-36.13	A
203	0.69	0.11	15.94	-82.44	N

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
204	1.60	0.17	10.63	-59.29	W
206	2.30	0.41	17.83	-41.48	A
207	0.78	0.07	8.68	-80.08	N
209	2.14	0.19	8.88	-45.55	A
219	0.85	0.04	4.71	-78.37	N
222	12.40	0.50	4.03	215.52	N
234	2.07	0.29	14.01	-47.33	A
236	2.00	0.03	1.50	-49.11	A
238	2.66	0.38	14.14	-32.32	A
244	2.81	0.76	27.05	-28.50	A
252	1.78	0.18	10.11	-54.71	W
253	2.39	0.09	3.77	-39.19	A
260	3.10	0.30	9.68	-21.12	A
261	2.20	0.40	18.18	-44.02	A
264	0.72	0.04	5.90	-81.64	N
265	0.80	0.01	1.88	-79.67	N
266	1.31	0.02	1.53	-66.67	W
267	2.29	0.08	3.49	-41.73	A
271	2.61	0.72	27.44	-33.61	A
273	8.00	1.80	22.50	103.56	N
274	0.82	0.08	10.02	-79.19	N
276	2.03	0.10	5.17	-48.37	A
278	3.15	0.77	24.44	-19.85	A
282	0.97	0.15	14.99	-75.22	N
286	2.41	0.37	15.35	-38.68	A
288	4.95	1.24	25.05	25.95	A
294	2.91	0.08	2.68	-26.03	A
297	15.90	1.99	12.52	304.58	N
298	8.90	1.90	21.35	126.46	N
299	2.38	0.24	10.00	-39.44	A

Performance evaluation of gross alpha measurement results

Spiked water sample 5

Target Value: 7.68 ± 0.15 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
1	6.99	1.05	15.02	-8.98	A
2	2.29	0.23	10.27	-70.21	W
3	6.09	0.15	2.46	-20.70	A
4	6.97	1.08	15.49	-9.24	A
5	5.50	0.58	10.57	-28.33	A
6	7.29	0.08	1.12	-5.08	A
8	4.10	0.30	7.32	-46.61	A
11	9.60	0.50	5.21	25.00	A
13	5.46	0.14	2.56	-28.91	A
14	8.30	0.20	2.41	8.07	A
15	9.61	1.42	14.72	25.18	A
18	6.29	0.37	5.88	-18.10	A
20	7.97	1.02	12.80	3.78	A
21	6.00	0.85	14.17	-21.87	A
22	4.67	0.61	13.12	-39.17	A
23	5.05	0.21	4.16	-34.24	A
26	3.32	0.38	11.45	-56.77	W
30	11680.00	400.00	3.42	151983.3	N
32	6.40	2.00	31.25	-16.67	A
33	3.00	0.21	7.00	-60.94	W
37	6.78	0.58	8.55	-11.72	A
38	4.89	0.23	4.70	-36.33	A
39	0.46	0.04	8.70	-94.01	N
40	5.60	1.30	23.21	-27.08	A
42	3.91	0.24	6.11	-49.04	A
43	8.11	0.79	9.74	5.60	A

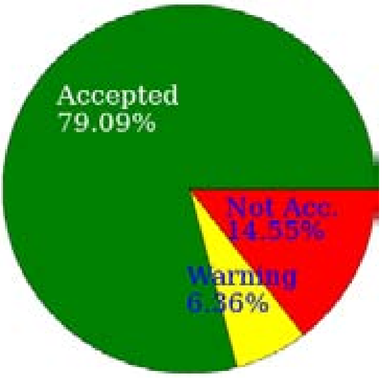
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
44	7.43	0.09	1.21	-3.26	A
45	5.51	1.10	19.96	-28.26	A
46	10.33	1.18	11.42	34.51	A
47	2.35	0.14	6.13	-69.40	W
49	3.44	0.62	18.02	-55.21	W
50	6.74	0.96	14.24	-12.24	A
51	6.50	0.10	1.54	-15.36	A
53	3.25	0.08	2.46	-57.68	W
54	5.33	1.18	22.14	-30.60	A
56	4.51	0.08	1.68	-41.22	A
57	5.40	0.10	1.85	-29.69	A
58	5.12	0.09	1.84	-33.37	A
59	9.10	1.20	13.19	18.49	A
60	6.19	0.08	1.34	-19.35	A
62	4.80	1.20	25.00	-37.50	A
63	0.24	0.07	27.98	-96.84	N
64	6.91	0.55	7.96	-10.03	A
67	5.68	0.27	4.75	-26.04	A
68	3.60	0.10	2.78	-53.13	W
69	5.75	0.20	3.48	-25.13	A
70	6.03	0.15	2.49	-21.48	A
72	5.59	0.50	8.94	-27.21	A
78	8.98	0.56	6.24	16.93	A
79	9.37	0.79	8.43	22.01	A
80	6.21	0.47	7.57	-19.14	A
81	0.02	0.02	100.00	-99.74	N
82	5.38	0.29	5.39	-29.95	A
84	6.39	0.35	5.56	-16.80	A
85	2.60	0.70	26.92	-66.15	W
86	4.60	0.50	10.87	-40.10	A
91	5.70	1.60	28.07	-25.78	A
92	3.44	0.04	1.16	-55.21	W
93	6.93	0.13	1.89	-9.77	A
94	6.91	0.47	6.82	-10.07	A
95	3.50	0.21	6.01	-54.47	W
97	4.80	0.30	6.25	-37.50	A
101	0.53	0.11	20.75	-93.10	N
102	7.33	3.59	48.98	-4.56	A
103	0.06	0.01	14.55	-99.28	N
105	7.17	0.16	2.23	-6.64	A

Lab code	**Rep. Value**	**Rep. Unc.**	**Unc. [%]**	**Rel. Bias**	**Final Score**
107	5.49	0.52	9.38	-28.54	A
113	0.52	0.11	21.15	-93.23	N
114	7.20	0.50	6.94	-6.25	A
117	0.10	0.01	10.00	-98.70	N
119	5.48	0.35	6.39	-28.65	A
124	0.00	0.00	145.17	-100.00	N
125	2.50	0.18	7.20	-67.45	W
126	7.20	1.10	15.28	-6.25	A
128	0.04	0.00	8.57	-99.54	N
132	3.15	0.19	5.97	-58.98	W
133	3.90	0.60	15.38	-49.22	A
134	0.40	0.02	5.92	-94.86	N
136	7.20	0.50	6.94	-6.25	A
138	3.42	0.27	7.89	-55.47	W
143	0.57	0.05	8.77	-92.58	N
144	1.77	0.12	6.85	-76.99	N
154	5.26	0.55	10.51	-31.47	A
156	6.20	0.60	9.68	-19.27	A
157	4.17	0.28	6.74	-45.72	A
158	2.93	0.27	9.22	-61.85	W
160	0.60	0.18	30.03	-92.24	N
161	8.30	1.40	16.87	8.07	A
164	4.74	0.97	20.46	-38.28	A
165	5.25	0.15	2.86	-31.64	A
167	11.23	0.98	8.73	46.22	A
169	5.58	0.26	4.66	-27.34	A
173	5.43	0.84	15.55	-29.35	A
176	8.80	1.30	14.77	14.58	A
177	10.30	0.80	7.77	34.11	A
186	8.14	1.10	13.51	5.99	A
187	5.89	0.36	6.11	-23.31	A
188	0.04		947.37	-99.51	N
191	0.50	0.12	24.00	-93.49	N
193	1.78	0.30	16.85	-76.82	N
194	2.20	0.39	17.73	-71.35	W
195	6.80	0.80	11.76	-11.46	A
196	7.02	0.56	7.98	-8.59	A
197	5.21	0.09	1.73	-32.16	A
200	6.34	0.15	2.37	-17.45	A
201	3.79	0.15	3.96	-50.65	W

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
202	6.77	0.52	7.68	-11.85	A
203	2.58	0.24	9.30	-66.41	W
204	7.07	0.44	6.22	-7.94	A
206	6.85	0.75	10.95	-10.81	A
207	1.88	0.06	3.19	-75.52	N
209	3.91	0.29	7.42	-49.09	A
219	0.90	0.05	5.56	-88.28	N
222	28.45	1.09	3.83	270.44	N
234	5.79	0.51	8.81	-24.61	A
236	3.97	0.05	1.26	-48.31	A
238	6.34	0.53	8.41	-17.45	A
244	5.44	1.47	27.02	-29.17	A
252	1.77	0.18	10.17	-76.95	N
253	5.21	0.20	3.84	-32.16	A
260	7.40	0.60	8.11	-3.65	A
261	4.10	0.80	19.51	-46.61	A
264	2.12	0.11	5.34	-72.34	W
265	1.46	0.02	1.37	-80.99	N
266	2.90	0.04	1.38	-62.24	W
267	6.23	0.21	3.37	-18.88	A
271	13.12	3.50	26.71	70.85	W
273	11.50	1.90	16.52	49.74	A
274	1.85	0.19	10.27	-75.91	N
276	4.76	0.20	4.26	-38.01	A
278	7.20	1.60	22.22	-6.25	A
282	3.48	0.51	14.66	-54.69	W
286	5.07	0.57	11.24	-33.98	A
288	9.89	1.48	14.96	28.78	A
294	6.57	0.14	2.13	-14.45	A
297	29.10	2.91	10.00	278.91	N
298	14.60	2.20	15.07	90.10	N
299	7.57	0.76	9.98	-1.39	A

Performance evaluation of gross beta measurement results

Water sample 3 (Blank water)



Lab code	Rep. Value	Reported Unc.	Unc. [%]	F	Final Score
2	0.11	0.02	18.92	0.07	A
5	0.12	0.04	30.00	0.04	A
6	0.28	0.08	28.34	0.12	A
11	0.20	0.50	250.00	-0.8	A
13	0.11	0.05	45.45	0.01	A
14	0.05	0.06	120.00	-0.07	A
15	0.16	0.02	13.92	0.12	A
18	0.74	0.08	10.81	0.58	N
20	<0.60				A
21	0.13	0.01	9.30	0.11	A
22	0.29	0.05	16.78	0.19	A
26	0.11	0.03	27.27	0.05	A
30	119650	840.00	0.70	117970	N
33	0.10	0.01	12.50	0.08	A
37	0.44	0.12	27.27	0.2	A
39	1.05			1.05	N
42	0.31	0.06	18.57	0.19	A
44	0.14	0.04	28.57	0.06	A
45	0.09	0.15	166.67	-0.21	A
46	0.15	0.02	11.11	0.11	A
50	0.14	0.05	33.33	0.04	A
51	0.17	0.06	36.84	0.05	A
53	0.12	0.02	17.39	0.08	A
54	0.16	0.04	25.00	0.08	A
56	0.13	0.02	16.42	0.09	A
57	6.10	1.10	18.03	3.9	N
58	0.08	0.12	157.65	-0.16	A
59	0.16	0.06	38.22	0.04	A

Lab code	Rep. Value	Reported Unc.	Unc. [%]	F	Final Score
60	0.10	0.02	23.71	0.06	A
62	0.20	0.04	20.00	0.12	A
64	0.97	1.47	151.55	-1.97	A
67	0.09	0.04	49.44	0.01	A
68	0.14	0.02	14.29	0.1	A
69	0.15	0.04	27.33	0.07	A
70	0.12	0.09	75.00	-0.06	A
72	0.21	0.04	19.05	0.13	A
78	0.30	0.07	23.33	0.16	A
79	1.75	0.15	8.57	1.45	N
80	0.10	0.04	33.65	0.02	A
81	0.32	0.07	21.88	0.18	A
82	<0.968				A
84	0.18	0.03	18.04	0.12	A
85	0.44	0.27	61.36	-0.1	A
86	0.12	0.03	25.00	0.06	A
91	<0.2				A
92	0.29	0.03	9.09	0.23	W
93	0.21	0.08	38.35	0.05	A
94	0.81	0.25	30.34	0.31	N
95	0.34	0.03	7.89	0.28	W
97	14.40	0.50	3.47	13.4	N
101	0.17	0.07	41.18	0.03	A
102	0.35	0.21	60.00	-0.07	A
103	36.55	0.10	0.27	36.35	N
105	0.24	0.06	25.00	0.12	A
107	0.06	0.02	36.36	0.02	A
108	2.07	0.07	3.38	1.93	N
114	0.50	0.08	16.00	0.34	N
124	0.00	0.00	183.77	0	A
125	0.10	0.03	30.00	0.04	A
132	0.20	0.23	115.66	-0.26	A
133	0.02	0.01	21.74	0	A
134	0.35	0.16	44.51	0.03	A
136	0.25	0.08	32.00	0.09	A
138	3.44	0.22	6.40	3	N
143	0.30	0.20	66.67	-0.1	A
144	0.04	0.09	222.22	-0.14	A
154	0.19	0.04	21.51	0.11	A
156	0.17	0.02	11.76	0.13	A

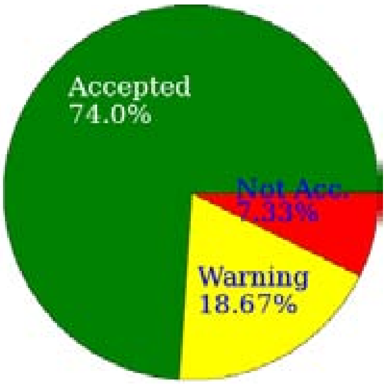
Lab code	Rep. Value	Reported Unc.	Unc. [%]	F	Final Score
157	0.16	0.02	12.10	0.12	A
160	0.06	0.02	30.00	0.02	A
161	0.07	0.65	928.57	-1.23	A
165	<1				A
167	0.21	0.05	23.81	0.11	A
169	0.14	0.09	64.29	-0.04	A
173	0.23	0.06	27.39	0.11	A
177	0.45	0.06	13.33	0.33	N
186	0.25	0.25	100.00	-0.25	A
188	0.36			0.36	A
191	0.50	0.12	24.00	0.26	W
193	0.04	0.04	100.00	-0.04	A
194	0.02	0.04	200.00	-0.06	A
195	<4				A
196	0.08	0.04	54.32	0	A
197	1.81	0.08	4.42	1.65	N
200	0.23	0.01	5.68	0.21	W
201	<0.032				A
203	0.12	0.01	8.33	0.1	A
204	0.19	0.18	98.40	-0.17	A
206	0.65	0.66	101.54	-0.67	A
207	0.12	0.02	18.18	0.08	A
208	<0.7				A
209	0.21			0.21	A
213	0.00			0	A
214	<0.67				A
216	0.61			0.61	N
217	<0.53				A
218	0.15	0.02	13.33	0.11	A
219	<0.29				A
221	<0.65				A
224	<0.28				A
227	<0.61				A
234	0.01	0.08	615.38	-0.15	A
236	0.22	0.04	18.18	0.14	A
238	0.13	0.46	352.67	-0.79	A
252	0.18	0.02	9.94	0	A
253	0.33	0.05	13.86	0.23	W
260	0.44	0.09	20.45	0.26	W
261	0.30			0.3	N

Lab code	Rep. Value	Reported Unc.	Unc. [%]	F	Final Score
264	0.15	0.01	6.26	0.13	A
265	0.14	0.01	9.35	0.12	A
266	0.12	0.00	1.67	0.12	A
267	0.17	0.23	135.29	-0.29	A
271	0.14	0.11	80.15	-0.08	A
273	2.11	0.42	19.91	1.27	N
274	0.19	0.03	14.97	0.13	A
275	14.00	5.00	35.71	4	N
276	0.25	0.02	8.30	0.21	W
278	0.28	0.15	53.57	-0.02	A
282	0.94	0.18	19.15	0.58	N
286	0.08	0.08	92.77	-0.08	A
288	0.29	0.12	41.38	0.05	A
294	0.31	0.09	29.97	0.13	A
297	0.20	1.10	550.00	-2	A
298	2.60	0.70	26.92	1.2	N
299	0.19	0.03	15.79	0.13	A

Performance evaluation of gross beta measurement results

Spiked water sample 4

Target Value: 15.7 ± 0.3 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
2	7.98	0.80	10.03	-49.19	W
5	14.89	1.01	6.82	-5.14	A
6	17.90	1.20	6.68	14.01	A
8	11.80	0.50	4.24	-24.84	A
11	14.00	0.50	3.57	-10.83	A
13	13.90	0.50	3.60	-11.46	A
14	12.40	0.20	1.61	-21.02	A
15	14.90	0.93	6.22	-5.10	A
18	8.84	0.94	10.63	-43.69	W
20	11.37	0.87	7.65	-27.58	A
21	10.61	0.85	8.01	-32.42	W
22	12.76	0.94	7.33	-18.73	A
26	4.87	0.30	6.16	-68.98	N
30	14393.0	900.00	6.25	91575.1	N
33	10.27	0.23	2.24	-34.59	W
35	10.80	1.63	15.09	-31.21	W
37	16.23	1.78	10.97	3.38	A
38	15.94	0.32	2.01	1.53	A
39	8.34	0.89	10.67	-46.88	W
42	7.41	0.17	2.27	-52.78	W
43	16.88	1.47	8.71	7.52	A
44	14.88	0.13	0.87	-5.22	A
45	10.42	0.31	2.98	-33.63	W
46	13.97	0.86	6.16	-11.02	A
47	13.90	0.24	1.71	-11.46	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
49	12.20	0.55	4.51	-22.29	A
50	15.09	0.51	3.38	-3.89	A
51	13.60	0.10	0.74	-13.38	A
53	13.35	0.11	0.82	-14.97	A
54	13.13	3.23	24.60	-16.37	A
56	14.65	0.19	1.32	-6.68	A
57	9.10	1.90	20.88	-42.04	W
58	6.68	0.14	2.10	-57.48	W
59	13.80	0.40	2.90	-12.10	A
60	7.22	0.08	1.10	-53.99	W
62	15.00	2.00	13.33	-4.46	A
64	11.80	1.10	9.32	-24.84	A
67	13.15	0.28	2.13	-16.24	A
68	12.90	0.10	0.78	-17.83	A
69	14.40	0.35	2.43	-8.28	A
70	12.60	0.70	5.56	-19.75	A
72	14.30	0.71	4.97	-8.92	A
78	28.40	1.67	5.88	80.89	N
79	11.98	0.65	5.43	-23.69	A
80	14.20	1.60	11.27	-9.55	A
81	16.39	0.22	1.34	4.39	A
82	11.94	0.94	7.87	-23.95	A
84	13.80	0.54	3.93	-12.10	A
85	11.40	0.80	7.02	-27.39	A
86	12.50	0.40	3.20	-20.38	A
91	11.20	0.80	7.14	-28.66	A
92	15.61	0.07	0.47	-0.55	A
93	11.85	0.34	2.86	-24.53	A
94	17.00	1.14	6.71	8.28	A
95	7.51	0.45	6.00	-52.15	W
97	31.30	0.50	1.60	99.36	N
99	11.70	1.15	9.83	-25.48	A
101	13.80	2.80	20.29	-12.10	A
102	13.02	0.58	4.45	-17.07	A
103	15.99	0.07	0.44	1.85	A
105	13.09	0.14	1.07	-16.62	A
107	17.21	0.60	3.47	9.65	A
108	12.53	0.15	1.20	-20.19	A
113	6.91	0.50	7.24	-55.99	W
114	13.50	1.10	8.15	-14.01	A

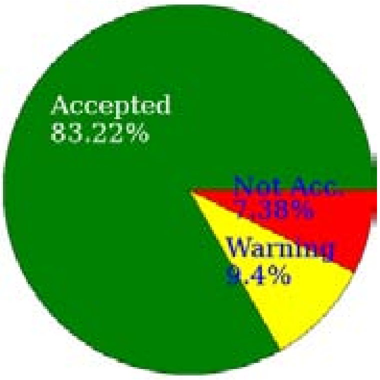
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
117	4.13	0.20	4.84	-73.69	N
119	15.65	0.90	5.75	-0.32	A
124	0.00	0.00	58.07	-99.99	N
125	8.90	0.40	4.49	-43.31	W
126	11.94	0.43	3.60	-23.95	A
132	14.20	0.16	1.11	-9.55	A
133	2.40	0.20	8.33	-84.71	N
134	20.76	2.45	11.80	32.23	W
136	17.30	0.90	5.20	10.19	A
138	14.28	0.43	3.01	-9.04	A
143	15.60	0.30	1.92	-0.64	A
144	22.38	0.39	1.76	42.52	W
145	10.13	1.69	16.68	-35.48	W
154	14.39	0.99	6.85	-8.36	A
156	11.10	0.80	7.21	-29.30	A
157	10.62	0.38	3.60	-32.38	W
158	12.00	1.40	11.67	-23.57	A
160	0.36	0.11	30.08	-97.71	N
161	13.30	0.50	3.76	-15.29	A
164	17.00	2.60	15.29	8.28	A
165	10.03	0.30	2.99	-36.11	W
167	14.62	0.87	5.95	-6.88	A
169	14.91	0.28	1.88	-5.03	A
173	14.46	2.89	20.00	-7.89	A
177	12.10	0.48	3.97	-22.93	A
186	16.00	2.30	14.37	1.91	A
187	10.35	0.79	7.63	-34.08	W
188	8.01	0.04	0.47	-48.98	W
191	0.53	0.13	24.53	-96.62	N
193	14.30	1.70	11.89	-8.92	A
194	11.40	0.81	7.11	-27.39	A
195	12.00	2.00	16.67	-23.57	A
196	11.81	0.65	5.50	-24.78	A
197	18.40	0.30	1.63	17.20	A
200	14.11	0.29	2.06	-10.13	A
201	11.72	0.11	0.94	-25.35	A
202	14.00	0.60	4.29	-10.83	A
203	9.61	0.84	8.74	-38.79	W
204	12.40	0.40	3.23	-21.02	A
206	16.20	1.00	6.17	3.18	A

Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
207	10.80	0.40	3.70	-31.21	W
208	14.60	1.20	8.22	-7.01	A
209	13.78	0.77	5.59	-12.23	A
213	13.10	0.60	4.58	-16.56	A
214	14.00	1.10	7.86	-10.83	A
216	13.00	1.10	8.46	-17.20	A
217	13.20	1.10	8.33	-15.92	A
218	12.50	0.70	5.60	-20.38	A
219	13.10	0.50	3.82	-16.56	A
220	12.07	0.93	7.71	-23.12	A
221	13.80	0.60	4.35	-12.10	A
224	12.00	0.93	7.75	-23.57	A
227	12.20	0.70	5.74	-22.29	A
234	11.40	0.48	4.21	-27.39	A
236	15.82	0.11	0.70	0.76	A
238	13.40	1.13	8.43	-14.65	A
244	10.58	2.85	26.94	-32.61	W
252	11.50	1.20	10.43	-26.75	A
253	12.95	0.45	3.47	-17.52	A
260	12.70	0.60	4.72	-19.11	A
261	11.40	1.60	14.04	-27.39	A
264	12.51	0.63	5.05	-20.30	A
265	13.50	0.06	0.44	-14.01	A
266	14.00	0.33	2.36	-10.83	A
267	13.70	0.40	2.92	-12.74	A
271	12.82	3.41	26.62	-18.34	A
273	15.50	2.50	16.13	-1.27	A
274	10.80	1.00	9.26	-31.21	W
275	36.00	5.00	13.89	129.30	N
276	12.45	0.46	3.72	-20.71	A
278	20.10	2.30	11.44	28.03	A
282	20.84	3.21	15.40	32.74	W
286	12.09	0.79	6.53	-22.99	A
288	13.50	2.30	17.04	-14.01	A
294	12.06	0.26	2.16	-23.18	A
297	11.70	1.75	14.96	-25.48	A
298	11.20	0.80	7.14	-28.66	A
299	12.82	0.57	4.47	-18.34	A

Performance evaluation of gross beta measurement results

Spiked water sample 5

Target Value: 30.7 ± 0.6 [Bq kg^{-1}]



Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
2	18.43	1.84	10.01	-39.97	W
5	33.46	1.95	5.83	9.00	A
6	33.30	2.77	8.30	8.47	A
8	27.10	1.00	3.69	-11.73	A
11	30.00	0.50	1.67	-2.28	A
13	32.45	1.16	3.57	5.70	A
14	28.60	0.30	1.05	-6.84	A
15	32.37	1.99	6.14	5.45	A
18	19.86	1.62	8.16	-35.31	W
20	26.70	1.39	5.21	-13.03	A
21	25.24	2.02	8.00	-17.79	A
22	29.99	2.12	7.06	-2.31	A
26	14.89	0.70	4.70	-51.50	W
30	92370	790.00	0.86	300779	N
33	22.70	0.48	2.11	-26.06	A
35	26.20	3.96	15.11	-14.66	A
37	39.37	4.30	10.92	28.24	A
38	35.69	0.46	1.29	16.25	A
39	23.68	1.42	6.00	-22.87	A
42	15.62	0.24	1.53	-49.10	W
43	37.93	3.22	8.49	23.55	A
44	35.78	0.19	0.53	16.55	A
45	28.54	0.60	2.10	-7.04	A
46	32.93	2.01	6.10	7.26	A
47	36.30	0.38	1.05	18.24	A

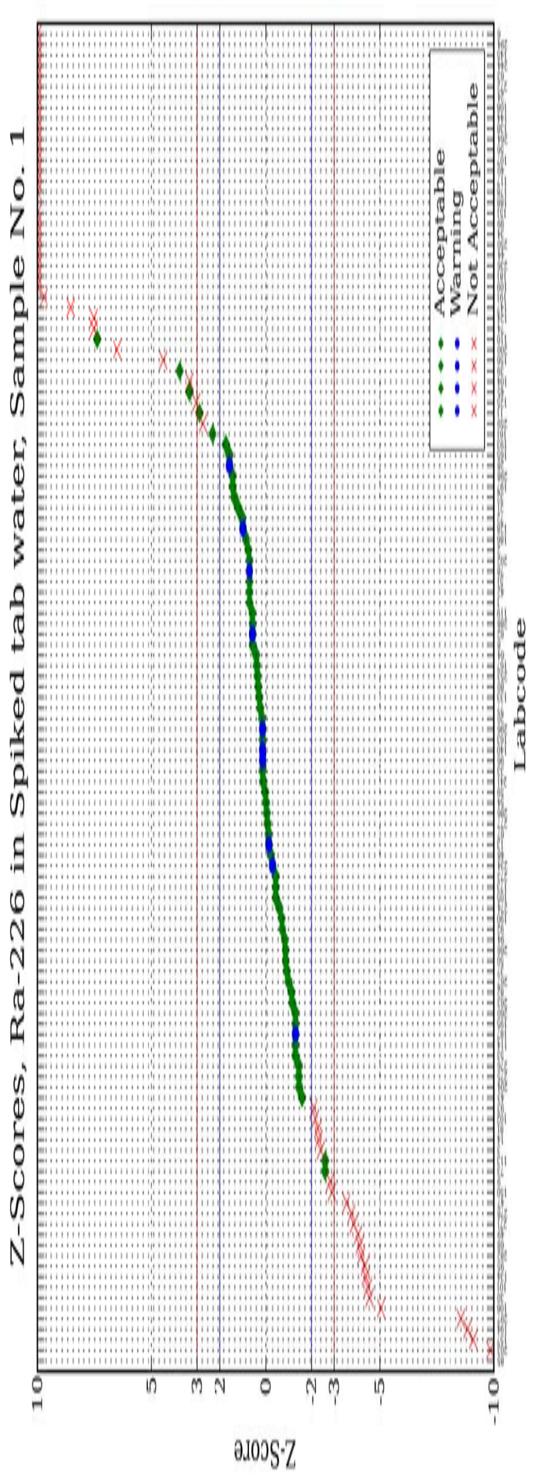
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
49	28.00	1.25	4.46	-8.79	A
50	35.64	1.18	3.31	16.09	A
51	32.50	0.10	0.31	5.86	A
53	30.90	0.15	0.49	0.65	A
54	32.32	7.89	24.41	5.28	A
56	36.78	0.46	1.24	19.82	A
57	23.80	3.80	15.97	-22.48	A
58	13.29	0.13	0.97	-56.72	W
59	33.00	1.20	3.64	7.49	A
60	14.60	0.17	1.15	-52.45	W
62	28.00	4.00	14.29	-8.79	A
64	28.50	2.40	8.42	-7.17	A
67	29.70	0.50	1.68	-3.26	A
68	28.20	0.10	0.35	-8.14	A
69	29.40	1.40	4.76	-4.23	A
70	30.00	1.60	5.33	-2.28	A
72	32.20	1.62	5.03	4.89	A
78	64.06	3.71	5.79	108.66	N
79	50.78	2.59	5.10	65.41	N
80	31.10	3.40	10.93	1.30	A
81	36.61	0.34	0.93	19.25	A
82	24.10	1.20	4.98	-21.50	A
84	32.20	1.22	3.79	4.89	A
85	34.90	1.30	3.72	13.68	A
86	31.30	0.90	2.88	1.95	A
91	26.20	1.50	5.73	-14.66	A
92	36.70	0.10	0.27	19.54	A
93	25.65	0.39	1.54	-16.46	A
94	37.02	2.40	6.48	20.59	A
95	18.56	1.11	5.98	-39.54	W
97	35.10	0.70	1.99	14.33	A
99	21.66	1.82	8.40	-29.45	A
101	34.00	7.00	20.59	10.75	A
102	32.53	1.16	3.57	5.96	A
103	0.29	0.03	10.34	-99.06	N
105	28.89	0.21	0.73	-5.90	A
107	37.91	1.29	3.40	23.50	A
108	18.69	0.29	1.55	-39.12	W
113	20.46	1.17	5.72	-33.36	W
114	32.20	2.50	7.76	4.89	A

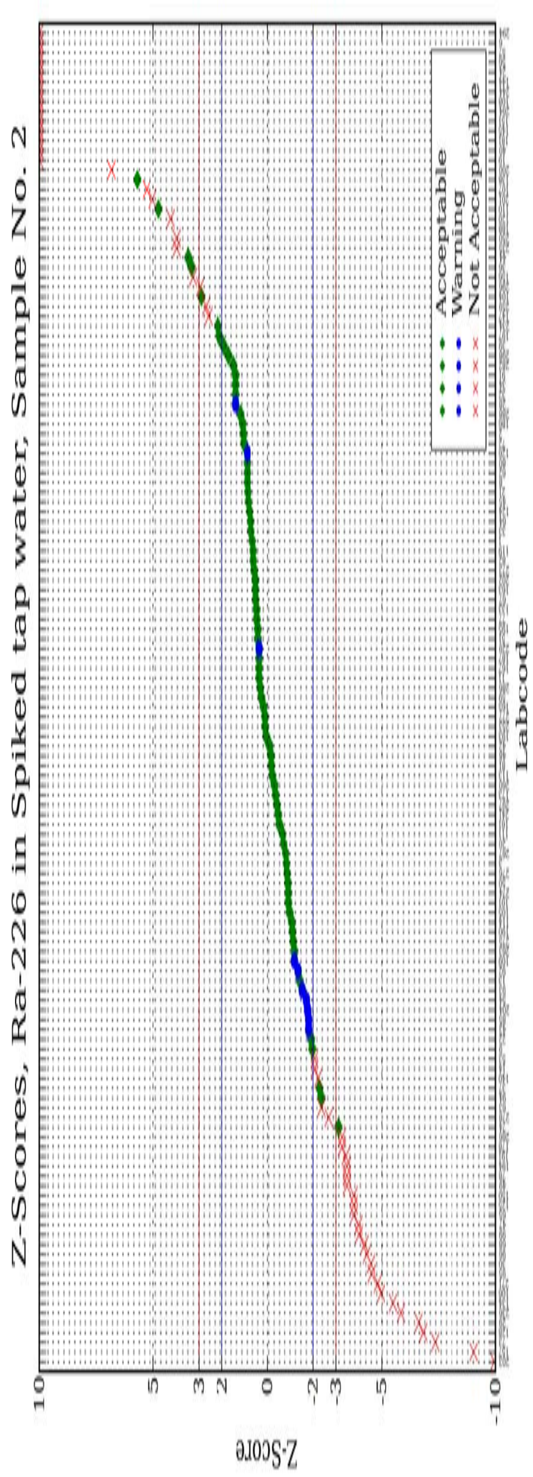
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
119	34.95	1.90	5.44	13.84	A
124	0.00	0.00	83.22	-100.00	N
125	18.60	0.90	4.84	-39.41	W
126	26.87	0.64	2.38	-12.48	A
132	33.20	0.41	1.22	8.14	A
133	5.90	0.60	10.17	-80.78	N
134	27.87	0.78	2.79	-9.22	A
136	34.60	1.80	5.20	12.70	A
138	27.78	0.54	1.94	-9.51	A
143	34.30	0.30	0.87	11.73	A
144	45.83	0.57	1.25	49.28	W
145	23.77	2.23	9.38	-22.57	A
154	32.90	1.92	5.82	7.15	A
156	24.80	1.00	4.03	-19.22	A
157	23.64	0.85	3.58	-22.99	A
158	32.00	1.50	4.69	4.23	A
160	0.66	0.20	30.00	-97.85	N
161	29.30	1.20	4.10	-4.56	A
164	39.90	6.10	15.29	29.97	A
165	24.52	0.74	3.02	-20.13	A
167	31.45	0.63	2.00	2.44	A
169	35.31	0.55	1.56	15.02	A
173	25.87	5.24	20.26	-15.74	A
177	27.30	0.70	2.56	-11.07	A
186	36.70	5.40	14.71	19.54	A
187	24.32	2.14	8.80	-20.78	A
188	20.59	0.04	0.21	-32.93	W
191	2.41	0.27	11.20	-92.15	N
193	30.00	3.60	12.00	-2.28	A
194	33.04	1.40	4.24	7.62	A
195	34.00	3.00	8.82	10.75	A
196	29.31	1.46	4.98	-4.53	A
197	39.30	0.60	1.53	28.01	A
200	30.00	0.61	2.03	-2.28	A
201	26.46	0.17	0.64	-13.81	A
202	31.00	1.40	4.52	0.98	A
203	43.05	3.80	8.83	40.23	W
204	25.70	0.90	3.50	-16.29	A
206	39.10	2.30	5.88	27.36	A
207	29.60	1.10	3.72	-3.58	A

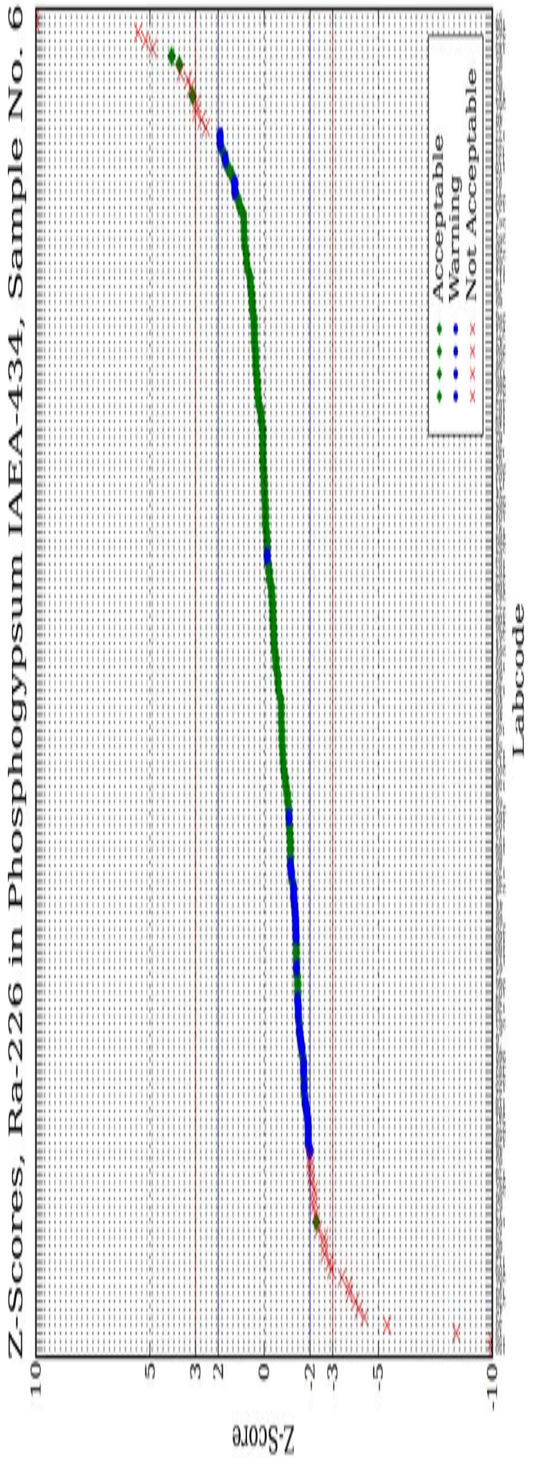
Lab code	Rep. Value	Rep. Unc.	Unc. [%]	Rel. Bias	Final Score
208	31.70	2.50	7.89	3.26	A
209	30.43	1.60	5.26	-0.88	A
213	30.20	1.20	3.97	-1.63	A
214	31.00	2.40	7.74	0.98	A
216	31.00	2.40	7.74	0.98	A
217	27.90	2.10	7.53	-9.12	A
218	28.50	1.50	5.26	-7.17	A
219	27.10	1.00	3.69	-11.73	A
220	27.15	2.01	7.40	-11.56	A
221	31.10	1.20	3.86	1.30	A
224	30.00	2.30	7.67	-2.28	A
227	25.10	1.10	4.38	-18.24	A
234	25.39	0.98	3.86	-17.30	A
236	34.64	0.14	0.40	12.83	A
238	32.40	1.62	5.00	5.54	A
244	27.28	6.27	22.98	-11.14	A
252	26.80	2.70	10.07	-12.70	A
253	30.82	0.90	2.92	0.39	A
260	30.80	1.50	4.87	0.33	A
261	23.10	2.70	11.69	-24.76	A
264	31.85	1.60	5.02	3.76	A
265	30.50	0.09	0.30	-0.65	A
266	30.90	0.95	3.07	0.65	A
267	32.30	1.00	3.10	5.21	A
271	97.53	25.34	25.99	217.70	N
273	31.10	5.10	16.40	1.30	A
274	26.00	2.30	8.85	-15.31	A
275	63.00	5.00	7.94	105.21	N
276	28.61	1.03	3.60	-6.79	A
278	47.70	5.30	11.11	55.37	W
282	26.04	3.98	15.28	-15.18	A
286	26.60	1.60	6.02	-13.36	A
288	29.80	1.79	6.01	-2.93	A
294	28.70	0.56	1.95	-6.51	A
297	26.50	2.50	9.43	-13.68	A
298	28.80	1.10	3.82	-6.19	A
299	29.70	1.32	4.44	-3.26	A

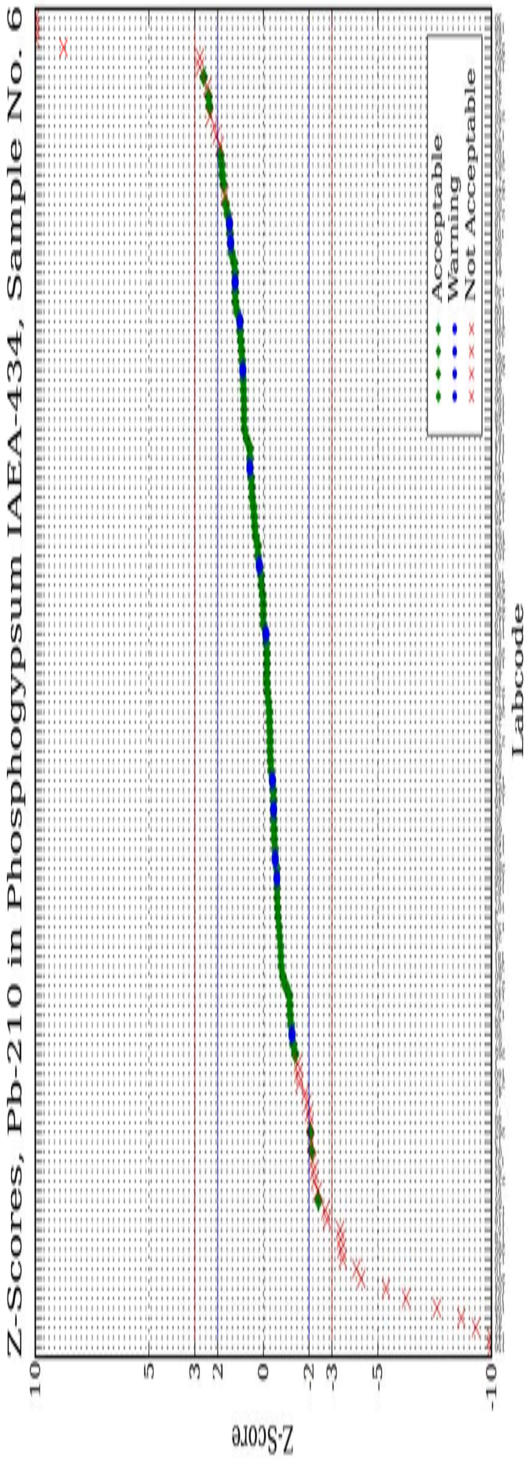
APPENDIX III: Z-SCORE CHARTS

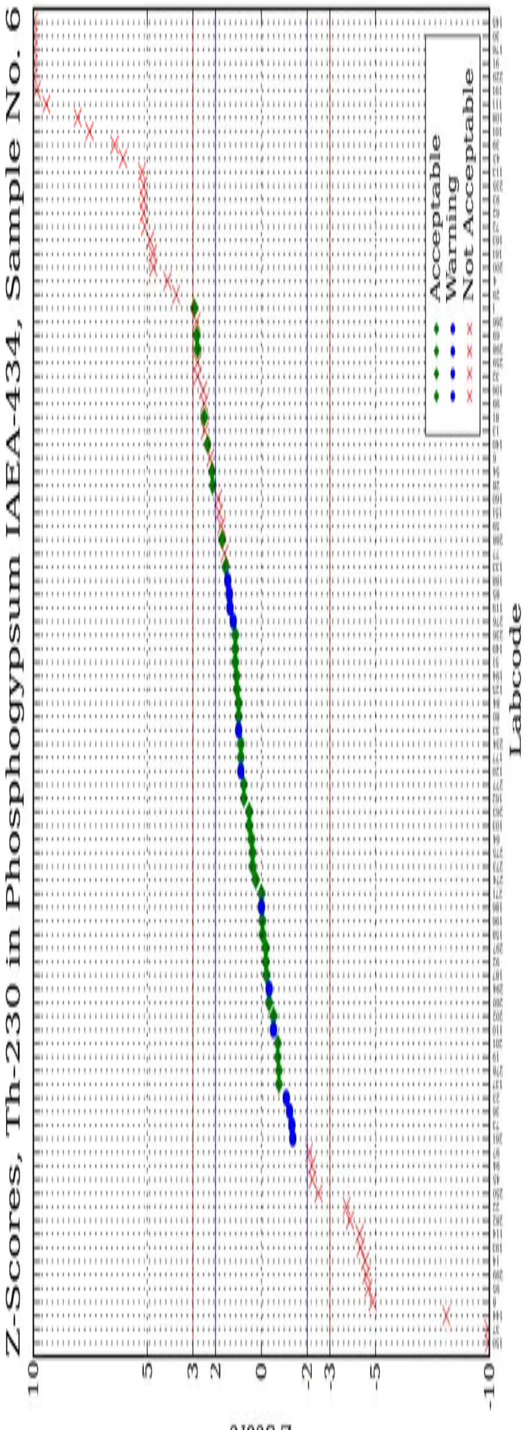
On the z-score charts warning limits are represented by a blue line, action limits by a red line.

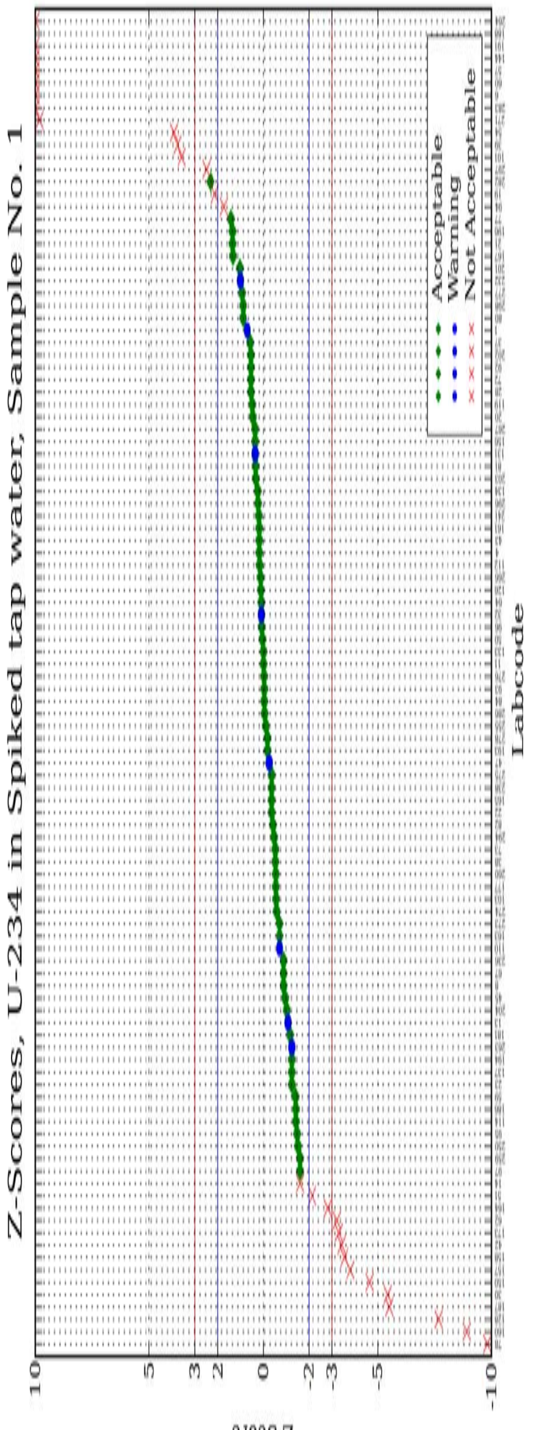


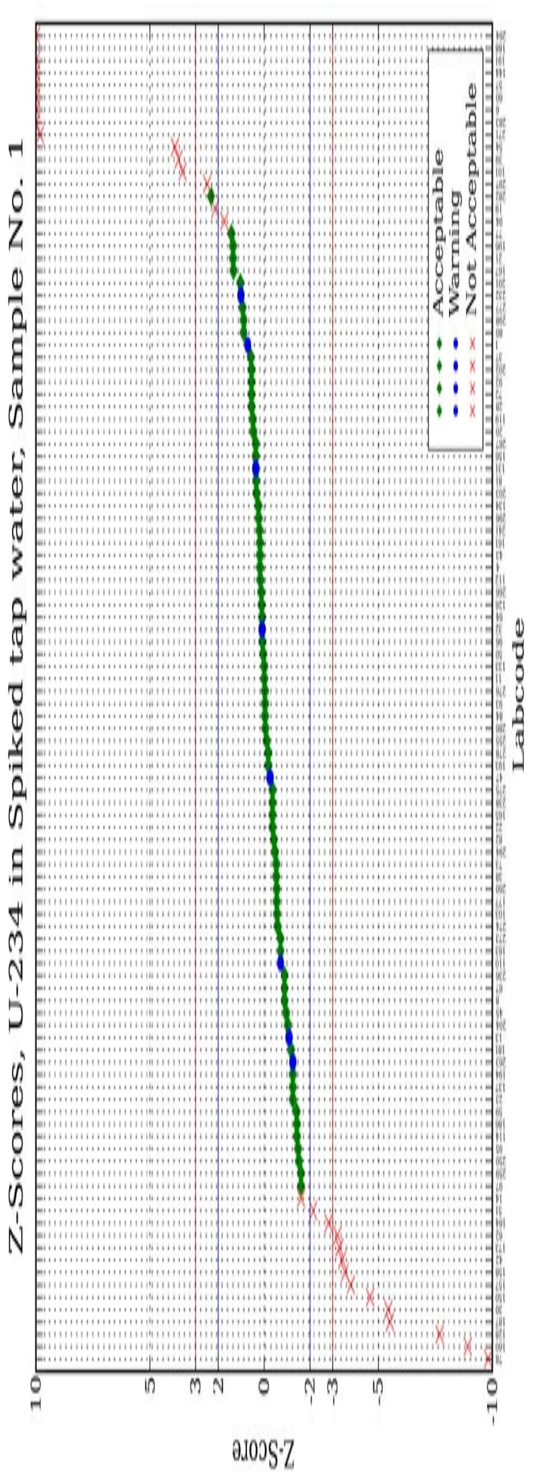


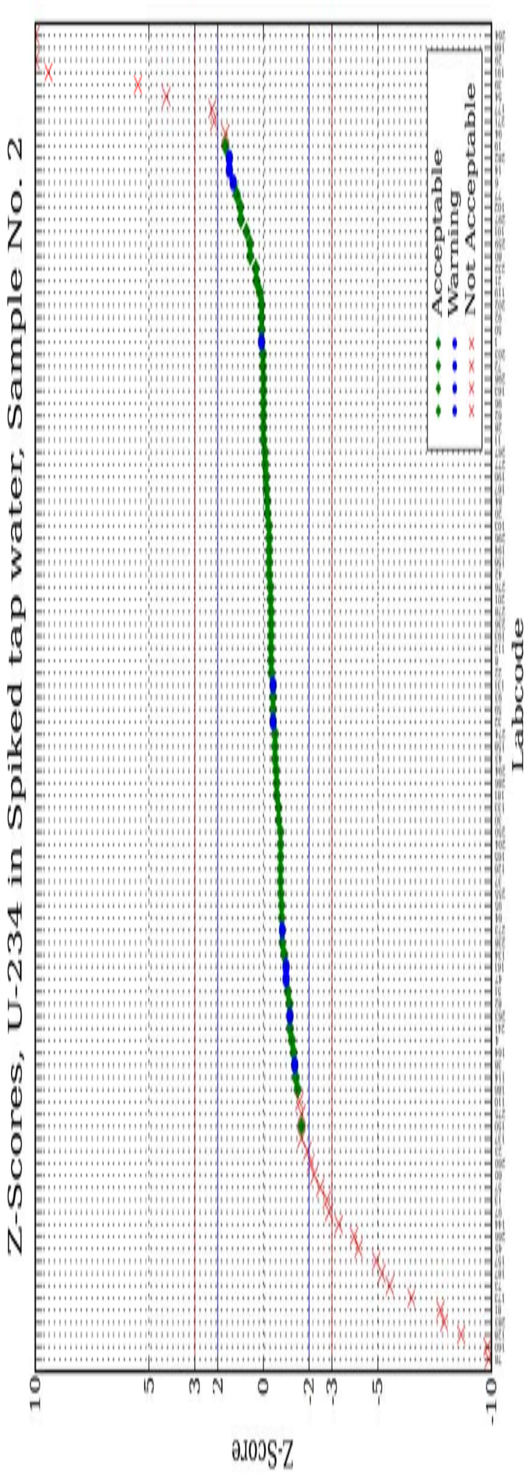

Z-Scores, Ra-226 in Phosphogypsum IAEA-434, Sample No. 6
Z-Score
Labcode
10
5
3
2
0
-2
-3
-5
-10
Acceptable
Warning
Not Acceptable

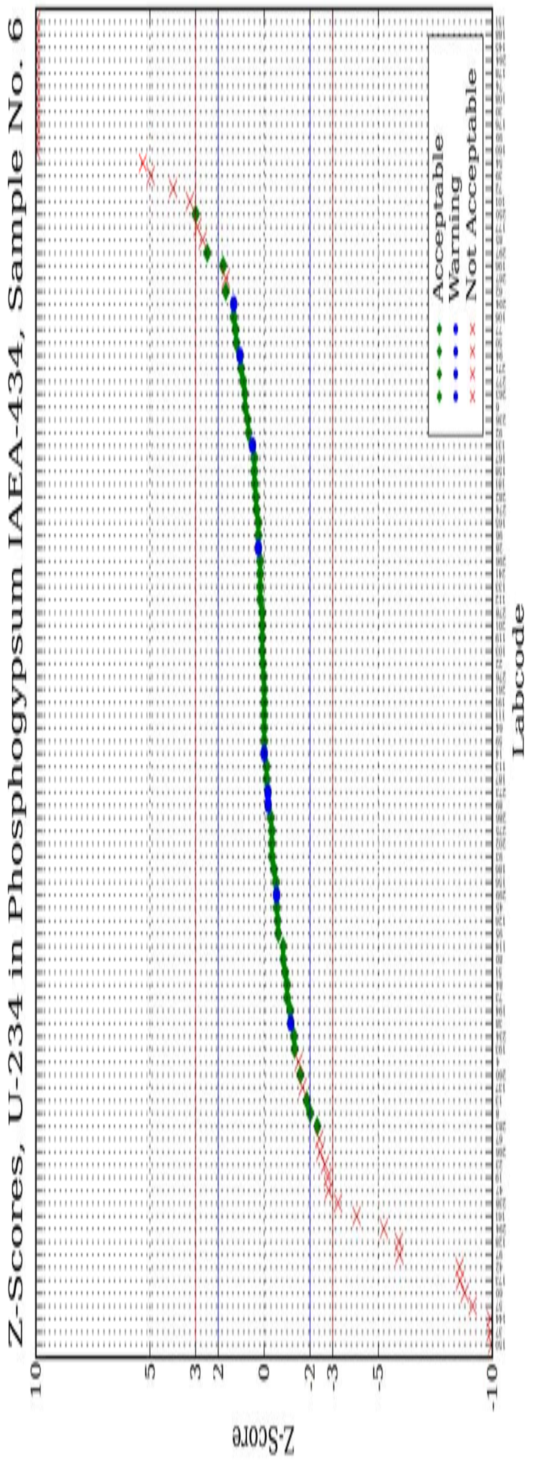

Z-Scores, Pb-210 in Phosphogypsum IAEA-434, Sample No. 6
Z-Score
Labcode
10
5
3
2
0
-2
-3
-5
-10
Acceptable
Warning
Not Acceptable


Z-Scores, Th-230 in Phosphogypsum IAEA-434, Sample No. 6


Z-Scores, U-234 in Spiked tap water, Sample No. 1


Z-Scores, U-234 in Spiked tap water, Sample No. 1
Z-Score
10
5
3
2
0
-2
-3
-5
-10
Labcode
Acceptable
Warning
Not Acceptable


Z-Scores, U-234 in Spiked tap water, Sample No. 2
Z-Score
10
5
3
2
0
-2
-3
-5
-10
Labcode
Acceptable
Warning
Not Acceptable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Z-Score
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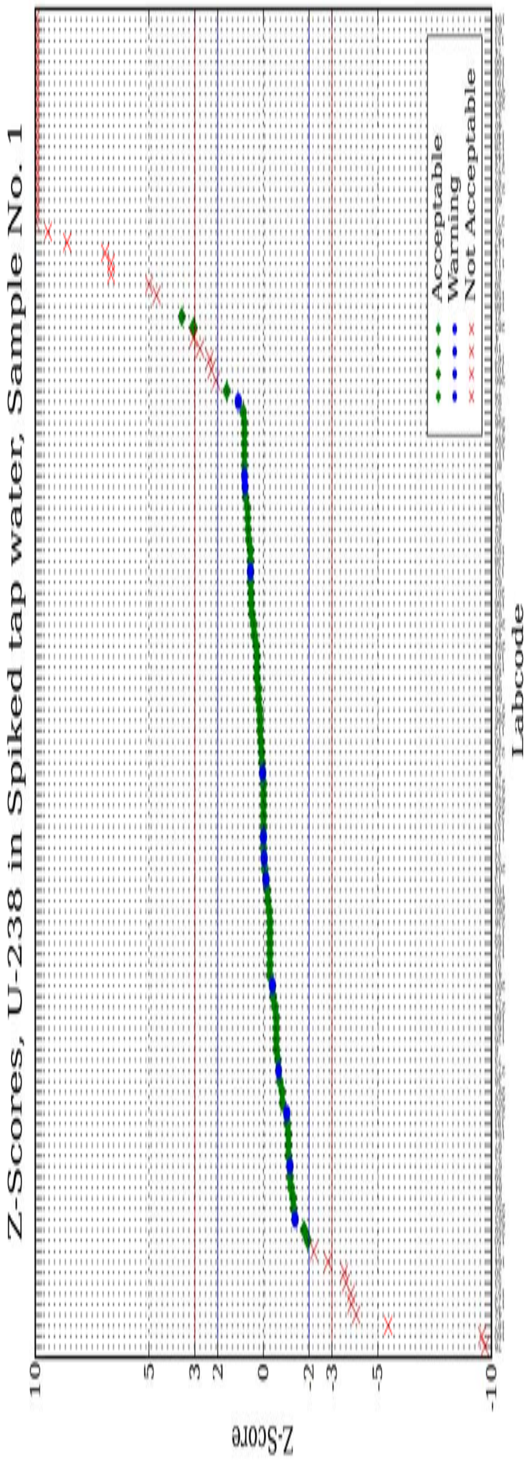
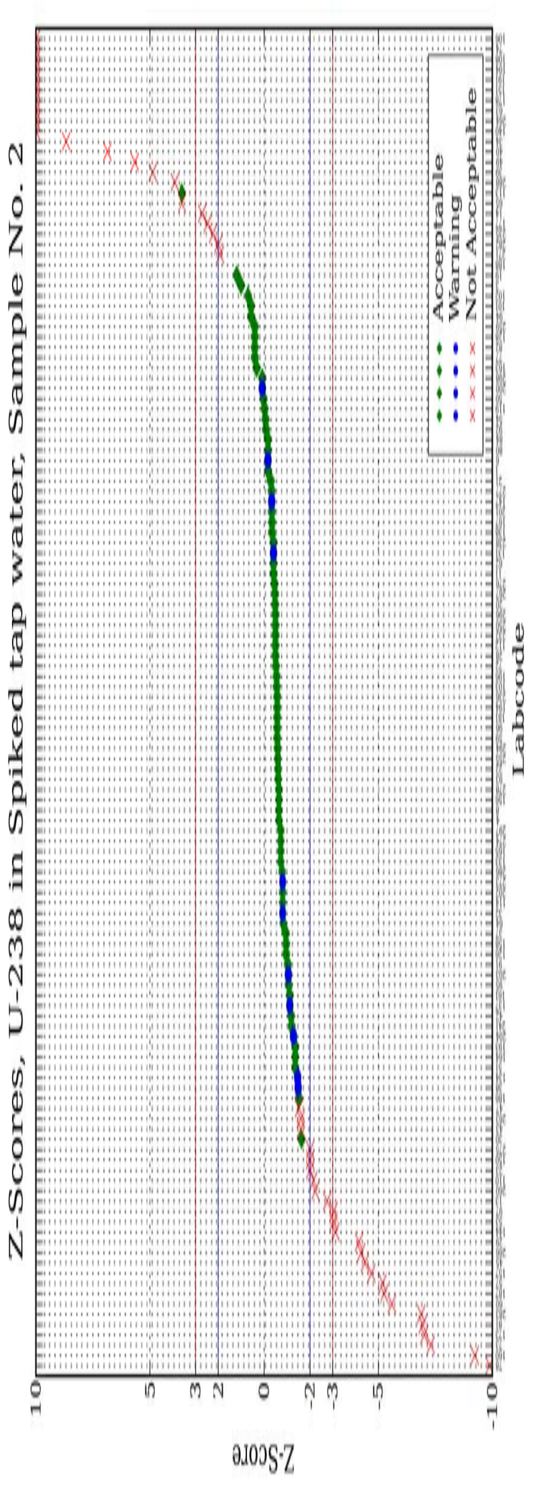
5
3
2
0
-2
-3
-5
-10
Labcode
Acceptable
Warning
Not Acceptable


Z-Scores, U-238 in Spiked tap water, Sample No. 1
Z-Score
10
5
3
2
0
-2
-3
-5
-10
Labcode
Acceptable
Warning
Not Acceptable


Z-Scores, U-238 in Spiked tap water, Sample No. 2
Z-Score
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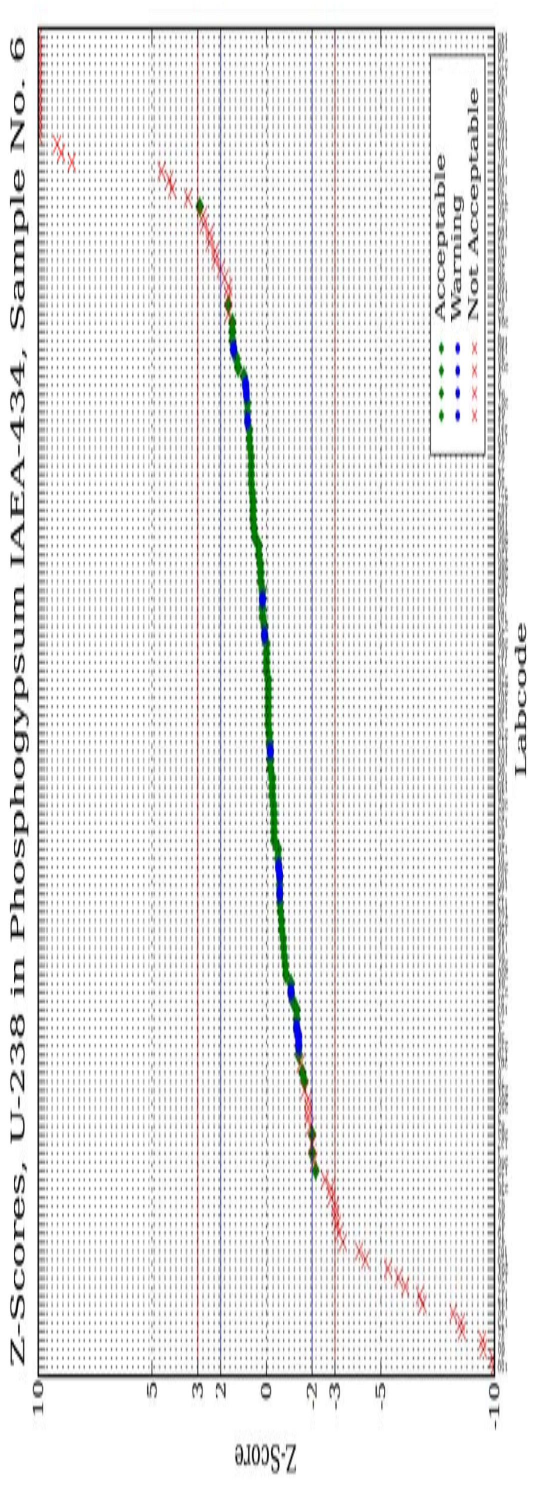
5
3
2
0
-2
-3
-5
-10
Labcode
Acceptable
Warning
Not Acceptable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Z-Score
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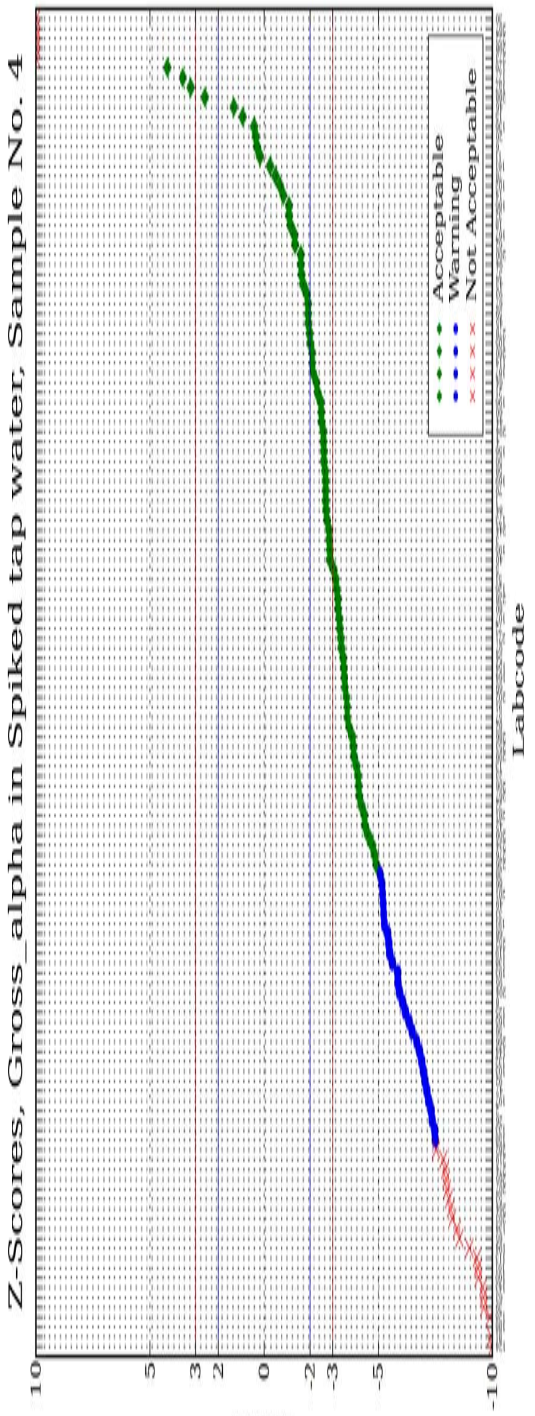
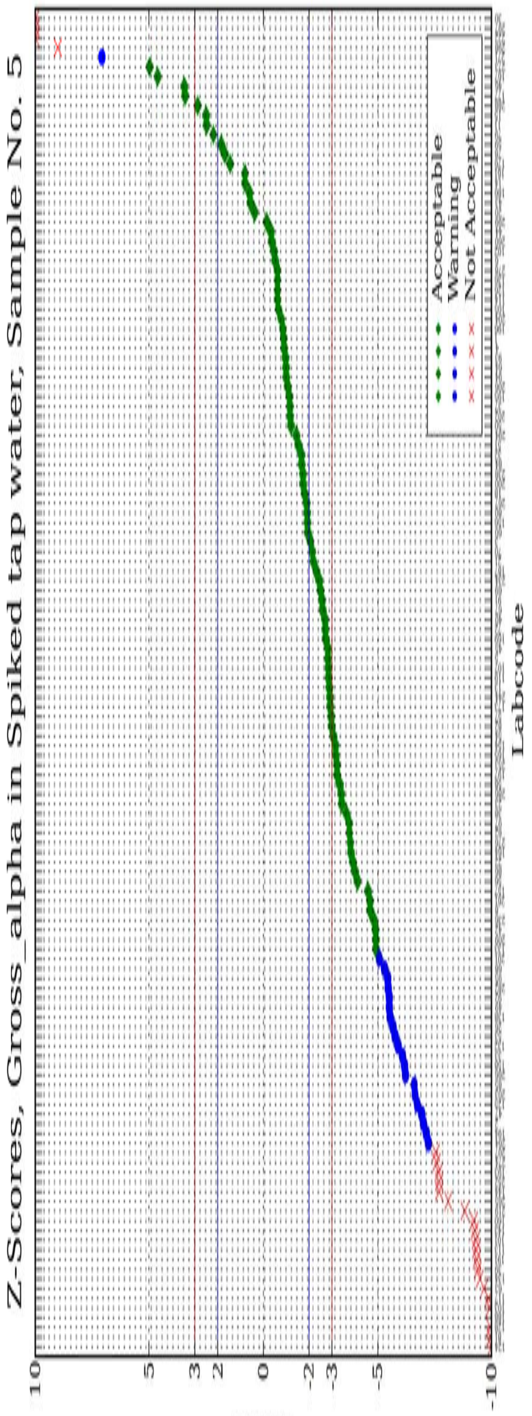
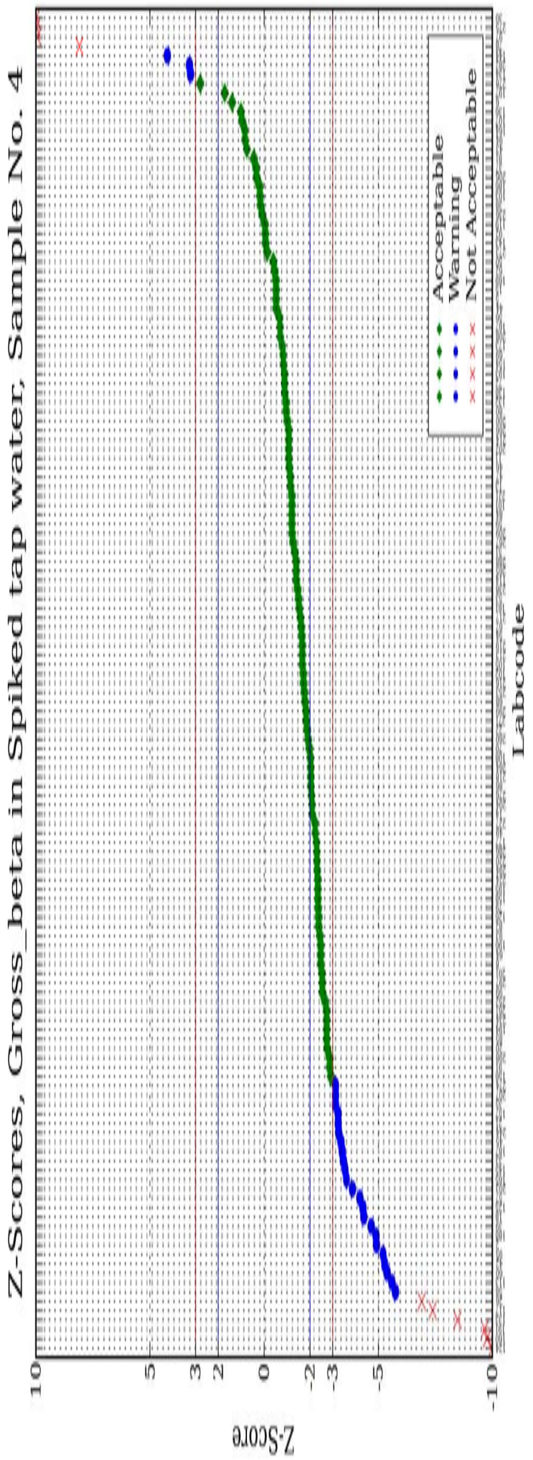
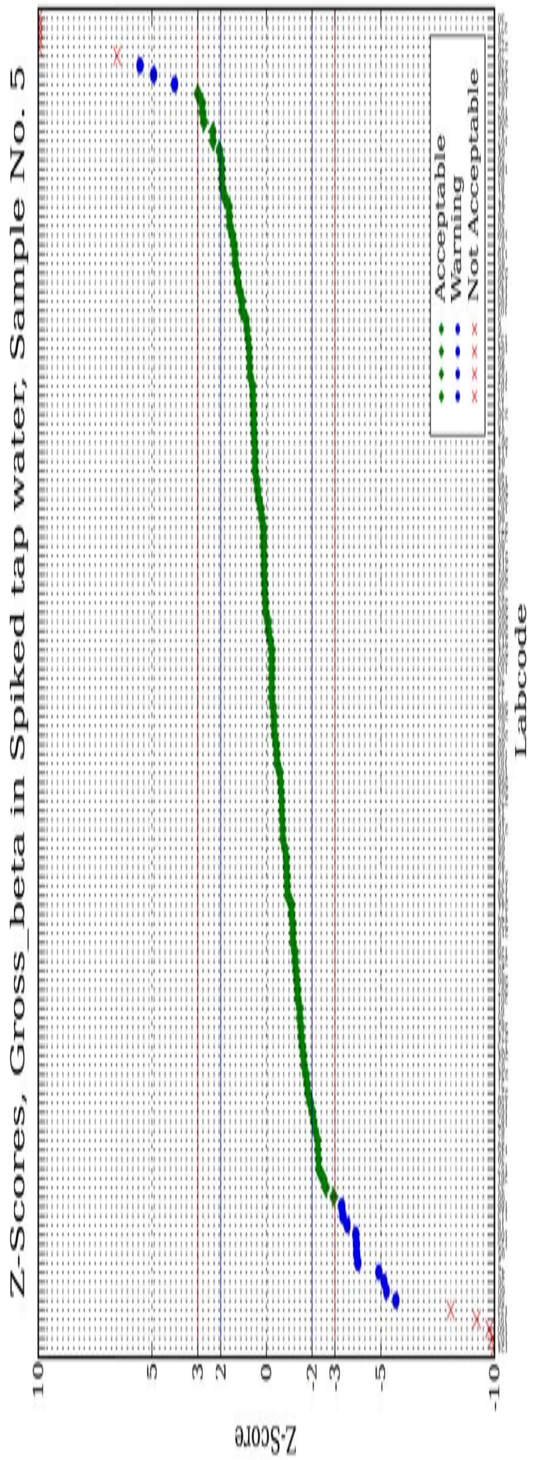
5
3
2
0
-2
-3
-5
-10
Labcode
Acceptable
Warning
Not Acceptable


Z-Scores, Gross_alpha in Spiked tap water, Sample No. 4
Z-Score
10
5
3
2
0
-2
-3
-5
-10
Labcode
Acceptable
Warning
Not Acceptable


Z-Scores, Gross_alpha in Spiked tap water, Sample No. 5
Z-Score
10
5
3
2
0
-2
-3
-5
-10
Labcode
Acceptable
Warning
Not Acceptable


Z-Scores, Gross_beta in Spiked tap water, Sample No. 4
Acceptable
Warning
Not Acceptable
Labcode
Z-Score
10
5
3
2
0
-2
-3
-5
-10


Z-Scores, Gross_beta in Spiked tap water, Sample No. 5
Acceptable
Warning
Not Acceptable
Labcode
Z-Score
10
5
3
2
0
-2
-3
-5
-10

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