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Worldwide Interlaboratory Comparison on the Determination of Trace Elements in the IAEA-457 Marine Sediment Sample

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WORLDWIDE INTERLABORATORY COMPARISON ON THE DETERMINATION OF TRACE ELEMENTS IN THE IAEA-457 MARINE SEDIMENT SAMPLE

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INTERNATIONAL ATOMIC ENERGY AGENCY
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FOREWORD

The primary goal of the IAEA Environment Laboratories is to assist Member States in the use of both stable and radioisotope analytical techniques to understand, monitor and protect the environment. In this context, the major impact of large coastal cities on marine ecosystems is an issue of primary concern for the IAEA and the IAEA Environment Laboratories. The marine pollution assessments required to understand such impacts depend on accurate knowledge of contaminant concentrations in various environmental compartments. Through the IAEA Environment Laboratories, the IAEA has been assisting national laboratories and regional laboratory networks since the early 1970s through the provision of a reference material programme for the analysis of radionuclides, trace elements and organic compounds in marine samples.

Quality assurance and quality control are two fundamental requirements to ensure the reliability of analytical results. Data that are not based on adequate quality assurance and quality control can be erroneous, and their misuse can lead to poor environmental management decisions. In this regard, the IAEA has a long history of organizing interlaboratory studies, which have evolved to include an increasing array of potential contaminants in the marine environment. Relevant activities comprise global interlaboratory comparison, regional proficiency tests, the production of marine reference materials and the development of reference methods for trace elements and organic pollutants analysis in marine samples.

This publication summarizes the results of the IAEA-457 interlaboratory comparison on the determination of trace elements in a marine sediment sample.

The IAEA wishes to thank the Korean Institute for Science and Technology for providing the raw material. The IAEA is also grateful to the Government of Monaco for its support. The IAEA officers responsible for this publication were E. Vasileva and S. Azemard of the IAEA Environment Laboratories.

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1 INTRODUCTION

The Marine Environmental Studies Laboratory (MESL) of the International Atomic Energy Agency's Environment Laboratories (IAEA-NAEL) has the programmatic responsibility to provide assistance to Member State laboratories in maintaining and improving the reliability of analytical measurement results for trace elements and organic pollutants. This is accomplished through the provision of reference materials of marine origin, validated analytical procedures, training in the implementation of internal quality control, and through the evaluation of measurement performance by the organization of worldwide and regional interlaboratory comparison exercises.

For nearly thirty years, the MESL has conducted worldwide laboratory performance studies, also known as intercomparison exercises [1, 2]. The results have been used to evaluate laboratory performance with respect to a wide range of organic [3, 4] and inorganic pollutants, including methylmercury [5, 6]. This work has been conducted in collaboration with the United Nations Environment Programme (UNEP) Regional Seas Programme.

The goal of interlaboratory exeercises is to demonstrate the measurment capabilities of laboratories participating in interlaboratory comaprisons (ILC) and proficiency tests (PT). The results from ILC or PT are of crucial interest for laboratories as these provide clear information of its measurement capabilities. It should be pointed out that the participation is either voluntary or forced by external requirements (e.g. legal, accreditation, control bodies). NAEL ILC and PT schemes involve comparison of participant's results with an assigned value, which usually is delivered as a consensus value from the overall population of test results.

These exercises are designed to monitor and demonstrate the performance and analytical capabilities of the participating laboratories, and to identify gaps and problematic areas where further development is needed. Continued participation has benefits in training and educational opportunities, enhanced mutual trust in results and methodologies and provide an objective evidence for accreditation purposes.

2 SCOPE OF THE INTERLABORATORY COMPARISON

In July 2011, 248 letters of invitation were sent to laboratories that had expressed an interest to participate in the IAEA ILC on the determination of trace elements in marine samples. Positive responses were received from 85 laboratories in 43 Member States.

Each participating laboratory received a package with one test sample of the marine sediment, identified as IAEA-457 test sample, an information sheet and one reporting form. Participants were requested to determine mass fractions of as many elements as possible from the following 15 elements: Al, As, Cd, Co, Cr, Cu, Fe, Hg (total and CH_3Hg), Mn, Ni, Pb, Se, V and Zn, applying the procedures used in their routine laboratory practice. The organisers were also interested in receiving results for any other elements that participating laboratories were able to provide.

The deadline for returning the results was initially set at November 2011, but due to delays of laboratories in the reporting of final results, extended to the end of December 2011 later on.

In total 72 laboratories from 38 countries participated in the IAEA-457 interlaboratory comparison and reported results for up to 48 elements (including CH_3Hg). Totally 78 datasets were reported in the determined by the organisers deadlines. All results were treated confidentially and each laboratory was identified with a unique code number.

Measurement results reported by the participating laboratories, together with statistical evaluation of the results are included in this report.

Further information concerning this report and the IAEA quality assurance programme can be obtained from the Marine Environmental Studies Laboratory, 4 Quai Antoine 1er, MC 98000, Monaco.

3 DESCRIPTION OF THE MATERIAL

The test sample distributed in the frame of this exercise was IAEA-457 certified reference material (CRM). All details about homogeneity, stability and characterization can be found in the certification report [7]. Certified values for trace elements in the IAEA-457 CRM (ILC test sample) are shown in Table 1.

For some elements (Ba, Ca, CH_3Hg, K, Na, Rb, Sb, and Se), were at least 5 results have been reported by participants, was possible to determine an assigned value. Those values were established from the robust means of the obtained data set, as described in ISO standard 13528 [8]. They are presented in Tables 2 and 3.

The uncertainties associated with the assigned values were calculated according to the ISO standard 35 [9]. The relative combined uncertainty of the certified value of the CRM consists of uncertainty related to characterization (u_{char}), between bottle heterogeneity (u_{hom}) and long–term stability (u_{stab}). Above mentioned contributions were combined to estimate the expanded uncertainty Eq. (1).

$$U = k \times \sqrt{u_{char}^2 + u_{hom}^2 + u_{stab}^2} \quad (1)$$

Where *k*: coverage factor 2, representing a level of confidence of about 95%.

u_{hom} – uncertainty on homogeneity of sediment sample is estimated at 2% and the estimation is based on results of the homogeneity study performed before the start of certification process [7]

u_{stab} - uncertainty on stability during the storage period , estimated at 1%. More detaols on stability and homogeneity study for the IAEA-457 sediment sample are described in the certification report [7].

u_{char} – uncertainty on characterisation of sediment sample are calculated following the Eq. (2).

$$u_{char} = 1.25 \times \frac{s^*}{\sqrt{n}} \quad (2)$$

Where s* is the robust standard deviation calculated as described in the IS0 13528 [8] and n is the number of datasets used for calculation of the robust mean.

As shown in Table 4, for Ca, CH_3Hg and Se, expanded uncertainty is beyond 30% due to broad distribution of reported data. As a consequence those values are given as informative values and will not be used for the evaluation of measurement performances of laboratories, participating in the IAEA-457 ILC.

TABLE 1. CERTIFIED VALUES IN THE IAEA-457 SEDIMENT SAMPLE

Element	Certified value mg kg^{-1}	Expanded uncertainty mg kg^{-1}
Ag	1.85	0.39
Al	82660	3430
As	10.2	1.0
Cd	1.09	0.08
Co	14.7	1
Cr	144	8
Cu	365	19
Fe	41450	2240
Hg	0.143	0.012
Li	64.2	5.5
Mn	427	30
Ni	53.31	2.7
Pb	105	7
Sn	27.40	0.75
Sr	137	10
V	87.4	8.1
Zn	425	25.8

TABLE 2. ASSIGNED VALUE IN IAEA-457 SEDIMENT SAMPLE

Element	Assigned value mg kg^{-1}	Expanded uncertainty mg kg^{-1}
Ba	514	63
K	23800	2700
Na	25900	3700
Rb	133	19
Sb	3.43	0.86

TABLE 3. INFORMATIVE VALUE IN IAEA-457 SEDIMENT SAMPLE

Element	Robust Mean mg kg^{-1}	Expanded uncertainty mg kg^{-1}
Ca	4750	1750
CH_3Hg (as Hg)	0.00013	0.00005
Se	0.54	0.20

4 EVALUATION OF ANALYTICAL PERFORMANCE

Initially, all obtained results from participating laboratories were evaluated with Kernel density plots, which offer an alternative to histograms and is a useful method to represent the overall structure of a data set [10]. The individual laboratory performance was assessed through evaluation of *z*-scores and Zeta-scores in accordance with ISO 13528 [8] and the IUPAC Harmonised Protocol for the Proficiency Testing of Analytical Chemistry Laboratories [11].

The determination of target standard deviation was done on the basis of the outcome of previous ILCs organized by the MESL for the same population of laboratories and similar sample matrix. The standard deviation for the proficiency assessment, σ_p, was fixed to 12.5 % of the assigned values. The appropriateness of this level of tolerated variability of results was confirmed by calculation of the robust standard deviation of the participants' results and the uncertainty of the assigned values for the respective measurants.

z-score, calculated following Eq. (3), effectively expresses the difference between the mean of the laboratory and the assigned value in units of target standard deviation (σ_p).

Zeta-score, calculated following the Eq. (4), states if the participant result agrees with the assigned value within the respective uncertainties. The denominator in the Eq. (4) is calculated from the combined uncertainty of the assigned value and the measurement uncertainty reported by participant.

$$z = \frac{x_{lab} - x_{ref}}{\sigma_p} \quad (3)$$

$$\text{Zeta} = \frac{x_{lab} - x_{ref}}{\sqrt{u_{x_{lab}}^2 + u_{x_{ref}}^2}} \quad (4)$$

Where:
X_{lab} : Reported results by participant (express as the mean of multiple determination)
x_{ref}: Certified value or assigned value
σ_p: Target standard deviation
u_{xlab}: Standard uncertainty reported by participant
u_{ref}: Standard uncertainty of certified (or assigned) value

The acceptability of a laboratory's performance was evaluated according to the following generally accepted limits [1]:

	$\lvert z \text{ or Zeta} \rvert \leq 2$	Satisfactory
$2 <$	$\lvert z \text{ or Zeta} \rvert < 3$	Questionable
	$\lvert z \text{ or Zeta} \rvert \geq 3$	Unsatisfactory

5 RESULTS AND DISCUSSION

5.1 OVERVIEW OF THE RESULTS

Seventy-two laboratories provided results for the requested trace elements in the IAEA-457 test sample by the exercise's final deadline. Seventy height sets of data were submitted (some laboratories reported data generated by multiple techniques) comprising 870 analytical results for 48 elements from which 812 results for 22 elements has been evaluated.

For all evaluated elements, the compiled data sets are given in Appendix III and graphical presentations of results sorted by element in Appendix I. Three sets of figures are provided for investigated trace elements in the Appendix I. Each set includes a) the Kernel Density plot (if more than 7 data have been reported), b) reported results with expanded uncertainties, c) *z*-score and Zeta-score for the reported results with a summary of the statistical evaluation of results for the respective element, including assigned value, combined uncertainty (k=2) and target standard deviation.

Results for informative assigned values (Ca, CH_3Hg and Se) are presented in Appendix II and III without *z*-score and Zeta score.

Elements with less than five results reported are not considered in this report.

5.2 LABORATORY PERFORMANCES

5.2.1 *z*-scores:

The overall performance (*z*-scores) of laboratories by element is illustrated in Table 4. The performances (*z*-scores) of the participating laboratories in the IAEA-457 ILC by element and by participating laboratory are summarized in Figures 1 and 3.

The *z*-score compares the participant's deviation from the reference value with the target standard deviation (σ_p for proficiency assessment). σ_p is defined by the ILC organizer as the maximum acceptable standard deviation (25%) of the assigned value for investigated trace elements.

In total from 812 *z*-scores calculated, 83% were with *z*-scores ≤ 2, 92% of results with *z*-scores < 3, and 8% of the results are considered as unsatisfactory with *z*-score ≥ 3. Among 78 participants, 31 laboratories (40%) were able to report analytical results with all *z*-score ≤ 2 and 47 (60%) with all *z*-score < 3. On the other hand 3 participants received satisfactory z-scores for less than 50% of their results, but all participants could report at least 67% of their results with *z*-score < 3.

Overall the performance of participating in this interlaboratory comparison laboratories is better than the performance observed in some previous exercises, but it should be noted that

only a part of laboratories are regularly participating, which makes the interpretation of the evolution of performance over time difficult.

It appears that more than 90% of laboratories measuring Co, Cu, Fe, Li, and Zn received *z*-score ≤ 2. This result shows that those elements are easily analyzed. On the other hand Al and Sr have less than 60% of reported data in the accepted range (*z*-score ≤ 2), probably reflecting unresolved analytical problems. For Al, Cr and Sr the observed bias for some of reported results is most probably linked to the use of wrong protocol for sample preparation (i.e. not total digestion).

The biased results could originate from the contamination during sample preparation or instrumental step. The laboratories concerned should carefully check analytical procedures (e.g., quality of purified water and reagents) and try to improve their working laboratory environment. Laboratories should also develop an effective scheme for cleaning of the lab ware and regularly control this process.

Erroneous calibration standards could be another source of bias. It is important to note that losses can occur at the low concentration level working standard solutions, leading to the overestimation of the concentrations of elements in the samples (e.g., standard solutions should not be stored for an extended period of time). Only standards (CRM) with stated value, its expanded uncertainty and SI traceability should be used for calibration purposes.

Laboratories with questionable and unacceptable results should carefully check all laboratory procedures, equipment, standards and instruments.

5.2.2 **Zeta-Scores:**

The overall performance (Zeta-scores) of laboratories by element is illustrated in Table 5. The performances (Zeta-scores) of the participating laboratories in the IAEA-457 ILC by element and by participating laboratory are summarized in Figures 2 and 4.

The Zeta-score shows if the laboratory result agrees with the assigned value within the respective uncertainties. The denominator in the Eq. (4) is the combined uncertainty of the assigned value and the combined uncertainty as stated by the laboratory.

The combined uncertainty of the laboratory, u_{lab}, was estimated by dividing the reported expanded uncertainty by the reported coverage factor, k. When k was not specified, the reported expanded uncertainty was considered as the half-width of a rectangular distribution and u_{lab} was then calculated by dividing this half-width by square root of 3, as recommended by Eurachem and CITAC guide [12]. For laboratories not providing data for uncertainty no Zeta-scores were calculated. Fourteen laboratories did not report uncertainties, and 3 laboratories did report uncertainties for part of reported results only.

As it can be seen in Figure 3 and 4, the comparison of laboratories performances evaluated with *z*-score with the laboratories performances evaluated with Zeta-score clearly indicate that the number of unsatisfactory zeta scores is considerably higher than the number of unsatisfactory *z*-scores (8% for *z*-scores and 22% for zeta scores). Only 8 laboratories (10%) could report 100% of their results with *z* and Zeta-scores <2. As the Zeta-score is the evaluation parameter, reflecting all parts of the measurement process; laboratories obtained unsatisfactory Zeta-scores should invest additional efforts in the proper evaluation of measurement uncertainty. Obtained results show that they are still remaining problems with the realistic estimation of measurement uncertainty.

If should be also mentioned that an unsatisfactory Zeta-score can be also caused by an inappropriate estimation of the mass fraction of the respective trace element.

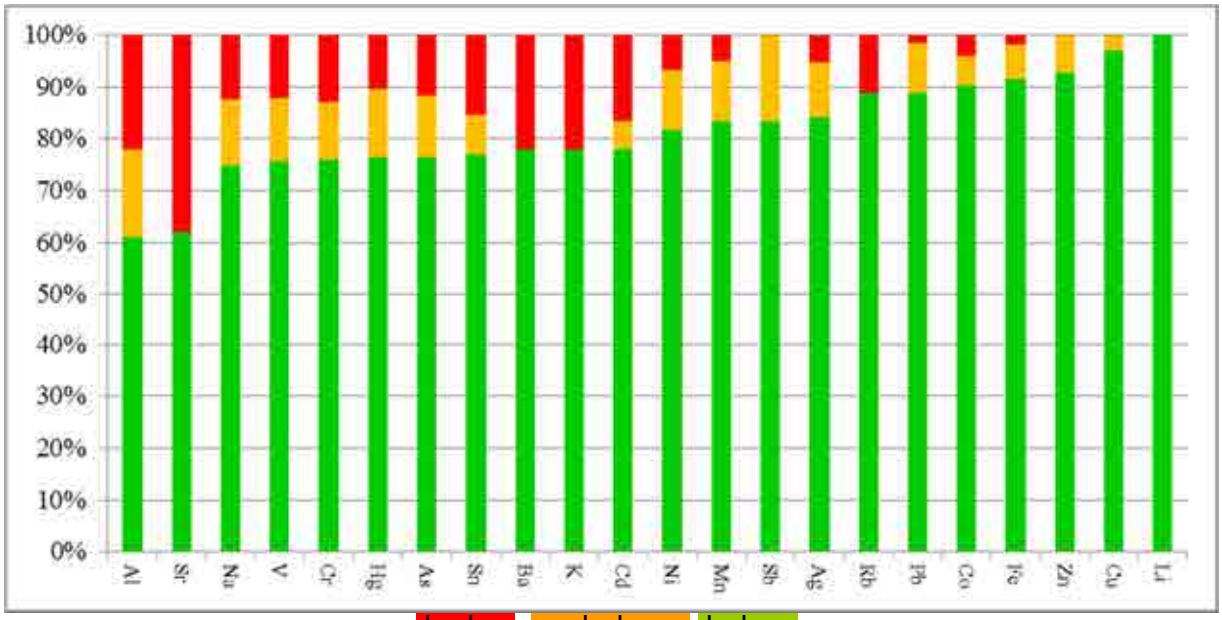


FIG. 1. The z-scores of results reported by the participants per element.

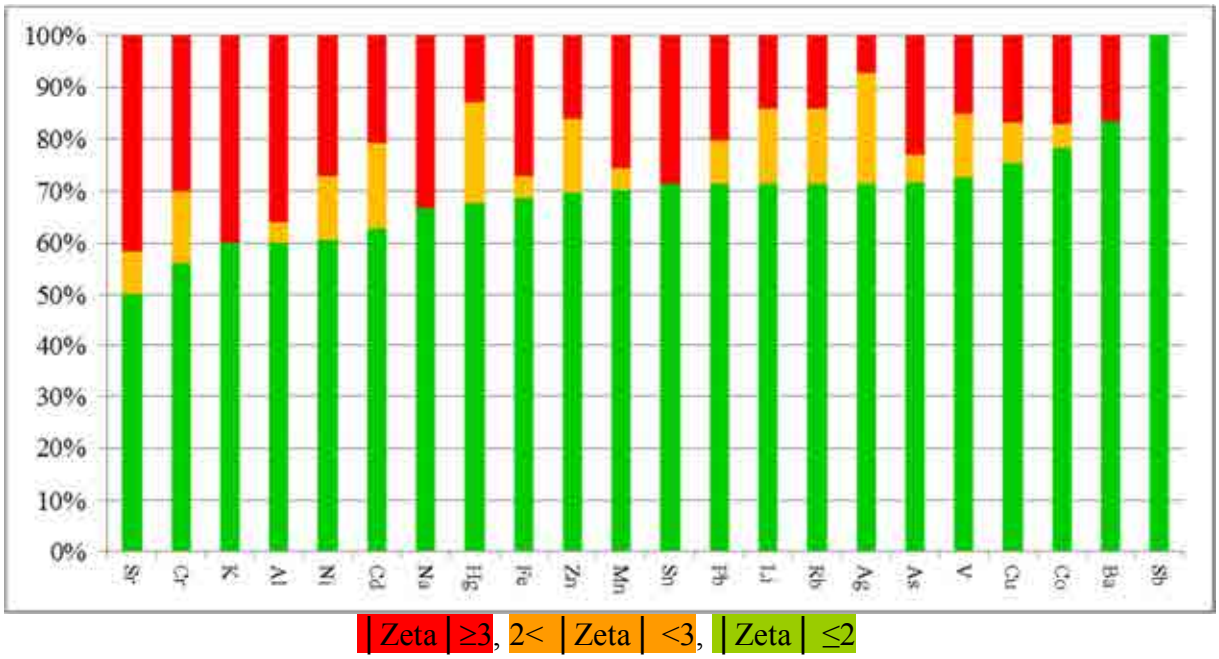


FIG. 2. The Zeta-scores of results reported by the participants per element.

TABLE 4. OVERALL ASSESSMENT OF LABORATORIES PERFORMANCE (*Z*-SCORE) BY ELEMENTS

Lab Code	Ag	Al	As	Ba	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mn	Na	Ni	Pb	Rb	Sb	Sn	Sr	V	Zn
1			1.04		0.91	0.35	-0.17	0.52	-0.44				0.28		0.41	0.37				-3.91	-0.25	1.20
2		-0.18	0.19		-1.00	-0.19	-0.31	-0.62	-0.36				0.06		-0.52	-0.66					-1.23	-2.10
3		-2.77	5.26		0.33		-0.47	-0.59	-0.92	-0.93		-1.75	-3.32		-3.16	-2.32						-0.73
4		-0.77	1.30		2.42		0.66	0.89	0.77	34.4		-0.18	0.14		0.83	0.90	-4.71				1.01	0.72
5	-1.95	-8.00			1.06			-0.53	0.36				-0.09		-0.57	2.12				0.25	-0.75	1.14
6					1.21		-2.31	-0.42	-1.56	-1.29			-2.92		-0.46	0.73						-0.14
7					-0.27			-0.32		-1.17					-3.67	0.43						0.16
8		0.38	4.05			6.57		-0.06	-0.86	2.35			-0.90		-2.45	-1.09						2.77
9	0.22	-0.31	0.59		-1.30	-1.23	2.42	0.43	-0.66	-2.46			0.62		0.52	1.64					-0.56	1.04
10			-1.70		1.58	1.28	-1.54	1.15					-0.51		-0.46	-0.03			-0.21		-2.51	0.48
11						35.7	1.69	-1.81	-8.00				2.97		0.24					1.95	10.4	2.53
12	-0.30	-0.34	0.35		0.40	-0.09	-0.03	0.36	-0.09	0.56			-0.17		-0.57	0.20			0.18	0.19	0.74	0.14
13			3.50		0.25	1.17	-0.59	-0.03	-1.66	-0.28					0.38	-0.49					0.50	0.20
14		1.68					-3.21	-0.29	-0.55		-0.17		0.17			-1.17	-1.67			-0.75		-0.29
15										-0.50												
16		0.08	3.19		-0.49		0.25	-0.03	0.42	-0.50			0.26		0.27	-1.81						-0.03
17	2.21	-2.19	-0.28		-0.27	0.02	-0.42	0.25	-0.51	-0.17			-0.45		-0.27	0.20			0.06	-1.92	-0.07	0.76
18			2.71		-1.37		-1.08	0.28	-1.24	2.07			-1.41		0.05	0.24						0.03
19		0.30			-0.19	0.30	0.36	0.36	0.15	0.39		-0.02	0.41		-0.03	0.88					0.69	0.42
20	0.39	-2.41	0.82		-0.04	-0.52	-1.37	-0.23	-0.65	-0.06			-0.45		-0.71	-0.11			-0.06	-4.57	-1.40	0.01
21					3.01	-0.67		-0.09	0.88				4.35		-1.02	-1.19	1.54			1.29		0.44
22		-0.37	1.93	0.17	0.10	0.02	0.08	-0.29	-0.26	1.34		0.74	0.30		-0.16	-0.30				-0.11	0.58	-0.43
23	-1.80		0.20		-0.63	-2.30	-2.36	-2.08					-2.76		-1.70	-0.93				-3.85	-0.43	2.73
24		-4.53	0.43		0.91	0.62	4.87	0.12	-2.87	-1.45			0.06		2.56	-0.03				-5.22	-3.41	-0.37
25		-2.37	-0.74		3.86	2.21	-0.76	0.32	-1.98	-4.20			-0.84		-0.95	-0.54					-2.02	-0.84
26		-0.64	0.51			0.08	-1.43		-0.36		-0.41		-0.28	-0.04			0.81	-0.42				0.61

TABLE 4. OVERALL ASSESSMENT OF LABORATORIES PERFORMANCE (*z*-SCORE) BY ELEMENTS (cont.)

Lab Code	Ag	Al	As	Ba	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mn	Na	Ni	Pb	Rb	Sb	Sn	Sr	V	Zn
27		0.07							-0.02		0.42		1.74									
28			-2.17	1.34		0.41	0.33		0.38					0.15			0.45	0.79				-0.05
29		1.00	0.27		1.72	-0.19	0.30	0.28	0.69	0.39			-0.13		-0.46	-0.56						-0.14
30						-1.18	-3.59	-2.81	0.02				-0.37		-0.55	-1.22						1.09
31			0.75		0.62	0.46	0.08	0.01	-0.45	-0.28			0.54		-0.16	0.58					0.05	0.89
32							-2.73	-0.18	-1.27				-1.34		-3.06	-0.47						-0.35
33		-0.14	-0.33			0.46	-0.92		-0.41				-0.52								-1.52	-0.24
34	-1.08				1.13			0.30														1.82
35		-1.61	-2.62		-6.41		-2.48	0.39	0.36	-1.45			0.96		-0.89	-2.91						0.38
36		-5.73	-2.02		-0.56	-1.45	-2.97	-0.93	-1.90	1.23			-2.04		-2.06	-0.96					-5.07	-1.05
37										-1.17												
38	0.04		-0.41		0.25	-1.49	-3.93	-0.18		4.87			-0.66		-2.42	-0.79			6.41		-0.41	-0.58
39								-0.94							-2.34	-1.83						
40		0.15	-0.83		-1.37	-0.85	-1.21	-0.98	0.05		0.64		0.52	0.79	-1.28	-0.77			-0.26	0.19	-0.99	-0.19
41		-0.47	7.91		-0.63	-0.90	-0.59	-0.84	0.07	0.84		-0.09	-0.09		-1.37	0.12		-1.73	-1.00		-0.53	-0.99
42	-2.08		-2.09	-0.53	2.31	-0.52	-0.65	-0.95							-0.92	-0.94	0.39				-0.31	
43							0.04	0.10	0.16		0.71		-2.81	1.44		-1.42						1.89
44						0.16	-0.48		-0.41				0.13		0.08	-0.35					0.06	0.38
45		0.22	1.38		1.94	0.62	1.03	0.34	0.01				0.77								0.88	0.67
46						0.46	-1.09		-0.38	-1.17	1.07			0.27			-1.07	2.59				-1.37
47										-0.95												
48	0.61	-2.59	-0.69		3.86	0.19	-0.92	1.00	-1.17		-3.26		0.66	-2.32		-0.11					-2.02	-0.58
49		-7.33	0.43	-4.03	-6.47	-1.34	-1.09	-1.32	-0.67				-0.64		-1.22	-2.41					0.12	0.59
50		-5.26	-1.22	-6.49	57.5	2.70	-3.04	-0.10	-1.75			-1.62	-0.84		-0.87	-1.07					-4.53	-0.46
51	-1.08		0.19			0.13	-0.50	-0.31	-0.35				-0.42		0.35	1.46					-2.18	-1.07
52		-6.33	20.9		-3.58	-1.78	-2.71	-0.10	-2.28				-2.36		-2.54	-1.50			-2.65	-6.30	-4.55	-0.11

TABLE 4. OVERALL ASSESSMENT OF LABORATORIES PERFORMANCE (*z*-SCORE) BY ELEMENTS (cont.)

Lab Code	Ag	Al	As	Ba	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mn	Na	Ni	Pb	Rb	Sb	Sn	Sr	V	Zn
53			-0.52		-0.71		-0.70	-0.03	-2.42						-0.86	-4.21				-3.38		1.31
54						1.33		0.48							-0.06							-0.83
55		-2.87	-0.36		-0.07	-0.05	-0.89	0.17	-1.09				-0.55		-0.18	-0.07					-2.82	0.08
56	1.47		0.82	-0.48	0.47	-0.25	0.19	-0.38		-0.62					-0.16	0.12		-0.91		-0.11	0.18	-0.46
57	0.76	-4.59	1.51		1.72	0.31	-0.50	0.57	-0.59	-0.15			-0.22		0.20	0.32			0.45	-4.18		0.53
58			0.43		-0.19		0.25	0.14	-0.41	1.68			-0.81		-0.01	-0.33						-0.99
59					3.05		-0.03	-0.10	-0.45	2.07			-0.66			1.11						-0.33
60										1.25												
61		-3.75	-1.94		1.20		-1.35	0.36	0.31	-0.37			-0.34		-1.35	-0.43						-0.17
62	-0.09		-0.49		-1.63			0.43	-1.13				-0.66		0.02	-0.33						-0.37
64			-0.12		-0.03		-1.58	0.07					-0.76		-0.55	-0.02						0.26
65	-0.65		-0.83		0.10	-0.90		-0.95							-1.22	-0.33						-0.46
66			-2.41		1.94	0.42	-3.40	-1.56	-2.95	2.07	-6.01		-3.22	-3.60	-1.33	0.73						-1.33
67						-0.09	-0.37		-0.68				-0.21		-0.07	0.14					0.29	-0.24
68	-6.62		-0.18		2.39	1.28	-1.20	1.15					-1.80		-1.20	-0.11			36.7		-0.09	
69		0.21		0.72			-1.15	-0.56	0.16				-1.12				0.45			1.12	-0.68	-0.33
70			0.04		0.77	0.46	0.02	0.77		-0.95					0.26	2.05				-3.18	-1.03	1.24
71			1.14		-0.79	1.28	4.98	1.57	-0.83	8.73			0.60		-4.22	-0.17					-0.17	2.95
72		0.04	-0.44	0.05	0.10	0.90	-0.26	-0.18	-0.01	-0.28			0.43		0.02	0.12			0.50	-0.05	0.03	-0.39
73								0.60	-0.63				-2.68		-0.31	-1.85						-1.71
74	-0.22		-0.28		0.10	-0.36		-0.56							-0.77	0.05						-0.07
75	0.48	-0.26	1.22			0.19	-0.09		-0.32				-0.19								-0.18	-0.03
76					4.08		-1.45	-0.89							2.78	2.08						
77						-1.05	-4.58	-0.80	-1.12				-1.87			-1.08						0.25
78		0.06			0.08	-0.42	-0.53	0.14	0.40	-0.17		0.25	0.52		0.37	0.09			-0.74	0.18	0.63	0.76

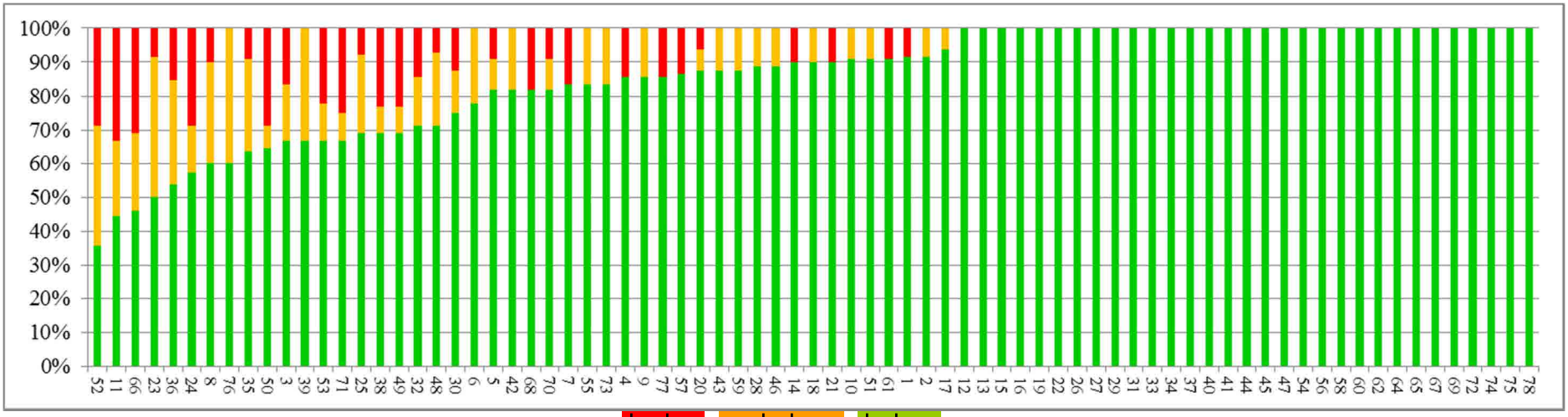


FIG. 3. The z-scores of results reported by the participants per laboratory.

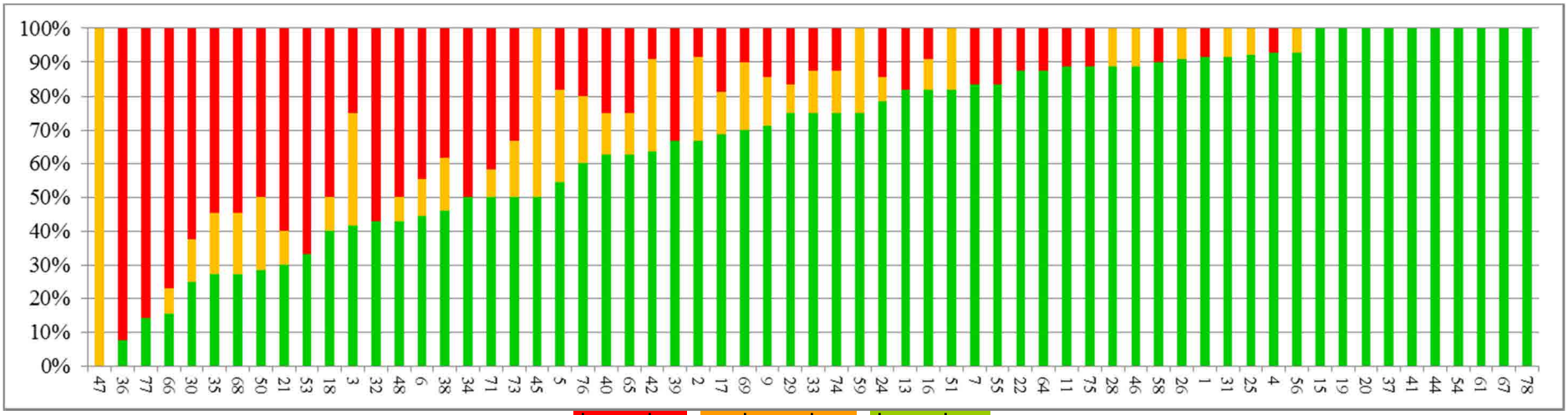


FIG. 4. The Zeta-scores of results reported by the participants per laboratory.

TABLE 5. OVERALL ASSESSMENT OF LABORATORIES PERFORMANCE (ZETA-SCORE) BY ELEMENTS

Lab Code	Ag	Al	As	Ba	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mn	Na	Ni	Pb	Rb	Sb	Sn	Sr	V	Zn
1			1.75		1.38	0.22	-0.54	1.56	-1.56				0.50		0.60	1.26				-13.0	-0.59	1.77
2		-0.87	0.24		-1.26	-0.35	-0.97	-2.94	-0.72				0.12		-2.09	-1.91					-2.96	-8.43
3		-2.17	1.57		0.66		-0.73	-1.46	-1.23	-2.66		-4.78	-8.51		-4.48	-2.58						-2.57
4		-1.09	0.39		1.12		1.28	1.33	1.29	1.81		-0.19	0.18		0.81	0.59	-3.54				0.86	1.10
5	-2.30	-48.1			2.81			-1.68	1.18				-0.28		-1.79	6.50				0.70	-1.85	2.45
6					3.20		-9.62	-1.41	-6.84	-1.10			-10.0		-2.05	1.86						-0.48
7					-0.42			-0.54		-1.82					-10.1	0.65						0.26
8																						
9	0.17	-1.21	1.10		-2.41	-1.75	4.58	0.82	-1.48	-2.59			1.24		0.79	3.62					-1.10	1.88
10																						
11						0.71	0.16	-0.28	-36.9				0.27		0.03					0.18	0.49	0.22
12																						
13			3.42		0.42	1.94	-1.30	-0.07	-4.05	-0.51					0.71	-0.96					0.80	0.41
14																						
15										-0.67												
16		0.22	4.82		-0.41		0.28	-0.05	0.60	-0.95			0.33		0.44	-2.70						-0.05
17	2.64	-9.26	-0.63		-0.86	0.09	-1.77	1.22	-2.24	-0.49			-1.59		-1.28	0.76			0.24	-5.03	-0.18	3.13
18			6.47		-3.50		-4.57	1.32	-5.71	2.60			-4.87		0.23	0.97						0.11
19		0.36			-0.29	0.45	0.54	0.54	0.14	0.56		-0.02	0.59		-0.04	1.21					0.93	0.48
20	0.21		0.73		-0.05	-0.80	-1.79	-0.39	-0.74	-0.11			-0.56		-0.76	-0.10			-0.10		-1.92	0.01
21					3.00	-1.43		-0.36	3.91				10.81		-3.98	-3.98	2.70			3.81		1.62
22		-1.84	3.82	0.32	0.12	0.08	0.29	-1.16	-0.90	3.13		1.98	0.83		-0.48	-0.91				-0.28	1.39	-1.50
23																						
24		-4.28	0.10		0.34	0.24	1.26	0.05	-1.86	-0.48			0.02		0.81	-0.01				-5.90	-2.38	-0.16
25		-1.61	-0.20		0.65	0.54	-0.52	0.19	-1.17	-2.38			-0.39		-0.38	-0.29					-1.30	-0.58
26		-1.59	0.69			0.15	-2.01		-1.43		-0.74		-0.83	-0.07			1.03	-0.36				1.41

TABLE 5. OVERALL ASSESSMENT OF LABORATORIES PERFORMANCE (ZETA-SCORE) BY ELEMENTS (cont.)

Lab Code	Ag	Al	As	Ba	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mn	Na	Ni	Pb	Rb	Sb	Sn	Sr	V	Zn
27																						
28			-2.89	1.01		1.30	0.81		1.64					0.25			0.29	0.77				-0.07
29		3.60	0.62		4.56	-0.49	0.53	0.77	2.58	0.61			-0.28		-1.66	-1.24						-0.54
30						-3.87	-14.1	-11.7	0.08				-1.13		-2.10	-4.19						3.39
31			1.62		1.64	1.36	0.16	0.04	-1.50	-0.37			1.56		-0.52	1.57					0.13	2.31
32							-5.47	-0.47	-3.64				-4.69		-8.05	-0.76						-1.14
33		-0.71	-0.82			1.34	-2.10		-1.77				-1.28								-3.63	-0.74
34	-1.27				3.60			1.44														5.71
35		-4.43	-4.07		-18.1		-9.97	1.51	1.36	-2.09			3.36		-2.52	-9.04						1.57
36		-34.0	-5.00		-1.48	-4.27	-10.9	-3.87	-8.09	3.74			-6.63		-8.53	-3.55					-13.6	-3.50
37										-0.56												
38	0.04		-0.90		0.11	-4.86	-16.3	-0.88		0.29			-2.33		-11.9	-3.08			18.34		-0.75	-2.28
39								-3.96							-1.23	-1.63						
40		0.75	-0.67		-2.28	-3.16	-3.62	-4.55	0.22		1.33		1.76	1.37	-5.84	-1.42			-0.13	0.57	-2.56	-0.71
41		-0.48	1.96		-0.34	-0.63	-0.73	-1.12	0.06	0.51		-0.05	-0.08		-1.16	0.11		-0.92	-0.70		-0.53	-1.34
42	-2.08		-4.68	-0.83	2.15	-0.94	-1.17	-2.84							-1.44	-1.61	0.67				-0.47	
43																						
44						0.45	-0.87		-0.71				0.28		0.17	-0.76					0.12	0.92
45		0.68	1.94		2.44	2.11	2.49	0.77	0.04				2.13								0.82	2.09
46						0.54	-1.69		-0.82	-1.58	1.63			0.37			-1.61	1.54				-2.22
47										-2.93												
48	0.55	-13.8	-0.97		5.29	0.52	-3.23	2.88	-5.30		-7.10		1.90	-3.98		-0.21					-4.69	-1.70
49																						
50		-18.4	-1.51	-12.9	25.80	5.84	-11.8	-0.24	-4.44			-2.59	-1.42		-2.33	-2.21					-11.4	-1.07
51	-0.90		0.17			0.15	-1.26	-1.35	-1.17				-1.00		0.49	1.96					-2.71	-2.50
52																						

TABLE 5. OVERALL ASSESSMENT OF LABORATORIES PERFORMANCE (ZETA-SCORE) BY ELEMENTS (cont.)

Lab Code	Ag	Al	As	Ba	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mn	Na	Ni	Pb	Rb	Sb	Sn	Sr	V	Zn
53			-1.30		-0.86		-3.02	-0.15	-11.1						-4.27	-17.0				-11.6		5.38
54						0.54		0.55							-0.24							-1.14
55		-6.86	-0.51		-0.11	-0.11	-1.54	0.36	-1.94				-1.19		-0.30	-0.15					-5.25	0.16
56	1.78		2.01	-0.98	1.48	-0.95	0.81	-1.80		-1.87					-0.81	0.48		-0.90		-0.36	0.48	-1.90
57																						
58			1.07		-0.48		1.01	0.69	-1.82	1.98			-1.52		-0.04	-1.07						-4.00
59					2.66		-0.09	-0.37	-1.56	1.78			-1.94			2.14						-1.08
60																						
61								0.85	0.65	-0.63			-0.66									-0.44
62																						
64			-0.19		-0.05		-3.78	0.14					-1.62		-1.23	-0.03						0.41
65	-0.78		-1.96		0.33	-2.95		-3.54							-4.52	-1.34						-1.56
66			-4.32		2.66	0.90	-10.1	-5.19	-8.33	3.20	-12.6		-8.95	-6.00	-3.93	1.61						-4.33
67						-0.21	-0.56		-1.21				-0.43		-0.16	0.29					0.58	-0.51
68	-7.91		-0.43		6.32	3.39	-2.92	3.82					-5.32		-2.73	-0.21			8.31		-0.17	
69		0.62		0.98			-2.28	-1.43	0.62				-3.12				0.60			2.23	-1.47	-0.74
70																						
71			1.30		-1.15	1.58	2.54	3.24	-3.78	3.23			0.80		-13.9	-0.31					-0.16	4.19
72																						
73								0.78	-0.94				-4.90		-0.45	-3.16						-2.85
74	-0.26		-0.57		0.13	-1.35		-2.63							-3.58	0.17						-0.27
75	0.56	-1.57	3.09			0.72	-0.38		-1.49				-0.67								-0.47	-0.12
76					1.89		-2.82	-1.01							3.56	1.68						
77						-4.02	-19.7	-3.88	-5.16				-6.64			-4.37						1.01
78		0.07			0.12	-0.60	-0.67	0.18	0.60	-0.29		0.41	1.28		0.56	0.11			-1.50	0.32	0.67	1.64

5.3 ANALYTICAL METHODS

Abbreviation used in the Figure 5 and Appendix III are shown in Table 6.

As it can be concluded from Figure 5, a wide range of analytical methodologies was used to provide data for the determination of trace elements in marine sediment IAEA-457. Generally they can be divided to three groups: non-destructive techniques (XRF and NAA); plasma spectrometric methods (ICP-MS and ICP-AES) and atomic absorption spectrometry methods, representing 14%, 46% and 38% respectively.

TABLE 6. INSTRUMENTAL TECHNIQUES USED IN THE IAEA-457 INTERLABORATORY COMPARISON AND THEIR ABBREVIATIONS

Method code	**Instrumental technique**
F-AAS	Flame Atomic Absorption Spectrometry
ET-AAS	Electro Thermal Atomic Absorption Spectrometry
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
ICP-OES	Inductively Coupled Plasma Optical Emission Spectrometry
AFS	Atomic Fluorescence Spectrometry
XRF	X-ray Fluorescence Spectrometry
NAA	Neutron Activation Analysis
CV-AAS	Cold Vapour Atomic Absorption Spectrometry
HYD-AAS	Hydride Generation Atomic Absorption Spectrometry

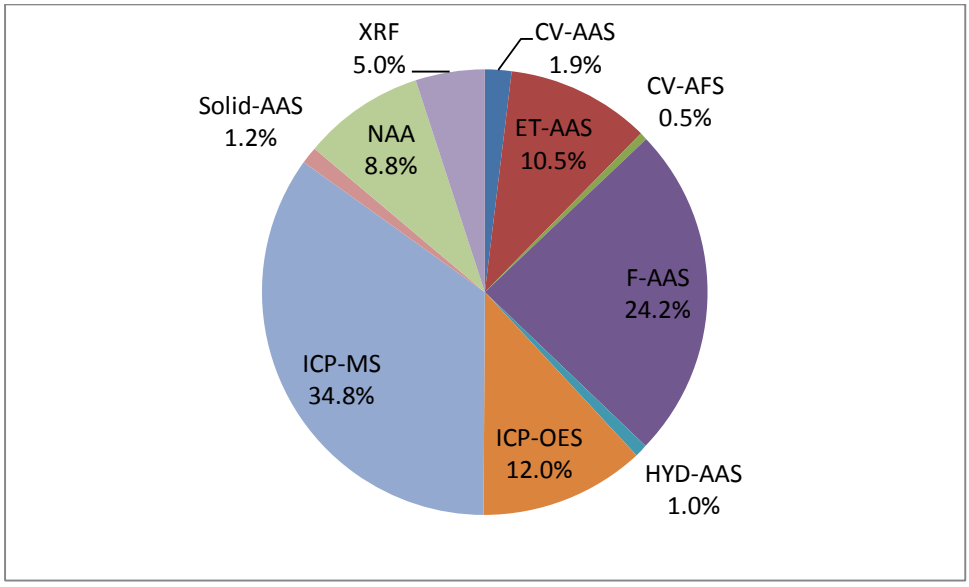


FIG. 5. Graphical distribution of instrumental techniques.

5.4 SAMPLE TREATMENT, IMPACT OF WATER CONTENT, USE OF CRM AND RECOVERY CORRECTIONS

In the IAEA-457 interlaboratory comparison (ILC), a wide range of sample pre-treatment methods were applied. Despite the use of different methods, clustering of obtained results was observed only in relation with the sample preparation step for refractory trace elements. When using acid digestion for sample preparation, the addition of hydrofluoric acid is required for breaking down the silicate lattice of a sediment matrix. Without hydrofluoric acid, the dissolution of sediment will be incomplete, resulting in obtaining lower concentrations for certain refractory elements, such as Al, Cr, V and Sr.

Twenty-nine laboratories did not use hydrofluoric acid; this fact can explain the obtained negative bias and bimodal distribution for refractory elements (see Appendix I). As a result Al was the element with the lowest number of satisfactory results. This is important conclusion because Al is often used for 'normalising' other data for trace elements mass fractions in sediments [13].

Out of the 78 data sets received, 14 laboratories did not included results for QC as requested in the report form. An important principle for the selection of reference material by laboratories is the principle for matrix and concentration range matching. CRMs used in the IAEA-457 ILC were generally adequate as most laboratories used marine sediment (i.e. MESS-3 from NRCC, IAEA-158, IAEA-433, IAEA-405).

Thirty-four participants reported to be accredited. Ten of them (34%) were able to produce 100% of reported results with z-score ≤ 2. Six laboratories did not report results for their quality control as requested in the reporting form, despite their statement of using CRM for quality assurance purposes.

Sixty-nine laboratories, did not correct their results for the recovery of the method when reporting final results. Only 9 laboratories implemented correction for recovery. Different justifications were given by those who did not apply a correction factor for recovery. Most of them indicated that they are able to provide evidences from the protocols, obtained during

validation of the method (CRMs and spiked samples used as control samples), that their results were not biased. Several laboratories indicated that correction for recovery is not included in their procedures.

Actually, high proportion of laboratories that did not correct for recovery still obtained satisfactory scorings, meaning that the laboratories have correctly estimated that the recovery achieved was not significantly different from 100%. Nevertheless, even if satisfactory, some of the scorings results were negative – which shows a tendency to overestimate the recovery. Such a tendency was not observed in the reported results corrected for recovery.

Participants were requested to evaluate the moisture content of the test material on a separate subsample in parallel with the analysis of the sample. Measurement results were to be reported to the IAEA after correction for the moisture content of the sediment sample..

IAEA-457 sample was subjected to freeze drying as part of its preparation procedure. At the time of bottling, the moisture content of the material was around 2.5%. Depending on local storage conditions and humidity levels the ILC sample might absorb moisture from the atmosphere. As the moisture is operationally dependent parameter, procedure on moisture content determination in the IAEA-457 test sample was provided in the accompanying letter [14]. Ten laboratories did not correct their results for the moisture content of the sample. The moisture content reported by the laboratories that applied a correction factor was in the range from 0.3 to 10%.

6 RECOMMENDATIONS

Participants are recommended to review their data element-by-element, appraising whether the z and Zeta scores are less than or equal to 2. The use of z-scores and Zeta-scores will help to identify systematic errors in the measurement results (e.g. from calibration, reagent contamination or incomplete digestion) and should ultimately improve the quality of measurement results. Participants should investigate the cause of any unsatisfactory scores (i.e. $|z| > 3$) and put in place the necessary corrective actions in order to prevent the repetition of the same or similar problem.

Some laboratories still need to improve QA/QC procedures. Interlaboratory comparisons represent only one aspect of data quality assurance and can only provide occasional indicators of data reliability. Another valuable approach is through the regular analysis of certified reference materials, and by plotting the resulting data on a quality control chart. Control chart provides continuous feedback for the analyst, it is an essential tool for monitoring of data quality and assuring acceptable results in the future interlaboratory comparison exercises.

A full catalogue of available IAEA reference materials is published regularly and can be consulted on the IAEA website: http://www.iaea.org/programmes/aqcs

7 CONCLUSIONS

The current interlaboratory comparison for the determination of trace elements in sediment sample attracted a considerable number of participants. Although the overall performance of the laboratories is quite satisfactory, it must be pointed that number of laboratories still has problems with the proper use of reference material and internal quality control.

The material used in IAEA-457 ILC was further certified by expert laboratories for the mass fractions of 16 trace elements. Participants in the interlaboratory comparison could retain

their samples and request from the IAEA reference sheets with the certified value in the IAEA-457 sediment sample. The reference material is suitable for the validation of analytical procedure when sediment samples need to be analysed for trace elements content.

Once more, it became evident that extra effort is needed in the evaluation of measurement uncertainties, associated with the results, since the number of unsatisfactory Zeta-scores was systematically higher than the number of unsatisfactory *z*-scores for determined trace elements. The uncertainty associated with measurement results is of paramount importance in in the frame of different regulations and international agreements, so it is fundamental for one laboratory to be able to report a sound uncertainty statement.

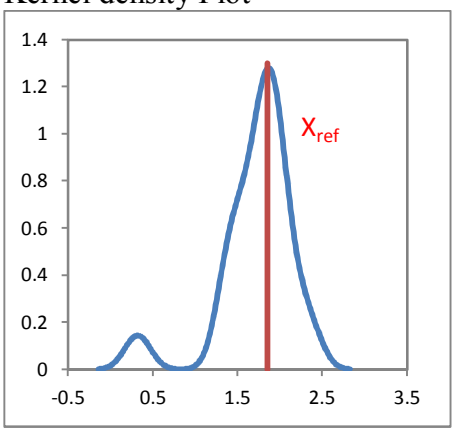
In general, laboratories should keep in mind that uncertainties estimated only on the basis of the precision of measurement results are frequently underestimated. In many cases, they just reflect variations coming from the measurement step and usually do not include the contribution of uncertainty coming from other major contributors like uncertainty on recovery, procedural blank, moisture content etc.

APPENDIX I

PERFORMANCE EVALUATION BY ELEMENT IN IAEA-457

Performance evaluation for silver in IAEA-457

Kernel density Plot

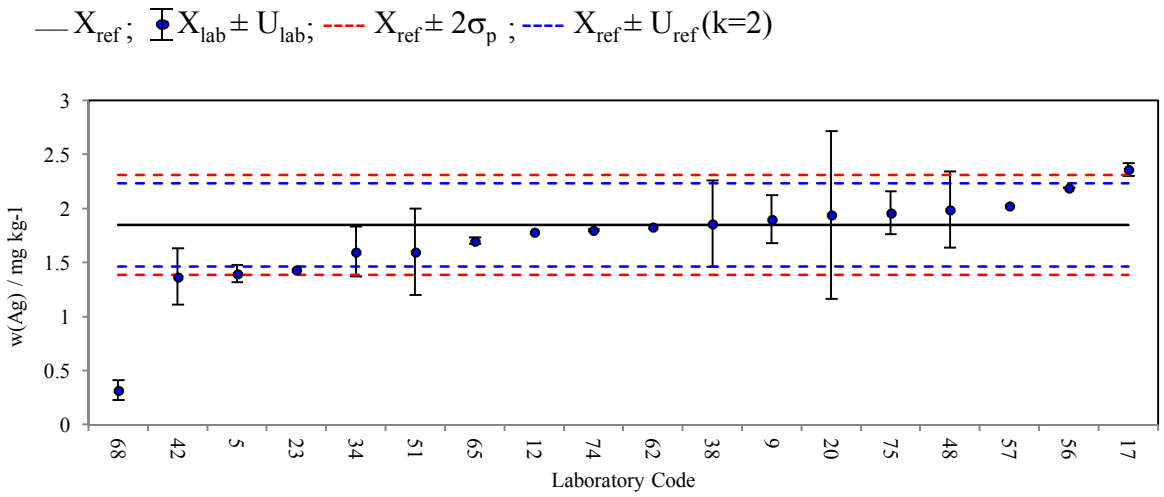


Summary of results:

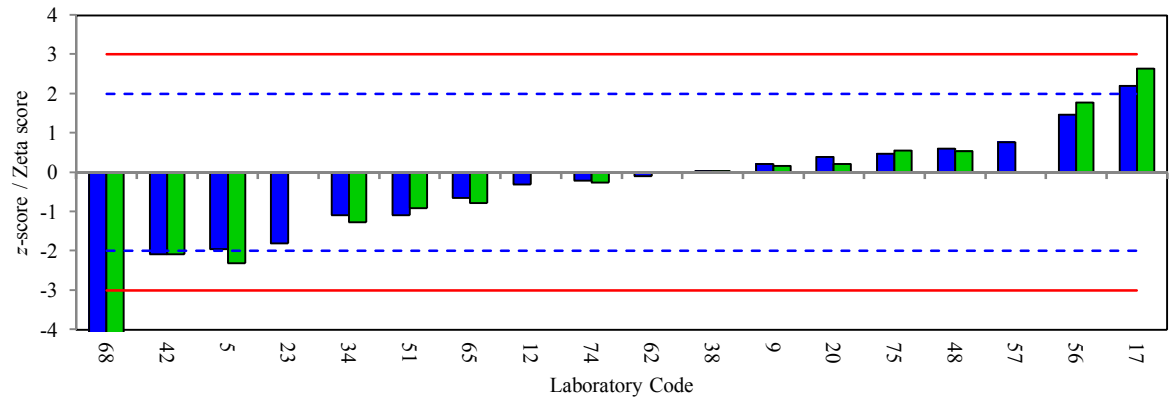
	Satisfactory	Questionable	Unsatisfactory
z-score	78%	17%	6%
Zeta-score	71%	21%	7%

X_{cert}:	1.85 mg kg^{-1}
U_{cert} (k=2) :	0.39 mg kg^{-1}
$2\sigma_p$:	0.46 mg kg^{-1}
Number of results:	18
Number of methods:	4

Reported results and expanded uncertainties:

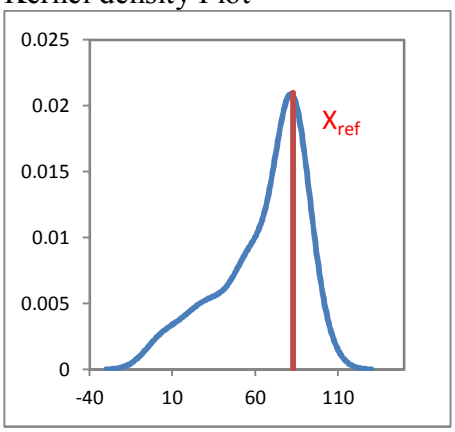


Performance evaluation: *z*-score Zeta-score



Performance evaluation for aluminium in IAEA-457

Kernel density Plot



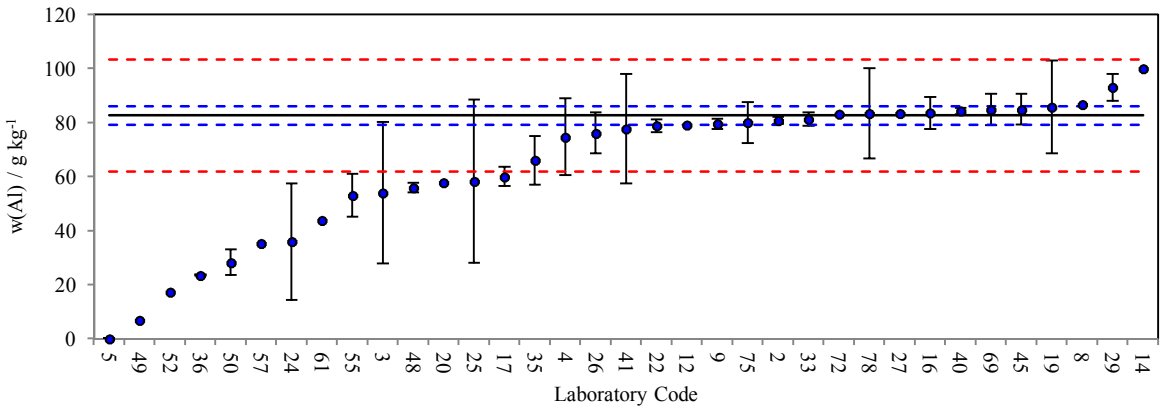
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	60%	17%	23%
Zeta-score	60%	4%	36%

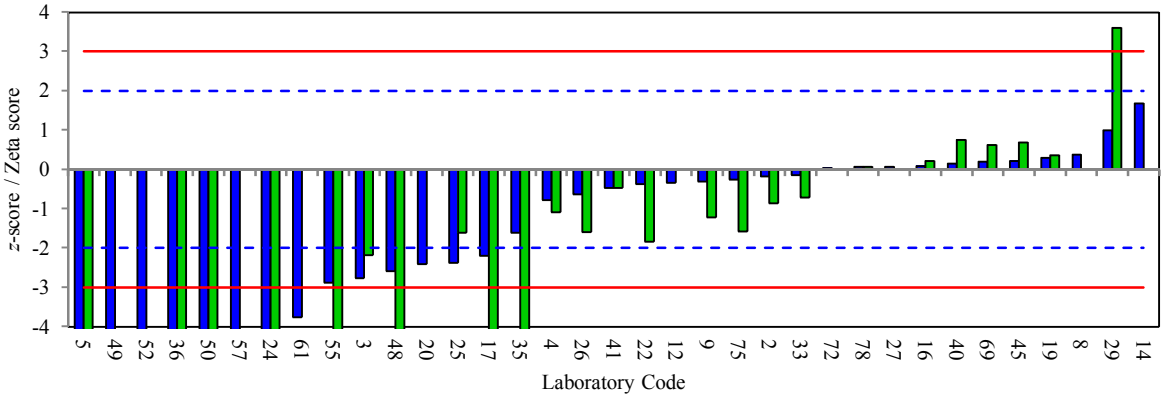
X_{cert}:	82.66 g kg^{-1}
U_{cert} (k=2) :	3.43 g kg^{-1}
$2\sigma_p$:	20.66 g kg^{-1}
Number of results:	35
Number of methods:	7

Reported results and expanded uncertainties:

— X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

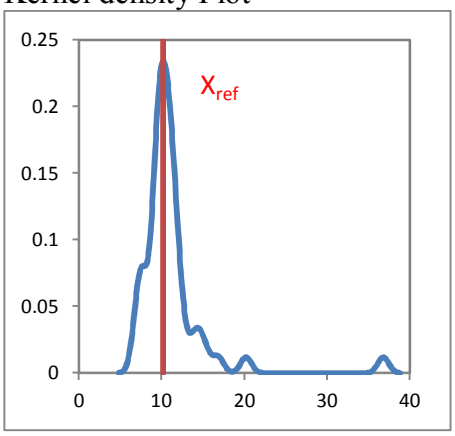


Performance evaluation: *z*-score Zeta-score



Performance evaluation for arsenic in IAEA-457

Kernel density Plot



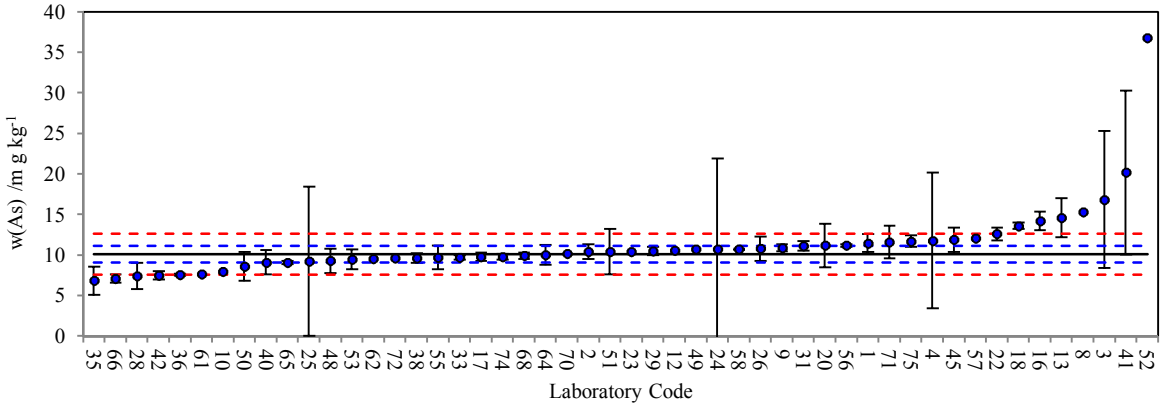
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	76%	12%	12%
Zeta-score	72%	5%	23%

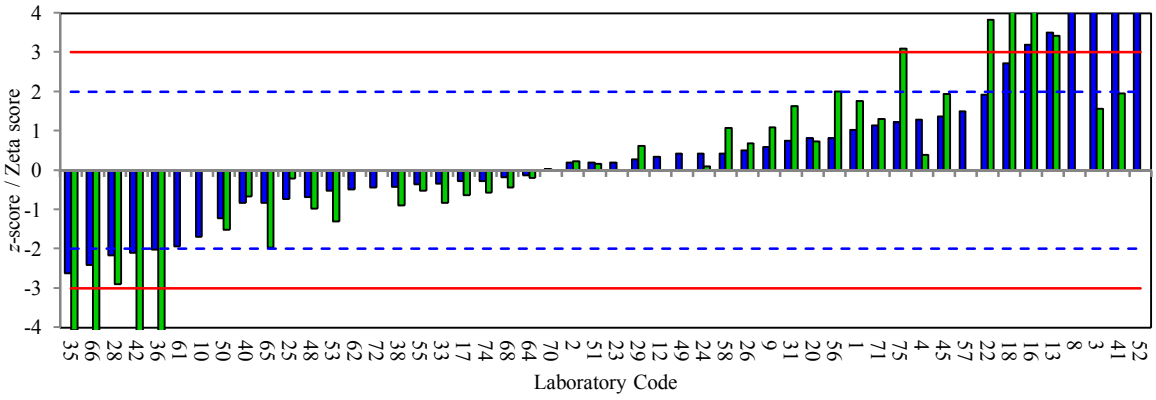
X_{cert}:	10.2 mg kg^{-1}
U_{cert} (*k*=2) :	1.0 mg kg^{-1}
$2\sigma_p$:	2.5 mg kg^{-1}
Number of results:	50
Number of methods:	7

Reported results and expanded uncertainties:

X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$ (k=2)

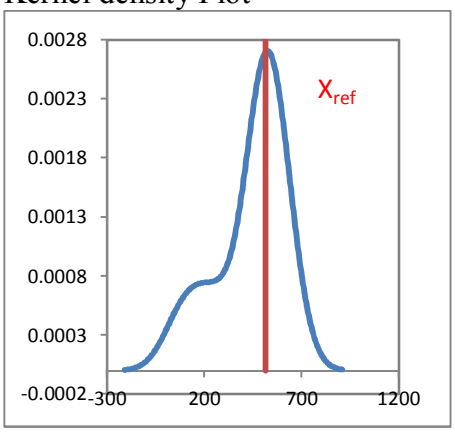


Performance evaluation: *z*-score Zeta-score



Performance evaluation for barium in IAEA-457

Kernel density Plot



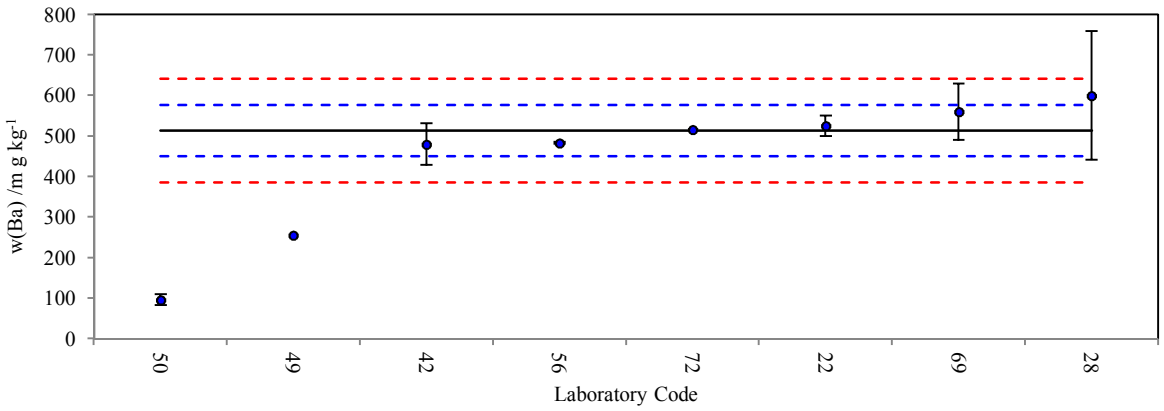
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	75%	0%	25%
Zeta-score	83%	0%	17%

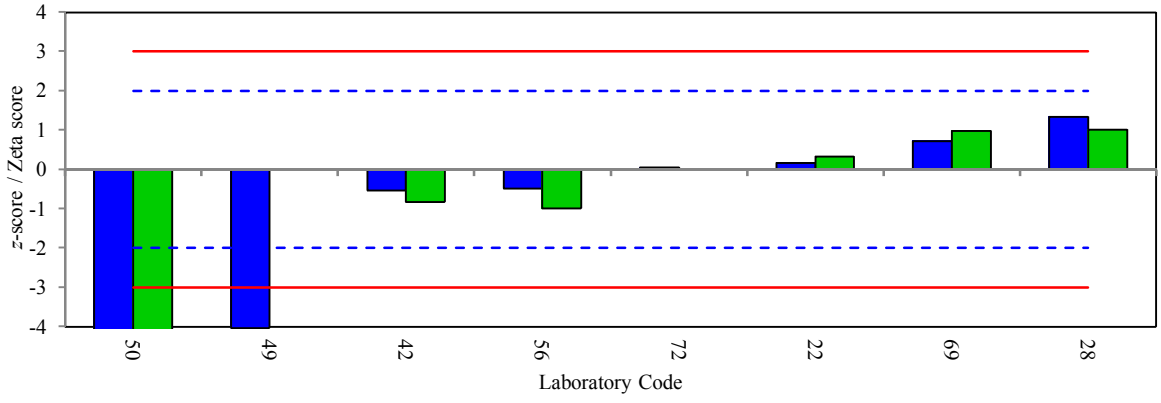
$X_{assigne}$:	514 mg kg^{-1}
$U_{assigne}$ (k=2) :	63 mg kg^{-1}
$2\sigma_p$:	128 mg kg^{-1}
Number of results:	8
Number of methods:	4

Reported results and expanded uncertainties:

— X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

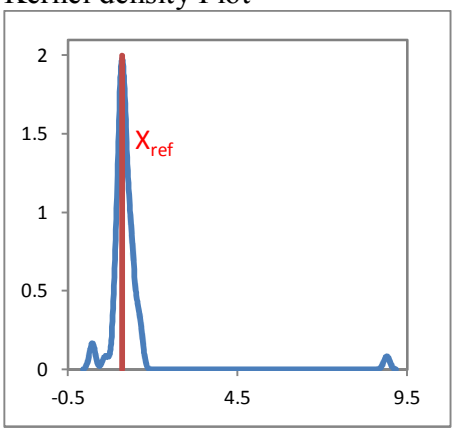


Performance evaluation: *z*-score Zeta-score



Performance evaluation for cadmium in IAEA-457

Kernel density Plot



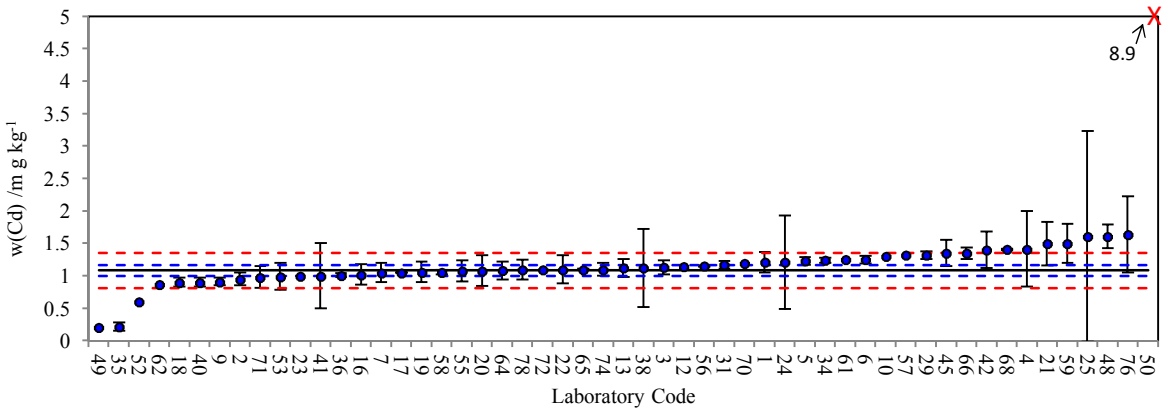
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	77%	6%	17%
Zeta-score	63%	16%	21%

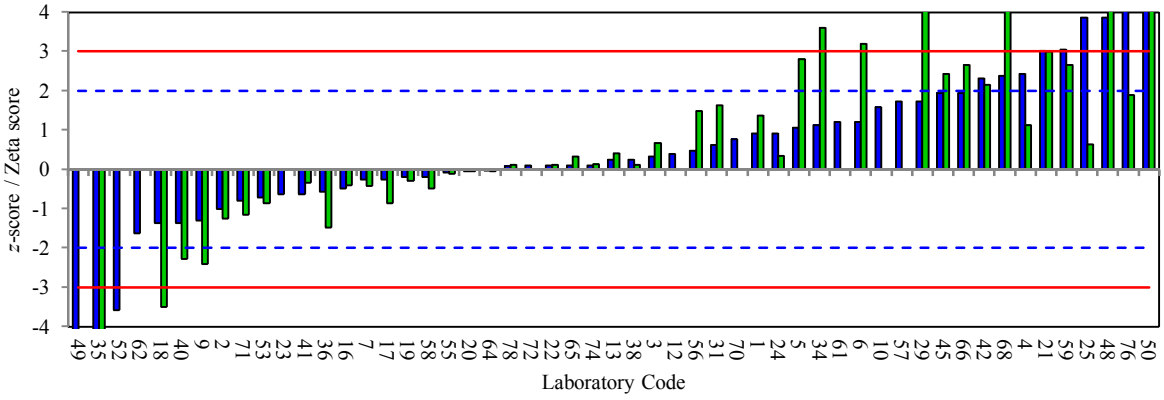
X_{cert}:	1.09 mg kg^{-1}
U_{cert} (k=2) :	0.08 mg kg^{-1}
$2\sigma_p$:	0.27 mg kg^{-1}
Number of results:	53
Number of methods:	4

Reported results and expanded uncertainties:

— X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

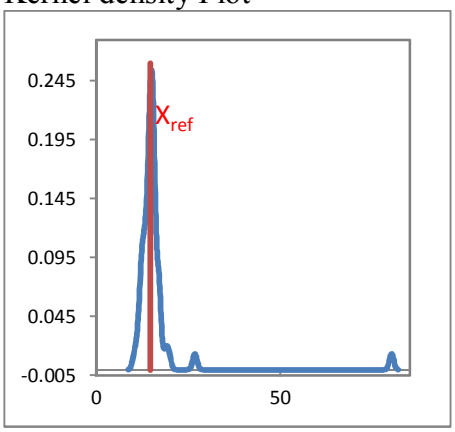


Performance evaluation: *z*-score Zeta-score



Performance evaluation for cobalt in IAEA-457

Kernel density Plot



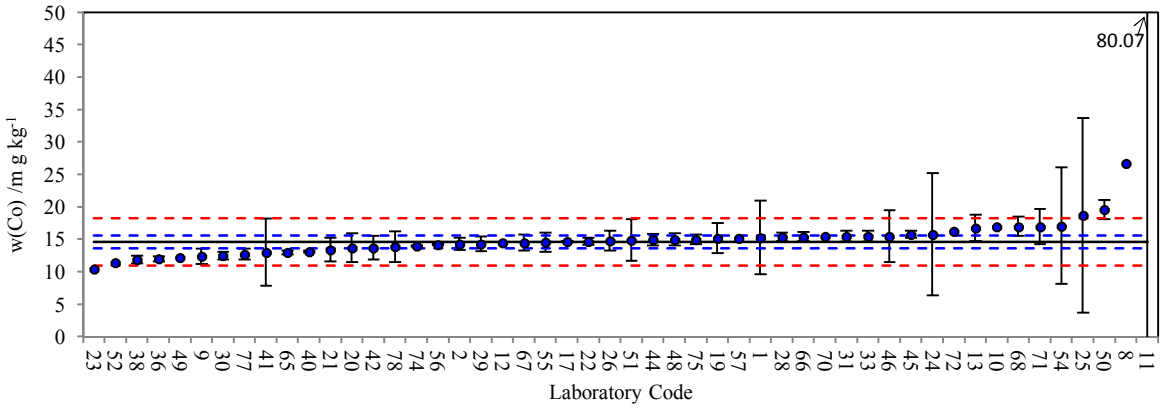
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	90%	6%	4%
Zeta-score	78%	5%	17%

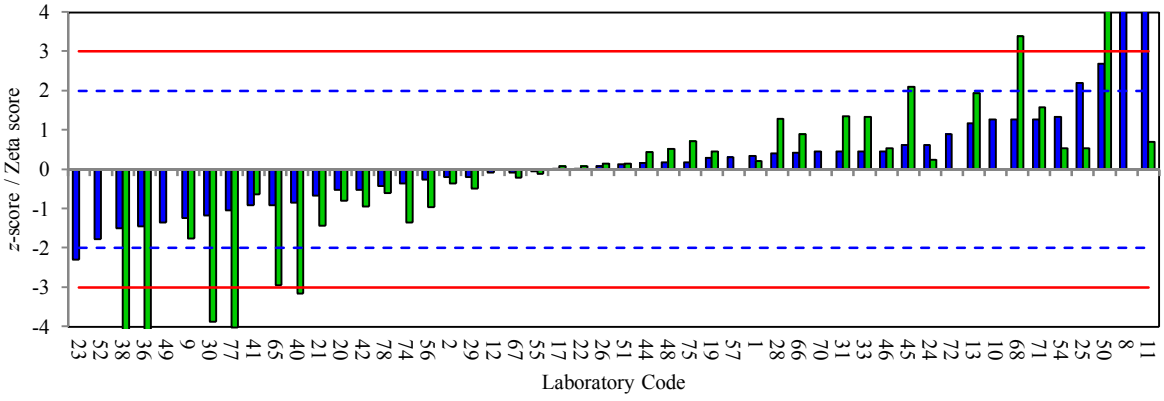
X_{cert}:	14.7 mg kg^{-1}
U_{cert} (k=2) :	1.0 mg kg^{-1}
$2\sigma_p$:	3.7 mg kg^{-1}
Number of results:	50
Number of methods:	6

Reported results and expanded uncertainties:

— X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

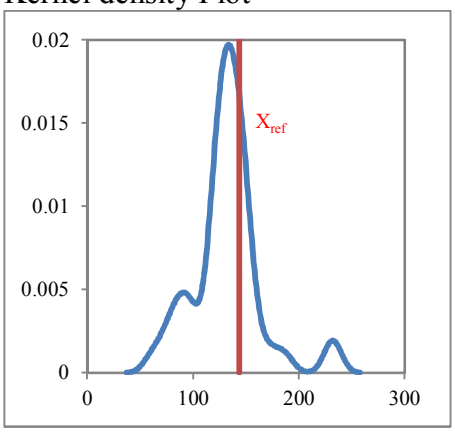


Performance evaluation: *z*-score Zeta-score



Performance evaluation for chromium in IAEA-457

Kernel density Plot



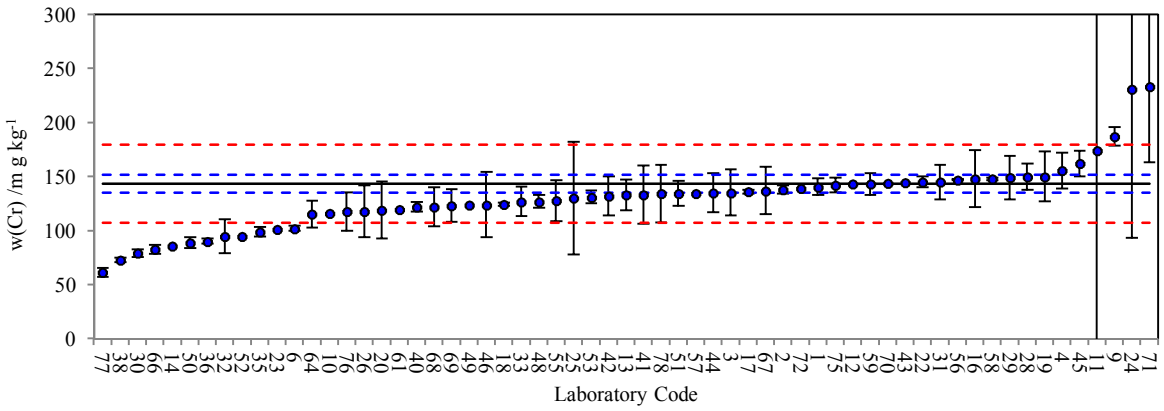
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	75%	11%	13%
Zeta-score	56%	14%	30%

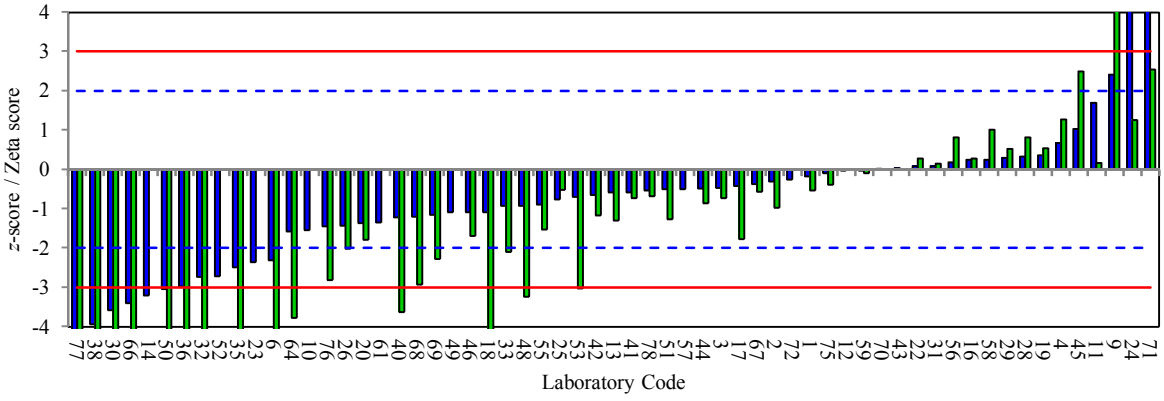
X_{cert}:	144 mg kg^{-1}
U_{cert} (k=2) :	8 mg kg^{-1}
$2\sigma_p$:	36 mg kg^{-1}
Number of results:	61
Number of methods:	7

Reported results and expanded uncertainties:

X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

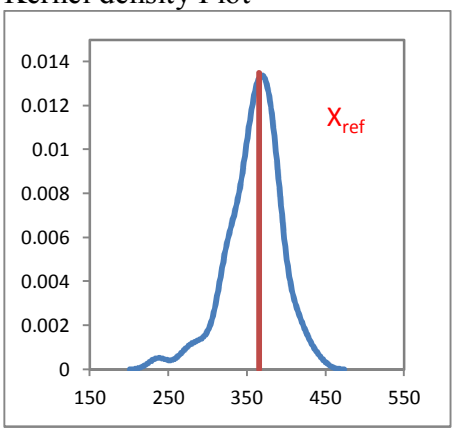


Performance evaluation: *z*-score Zeta-score



Performance evaluation for copper in IAEA-457

Kernel density Plot



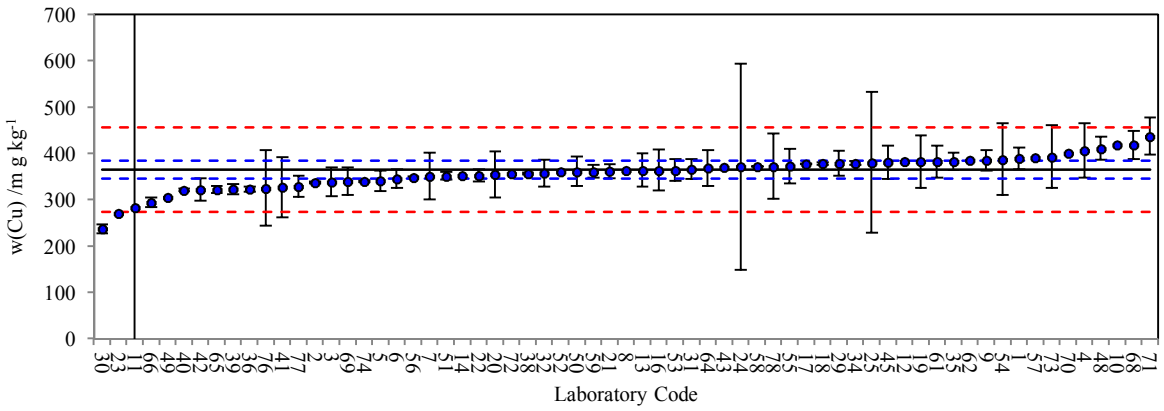
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	97%	3%	0%
Zeta-score	75%	8%	17%

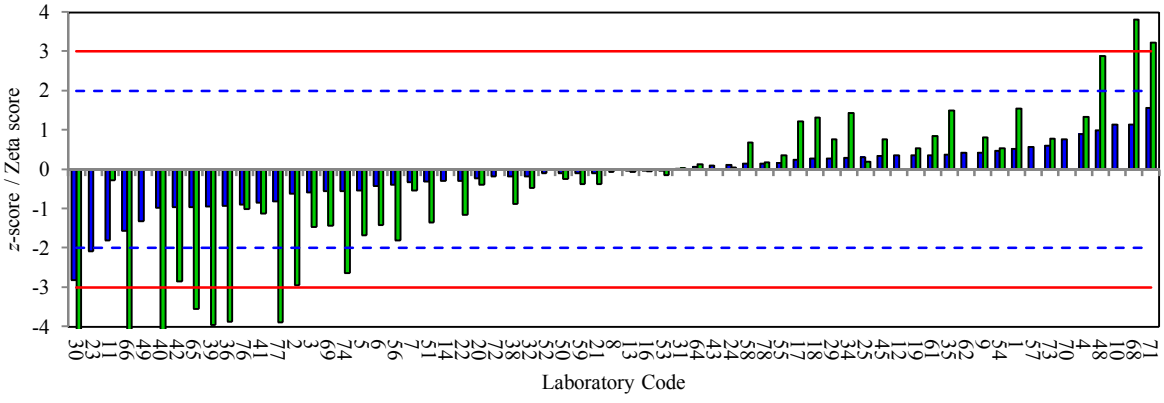
X_{cert}:	365 mg kg^{-1}
U_{cert} (k=2) :	19 mg kg^{-1}
$2\sigma_p$:	91 mg kg^{-1}
Number of results:	65
Number of methods:	6

Reported results and expanded uncertainties:

X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

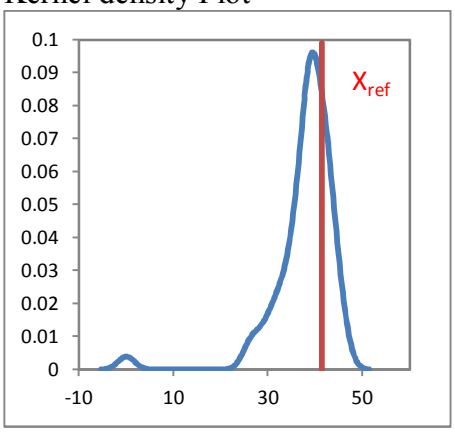


Performance evaluation: *z*-score Zeta-score



Performance evaluation for iron in IAEA-457

Kernel density Plot



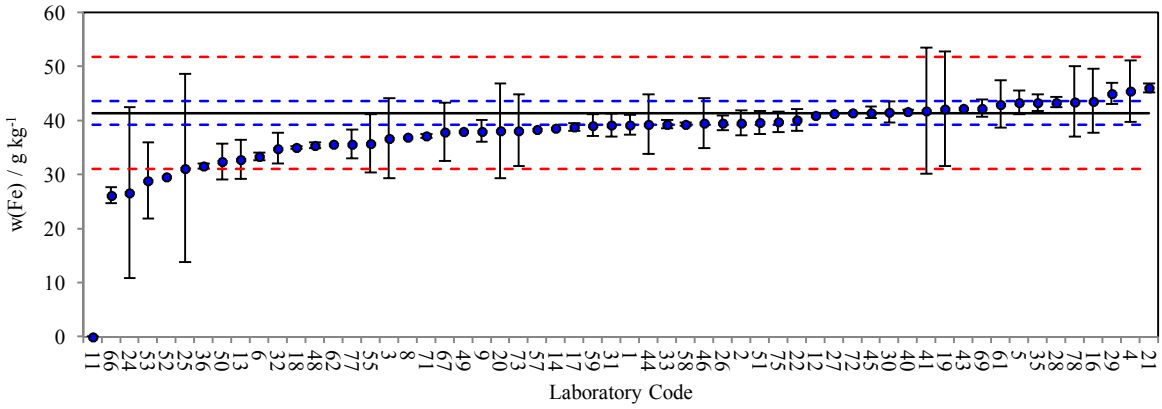
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	91%	7%	2%
Zeta-score	69%	4%	27%

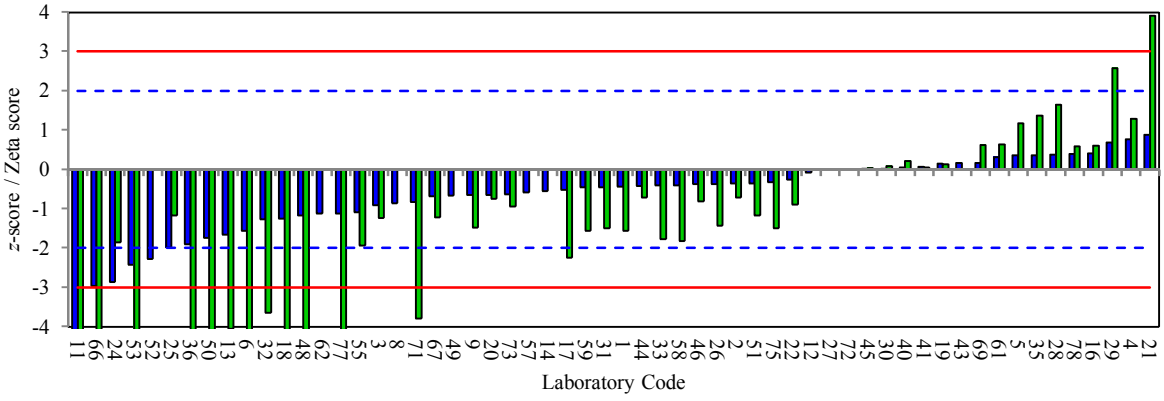
X_{cert}:	41.45 g kg^{-1}
U_{cert} (k=2) :	2.24 g kg^{-1}
$2\sigma_p$:	10.4 g kg^{-1}
Number of results:	58
Number of methods:	7

Reported results and expanded uncertainties:

— X_{ref} ; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

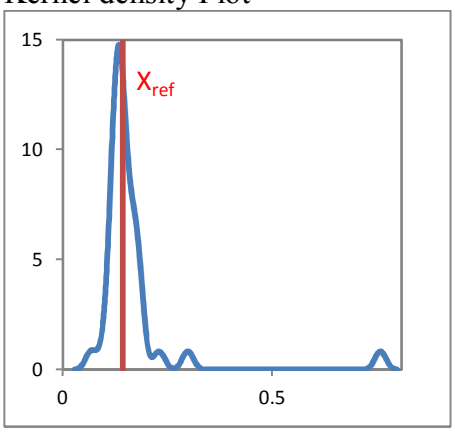


Performance evaluation: *z*-score Zeta-score



Performance evaluation for mercury in IAEA-457

Kernel density Plot



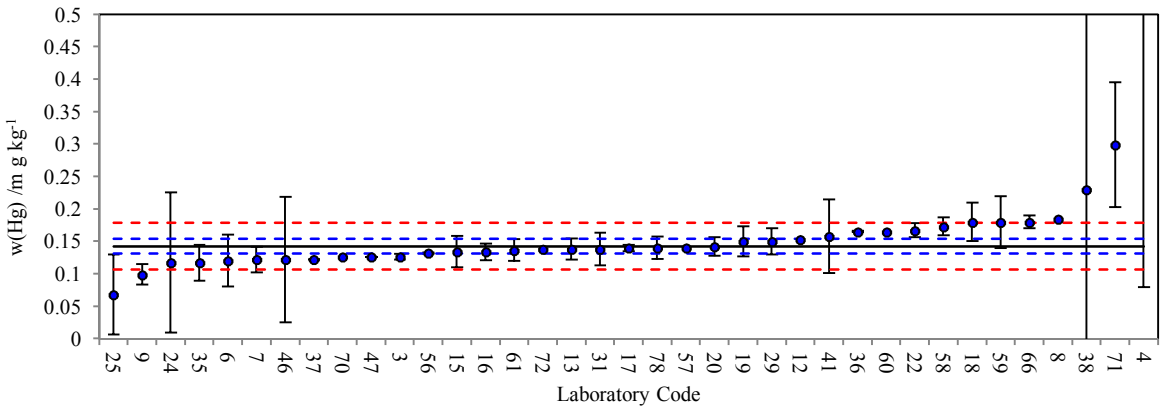
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	76%	14%	11%
Zeta-score	68%	19%	13%

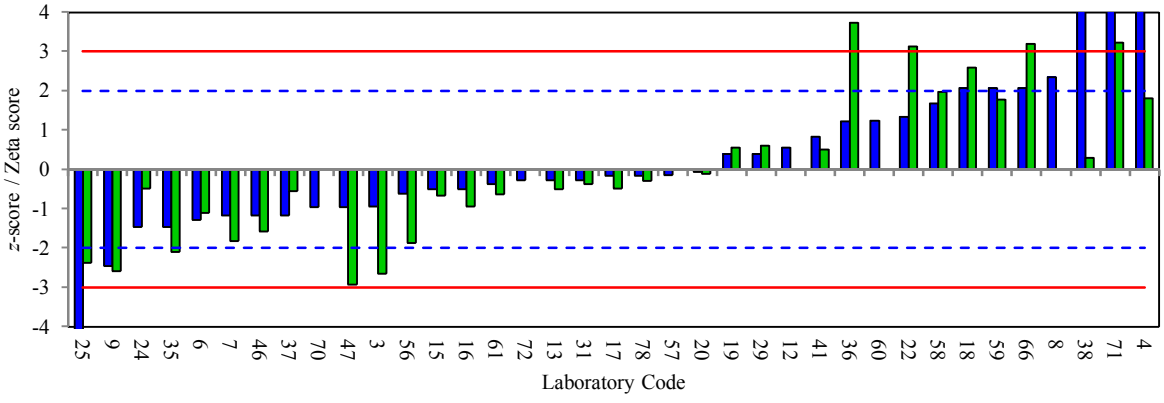
X_{cert}:	0.143 mg kg^{-1}
U_{cert} (k=2) :	0.012 mg kg^{-1}
$2\sigma_p$:	0.036 mg kg^{-1}
Number of results:	37
Number of methods:	9

Reported results and expanded uncertainties:

— X_{ref} ; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

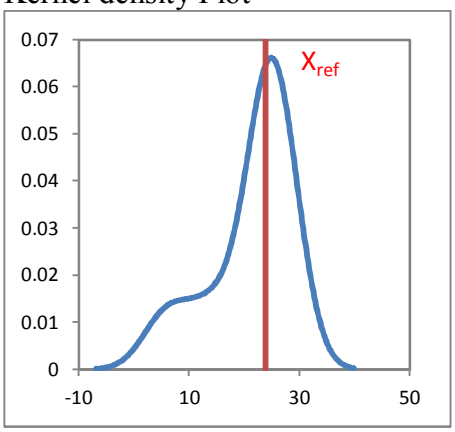


Performance evaluation: *z*-score Zeta-score



Performance evaluation for potassium in IAEA-457

Kernel density Plot



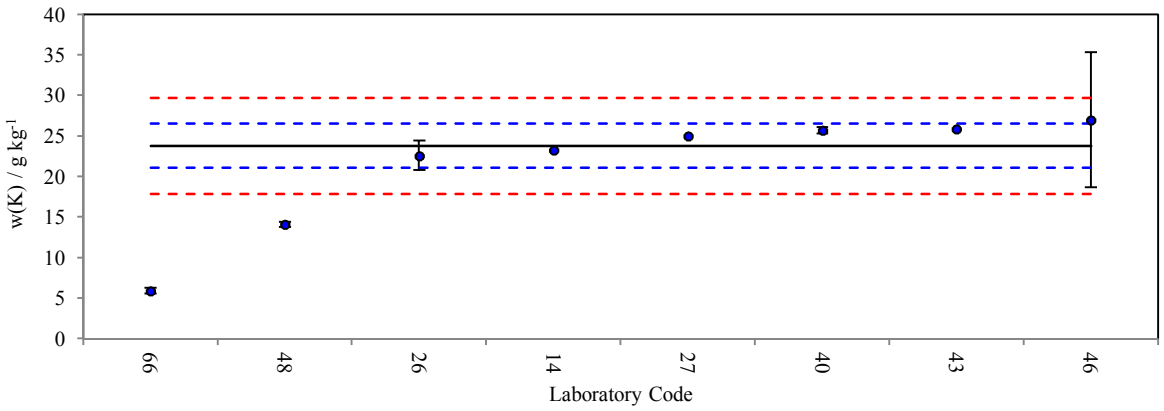
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	75%	0%	25%
Zeta-score	60%	0%	40%

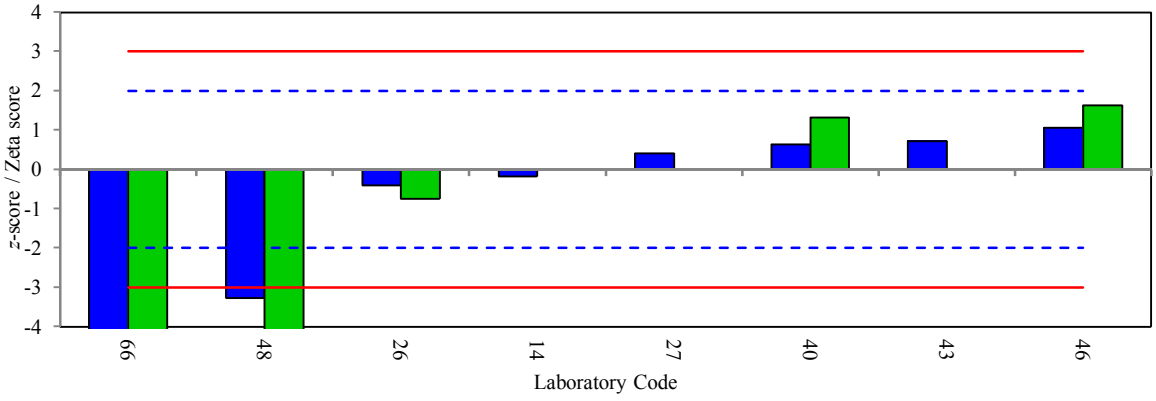
$X_{assigne}$:	23.8 g kg^{-1}
$U_{assigne}$ (k=2) :	2.7 g kg^{-1}
$2\sigma_p$:	5.9 mg kg^{-1}
Number of results:	37
Number of methods:	9

Reported results and expanded uncertainties:

— X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)



Performance evaluation: *z*-score Zeta-score



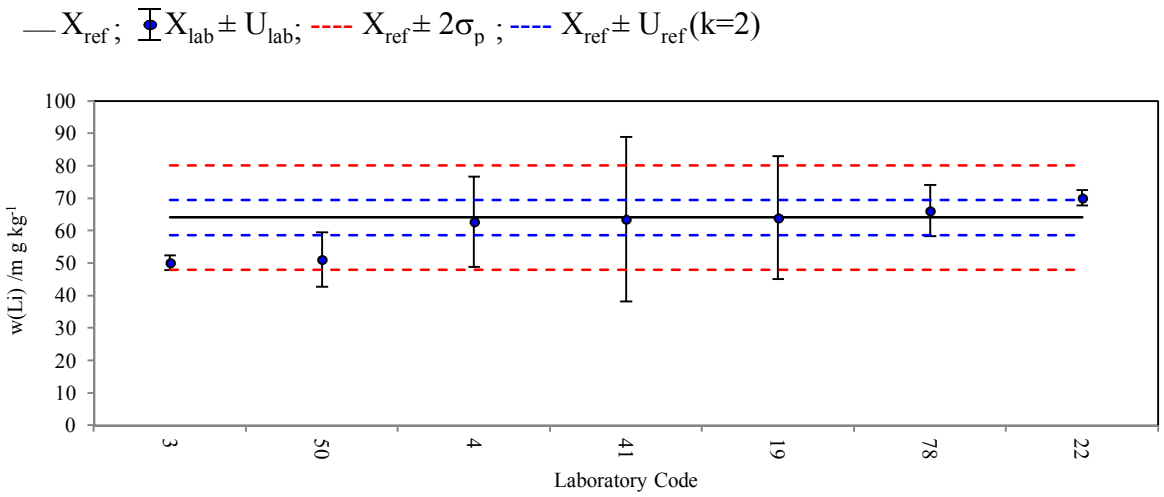
Performance evaluation for lithium in IAEA-457

Summary of results:

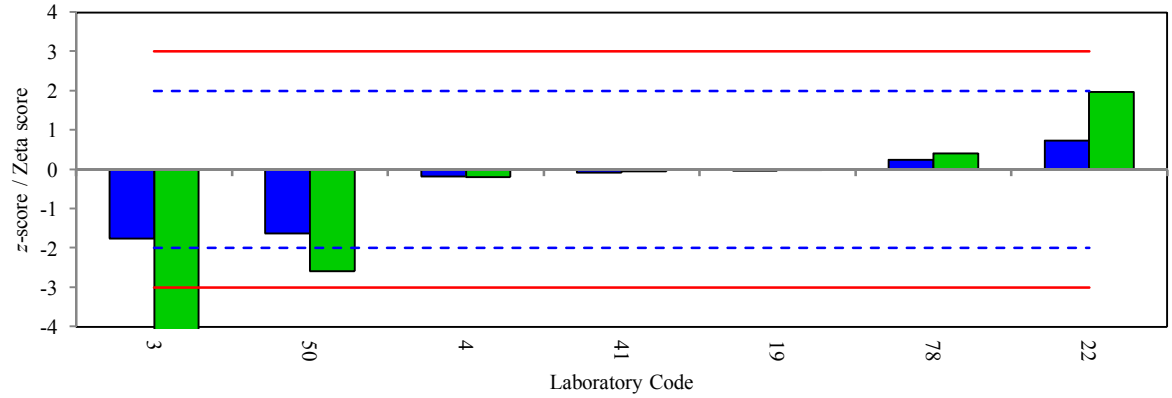
	Satisfactory	Questionable	Unsatisfactory
z-score	100%	0%	0%
Zeta-score	71%	14%	14%

X_{cert}:	64.2 mg kg^{-1}
U_{cert} (k=2) :	5.5 mg kg^{-1}
$2\sigma_p$:	16.1 mg kg^{-1}
Number of results:	7
Number of methods:	3

Reported results and expanded uncertainties:

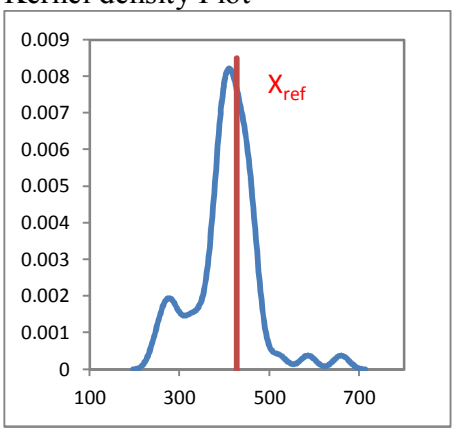


Performance evaluation: *z*-score Zeta-score



Performance evaluation for manganese in IAEA-457

Kernel density Plot



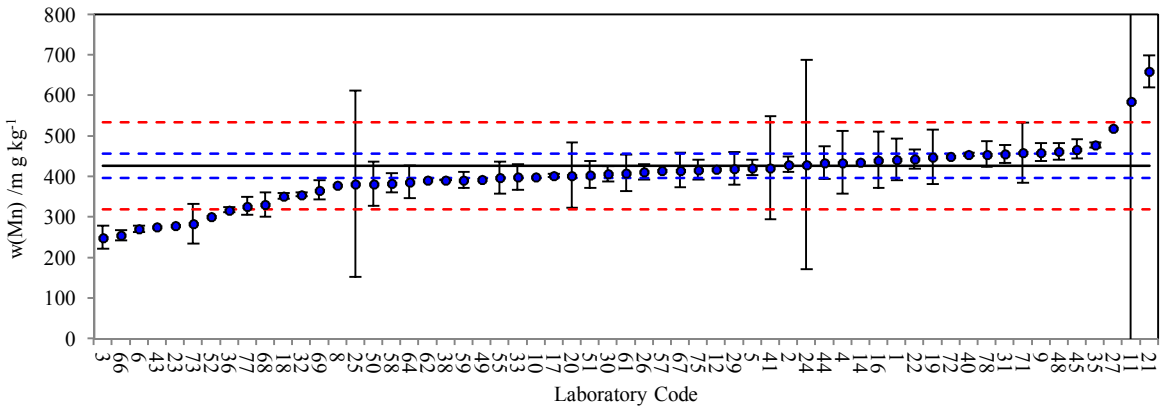
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	83%	12%	5%
Zeta-score	70%	4%	26%

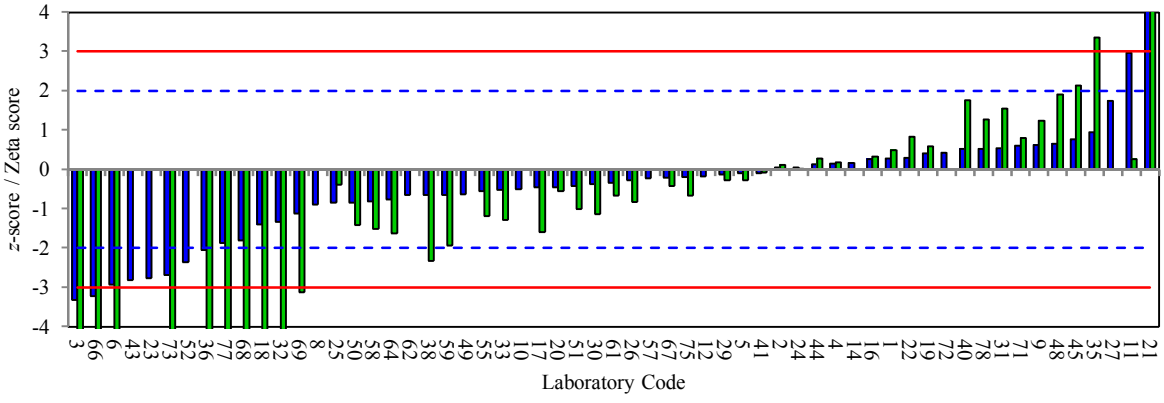
X_{cert}:	427 mg kg^{-1}
U_{cert} (k=2) :	30 mg kg^{-1}
$2\sigma_p$:	107 mg kg^{-1}
Number of results:	59
Number of methods:	7

Reported results and expanded uncertainties:

X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)



Performance evaluation: *z*-score Zeta-score



Performance evaluation for sodium in IAEA-457

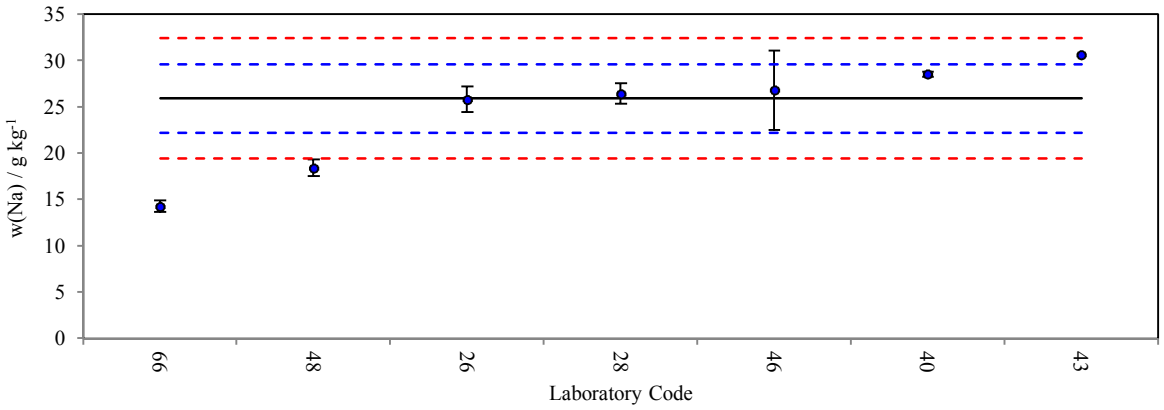
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	71%	14%	14%
Zeta-score	67%	0%	33%

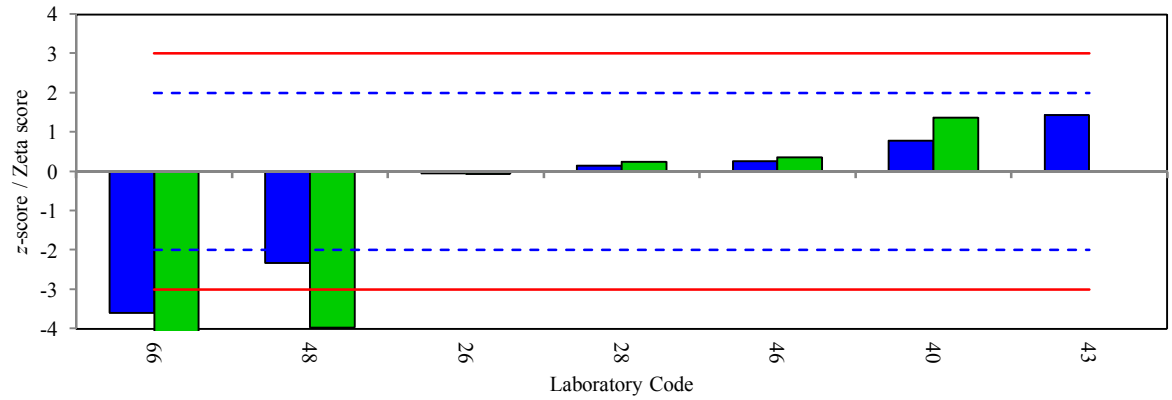
$X_{assigne}$:	25.9 g kg^{-1}
$U_{assigne}$ (k=2) :	3.7 g kg^{-1}
$2\sigma_p$:	6.5 g kg^{-1}
Number of results:	7
Number of methods:	2

Reported results and expanded uncertainties:

— X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

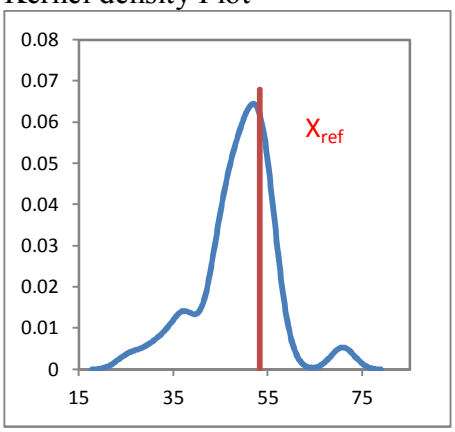


Performance evaluation: *z*-score Zeta-score



Performance evaluation for nickel in IAEA-457

Kernel density Plot



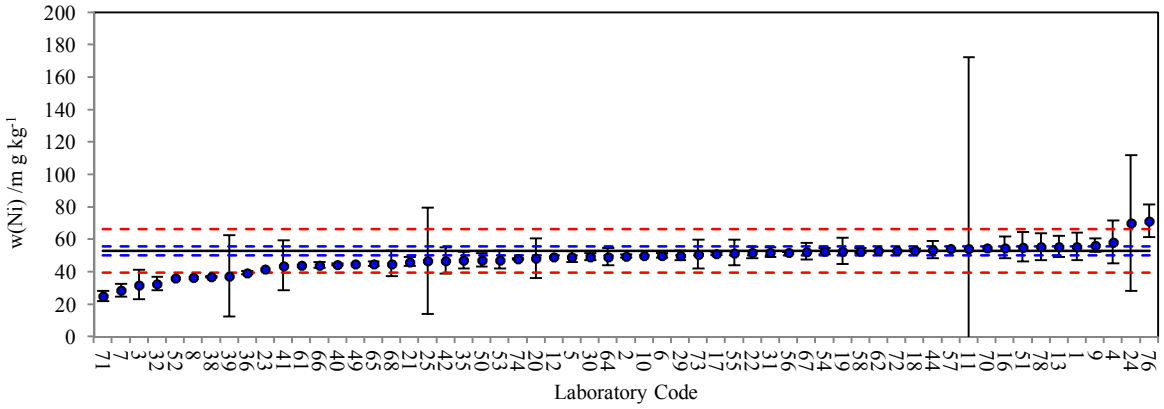
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	81%	12%	7%
Zeta-score	60%	13%	27%

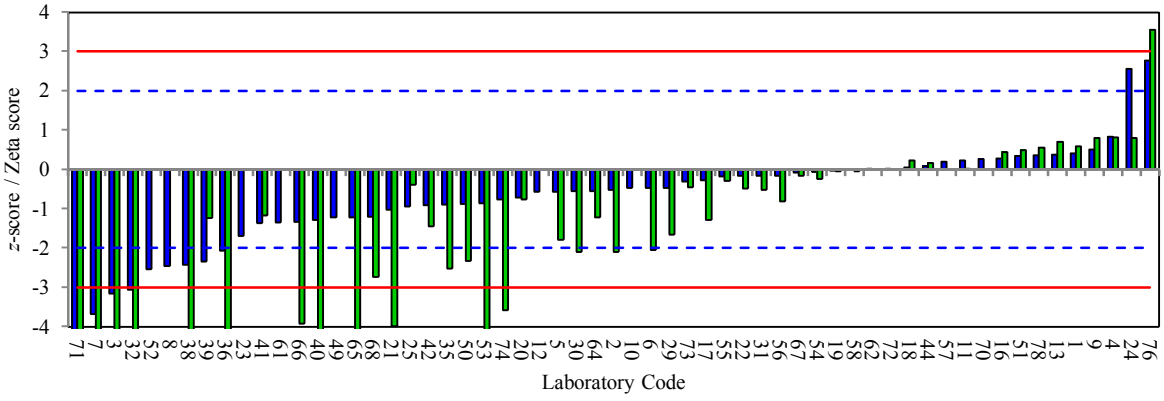
X_{cert}:	53.3 mg kg^{-1}
U_{cert} (k=2) :	2.7 mg kg^{-1}
$2\sigma_p$:	13.3 mg kg^{-1}
Number of results:	59
Number of methods:	6

Reported results and expanded uncertainties:

X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

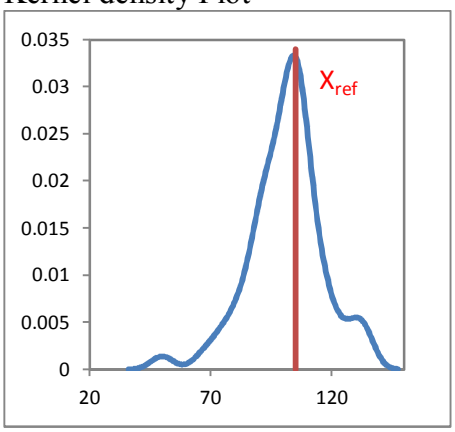


Performance evaluation: *z*-score Zeta-score



Performance evaluation for lead in IAEA-457

Kernel density Plot



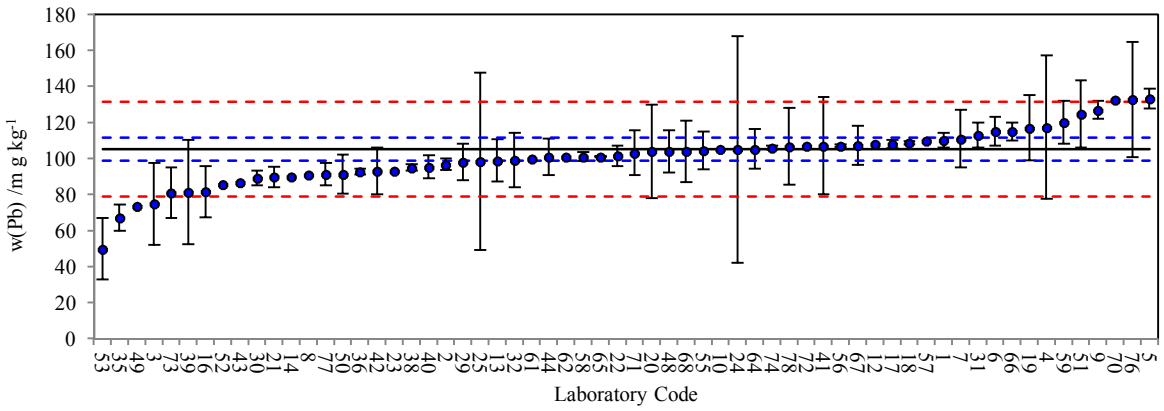
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	89%	10%	2%
Zeta-score	60%	13%	27%

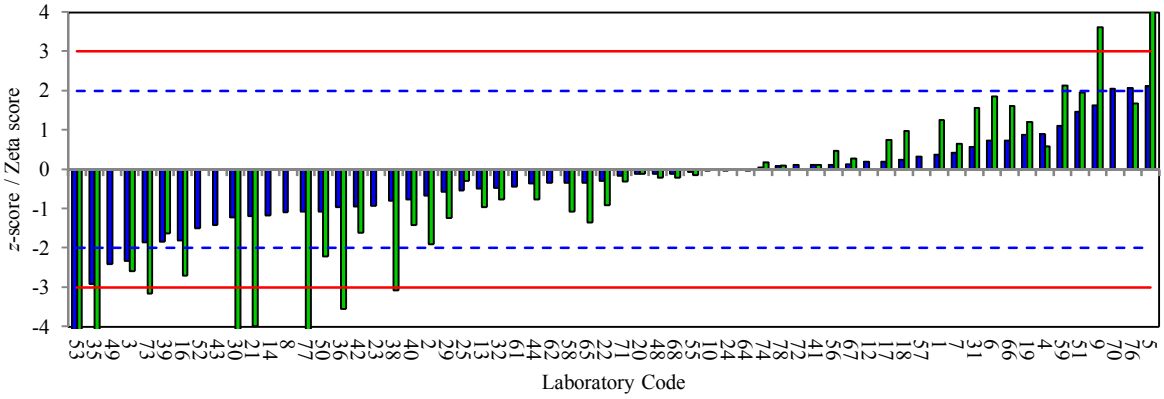
X_{cert}:	105 mg kg^{-1}
U_{cert} (k=2) :	7 mg kg^{-1}
$2\sigma_p$:	26 mg kg^{-1}
Number of results:	62
Number of methods:	6

Reported results and expanded uncertainties:

— X_{ref} ; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

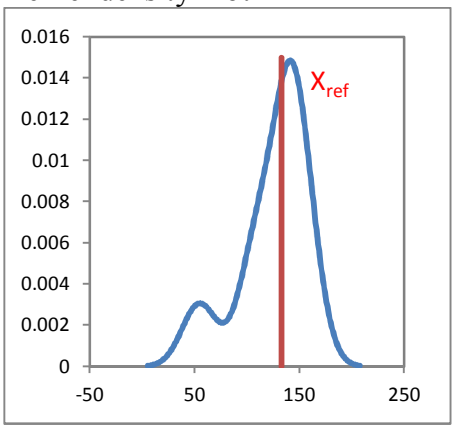


Performance evaluation: *z*-score Zeta-score



Performance evaluation for rubidium in IAEA-457

Kernel density Plot



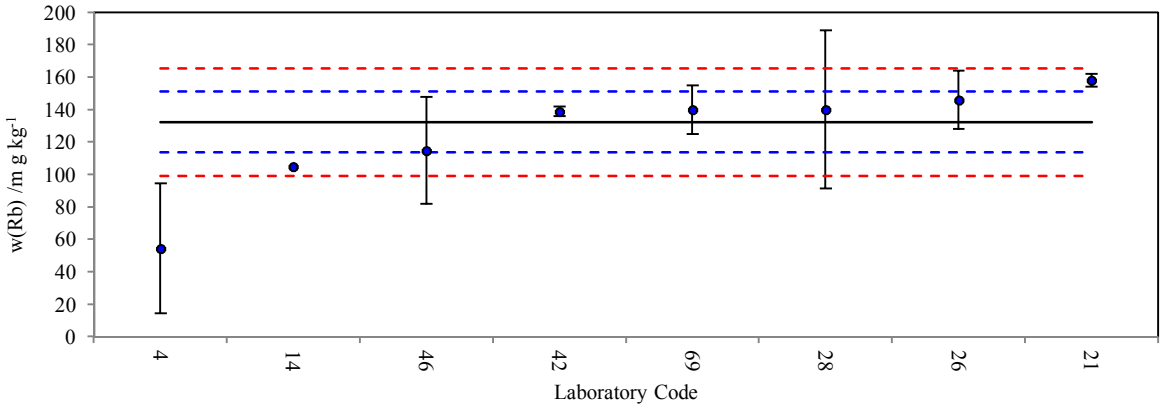
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	88%	0%	13%
Zeta-score	71%	14%	14%

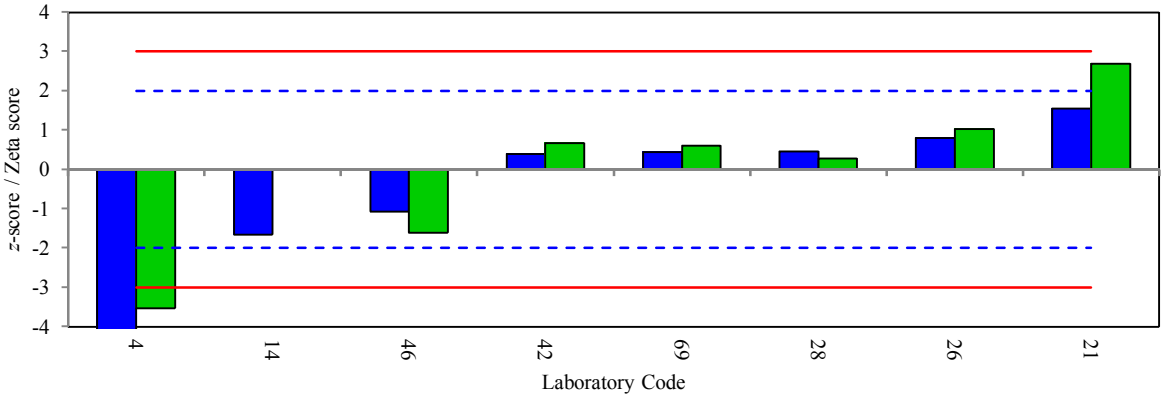
$X_{assigned}$:	133 mg kg^{-1}
$U_{assigned}$ (k=2) :	19 mg kg^{-1}
$2\sigma_p$:	33 mg kg^{-1}
Number of results:	8
Number of methods:	4

Reported results and expanded uncertainties:

X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)



Performance evaluation: *z*-score Zeta-score



Performance evaluation for antimony in IAEA-457

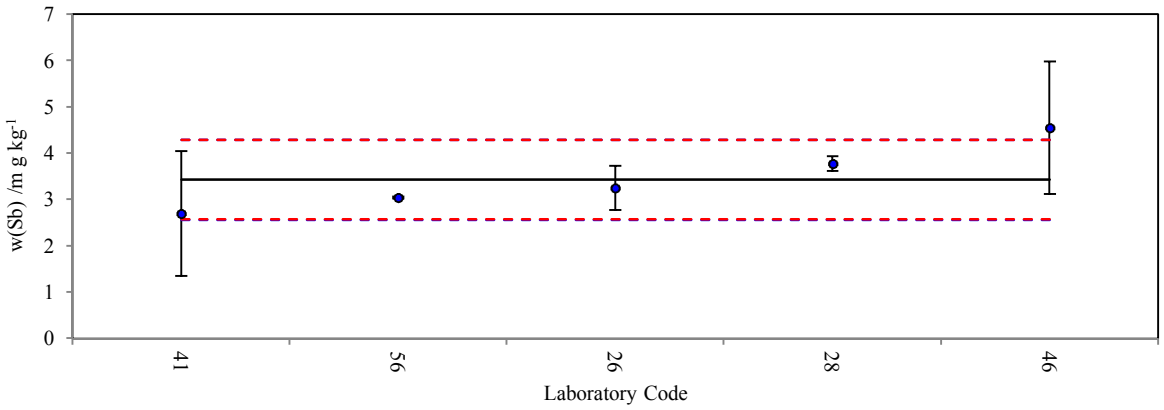
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	80%	20%	0%
Zeta-score	100%	0%	0%

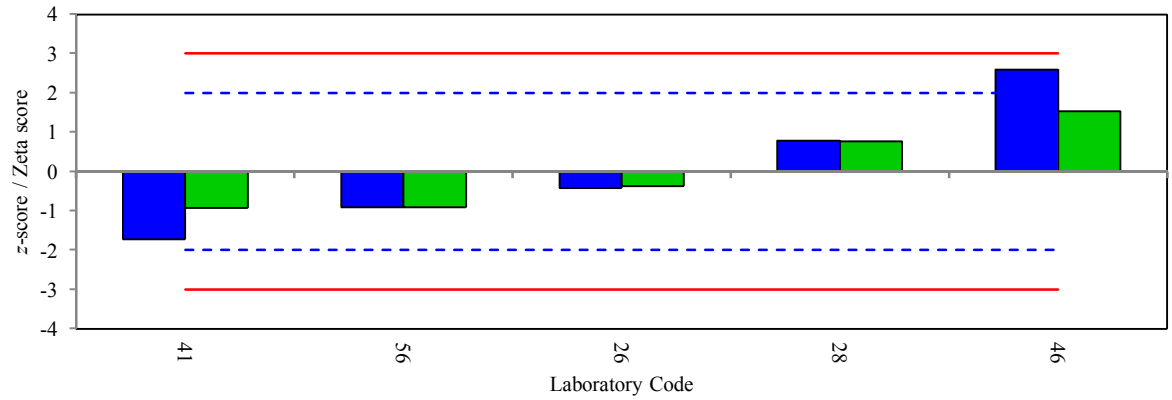
$X_{assigne}$:	3.4 mg kg^{-1}
$U_{assigne}$ (k=2) :	0.9 mg kg^{-1}
$2\sigma_p$:	0.9 mg kg^{-1}
Number of results:	5
Number of methods:	2

Reported results and expanded uncertainties:

X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

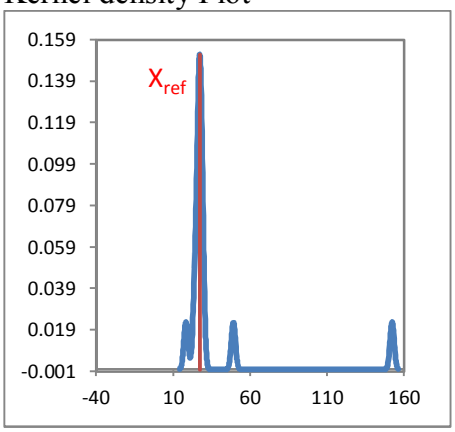


Performance evaluation: *z*-score Zeta-score



Performance evaluation for tin in IAEA-457

Kernel density Plot



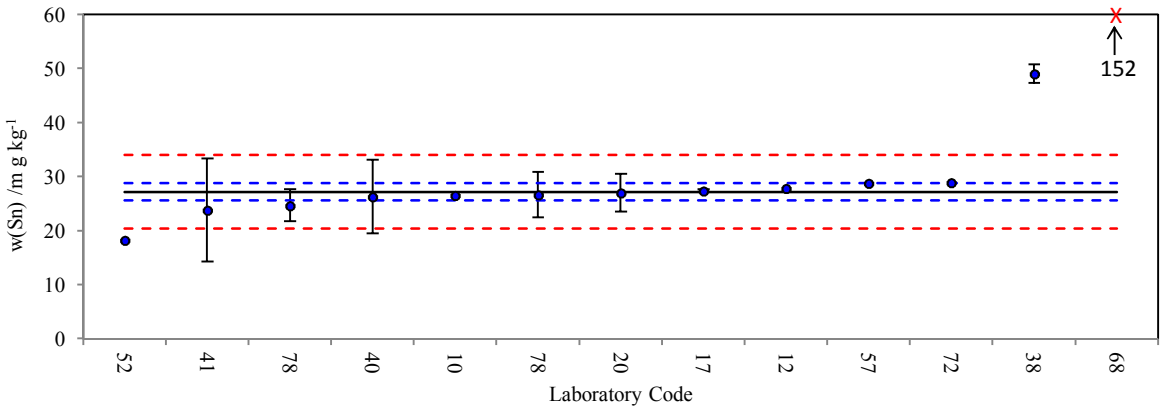
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	75%	8%	17%
Zeta-score	50%	8%	42%

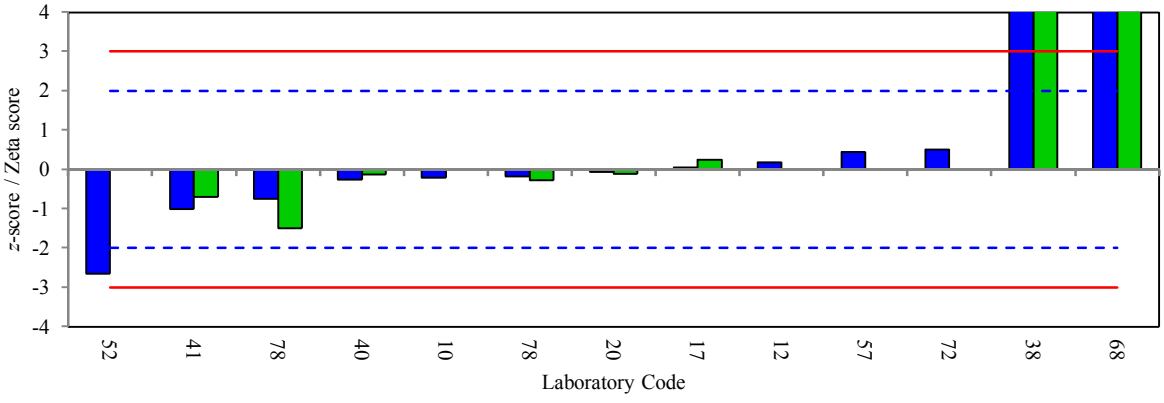
X_{cert}:	27.40 mg kg^{-1}
U_{cert} (k=2) :	0.75 mg kg^{-1}
$2\sigma_p$:	6.85 mg kg^{-1}
Number of results:	12
Number of methods:	3

Reported results and expanded uncertainties:

X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

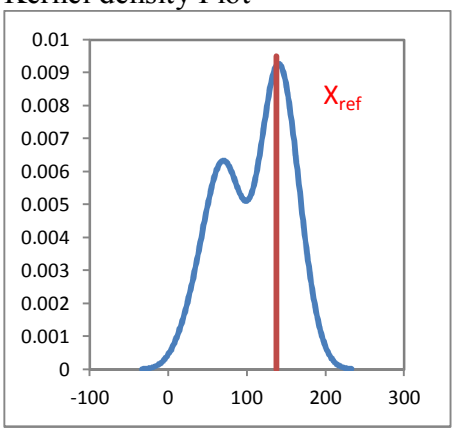


Performance evaluation: *z*-score Zeta-score



Performance evaluation for strontium in IAEA-457

Kernel density Plot



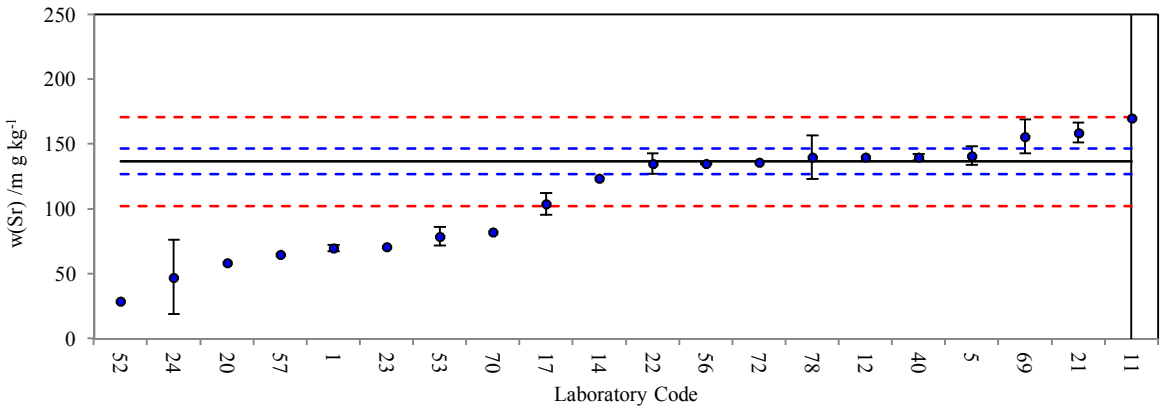
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	60%	0%	40%
Zeta-score	50%	8%	42%

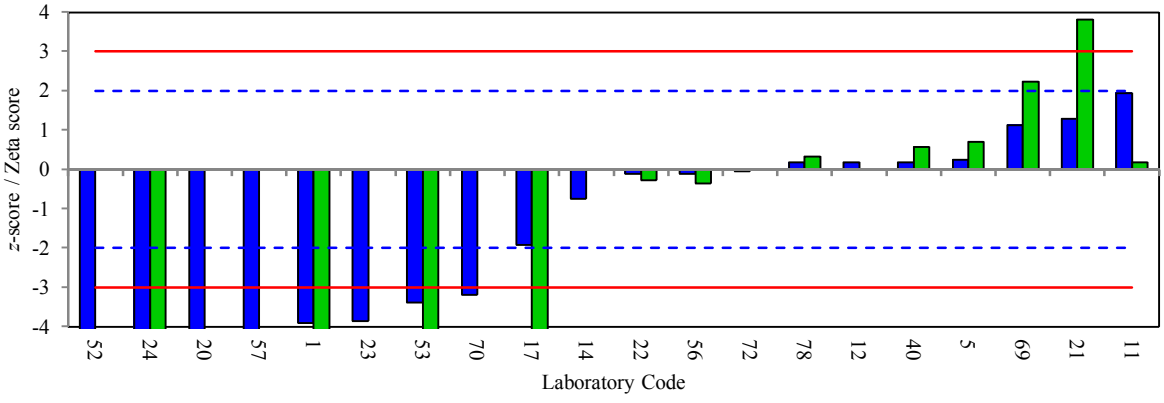
X_{cert}:	137 mg kg^{-1}
U_{cert} (k=2) :	10 mg kg^{-1}
$2\sigma_p$:	34 mg kg^{-1}
Number of results:	20
Number of methods:	5

Reported results and expanded uncertainties:

— X_{ref} ; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$ (k=2)

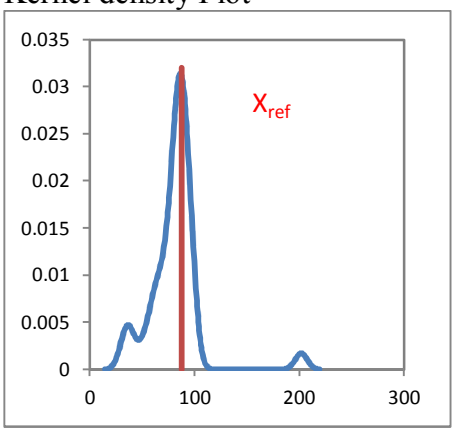


Performance evaluation: *z*-score Zeta-score



Performance evaluation for vanadium in IAEA-457

Kernel density Plot



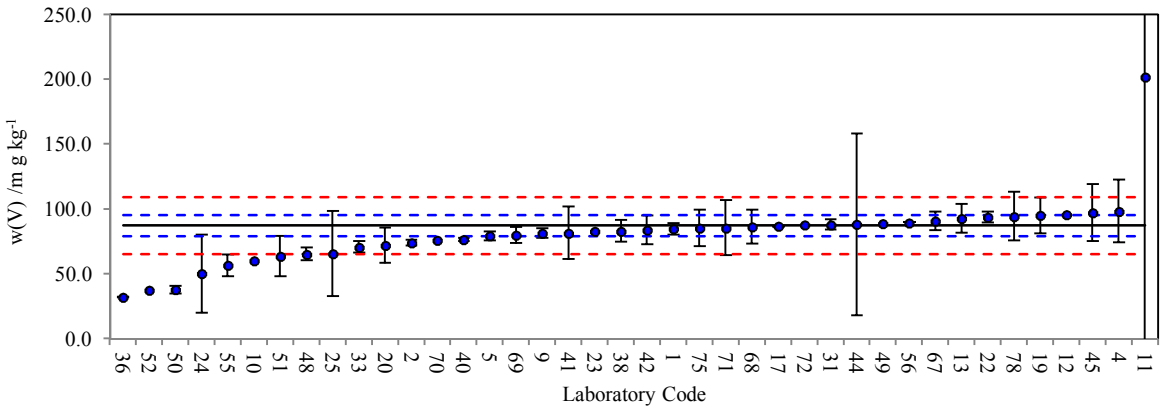
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	75%	13%	13%
Zeta-score	73%	12%	15%

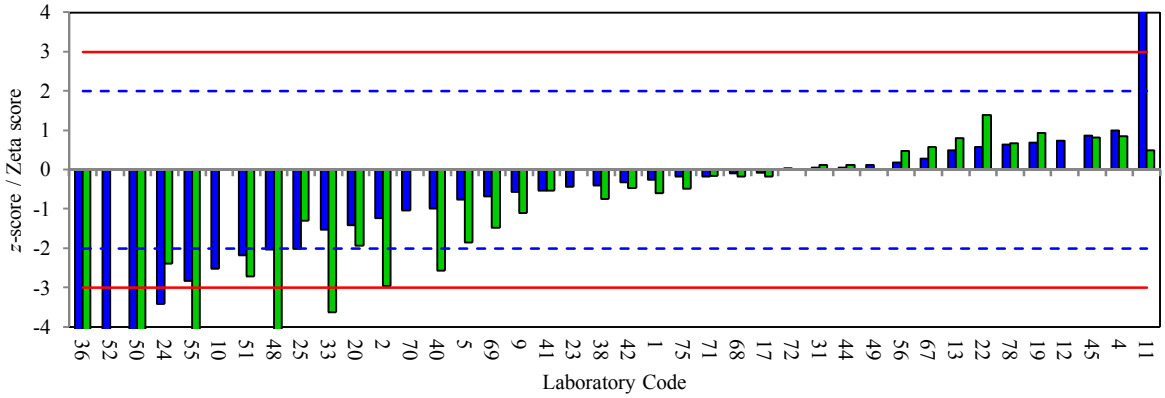
X_{cert}:	87.4 mg kg^{-1}
U_{cert} (k=2) :	8.1 mg kg^{-1}
$2\sigma_p$:	10.9 mg kg^{-1}
Number of results:	40
Number of methods:	7

Reported results and expanded uncertainties:

X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)

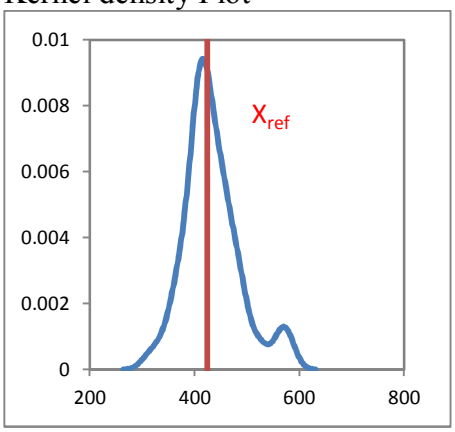


Performance evaluation: *z*-score Zeta-score



Performance evaluation for zinc in IAEA-457

Kernel density Plot



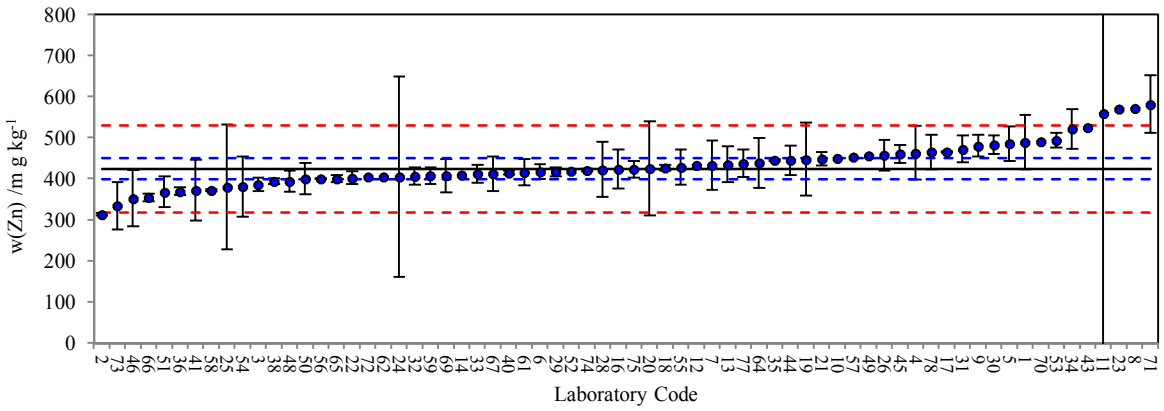
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	93%	7%	0%
Zeta-score	70%	14%	16%

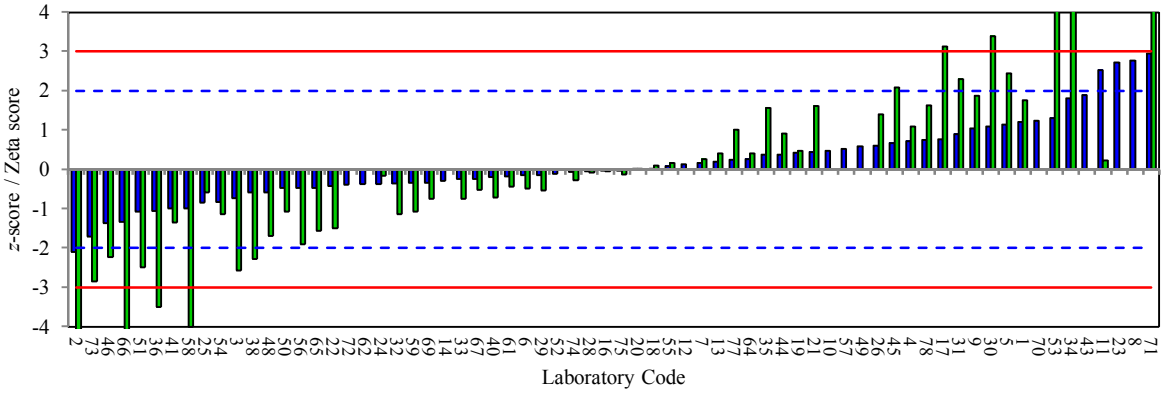
X_{cert}:	425 mg kg^{-1}
U_{cert} (k=2) :	25.8 mg kg^{-1}
$2\sigma_p$:	106 mg kg^{-1}
Number of results:	68
Number of methods:	7

Reported results and expanded uncertainties:

X_{ref}; $X_{lab} \pm U_{lab}$; ---- $X_{ref} \pm 2\sigma_p$; ---- $X_{ref} \pm U_{ref}$(k=2)



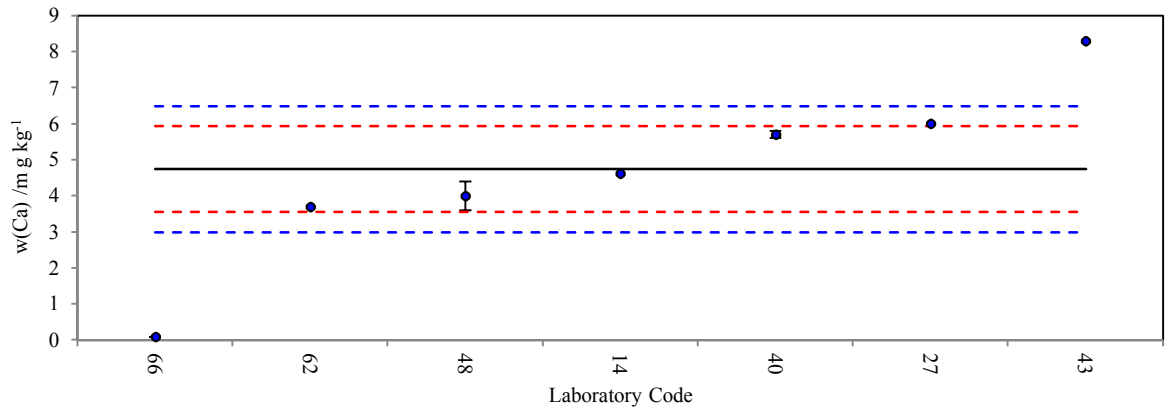
Performance evaluation: *z*-score Zeta-score



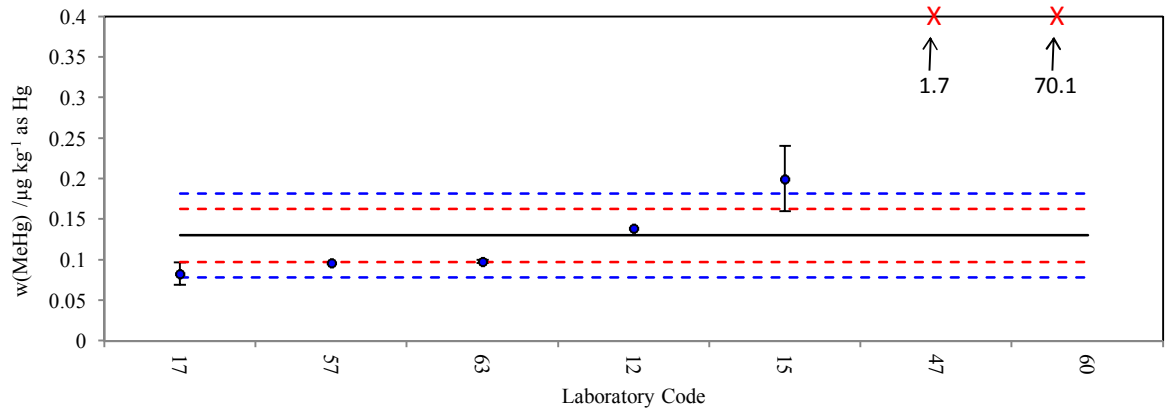
APPENDIX II

GRAPHICAL REPRESENTATION OF REPORTED DATA FOR CA, MeHg AND Se IN IAEA-457

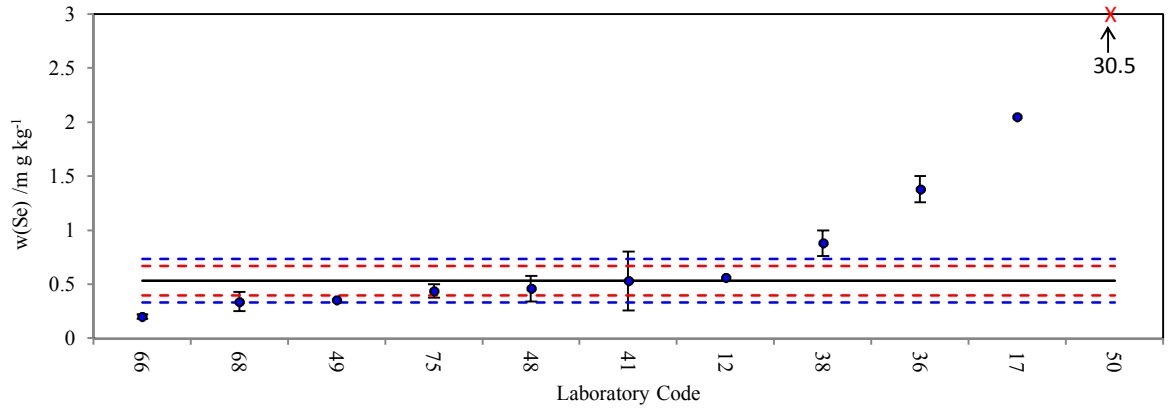
Reported results for calcium in IAEA-457



Reported results for methyl mercury in IAEA-457



Reported results for selenium in IAEA-457



— X_{Info}; $X_{lab} \pm U_{lab}$; ---- $X_{Info} \pm 2\sigma_p$; ---- $X_{Info} \pm U_{Info}(k=2)$

APPENDIX III

REPORTED RESULTS BY PARTICIPANTS

TABLE 7. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR SILVER

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
5	1.40	0.04	0.08	PACS-2	ICP-AES	-1.95	-2.30
9	1.90	0.22	0.22	MESS-3	ET-AAS	0.22	0.17
12	1.78			PACS-2	ICP-MS	-0.30	
17	2.36	0.03	0.06	NIST 2709a	ICP-MS	2.21	2.64
20	1.94	0.39	0.78	IAEA-158	ICP-MS	0.39	0.21
23	1.43				ICP-MS	-1.80	
34	1.60	0.05	0.23	IAEA-356	ET-AAS	-1.08	-1.27
38	1.86	0.20	0.40		ICP-MS	0.04	0.04
42	1.37	0.13	0.26	IAEA-158	ICP-MS	-2.08	-2.08
48	1.99	0.17	0.35		NAA	0.61	0.55
51	1.60	0.20	0.40	IAEA-SL1	ET-AAS	-1.08	-0.90
56	2.19	0.01	0.01		ICP-MS	1.47	1.78
57	2.03			IAEA-405		0.76	
62	1.83			IAEA-433	ICP-MS	-0.09	
65	1.70	0.03	0.03	MESS-3	ICP-MS	-0.65	-0.78
68	0.320	0.030	0.090	IAEA-SL1	ICP-MS	-6.62	-7.91
74	1.80	0.01	0.01	MESS-3	ICP-MS	-0.22	-0.26
75	1.96	0.05	0.20	IAEA-405	NAA	0.48	0.56

TABLE 8. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR ALUMINIUM

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
2	80.8	1.3	1.3	IAEA-405	ET-AAS	-0.18	-0.87
3	54.0	13.1	26.2	BCR-277R	F-AAS	-2.77	-2.17
4	74.7	7.1	14.1	PACS-2	AAS	-0.77	-1.09
5	0.008	0.000	0.000	PACS-2	ICP-AES	-8.00	-48.12
8	86.6			IAEA-356	F-AAS	0.38	
9	79.5	2.0	2.0	MESS-3	F-AAS	-0.31	-1.21
12	79.2			PACS-2	ICP-AES	-0.34	
14	100			IAEA-356	XRF	1.68	
16	83.5	3.5	6.0	MESS-2	F-AAS	0.08	0.22
17	60.0	1.7	3.5	NIST 2709a	ICP-MS	-2.19	-9.26
19	85.8	8.6	17.2	MESS-3	ICP-MS	0.30	0.36
20	57.8			IAEA-158	ICP-MS	-2.41	
22	78.8	1.2	2.4	IAEA-433	ICP-MS	-0.37	-1.84
24	35.9	10.8	21.6	OK-TEP5	ET-AAS	-4.53	-4.28
25	58.2	15.1	30.2	GSO5364-90	ICP-AES	-2.37	-1.61
26	76.1	3.8	7.6	IAEA SL-1	NAA	-0.64	-1.59
27	83.4			NIES 2	XRF	0.07	

TABLE 8. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR ALUMINIUM (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
29	93.0	2.3	5.0	GBW 7313	ET-AAS	1.00	3.60
33	81.2	1.2	2.5	IAEA SL-1	NAA	-0.14	-0.71
35	66.0	3.4	9.0	IAEA-433	ET-AAS	-1.61	-4.43
36	23.5	0.3	0.3	PACS-2	ICP-MS	-5.73	-34.06
40	84.2	1.1	1.1	MESS-3		0.15	0.75
41	77.8	10.1	20.2	IAEA-433	ICP-AES	-0.47	-0.48
45	84.9	2.8	5.6	PACS-2	NAA	0.22	0.68
48	55.9	0.9	1.8		NAA	-2.59	-13.80
49	6.89					-7.33	
50	28.3	2.4	4.7		F-AAS	-5.26	-18.42
52	17.2				ICP-AES	-6.33	
55	53.0	4.0	7.9	NIST 2702	ICP-MS	-2.87	-6.86
57	35.2			IAEA-405		-4.59	
61	43.9			WQB1	F-AAS	-3.75	
69	84.8	3.0	5.8	IAEA-158	XRF	0.21	0.62
72	83.1			MESS-3	ICP-AES	0.04	
75	80.0	0.0	7.5	IAEA-405	NAA	-0.26	-1.57
78	83.3	8.3	16.7	IAEA-158	F-AAS	0.06	0.07

TABLE 9. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR ARSENIC

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	11.5	0.6	1.1	CZ 120	ICP-MS	1.04	1.75
2	10.4	0.9	0.9	IAEA-405	ET-AAS	0.19	0.24
3	16.8	4.2	8.4	BCR-277R	ET-AAS	5.26	1.57
4	11.8	4.2	8.4	PACS2	ICP-AES	1.30	0.39
8	15.3			IAEA-356	F-AAS	4.05	
9	10.9	0.5	0.5	MESS-3	HYD-AAS	0.59	1.10
10	8.00				ICP-AES	-1.70	
12	10.6			PACS-2	ICP-MS	0.35	
13	14.6	1.2	2.4	PACS-2	ICP-MS	3.50	3.42
16	14.2	0.7	1.2	MESS-2	ET-AAS	3.19	4.82
17	9.80	0.25	0.50	NIST 2709a	ICP-MS	-0.28	-0.63
18	13.6	0.2	0.4		HYD-AAS	2.71	6.47
20	11.2	1.3	2.7	IAEA-158	ICP-MS	0.82	0.73
22	12.6	0.4	0.8	IAEA-433	ICP-MS	1.93	3.82
23	10.4				ICP-MS	0.20	
24	10.7	5.6	11.2	OK-TEP5	ET-AAS	0.43	0.10
25	9.22	4.61	9.22	GSO5364-90	ICP-AES	-0.74	-0.20

TABLE 9. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR ARSENIC (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
26	10.8	0.8	1.5	IAEA SL-1	NAA	0.51	0.69
28	7.40	0.81	1.62	IAEA soil 5	NAA	-2.17	-2.89
29	10.5	0.3	0.5	GBW 7313	AFS	0.27	0.62
31	11.1	0.3	0.6	NIST 2702	ICP-MS	0.75	1.62
33	9.73	0.13	0.26	IAEA SL-1	NAA	-0.33	-0.82
35	6.83	0.65	1.73	IAEA-433	ET-AAS	-2.62	-4.07
36	7.59	0.12	0.12	PACS-2	ICP-MS	-2.02	-5.00
38	9.63	0.30	0.60		ICP-MS	-0.41	-0.90
40	9.10	1.49	1.49	MESS-3		-0.83	-0.67
41	20.2	5.1	10.1	IAEA-433	ICP-MS	7.91	1.96
42	7.50	0.27	0.53	IAEA-158	ICP-MS	-2.09	-4.68
45	11.9	0.8	1.5	PACS-2	NAA	1.38	1.94
48	9.28	0.75	1.50		NAA	-0.69	-0.97
49	10.7					0.43	
50	8.60	0.90	1.80		ET-AAS	-1.22	-1.51
51	10.4	1.4	2.8	IAEA-SL1	ET-AAS	0.19	0.17
52	36.8				ICP-AES	20.99	
53	9.50	0.06	1.23	IAEA-433	HYD-AAS	-0.52	-1.30
55	9.70	0.73	1.46	NIST 2702	ICP-MS	-0.36	-0.51
56	11.2	0.2	0.2		ICP-MS	0.82	2.01
57	12.1			IAEA-405		1.51	
58	10.7	0.1	0.1	IAEA-405	HYD-AAS	0.43	1.07
61	7.69			WQB1	Hyd-AAS	-1.94	
62	9.53			IAEA-433	ICP-MS	-0.49	
64	10.0	0.6	1.2	MESS-3	ICP-MS	-0.12	-0.19
65	9.10	0.20	0.20	MESS-3	ICP-MS	-0.83	-1.96
66	7.10	0.50	0.50	BCR 277-R	Hyd-AAS	-2.41	-4.32
68	9.93	0.13	0.39	IAEA-SL1	ICP-MS	-0.18	-0.43
70	10.2			MESS-3	ICP-MS	0.04	
71	11.6	1.0	2.0	IAEA-158	ICP-MS	1.14	1.30
72	9.60			MESS-3	ICP-MS	-0.44	
74	9.80	0.37	0.37	MESS-3	ICP-MS	-0.28	-0.57
75	11.7	0.0	0.7	IAEA-405	NAA	1.22	3.09

TABLE 10. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR CALCIUM

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
14	4.61			IAEA-356	XRF	n.a.	n.a.
27	6.00			NIES 2	XRF	n.a.	n.a.
40	5.70	0.10	0.10	MESS-3		n.a.	n.a.
43	8.30				F-AAS	n.a.	n.a.
48	4.00	0.20	0.40		NAA	n.a.	n.a.
62	3.70			IAEA-433	ICP-AES	n.a.	n.a.
66	0.081	0.006	0.006	BCR 277-R	F-AAS	n.a.	n.a.

Note: n.a. not applicable.

TABLE 11. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR CADMIUM

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	1.21	0.08	0.16	CZ 120	ICP-MS	0.91	1.38
2	0.950	0.100	0.100	IAEA-405	ET-AAS	-1.00	-1.26
3	1.13	0.05	0.10	BCR-277R	ET-AAS	0.33	0.66
4	1.42	0.29	0.58	PACS2	ICP-AES	2.42	1.12
5	1.23	0.03	0.06	PACS2	ICP-AES	1.06	2.81
6	1.25	0.03	0.06		F-AAS	1.21	3.20
7	1.05	0.08	0.15	IAEA-433	ET-AAS	-0.27	-0.42
9	0.910	0.060	0.060	MESS-3	ET-AAS	-1.30	-2.41
10	1.30				ICP-AES	1.58	
12	1.14			PACS-2	ICP-MS	0.40	
13	1.12	0.07	0.14	PACS-2	ICP-MS	0.25	0.42
16	1.02	0.16	0.16	MESS-2	ET-AAS	-0.49	-0.41
17	1.05	0.01	0.01	NIST 2709a	ICP-MS	-0.27	-0.86
18	0.900	0.033	0.070		F-AAS	-1.37	-3.50
19	1.06	0.08	0.16	MESS-3	ICP-MS	-0.19	-0.29
20	1.08	0.12	0.24	IAEA-158	ICP-MS	-0.04	-0.05
21	1.50	0.13	0.33	BCSS-1	ET-AAS	3.01	3.00
22	1.10	0.11	0.22	IAEA-433	ICP-MS	0.10	0.12
23	1.00				ICP-MS	-0.63	
24	1.21	0.36	0.72	OK-TEP5	ET-AAS	0.91	0.34
25	1.61	0.81	1.62	GSO5364-90	ICP-AES	3.86	0.65
29	1.32	0.03	0.06	GBW 7313	ET-AAS	1.72	4.56
31	1.17	0.03	0.06	NIST 2709a	ICP-MS	0.62	1.64
34	1.24	0.01	0.04	IAEA-356	ET-AAS	1.13	3.60
35	0.216	0.024	0.064	IAEA-433	ET-AAS	-6.41	-18.12
36	1.01	0.03	0.03	PACS-2	ICP-MS	-0.56	-1.48
38	1.12	0.30	0.60		ICP-MS	0.25	0.11
40	0.900	0.070	0.070	MESS-3		-1.37	-2.28

TABLE 11. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR CADMIUM (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
41	1.00	0.25	0.50	IAEA-433	ICP-MS	-0.63	-0.34
42	1.40	0.14	0.28	IAEA-158	ICP-MS	2.31	2.15
45	1.35	0.10	0.20	PACS-2	ICP-MS	1.94	2.44
48	1.61	0.09	0.18		ET-AAS	3.86	5.29
49	0.208					-6.47	
50	8.90	0.30	0.70		F-AAS	57.56	25.80
52	0.600				ICP-AES	-3.58	
53	0.990	0.104	0.210	IAEA-433	ET-AAS	-0.71	-0.86
55	1.08	0.08	0.16	NIST 2702	ICP-MS	-0.07	-0.11
56	1.15	0.01	0.01		ICP-MS	0.47	1.48
57	1.32			IAEA-405		1.72	
58	1.06	0.04	0.04	IAEA-405	ET-AAS	-0.19	-0.48
59	1.50	0.15	0.30	GB-07312	ET-AAS	3.05	2.66
61	1.25			WQB1	F-AAS	1.20	
62	0.865			IAEA-433	ICP-MS	-1.63	
64	1.08	0.07	0.14	MESS-3	ICP-MS	-0.03	-0.05
65	1.10	0.01	0.01	MESS-3	ICP-MS	0.10	0.33
66	1.35	0.09	0.09	BCR 277-R	F-AAS	1.94	2.66
68	1.41	0.03	0.01	IAEA-SL1	ICP-MS	2.39	6.32
70	1.19			MESS-3	ET-AAS	0.77	
71	0.979	0.083	0.166	IAEA-158	ICP-MS	-0.79	-1.15
72	1.10			MESS-3	ICP-MS	0.10	
74	1.10	0.10	0.10	MESS-3	ICP-MS	0.10	0.13
76	1.64	0.29	0.59	MESS-3	ET-AAS	4.08	1.89
78	1.10	0.08	0.15	IAEA-158	ET-AAS	0.08	0.12

TABLE 12. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR COBALT

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	15.3	2.9	5.6	CZ 120	ICP-MS	0.35	0.22
2	14.3	0.9	0.9	IAEA-405	ET-AAS	-0.19	-0.35
8	26.7			IAEA-356	F-AAS	6.57	
9	12.4	1.2	1.2	MESS-3	ET-AAS	-1.23	-1.75
10	17.0				ICP-AES	1.28	
11	80.1	92.1	184.1		XRF	35.70	0.71
12	14.5			PACS-2	ICP-MS	-0.09	
13	16.8	1.0	2.0	PACS-2	ICP-AES	1.17	1.94
17	14.7	0.0	0.1	NIST 2709a	ICP-MS	0.02	0.09
19	15.2	1.1	2.3	MESS-3	ICP-MS	0.30	0.45
20	13.7	1.1	2.2	IAEA-158	ICP-MS	-0.52	-0.80
21	13.4	0.7	1.8	BCSS-1	F-AAS	-0.67	-1.43
22	14.7	0.3	0.5	IAEA-433	ICP-MS	0.02	0.08
23	10.4				ICP-MS	-2.30	
24	15.8	4.7	9.4	OK-TEP5	F-AAS	0.62	0.24
25	18.7	7.5	15.0	GSO5364-90	ICP-AES	2.21	0.54
26	14.8	0.8	1.5	IAEA SL-1	NAA	0.08	0.15
28	15.4	0.3	0.7	IAEA soil 5	NAA	0.41	1.30
29	14.3	0.6	1.1	GBW 7313	ET-AAS	-0.19	-0.49
30	12.5	0.3	0.6	IAEA Soil 7	F-AAS	-1.18	-3.87
31	15.5	0.4	0.8	NIST 2709a	ICP-MS	0.46	1.36
33	15.5	0.4	0.8	IAEA SL-1	NAA	0.46	1.34
36	12.0	0.4	0.4	PACS-2	ICP-MS	-1.45	-4.27
38	11.9	0.3	0.6		ICP-MS	-1.49	-4.86
40	13.1	0.1	0.1	MESS-3		-0.85	-3.16
41	13.0	2.6	5.2	IAEA-433	ICP-MS	-0.90	-0.63
42	13.7	0.9	1.8	IAEA-158	ICP-MS	-0.52	-0.94
44	15.0	0.5	0.9	IAEA-SL1	ICP-MS	0.16	0.45
45	15.8	0.3	0.5	PACS-2	NAA	0.62	2.11
46	15.5	1.5	4.0	IAEA-SL1	NAA	0.46	0.54
48	15.0	0.5	0.9		NAA	0.19	0.52
49	12.2					-1.34	
50	19.6	0.7	1.5		F-AAS	2.70	5.84
51	14.9	1.6	3.2	IAEA-SL1	ET-AAS	0.13	0.15
52	11.4				ICP-AES	-1.78	
54	17.1	4.5	9.0		ICP-AES	1.33	0.54
55	14.6	0.7	1.5	NIST 2702	ICP-MS	-0.05	-0.11
56	14.2	0.1	0.1		ICP-MS	-0.25	-0.95
57	15.2			IAEA 405		0.31	
65	13.0	0.3	0.3	MESS-3	ICP-MS	-0.90	-2.95
66	15.4	0.7	0.7	BCR 277-R	F-AAS	0.42	0.90

TABLE 12. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR COBALT (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
67	14.5	0.6	1.2	IAEA-SL1	ICP-MS	-0.09	-0.21
68	17.0	0.5	1.5	IAEA-SL1	ICP-MS	1.28	3.39
70	15.5			MESS-3	ICP-MS	0.46	
71	17.0	1.4	2.7	IAEA-158	ICP-MS	1.28	1.58
72	16.3			MESS-3	ICP-MS	0.90	
74	14.0	0.1	0.1	MESS-3	ICP-MS	-0.36	-1.35
75	15.0	0.0	0.7	IAEA-405	NAA	0.19	0.72
77	12.7	0.0	0.9	IAEA soil7	F-AAS	-1.05	-4.02
78	13.9	1.2	2.4	IAEA-158	ET-AAS	-0.42	-0.60

TABLE 13. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR CHROMIUM

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	141	4	8	CZ 120	ICP-MS	-0.17	-0.54
2	138	4	4	IAEA 405	ET-AAS	-0.31	-0.97
3	135	11	21	BCR-277R	F-AAS	-0.47	-0.73
4	156	8	17	PACS-2	AAS	0.66	1.28
6	102	1	2		F-AAS	-2.31	-9.62
9	187	9	9	MESS-3	F-AAS	2.42	4.58
10	116				ICP-AES	-1.54	
11	174	185	371		XRF	1.69	0.16
12	143			PACS-2	ICP-AES	-0.03	
13	133	7	14	PACS-2	ICP-AES	-0.59	-1.30
14	86.0			IAEA-356	XRF	-3.21	
16	148	15	27	MESS-2	ET-AAS	0.25	0.28
17	136	1	2	NIST 2709a	ICP-MS	-0.42	-1.77
18	124	1	2		F-AAS	-1.08	-4.57
19	150	11	23	MESS-3	ICP-MS	0.36	0.54
20	119	13	26	IAEA-158	ICP-MS	-1.37	-1.79
22	145	3	5	IAEA-433	ICP-MS	0.08	0.29
23	101				ICP-MS	-2.36	
24	231	69	138	OK-TEP5	F-AAS	4.87	1.26
25	130	26	52	GSO5364-90	ICP-AES	-0.76	-0.52
26	118	12	24	IAEA SL-1	NAA	-1.43	-2.01
28	150	6	12	IAEA soil 5	NAA	0.33	0.81
29	149	9	20	GBW 7313	ET-AAS	0.30	0.53
30	79.2	1.8	3.6	IAEA Soil 7	F-AAS	-3.59	-14.15

TABLE 13. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR CHROMIUM (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
31	145	8	16	NIST 2702	ICP-MS	0.08	0.16
32	94.6	7.9	15.9	IAEA-433	F-AAS	-2.73	-5.47
33	127	7	13	IAEA SL-1	NAA	-0.92	-2.10
35	99.0	1.6	4.3	IAEA-433	ET-AAS	-2.48	-9.97
36	90.2	2.5	2.5	PACS-2	ICP-MS	-2.97	-10.98
38	73.0	1.1	2.1		ICP-MS	-3.93	-16.36
40	122	4	4	MESS-3		-1.21	-3.62
41	133	14	27	IAEA-433	ICP-MS	-0.59	-0.73
42	132	9	18	IAEA-158	ICP-MS	-0.65	-1.17
43	144				F-AAS	0.04	
44	135	9	18	IAEA-SL1	ICP-MS	-0.48	-0.87
45	162	6	12	PACS-2	NAA	1.03	2.49
46	124	11	30	IAEA-SL1	NAA	-1.09	-1.69
48	127	3	6		NAA	-0.92	-3.23
49	124					-1.09	
50	89.0	2.0	5.0		F-AAS	-3.04	-11.80
51	135	6	12	IAEA-SL1	F-AAS	-0.50	-1.26
52	94.9				ICP-AES	-2.71	
53	131	0.02	6	IAEA-433	F-AAS	-0.70	-3.02
55	128	10	19	NIST 2702	ICP-MS	-0.89	-1.54
56	147	0.5	0.5		ICP-MS	0.19	0.81
57	135			IAEA-405		-0.50	
58	148	1	1	IAEA-405	F-AAS	0.25	1.01
59	143	5	10	GB-07312	ICP-AES	-0.03	-0.09
61	119			WQB1	F-AAS	-1.35	
64	115	6	12	MESS-3	ICP-MS	-1.58	-3.78
66	82.6	4.3	4.3	BCR 277-R	F-AAS	-3.40	-10.18
67	137	11	22	IAEA-SL1	ICP-MS	-0.37	-0.56
68	122	6	18	IAEA-SL1	ICP-MS	-1.20	-2.92
69	123	8	15	IAEA-158	XRF	-1.15	-2.28
70	144			MESS-3	ICP-MS	0.02	
71	233	35	70	IAEA-158	F-AAS	4.98	2.54
72	139			MESS-3	ICP-AES	-0.26	
75	142	0.02	7	IAEA-405	NAA	-0.09	-0.38
76	118	8	18	MESS-3	ET-AAS	-1.45	-2.82
77	61.4	0.0	4.2	IAEA soil7	F-AAS	-4.58	-19.70
78	134	13	27	IAEA-158	ET-AAS	-0.53	-0.67

TABLE 14. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR COPPER

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	389	12	24	CZ 120	ICP-MS	0.52	1.56
2	337	2	2	IAEA-405	ET-AAS	-0.62	-2.94
3	339	16	32	BCR-277R	F-AAS	-0.59	-1.46
4	406	29	58	PACS2	AAS	0.89	1.33
5	341	11	22	PACS2	F-AAS	-0.53	-1.68
6	346	10	20		F-AAS	-0.42	-1.41
7	351	25	50	IAEA-433	ET-AAS	-0.32	-0.54
8	363			IAEA-356	F-AAS	-0.06	
9	385	22	22	MESS-3	F-AAS	0.43	0.82
10	418				ICP-AES	1.15	
11	283	295	591		XRF	-1.81	-0.28
12	382			PACS-2	ICP-AES	0.36	
13	364	18	36	PACS-2	ICP-AES	-0.03	-0.07
14	352			IAEA-356	XRF	-0.29	
16	364	25	44	MESS-2	F-AAS	-0.03	-0.05
17	377	1	1	NIST 2709a	ICP-MS	0.25	1.22
18	378	1	3		F-AAS	0.28	1.32
19	382	29	57	MESS-3	ICP-MS	0.36	0.54
20	355	25	50	IAEA-158	ICP-MS	-0.23	-0.39
21	361	6	15	BCSS-1	F-AAS	-0.09	-0.36
22	352	7	13	IAEA-433	ICP-MS	-0.29	-1.16
23	270				ICP-MS	-2.08	
24	371	111	222	OK-TEP5	F-AAS	0.12	0.05
25	380	76	152	GSO5364-90	ICP-AES	0.32	0.19
29	378	13	27	GBW 7313	ET-AAS	0.28	0.77
30	237	5	10	IAEA Soil 7	F-AAS	-2.81	-11.76
31	366	11	21	NIST 1646a	ICP-MS	0.01	0.04
32	357	15	30	IAEA-433	F-AAS	-0.18	-0.47
34	379	1	4	IAEA-356	F-AAS	0.30	1.44
35	383	7	18	IAEA-433	F-AAS	0.39	1.51
36	323	6	6	PACS-2	ICP-MS	-0.93	-3.87
38	357	1	2		ICP-MS	-0.18	-0.88
39	323	5	10	IAEA-158	F-AAS	-0.94	-3.96
40	321	3	3	MESS-3		-0.98	-4.55
41	327	33	65	IAEA-433	ICP-MS	-0.84	-1.12
42	322	12	24	IAEA-158	ICP-MS	-0.95	-2.84
43	370				F-AAS	0.10	
45	381	18	36	PACS-2	ICP-MS	0.34	0.77
48	411	13	25		F-AAS	1.00	2.88
49	305					-1.32	
50	361	16	32		F-AAS	-0.10	-0.24

TABLE 14. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR COPPER (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
51	351	4	8	IAEA-SL1	F-AAS	-0.31	-1.35
52	361				ICP-AES	-0.10	
53	364	0.03	23	IAEA-433	F-AAS	-0.03	-0.15
54	387	39	77		ICP-AES	0.48	0.55
55	373	19	37	NIST 2702	ICP-MS	0.17	0.36
56	348	2	2		ICP-MS	-0.38	-1.80
57	392			IAEA-405		0.57	
58	372	1	1	IAEA-405	F-AAS	0.14	0.69
59	361	7	14	GB-07312	ICP-AES	-0.10	-0.37
61	382	17	34	WQB1	F-AAS	0.36	0.85
62	385			IAEA-433	ICP-AES	0.43	
64	368	20	39	MESS-3	ICP-MS	0.07	0.14
65	322	8	8	MESS-3	ICP-MS	-0.95	-3.54
66	294	10	10	BCR 277-R	F-AAS	-1.56	-5.19
68	418	10	30	IAEA-SL1	ICP-MS	1.15	3.82
69	340	15	30	IAEA-158	XRF	-0.56	-1.43
70	401			MESS-3	ICP-MS	0.77	
71	437	20	40	IAEA-158	F-AAS	1.57	3.24
72	357			MESS-3	ICP-AES	-0.18	
73	393	34	68	IAEA-158	F-AAS	0.60	0.78
74	340	2	2	MESS-3	ICP-MS	-0.56	-2.63
76	325	39	81	MESS-3	ET-AAS	-0.89	-1.01
77	329	0.03	22	IAEA soil7	F-AAS	-0.80	-3.88
78	372	35	71	IAEA-158	F-AAS	0.14	0.18

TABLE 15. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR IRON

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	39.2	0.9	1.8	CZ 120	ICP-MS	-0.44	-1.56
2	39.6	2.3	2.3	IAEA-405	ET-AAS	-0.36	-0.72
3	36.7	3.7	7.4	BCR-277R	F-AAS	-0.92	-1.23
4	45.4	2.9	5.7	PACS-2	AAS	0.77	1.29
5	43.3	1.1	2.2	PACS-2	ICP-AES	0.36	1.18
6	33.4	0.4	0.7		F-AAS	-1.56	-6.84
8	37.0			IAEA-356	F-AAS	-0.86	
9	38.1	2.0	2.0	MESS-3	F-AAS	-0.66	-1.48
11	0.008	0.008	0.017		XRF	-8.00	-36.93
12	41.0			PACS-2	ICP-AES	-0.09	
13	32.8	1.8	3.6	PACS-2	ICP-AES	-1.66	-4.05
14	38.6			IAEA-356	XRF	-0.55	
16	43.6	3.4	5.9	MESS-2	F-AAS	0.42	0.60
17	38.8	0.4	0.7	NIST 2709a	ICP-MS	-0.51	-2.24
18	35.0	0.1	0.2		F-AAS	-1.24	-5.71
19	42.2	5.3	10.6	MESS-3	F-AAS	0.15	0.14
20	38.1	4.4	8.8	IAEA-158	ICP-MS	-0.65	-0.74
21	46.0	0.3	0.9	BCSS-1	XRF	0.88	3.91
22	40.1	1.0	2.0	IAEA-433	ICP-MS	-0.26	-0.90
24	26.6	7.9	15.8	OK-TEP5	F-AAS	-2.87	-1.86
25	31.2	8.7	17.4	GSO5364-90	ICP-AES	-1.98	-1.17
26	39.6	0.7	1.4	IAEA SL-1	NAA	-0.36	-1.43
27	41.3			NIES 2	XRF	-0.02	
28	43.4	0.4	0.9	IAEA soil 5	NAA	0.38	1.64
29	45.0	0.8	2.0	GBW 7313	F-AAS	0.69	2.58
30	41.6	1.0	1.9	IAEA Soil 7	F-AAS	0.02	0.08
31	39.1	1.1	2.1	NIST 1646a	ICP-MS	-0.45	-1.50
32	34.9	1.4	2.9	IAEA-433	F-AAS	-1.27	-3.64
33	39.3	0.4	0.8	IAEA SL-1	NAA	-0.41	-1.77
35	43.3	0.8	1.6	IAEA-433	F-AAS	0.36	1.36
36	31.6	0.5	0.5	PACS-2	ICP-MS	-1.90	-8.09
40	41.7	0.3	0.3	MESS-3		0.05	0.22
41	41.8	5.9	11.7	IAEA-433	ICP-AES	0.07	0.06
43	42.3				F-AAS	0.16	
44	39.3	2.8	5.5	IAEA-SL1	ICP-MS	-0.41	-0.71
45	41.5	0.6	1.1	PACS-2	NAA	0.01	0.04
46	39.5	2.1	4.6	IAEA-SL1	NAA	-0.38	-0.82
48	35.4	0.2	0.5		NAA	-1.17	-5.30
49	38.0					-0.67	
50	32.4	1.7	3.3		F-AAS	-1.75	-4.44
51	39.6	1.1	2.1	IAEA-SL1	F-AAS	-0.35	-1.17

TABLE 15. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR IRON (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
52	29.6				ICP-AES	-2.28	
53	28.9	0.1	7.0	IAEA-433	F-AAS	-2.42	-11.11
55	35.8	2.7	5.4	NIST 2702	ICP-MS	-1.09	-1.94
57	38.4			IAEA-405		-0.59	
58	39.3	0.3	0.3	IAEA-405	F-AAS	-0.41	-1.82
59	39.1	1.0	2.0	GB-07312	F-AAS	-0.45	-1.56
61	43.0	2.2	4.4	WQB1	F-AAS	0.31	0.65
62	35.6			IAEA-433	ICP-AES	-1.13	
66	26.1	1.5	1.5	BCR 277-R	F-AAS	-2.95	-8.33
67	37.9	2.7	5.4	IAEA-SL1	ICP-MS	-0.68	-1.21
69	42.3	0.8	1.6	IAEA-158	XRF	0.16	0.62
71	37.1	0.2	0.4	IAEA-158	F-AAS	-0.83	-3.78
72	41.4			MESS-3	ICP-AES	-0.01	
73	38.2	3.3	6.6	IAEA-158	F-AAS	-0.63	-0.94
75	39.8	0.0	1.9	IAEA-405	NAA	-0.32	-1.49
77	35.7	0.0	2.7	IAEA soil7	F-AAS	-1.12	-5.16
78	43.5	3.3	6.5	IAEA-158	F-AAS	0.40	0.60

TABLE 16. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR MERCURY

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
3	0.126	0.002	0.005	BCR-277R	CV-AAS	-0.93	-2.66
4	0.759	0.340	0.680	PACS2	ICP-AES	34.46	1.81
6	0.120	0.020	0.040		CV-AAS	-1.29	-1.10
7	0.122	0.010	0.020	IAEA-433	Solid-AAS	-1.17	-1.82
8	0.185			IAEA-356	CV-AAS	2.35	
9	0.099	0.016	0.016	MESS-3	CV-AAS	-2.46	-2.59
12	0.153			PACS-2	CV-AAS	0.56	
13	0.138	0.008	0.016	PACS-2	ICP-AES	-0.28	-0.51
15	0.134	0.012	0.024	MESS-3		-0.50	-0.67
16	0.134	0.008	0.013	MESS-2	CV-AAS	-0.50	-0.95
17	0.140	0.002	0.005	MESS-3	CV-AFS	-0.17	-0.49
18	0.180	0.013	0.030		CV-AAS	2.07	2.60
19	0.150	0.011	0.023	MESS-3	Solid-AAS	0.39	0.56
20	0.142	0.007	0.014	IAEA-158	Solid-AAS	-0.06	-0.11
22	0.167	0.005	0.011	IAEA-433	Solid-AAS	1.34	3.13
24	0.117	0.054	0.108	OK-TEP5	HYD-AAS	-1.45	-0.48
25	0.068	0.031	0.062	GSO5364-90	ET-AAS	-4.20	-2.38

TABLE 16. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR MERCURY (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
29	0.150	0.010	0.020	GBW 7313	AFS	0.39	0.61
31	0.138	0.012	0.025	BCR 142r	Solid-AAS	-0.28	-0.37
35	0.117	0.011	0.028	IAEA-433	CV-AAS	-1.45	-2.09
36	0.165	0.001	0.001	PACS-2	CV-AFS	1.23	3.74
37	0.122	0.037	0.001			-1.17	-0.56
38	0.230	0.300	0.500		ICP-MS	4.87	0.29
41	0.158	0.029	0.057	IAEA-452	CV-AAS	0.84	0.51
46	0.122	0.012	0.097	IAEA-SL1	NAA	-1.17	-1.58
47	0.126	0.00001	0.00001	IAEA-405	CV-AAS	-0.95	-2.93
56	0.132	0.001	0.001		ICP-MS	-0.62	-1.87
57	0.140			IAEA-405		-0.15	
58	0.173	0.014	0.014	IAEA-405	CV-AAS	1.68	1.98
59	0.180	0.020	0.040	GB-07312	CV-AAS	2.07	1.78
60	0.165			IAEA-433	solid-AAS	1.25	
61	0.136	0.009	0.017	WQB1	solid-AAS	-0.37	-0.63
66	0.180	0.010	0.010	BCR 277-R	CV-AAS	2.07	3.20
70	0.126			MESS-3	CV-AAS	-0.95	
71	0.299	0.048	0.096	IAEA-158	ICP-MS	8.73	3.23
72	0.138			MESS-3	solid-AAS	-0.28	
78	0.140	0.008	0.017	IAEA-158	solid-AAS	-0.17	-0.29

TABLE 17. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR METHYL MERCURY

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
12	0.139			PACS-2	GC-AFS	n.a.	n.a.
15	0.200	0.020	0.040	MESS-3		n.a.	n.a.
17	0.083	0.007	0.014	SQC-1238	CV-AFS	n.a.	n.a.
47	1.66	0.08	0.08	IAEA-405	GC-ECD	n.a.	n.a.
57	0.096			IAEA-405		n.a.	n.a.
60	70.2			IAEA-433		n.a.	n.a.
63	0.098	0.002	0.002	SQC 1238	HPLC-AFS	n.a.	n.a.

Note: n.a. not applicable.

TABLE 18. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR POTASSIUM

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
14	23.3			IAEA-356	XRF	-0.17	
26	22.6	0.9	1.8	IAEA SL-1	NAA	-0.41	-0.74
27	25.1			NIES 2	XRF	0.42	
40	25.7	0.4	0.4	MESS-3		0.64	1.33
43	25.9				F-AAS	0.71	
46	27.0	1.4	8.3	IAEA-SL1	NAA	1.07	1.63
48	14.1	0.1	0.3		NAA	-3.26	-7.10
66	5.93	0.36	0.36	BCR 277-R	F-AAS	-6.01	-12.67

TABLE 19. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR LITHIUM

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
3	50.1	1.1	2.2	BCR-277R	F-AAS	-1.75	-4.78
4	62.8	7.0	14.0	PACS2	ICP-AES	-0.18	-0.19
19	64.0	10.0	19.0	MESS-3	ICP-MS	-0.02	-0.02
22	70.1	1.2	2.4	IAEA-433	ICP-MS	0.74	1.98
41	63.5	12.7	25.4	IAEA-433	ICP-MS	-0.09	-0.05
50	51.2	4.2	8.4		F-AAS	-1.62	-2.59
78	66.2	4.0	7.9	IAEA-158	ICP-MS	0.25	0.41

TABLE 20. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR MANGANESE

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	442	26	51	CZ 120	ICP-MS	0.28	0.50
2	430	19	19	IAEA-405	ET-AAS	0.06	0.12
3	250	14	29	BCR-277R	F-AAS	-3.32	-8.51
4	435	39	78	PACS2	AAS	0.14	0.18
5	422	10	19	PACS2	F-AAS	-0.09	-0.28
6	271	4	8		F-AAS	-2.92	-10.04
8	379			IAEA-356	F-AAS	-0.90	
9	460	22	22	MESS-3	F-AAS	0.62	1.24
10	400				ICP-AES	-0.51	
11	585	591	1183		XRF	2.97	0.27
12	418			PACS-2	ICP-MS	-0.17	
14	436			IAEA-356	XRF	0.17	
16	441	40	70	MESS-2	ET-AAS	0.26	0.33
17	403	2	4	NIST 2709a	ICP-MS	-0.45	-1.59
18	352	3	7		F-AAS	-1.41	-4.87
19	449	34	67	MESS-3	ICP-MS	0.41	0.59
20	403	40	81	IAEA-158	ICP-MS	-0.45	-0.56
21	659	15	40	BCSS-1	XRF	4.35	10.81
22	443	12	24	IAEA-433	ICP-MS	0.30	0.83
23	279				ICP-MS	-2.76	
24	430	129	258	OK-TEP5	F-AAS	0.06	0.02
25	382	115	230	GSO5364-90	ICP-AES	-0.84	-0.39
26	412	10	19	IAEA SL-1	NAA	-0.28	-0.83
27	520			NIES 2	XRF	1.74	
29	420	20	40	GBW 7313	F-AAS	-0.13	-0.28
30	407	9	19	IAEA Soil 7	F-AAS	-0.37	-1.13
31	456	11	22	NIST 2702	ICP-MS	0.54	1.56
32	356	2	5	IAEA-433	F-AAS	-1.34	-4.69
33	399	16	32	IAEA SL-1	NAA	-0.52	-1.28
35	478	2	6	IAEA-433	F-AAS	0.96	3.36
36	318	7	7	PACS-2	ICP-MS	-2.04	-6.63
38	392	0.4	1		ICP-MS	-0.66	-2.33
40	455	4	4	MESS-3		0.52	1.76
41	422	64	127	IAEA-433	ICP-AES	-0.09	-0.08
43	277				F-AAS	-2.81	
44	434	20	40	IAEA-SL1	ICP-MS	0.13	0.28
45	468	12	24	PACS-2	NAA	0.77	2.13
48	462	11	21		NAA	0.66	1.90
49	393					-0.64	
50	382	28	55		F-AAS	-0.84	-1.42
51	405	17	33	IAEA-SL1	F-AAS	-0.42	-1.00

TABLE 20. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR MANGANESE (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
52	301				ICP-AES	-2.36	
55	397	20	40	NIST 2702	ICP-MS	-0.55	-1.19
57	415			IAEA-405		-0.22	
58	384	24	24	IAEA-405	F-AAS	-0.81	-1.52
59	392	10	20	GB-07312	ICP-AES	-0.66	-1.94
61	409	23	45	WQB1	F-AAS	-0.34	-0.66
62	392			IAEA-433	ICP-AES	-0.66	
64	386	20	40	MESS-3	ICP-MS	-0.76	-1.62
66	255	12	12	BCR 277-R	F-AAS	-3.22	-8.95
67	416	21	42	IAEA-SL1	ICP-MS	-0.21	-0.43
68	331	10	30	IAEA-SL1	ICP-MS	-1.80	-5.32
69	367	12	23	IAEA-158	XRF	-1.12	-3.12
71	459	37	74	IAEA-158	F-AAS	0.60	0.80
72	450			MESS-3	ICP-AES	0.43	
73	284	25	49	IAEA-158	F-AAS	-2.68	-4.90
75	417	0.03	24	IAEA-405	NAA	-0.19	-0.67
77	327	0.03	22	IAEA soil7	F-AAS	-1.87	-6.64
78	455	16	32	IAEA-158	F-AAS	0.52	1.28

TABLE 21. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR SODIUM

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
26	25.8	0.7	1.4	IAEA SL-1	NAA	-0.04	-0.07
28	26.4	0.5	1.1	IAEA soil 5	NAA	0.15	0.25
40	28.5	0.3	0.3	MESS-3		0.79	1.37
43	30.6				F-AAS	1.44	
46	26.8	1.5	4.3	IAEA-SL1	NAA	0.27	0.37
48	18.4	0.4	0.9		NAA	-2.32	-3.98
66	14.3	0.6	0.6	BCR 277-R	F-AAS	-3.60	-6.00

TABLE 22. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR NICKEL

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	55.8	4.3	8.5	CZ 120	ICP-MS	0.41	0.60
2	49.6	1.0	1.0	IAEA 405	ET-AAS	-0.52	-2.09
3	32.1	4.5	9.0	BCR-277R	F-AAS	-3.16	-4.48
4	58.6	6.6	13.2	PACS2	AAS	0.83	0.81
5	49.3	1.7	3.3	PACS2	F-AAS	-0.57	-1.79
6	50.0	0.7	1.4		F-AAS	-0.46	-2.05
7	28.7	2.0	4.0	IAEA-433	ET-AAS	-3.67	-10.16
8	36.8			IAEA-356	F-AAS	-2.45	
9	56.5	4.1	4.1	MESS-3	F-AAS	0.52	0.79
10	50.0				ICP-AES	-0.46	
11	54.7	58.8	117.5		XRF	0.24	0.03
12	49.3			PACS-2	ICP-AES	-0.57	
13	55.6	3.3	6.6	PACS-2	ICP-AES	0.38	0.71
16	54.9	3.9	6.7	MESS-2	ET-AAS	0.27	0.44
17	51.3	0.4	0.8	NIST 2709a	ICP-MS	-0.27	-1.28
18	53.4	0.3	0.7		F-AAS	0.05	0.23
19	52.9	4.0	8.0	MESS-3	ICP-MS	-0.03	-0.04
20	48.4	6.1	12.1	IAEA-158	ICP-MS	-0.71	-0.76
21	46.3	1.1	2.7	BCSS-1	F-AAS	-1.02	-3.98
22	52.0	1.8	3.6	IAEA-433	ICP-MS	-0.16	-0.48
23	41.8				ICP-MS	-1.70	
24	70.1	21.0	42.0	OK-TEP5	F-AAS	2.56	0.81
25	46.8	16.4	32.8	GSO5364-90	ICP-AES	-0.95	-0.38
29	50.0	1.3	3.0	GBW 7313	ET-AAS	-0.46	-1.66
30	49.4	1.1	2.3	IAEA Soil 7	ET-AAS	-0.55	-2.10
31	52.0	1.6	3.0	NIST 2702	ICP-MS	-0.16	-0.52
32	32.8	2.1	4.3	IAEA-433	F-AAS	-3.06	-8.05
35	47.2	1.9	5.1	IAEA-433	ET-AAS	-0.89	-2.52
36	39.4	0.9	0.9	PACS-2	ICP-MS	-2.06	-8.53
38	37.0	0.2	0.4		ICP-MS	-2.42	-11.95
39	37.6	12.6	25.1	IAEA-158	F-AAS	-2.34	-1.23
40	44.6	0.6	0.6	MESS-3		-1.28	-5.84
41	44.0	7.7	15.4	IAEA-433	ICP-MS	-1.37	-1.16
42	47.0	4.0	8.0	IAEA-158	ICP-MS	-0.92	-1.44
44	53.6	2.7	5.4	IAEA-SL1	ICP-MS	0.08	0.17
49	45.0					-1.22	
50	47.3	2.1	4.1		F-AAS	-0.87	-2.33
51	55.4	4.5	9.0	IAEA-SL1	ET-AAS	0.35	0.49
52	36.2				ICP-AES	-2.54	
53	47.4	0.1	5.5	IAEA-433	F-AAS	-0.86	-4.27
54	52.7	0.9	1.8		ICP-AES	-0.06	-0.24

TABLE 22. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR NICKEL (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
55	51.9	3.9	7.8	NIST 2702	ICP-MS	-0.18	-0.30
56	52.0	0.1	0.1		ICP-MS	-0.16	-0.81
57	54.4			IAEA-405		0.20	
58	53.0	1.5	1.5	IAEA-405	F-AAS	-0.01	-0.04
61	44.1			WQB1	F-AAS	-1.35	
62	53.2			IAEA-433	ICP-AES	0.02	
64	49.4	2.7	5.4	MESS-3	ICP-MS	-0.55	-1.23
65	45.0	1.2	1.2	MESS-3	ICP-MS	-1.22	-4.52
66	44.3	1.8	1.8	BCR 277-R	F-AAS	-1.33	-3.93
67	52.6	2.6	5.2	IAEA-SL1	ICP-MS	-0.07	-0.16
68	45.1	2.6	7.8	IAEA-SL1	ICP-MS	-1.20	-2.73
70	54.8			MESS-3	ICP-MS	0.26	
71	25.1	1.5	3.0	IAEA-158	F-AAS	-4.22	-13.97
72	53.2			MESS-3	ICP-AES	0.02	
73	51.0	4.4	8.8	IAEA-158	F-AAS	-0.31	-0.45
74	48.0	0.5	0.5	MESS-3	ICP-MS	-0.77	-3.58
76	71.5	5.0	10.0	MESS-3	ET-AAS	2.78	3.56
78	55.5	4.2	8.3	IAEA-158	ET-AAS	0.37	0.56

TABLE 23. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR LEAD

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	110	2	4	CZ 120	ICP-MS	0.37	1.26
2	96.7	3.2	3.2	IAEA-405	ET-AAS	-0.66	-1.91
3	74.8	11.4	22.8	BCR-277R	ET-AAS	-2.32	-2.58
4	117	20	40	PACS2	AAS	0.90	0.59
5	133	3	6	PACS2	F-AAS	2.12	6.50
6	115	4	8		F-AAS	0.73	1.86
7	111	8	16	IAEA-433	ET-AAS	0.43	0.65
8	91.0			IAEA-356	F-AAS	-1.09	
9	127	5	5	MESS-3	F-AAS	1.64	3.62
10	105				ICP-AES	-0.03	
12	108			PACS-2	ICP-MS	0.20	
13	98.9	5.9	11.8	PACS-2	ICP-AES	-0.49	-0.96
14	90.0			IAEA-356	XRF	-1.17	
16	81.6	8.2	14.2	MESS-2	ET-AAS	-1.81	-2.70
17	108	1	2	NIST 2709a	ICP-MS	0.20	0.76
18	109	0.5	1		F-AAS	0.24	0.97
19	117	9	18	MESS-3	ICP-MS	0.88	1.21

TABLE 23. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR LEAD (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
20	104	13	26	IAEA-158	ICP-MS	-0.11	-0.10
21	89.8	2.2	5.6	BCSS-1	F-AAS	-1.19	-3.98
22	102	3	6	IAEA-433	ICP-MS	-0.30	-0.91
23	93.2				ICP-MS	-0.93	
24	105	32	63	OK-TEP5	F-AAS	-0.03	-0.01
25	98.3	24.6	49.2	GSO5364-90	ICP-AES	-0.54	-0.29
29	98.0	5.0	10.0	GBW 7313	ET-AAS	-0.56	-1.24
30	89.3	2.1	4.1	IAEA Soil 7	F-AAS	-1.22	-4.19
31	113	4	7	NIST 2702	ICP-MS	0.58	1.57
32	99.2	7.5	15.1	IAEA-433	F-AAS	-0.47	-0.76
35	67.0	2.7	7.3	IAEA-433	ET-AAS	-2.91	-9.04
36	92.7	1.5	1.5	PACS-2	ICP-MS	-0.96	-3.55
38	95.0	0.9	1.7		ICP-MS	-0.79	-3.08
39	81.3	14.5	28.9	IAEA-158	F-AAS	-1.83	-1.63
40	95.3	6.3	6.3	MESS-3		-0.77	-1.42
41	107	14	27	IAEA-433	ICP-MS	0.12	0.11
42	93.0	7.0	13.0	IAEA-158	ICP-MS	-0.94	-1.61
43	86.7				F-AAS	-1.42	
44	101	5	10	IAEA-SL1	ICP-MS	-0.35	-0.76
48	104	6	12		F-AAS	-0.11	-0.21
49	73.6					-2.41	
50	91.3	5.5	11.0		F-AAS	-1.07	-2.21
51	125	9	19	IAEA-SL1	ET-AAS	1.46	1.96
52	85.6				ICP-AES	-1.50	
53	49.9	0.2	17.1	IAEA-433	ET-AAS	-4.21	-17.04
55	105	5	11	NIST 2702	ICP-MS	-0.07	-0.15
56	107	1	1		ICP-MS	0.12	0.48
57	110			IAEA-405		0.32	
58	101	3	3	IAEA-405	F-AAS	-0.33	-1.07
59	120	6	12	GB-07312	ET-AAS	1.11	2.14
61	99.7			WQB1	F-AAS	-0.43	
62	101			IAEA-433	ICP-MS	-0.33	
64	105	6	11	MESS-3	ICP-MS	-0.02	-0.03
65	101	0.4	0.4	MESS-3	ICP-MS	-0.33	-1.34
66	115	5	5	BCR 277-R	F-AAS	0.73	1.61
67	107	5	11	IAEA-SL1	ICP-MS	0.14	0.29
68	104	6	17	IAEA-SL1	ICP-MS	-0.11	-0.21
70	132			MESS-3	ICP-MS	2.05	
71	103	6	12	IAEA-158	F-AAS	-0.17	-0.31
72	107			MESS-3	ICP-MS	0.12	
73	81.0	7.0	14.0	IAEA-158	F-AAS	-1.85	-3.16

TABLE 23. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR LEAD (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
74	106	1	1	MESS-3	ICP-MS	0.05	0.17
76	133	16	32	MESS-3	ET-AAS	2.08	1.68
77	91.2	0.0	6.2	IAEA soil7	F-AAS	-1.08	-4.37
78	107	11	21	IAEA-158	ET-AAS	0.09	0.11

TABLE 24. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR RUBIDIUM

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
4	54.5	20.0	40.0	PACS2	ICP-AES	-4.71	-3.54
14	105			IAEA-356	XRF	-1.67	
21	158	2	4	BCSS-1	XRF	1.54	2.70
26	146	9	18	IAEA SL-1	NAA	0.81	1.03
28	140	24	49	IAEA soil 5	NAA	0.45	0.29
42	139	2	3	IAEA-158	ICP-MS	0.39	0.67
46	115	6	33	IAEA-SL1	NAA	-1.07	-1.61
69	140	8	15	IAEA-158	XRF	0.45	0.60

TABLE 25. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR ANTIMONY

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
26	3.25	0.24	0.48	IAEA SL-1	NAA	-0.42	-0.36
28	3.77	0.08	0.16	IAEA soil 5	NAA	0.79	0.77
41	2.69	0.68	1.35	IAEA-433	ICP-MS	-1.73	-0.92
46	4.54	0.58	1.43	IAEA-SL1	NAA	2.59	1.54
56	3.04	0.02	0.02		ICP-MS	-0.91	-0.90

TABLE 26. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR SELENIUM

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
12	0.563			PACS-2	ICP-MS	n.a.	n.a.
17	2.05			NIST 2709a	ICP-MS	n.a.	n.a.
36	1.38	0.12	0.12	PACS-2	ICP-MS	n.a.	n.a.
38	0.880	0.060	0.120		ICP-MS	n.a.	n.a.
41	0.530	0.140	0.270	IAEA-433	ICP-MS	n.a.	n.a.
48	0.460	0.060	0.120		NAA	n.a.	n.a.
49	0.354					n.a.	n.a.
50	30.5	5.2	10.3		F-AAS	n.a.	n.a.
66	0.200	0.020	0.020	BCR 277-R	Hyd-AAS	n.a.	n.a.
68	0.340	0.030	0.090	IAEA-SL1	ICP-MS	n.a.	n.a.
75	0.440	0.070	0.062	IAEA-405	NAA	n.a.	n.a.

Note: n.a. not applicable.

TABLE 27. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR TIN

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
10	26.5				ICP-AES	-0.21	
12	27.8			PACS-2	ICP-MS	0.18	
17	27.4	0.1	0.2	NIST 2709a	ICP-MS	0.06	0.24
20	27.0	1.8	3.5	IAEA-158	ICP-MS	-0.06	-0.10
38	49.0	0.9	1.7		ICP-MS	6.41	18.34
40	26.3	6.8	6.8	MESS-3		-0.26	-0.13
41	23.8	4.8	9.5	IAEA-433	ICP-MS	-1.00	-0.70
52	18.2				ICP-AES	-2.65	
57	28.7			IAEA-405		0.45	
68	152	15	45	IAEA-SL1	ICP-MS	36.71	8.31
72	28.9			MESS-3	ICP-MS	0.50	
78	24.7	1.5	3.0	IAEA-158	ICP-MS	-0.74	-1.50
78	26.6	2.1	4.2	IAEA-158	ET-AAS	-0.18	-0.27

TABLE 28. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR STRONTIUM

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	69.9	1.3	2.6	CZ 120	ICP-MS	-3.91	-12.99
5	141	4	7	PACS2	ICP-AES	0.25	0.70
11	170	182	364		XRF	1.95	0.18
12	140			PACS-2	ICP-MS	0.19	
14	124			IAEA-356	XRF	-0.75	
17	104	4	8	NIST 2709a	ICP-MS	-1.92	-5.03
20	58.7			IAEA-158	ICP-MS	-4.57	
21	159	3	8	BCSS-1	XRF	1.29	3.81
22	135	4	8	IAEA-433	ICP-MS	-0.11	-0.28
23	71.0				ICP-MS	-3.85	
24	47.5	14.3	28.6	OK-TEP5	ET-AAS	-5.22	-5.90
40	140	3	3	MESS-3		0.19	0.57
52	29.1				ICP-AES	-6.30	
53	79.0	0.0	7.0	IAEA-433	F-AAS	-3.38	-11.61
56	135	1	1		ICP-MS	-0.11	-0.36
57	65.3			IAEA-405		-4.18	
69	156	7	13	IAEA-158	XRF	1.12	2.23
70	82.4			MESS-3	ICP-MS	-3.18	
72	136			MESS-3	ICP-AES	-0.05	
78	140	8	17	IAEA-158	ICP-MS	0.18	0.32

TABLE 29. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR VANADIUM

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	84.7	2.2	4.3	CZ 120	ICP-MS	-0.25	-0.59
2	74.0	2.0	2.0	IAEA-405	ET-AAS	-1.23	-2.96
4	98.4	12.2	24.4	PACS2	AAS	1.01	0.86
5	79.2	1.8	3.6	PACS2	ICP-AES	-0.75	-1.85
9	81.3	3.8	3.8	MESS-3	F-AAS	-0.56	-1.10
10	60.0				ICP-AES	-2.51	
11	202	234	468		XRF	10.45	0.49
12	95.5			PACS-2	ICP-AES	0.74	
13	92.9	5.5	11.0	PACS-2	ICP-AES	0.50	0.80
17	86.7	0.3	0.6	NIST 2709a	ICP-MS	-0.07	-0.18
19	95.0	7.0	14.0	MESS-3	ICP-MS	0.69	0.93
20	72.1	6.8	13.7	IAEA-158	ICP-MS	-1.40	-1.92
22	93.8	2.1	4.2	IAEA-433	ICP-MS	0.58	1.39
23	82.7				ICP-MS	-0.43	
24	50.2	15.1	30.2	OK-TEP5	ET-AAS	-3.41	-2.38

TABLE 29. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR VANADIUM (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
25	65.4	16.4	32.8	GSO5364-90	ICP-AES	-2.02	-1.30
31	88.0	1.9	4.0	NIST 2702	ICP-MS	0.05	0.13
33	70.8	2.1	4.2	IAEA SL-1	NAA	-1.52	-3.63
36	32.0	0.3	0.3	PACS-2	ICP-MS	-5.07	-13.57
38	83.0	4.3	8.4		ICP-MS	-0.41	-0.75
40	76.6	1.1	1.1	MESS-3		-0.99	-2.56
41	81.6	10.2	20.4	IAEA-433	ICP-MS	-0.53	-0.53
42	84.0	6.0	11.0	IAEA-158	ICP-MS	-0.31	-0.47
44	88.1	3.5	70.0	IAEA-SL1	ICP-MS	0.06	0.12
45	97.0	11.0	22.0	PACS-2	NAA	0.88	0.82
48	65.3	2.4	4.8		NAA	-2.02	-4.69
49	88.7					0.12	
50	37.9	1.5	3.0		F-AAS	-4.53	-11.41
51	63.6	7.8	15.6	IAEA-SL1	ET-AAS	-2.18	-2.71
52	37.7				ICP-AES	-4.55	
55	56.6	4.2	8.5	NIST 2702	ICP-MS	-2.82	-5.25
56	89.4	0.1	0.1		ICP-MS	0.18	0.48
67	90.6	3.6	7.2	IAEA-SL1	ICP-MS	0.29	0.58
68	86.4	4.3	12.9	IAEA-SL1	ICP-MS	-0.09	-0.17
69	80.0	3.0	6.0	IAEA-158	XRF	-0.68	-1.47
70	76.2			MESS-3	ICP-MS	-1.03	
71	85.6	10.7	21.4	IAEA-158	ICP-MS	-0.17	-0.16
72	87.8			MESS-3	ICP-MS	0.03	
75	85.5	0.1	14.0	IAEA-405	NAA	-0.18	-0.47
78	94.4	9.4	18.9	IAEA-158	ET-AAS	0.63	0.67

TABLE 30. DATA REPORT OF THE INDIVIDUAL LABORATORY FOR ZINC

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
1	488	34	66	CZ 120	ICP-MS	1.20	1.77
2	313	3	3	IAEA-405	ET-AAS	-2.10	-8.43
3	386	8	16	BCR-277R	F-AAS	-0.73	-2.57
4	463	33	65	PACS2	AAS	0.72	1.10
5	485	21	42	PACS2	F-AAS	1.14	2.45
6	417	9	18		F-AAS	-0.14	-0.48
7	433	30	60	IAEA-433	ET-AAS	0.16	0.26
8	572			IAEA-356	F-AAS	2.77	
9	480	27	27	MESS-3	F-AAS	1.04	1.88
10	450				ICP-AES	0.48	
11	559	601	1202		XRF	2.53	0.22
12	432			PACS-2	ICP-MS	0.14	
13	435	22	44	PACS-2	ICP-AES	0.20	0.41
14	409			IAEA-356	XRF	-0.29	
16	423	27	47	MESS-2	F-AAS	-0.03	-0.05
17	465	1	1	NIST 2709a	ICP-MS	0.76	3.13
18	426	3	7		F-AAS	0.03	0.11
19	447	45	89	MESS-3	ICP-MS	0.42	0.48
20	425	57	115	IAEA-158	ICP-MS	0.01	0.01
21	448	6	16	BCSS-1	F-AAS	0.44	1.62
22	402	8	16	IAEA-433	ICP-MS	-0.43	-1.50
23	569				ICP-MS	2.73	
24	405	122	244	OK-TEP5	F-AAS	-0.37	-0.16
25	380	76	152	GSO5364-90	ICP-AES	-0.84	-0.58
26	457	19	37	IAEA SL-1	NAA	0.61	1.41
28	422	33	67	IAEA soil 5	NAA	-0.05	-0.07
29	417	6	11	GBW 7313	F-AAS	-0.14	-0.54
30	482	11	22	IAEA Soil 7	F-AAS	1.09	3.39
31	472	16	33	NIST 1646a	ICP-MS	0.89	2.31
32	406	10	21	IAEA-433	F-AAS	-0.35	-1.14
33	412	11	22	IAEA SL-1	NAA	-0.24	-0.74
34	521	11	48	IAEA-356	F-AAS	1.82	5.71
35	445	1	3	IAEA-433	F-AAS	0.38	1.57
36	369	9	9	PACS-2	ICP-MS	-1.05	-3.50
38	394	4	7		ICP-MS	-0.58	-2.28
40	415	5	5	MESS-3		-0.19	-0.71
41	372	37	74	IAEA-433	ICP-AES	-0.99	-1.34
43	525				F-AAS	1.89	
44	445	18	36	IAEA-SL1	ICP-MS	0.38	0.92
45	460	11	22	PACS-2	NAA	0.67	2.09
46	352	30	68	IAEA-SL1	NAA	-1.37	-2.22

DATA REPORT OF THE INDIVIDUAL LABORATORY FOR ZINC (cont.)

Lab code	Lab mean	Lab u	Lab U	QC	Technique	*z*-score	Zeta-score
48	394	13	25		NAA	-0.58	-1.70
49	456					0.59	
50	400	19	38		F-AAS	-0.46	-1.07
51	368	19	37	IAEA-SL1	F-AAS	-1.07	-2.50
52	419				ICP-AES	-0.11	
53	494	0.02	18	IAEA-433	F-AAS	1.31	5.38
54	381	36	73		ICP-AES	-0.83	-1.14
55	429	21	43	NIST 2702	ICP-MS	0.08	0.16
56	400	1	1		ICP-MS	-0.46	-1.90
57	453			IAEA-405		0.53	
58	372	3	3	IAEA-405	F-AAS	-0.99	-4.00
59	407	10	20	GB-07312	ICP-AES	-0.33	-1.08
61	415	16	32	WQB1	F-AAS	-0.17	-0.44
62	405			IAEA-433	ICP-AES	-0.37	
64	438	30	61	MESS-3	ICP-MS	0.26	0.41
65	400	9	9	MESS-3	ICP-MS	-0.46	-1.56
66	354	10	10	BCR 277-R	F-AAS	-1.33	-4.33
67	412	21	42	IAEA-SL1	ICP-MS	-0.24	-0.51
69	407	20	40	IAEA-158	XRF	-0.33	-0.74
70	491			MESS-3	ICP-MS	1.24	
71	581	35	70	IAEA-158	F-AAS	2.95	4.19
72	404			MESS-3	ICP-AES	-0.39	
73	334	29	58	IAEA-158	F-AAS	-1.71	-2.85
74	421	3	3	MESS-3	ICP-MS	-0.07	-0.27
75	423	0.02	20	IAEA-405	NAA	-0.03	-0.12
77	438	0.04	33	IAEA soil7	F-AAS	0.25	1.01
78	465	21	42	IAEA-158	F-AAS	0.76	1.64

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