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IAEA Analytical Quality in Nuclear Applications Series No. 55

Worldwide Interlaboratory Comparison on the Determination of Trace Elements in a Fish Sample

IAEA-MESL-ILC-TE-BIOTA-2017

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International Atomic Energy Agency

WORLDWIDE INTERLABORATORY COMPARISON ON THE DETERMINATION OF TRACE ELEMENTS IN A FISH SAMPLE

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IAEA-MESL-ILC-TE-BIOTA-2017

INTERNATIONAL ATOMIC ENERGY AGENCY
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FOREWORD

The primary goal of the IAEA Environment Laboratories is to help Member States to understand, monitor and protect the marine environment. In this connection, the substantial impacts of large coastal cities on marine ecosystems are of primary concern for the IAEA and its Environment Laboratories in particular.

The marine pollution assessments needed to understand these impacts depend on accurate knowledge of contaminant concentrations in various environmental compartments. With the need to base scientific conclusions on valid and internationally comparable measurement results, and to provide policy makers with accurate and reliable information on the state of the environment, ensuring the quality of measurement results produced by individual laboratories is indispensible.

The IAEA's Marine Environmental Studies Laboratory in Monaco, part of IAEA Environment Laboratories, serves as the analytical support centre for IAEA Member State laboratories and is a pillar of the IAEA's quality assurance programme for determination of non-nuclear pollutants — trace elements and organic contaminants — in the marine environment.

Since the 1960s, the IAEA has been providing assistance to Member States in the field of data quality and quality assurance. To support Member States in their marine monitoring activities, as well as in the domain of food safety, the Marine Environmental Studies Laboratory has produced certified reference materials characterized for trace elements and methylmercury using samples of marine origin (biota and sediments), and has organized interlaboratory comparisons.

The IAEA Environment Laboratories interlaboratory comparisons and proficiency tests involve the comparison of participants' results with an assigned value, usually a consensus value from the overall population of test results. The comparisons and tests are designed to allow participating laboratories to monitor and demonstrate their performance and analytical capabilities. At the same time, gaps and problem areas where further developments are needed can be also identified.

The present publication summarizes the results of the IAEA-MESL-ILC-TE-BIOTA-2017 interlaboratory comparison on the determination of trace elements and methylmercury in fish.

The IAEA is grateful to the Government of Monaco for the support provided to its Environment Laboratories. The IAEA is grateful to the participants and laboratories that took part in this intercomparison exercise. The IAEA officers responsible for this publication were S. Azemard and E. Vasileva 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 States' 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 of monitoring laboratories, via the organization of targeted worldwide and regional interlaboratory comparisons.

In order to assure reliability of analytical data for monitoring studies, one essential aspect of quality assurance and quality control is the periodic external assessments measurement performance of laboratories in charge of monitoring studies via Interlaboratory Comparisons (ILCs) or Proficiency Tests (PTs). The results from ILCs or PTs are of crucial interest for laboratories as they provide clear information of their measurement capabilities.

These exercises are designed to monitor the performance and analytical capabilities of the participating laboratoriesand to identify gaps and problem areas where further development is needed. Regular participation in the ILCs and PTs enhanced trust in results and methodologies and provides objective evidence for the accreditation purposes.

2 SCOPE OF THE INTERCOMPARISON

The present ILC was designed to evaluate the measurement performance of participating laboratories for the determination of trace elements in marine biota sample (fish).

Letters of invitation have been sent to 293 laboratories, previously participated or expressed the interest in the IAEA ILCs. Positive responses were received from 111 laboratories from 57 Member States. 61 laboratories from 38 IAEA Member States received the ILC test sample.

Each participating laboratory received one bottle of the test sample, accompanied by one information sheet and instruction for the use of the IAEA-NAEL on-line reporting system. Participants were requested to determine as many elements as possible from the following list of elements: Ag, As, Ca, Cd, Co, Cr, Cu, Fe, Hg, CH_3Hg, K, Mg, Mn, Ni, Pb, Se, Sn, Sr, V and Zn, using analytical procedures routinely applied in their laboratories.

In total 49 laboratories from 32 countries reported results back to the organizers. The data reported by laboratories, together with the technical and statistical evaluations of the results for investigated trace elements, are included in this report. All results were treated confidentially and each laboratory was identified with a unique confidential code number

3 DESCRIPTION OF ILC TEST MATERIAL

About 350 kg of mixed fish was collected in the eastern Irish Sea. After removal of the skin; the fish filleted was freeze-dried and grounded to powder and sieved at 250µm. The portion above 250µm was reprocessed by micronisation. The obtained sample material with grain size <100µm was further homogenized and bottled in plastic container.

Homogeneity test was performed at the MESL following the requirements ISO 35 guidelines [1], using preliminary validated in MESL's trace elements laboratories analytical methods.

All reported measurement results were evaluated by using Kernel density plots, as an appropriate method to represent the overall structure of a data set [2]. No bimodality structures linked to the sample preparation or analytical method were observed. Consequently, the assigned values and their measurement uncertainties have been calculated with all reported results.

Robust statistics was used for the determination of the assigned values. The robust mean and robust standard deviations were calculated as described in the ISO 13528, Annex C.21 [3].

The uncertainties associated with the assigned values were calculated according to the ISO standard 35 [1]. The combined uncertainty of the assigned value 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 using Eq. (1).

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

where:

k: coverage factor, k=2, representing level of confidence of about 95%

u_{hom} is the standard uncertainty, due to between unit inhomogeneity. u_{hom} was calculated as the between unit standard deviation using ANOVA statistical approach [1].

u_{stab} is the standard uncertainty, due to long term stability of the sample. As the raw sample was prepared more than 10 years ago u_{stab} component was considered to have negligible contribution and was not further propagated during the estimation of the total combined uncertainty.

u_{char} is the uncertainty of characterization, estimated according to the recommendations of the ISO 13528 [3] using Eq. (2).

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

Where: s^* is the robust standard deviation and n the number of measurement results.

Assigned values and expanded uncertainties are presented in Table 1. For Co, Cr, Ni and Sn expanded uncertainty was beyond 25%, therefore those values are given for information only and will not be used for the evaluation of measurement performances of laboratories, participating in this interlaboratory comparison.

TABLE 1. ASSIGNED VALUES AND UNCERTAINTY IN PT SAMPLE

Element	Unit	Assigned value	Expanded uncertainty (k=2)
Ag	mg kg^{-1}	0.066	0.008
As	mg kg^{-1}	19.9	1.1
Ca	mg kg^{-1}	27.4 × 10^3	4.6 × 10^3
Cd	mg kg^{-1}	0.032	0.004
CH_3Hg	mg kg^{-1} as Hg	0.531	0.092
Co	mg kg^{-1}	0.121	0.020
Cr	mg kg^{-1}	3.45	0.86
Cu	mg kg^{-1}	2.40	0.34
Fe	mg kg^{-1}	138	19
Hg	mg kg^{-1}	0.593	0.032
K	mg kg^{-1}	14.0 × 10^3	2.4 × 10^3
Mg	mg kg^{-1}	2.11 × 10^3	0.37 × 10^3
Mn	mg kg^{-1}	15.4	1.5
Ni	mg kg^{-1}	4.09	1.18
Pb	mg kg^{-1}	0.606	0.064
Se	mg kg^{-1}	2.17	0.20
Sn	mg kg^{-1}	0.182	0.054
Sr	mg kg^{-1}	136	23
V	mg kg^{-1}	0.405	0.085
Zn	mg kg^{-1}	52.1	3.0

4 EVALUATION OF ANALYTICAL PERFORMANCE

The individual laboratory performance was expressed in terms of z-scores and Zeta-scores, in accordance with the ISO 17043 [4].

The determination of target standard deviation was based on the outcome from the previous ILCs, organized by the MESL with similar sample matrices for the same population of laboratories. 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 the Eq. (3), effectively expresses the difference between the mean of the laboratory and the assigned value in the units of the target standard deviation (σ_p).

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

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 the respective participant.

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

Where:
x_{lab}: Reported result by the participating in the ILC laboratory (express as the mean of multiple determination)
x_{ass}: Assigned value
σ_p: Target standard deviation
u_{xlab}: Standard uncertainty reported by the participating in the ILC laboratory
u_{ref}: Standard uncertainty of assigned value

The interpretation of laboratory's performance was evaluated according to the following internationally accepted limits [4]:

	$\lvert z \text{ or Zeta} \rvert \leq 2$	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

Forty-nine sets of data were submitted comprising 568 analytical results for 21 elements. *z*-scores and Zeta-scores were evaluated only for 16 elements.

75% of participants reported results for at least half part of requested analytes. For Zn, Fe and Cu more than 75% of participants reported their obtained measurement results. On the other hand, only 12% of laboratories (6) reported results for methyl mercury mass fraction in the fish sample, while 35 could reported only results total mercury mass fraction.

Graphical presentations of reported results and Kernel density plots [2] (in the case were more than 8 measurement results were reported) are presented in Appendix I. z-score, Zeta-scores and summary of statistical evaluation for the assessed elements are presented in the Appendix I.

All reported by participants in this ILC measurement results, are compiled in the Appendix II. (For editorial purposes some results have been rounded to appropriate number of significant figures).

5.2 LABORATORY PERFORMANCES

5.2.1 *z*-scores:

Table 2 shows the overall performance (*z*-scores) of laboratories element by element. Figures 1 and 3 summarize *z*-scores of the participating in the ILC laboratories by element and by participating laboratory.

The *z*-score compares the bias of the reported result from the assigned value with the target standard deviation (σp for proficiency assessment). σp is defined by the ILC organizer as the

maximum acceptable standard deviation (25%) of the assigned value for investigated trace elements.

In total from 463 *z*-scores calculated, 81% were with $|z| \leq 2$, 87% with $|z| < 3$, and 13% were considered as unsatisfactory with $|z| > 3$. Among 49 datasets, 13 (27%) were with all $|z| \leq 2$ and 23 (47%) with $|z| < 3$. On the other hand, 6 datasets (12%) have more than half of their results considered as unsatisfactory with $|z| \geq 3$.

As shown on Figure 1 the proportion of the acceptable results per element was 50% or higher. Silver, cadmium and lead appeared to be the elements reported with the highest number of unsatisfactory *z*-scores. This result shows that the accurate determination of those elements in biological material is challenging, particularly at low concentration levels. For cadmium and silver most of unsatisfactory results, 86% and 73% were related with overestimation of the respective mass fractions. As these analytes have the lowest mass fractions, the observe results are probably arising from the contamination during sample preparation (e.g., digestion) or instrumental step. The laboratories concerned should carefully check their analytical procedures (e.g., quality of purified water and reagents applied) 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 measurement bias. Only standards (CRM) with stated SI traceability should be used for calibration purposes. It is important to note that losses related with the working standard solutions at low concentration levels, are leading to the overestimation of the concentrations of elements in the samples (e.g., standard solutions should not be stored for an extended period).

Laboratories with questionable and unacceptable results should carefully check the respective laboratory procedures and working instructions, related with the analytical method used in this ILC.

5.2.2 Zeta scores:

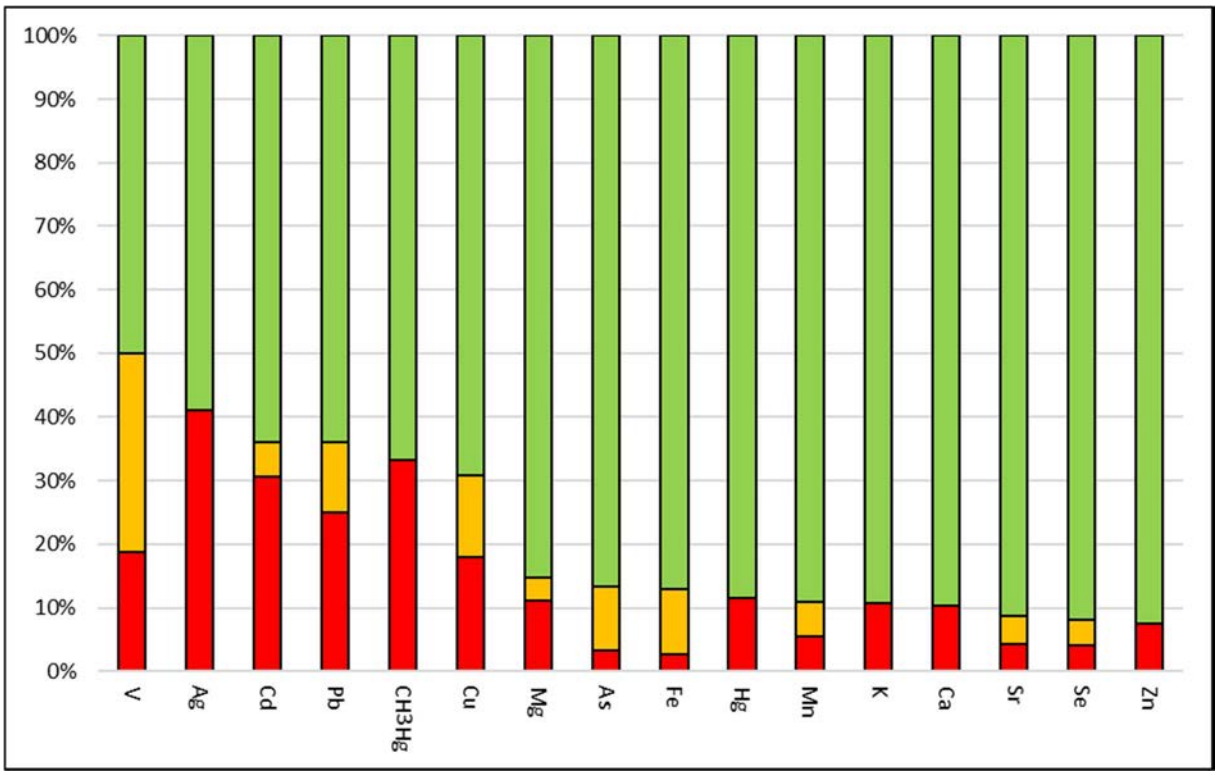
Table 5 shows the overall performance (Zeta-scores) of laboratories for all studied trace elements. Figure 2 and 4 summarizes Zeta-scores of the participating laboratories in the ILC by trace element and by participating laboratory.

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 measurement uncertainty as reported by the participating laboratory.

Nine laboratories (18%) didn't provide the uncertainty of their reported results and Zeta-scores could not have been calculated.

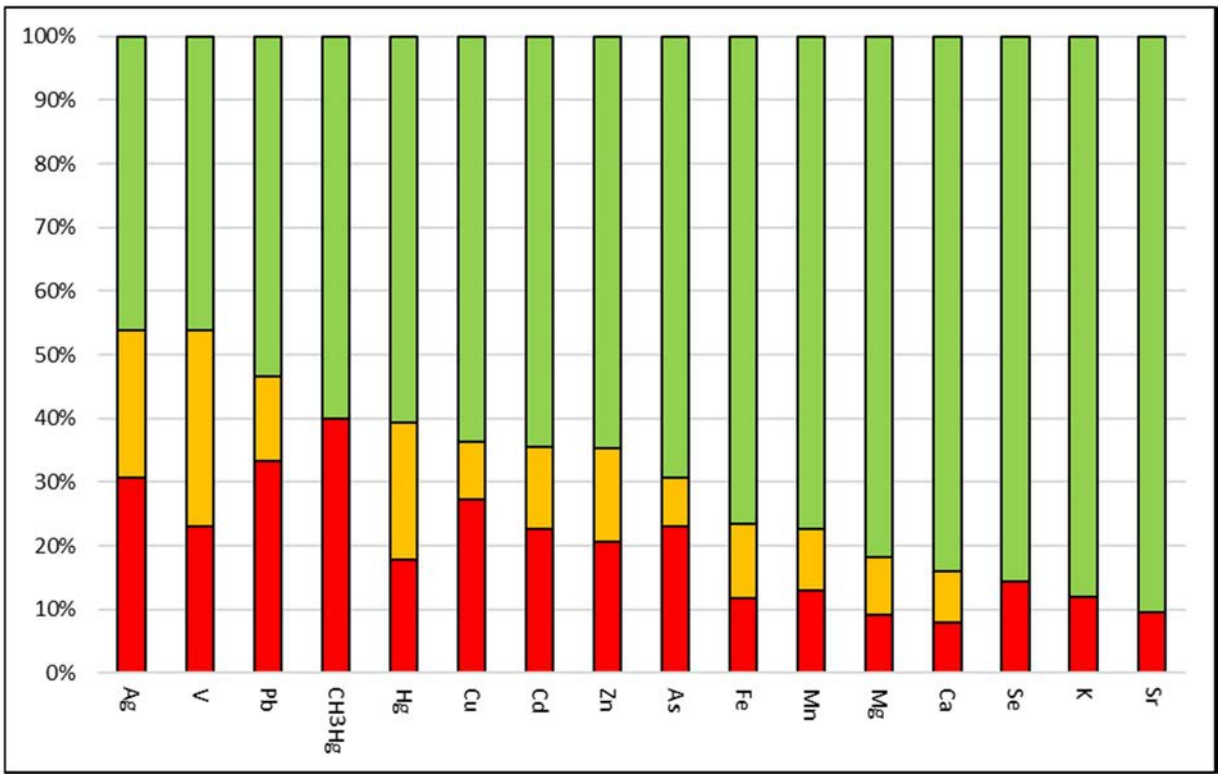
As it can be seen on Figures 1 and 2, the comparison of measurement performances evaluated with *z*-score and Zeta score clearly indicate that the number of unsatisfactory Zeta-scores is slightly higher than the number of unsatisfactory *z*-scores (13% for *z*-scores and 19% for Zeta-scores). Only 3 laboratories (6%) could report 100% of their results with $|z|$ and $|\text{Zeta}| \leq 2$. As the Zeta-score is the evaluation parameter, reflecting all parts of the measurement process, laboratories with 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 mentioned here that an unsatisfactory Zeta-score can be also caused by an inappropriate estimation of the mass fraction of the respective trace element.



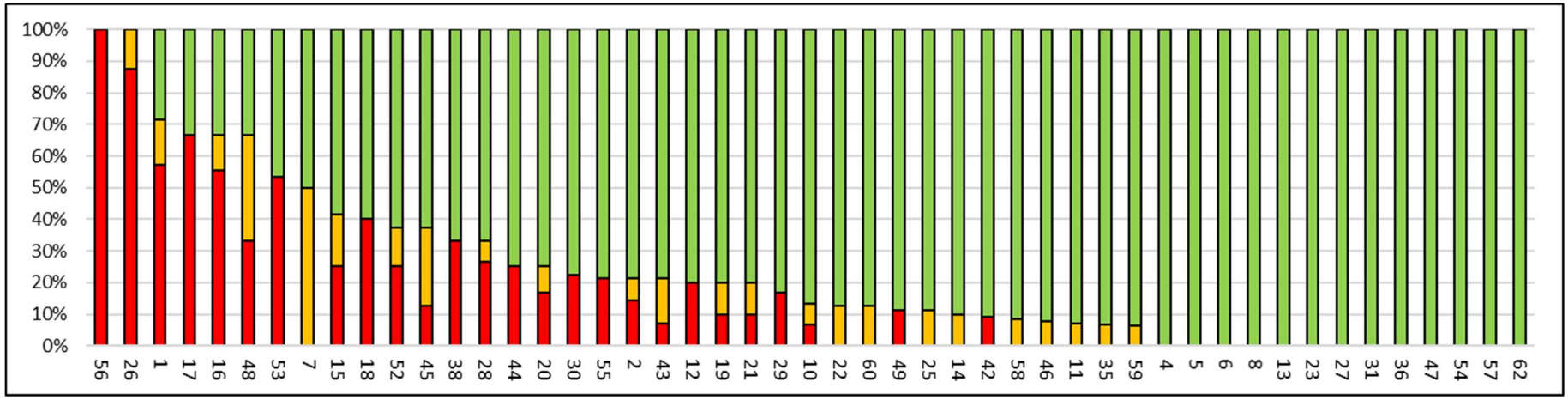
$|z| \geq 3$, $2 < |z| < 3$, $|z| \leq 2$

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



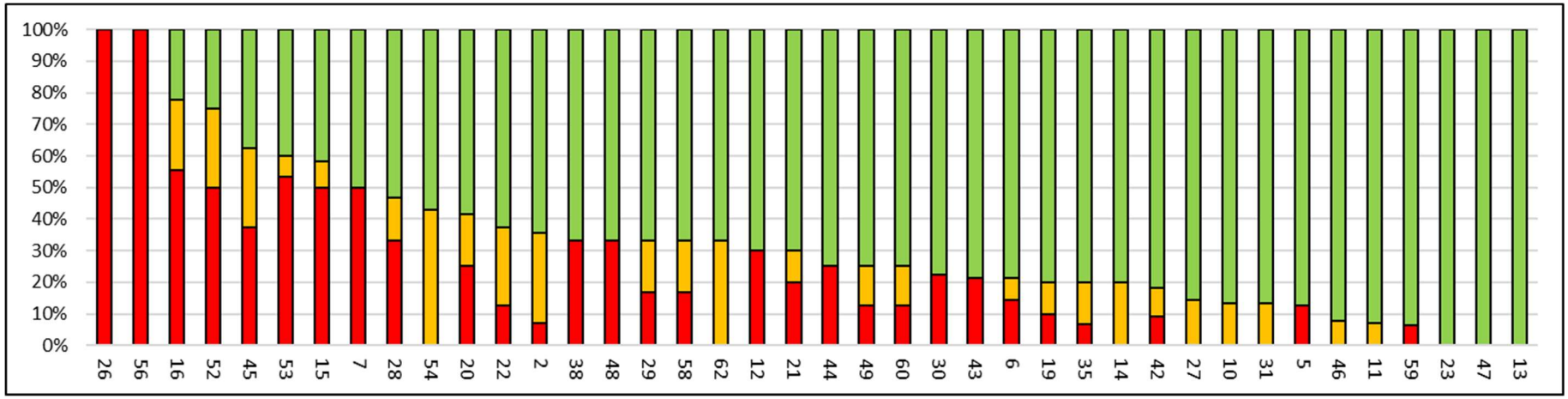
$|\text{Zeta}| \geq 3$, $2 < |\text{Zeta}| < 3$, $|\text{Zeta}| \leq 2$

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



$|z| \geq 3$, $2 < |z| < 3$, $|z| \leq 2$

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



$|\text{Zeta}| \geq 3$, $2 < |\text{Zeta}| < 3$, $|\text{Zeta}| \leq 2$

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

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

Lab. Code	Ag	As	Ca	Cd	Cu	Fe	Hg	K	MeHg	Mg	Mn	Pb	Se	Sr	V	Zn
1			**-4.26**		**-5.97**	**-2.59**				**-7.99**	-0.38	**-7.62**				-0.35
2	0.53		**-3.57**	**-3.29**	-0.05	-0.77	-1.79	-1.69		-1.30	-1.61	**-2.32**	-0.96	-0.97	-1.16	-0.05
4							-0.08									
5		0.03	-0.58			-0.32	-1.24	0.00					-0.21	-0.74		-0.32
6		0.25	0.80	-0.23	-0.41	-0.20	0.70	1.10		1.21	0.82	-0.72	1.50	0.75	1.95	1.59
7				-0.81	**-2.35**	**2.71**						-0.17				
8							0.10									
10	**4.12**	-0.13	0.62	-1.30	-1.34	-0.28	-1.53	-0.06		0.72	0.48	0.10	-0.63	0.32	**2.12**	-0.95
11		0.48	0.68	-0.91	-0.58	-0.64	0.24	0.74		0.66	0.31	0.39	-0.10	0.65	**-2.77**	-0.45
12		-1.28	0.65	0.93	**3.58**	0.10	0.24	0.73		0.68		**3.36**				-0.54
13		0.48	0.85	0.60	-0.98	0.09		-0.65		1.27	-0.30	0.30	-0.35	1.06		0.02
14		0.58		-0.04	0.71		-0.13		0.53		0.82	1.17	0.63		**2.05**	0.42
15		-0.07	-1.41		-1.95	**-2.34**		0.10		-0.14	**-2.65**	**-5.18**	-0.74	**3.31**	**13.44**	1.39
16	**14.46**			**16.31**	**-2.63**	1.96	**-7.22**				**-6.61**	1.77		-0.50		**21.33**
17				**-3.04**			**7.24**					-0.87				
18					**7.32**	1.54					1.13	**36.44**				0.76
19			0.52	**-2.13**		-0.22	1.59	0.14	**-5.73**	0.44	-1.08			0.00		-0.89
20	**58.67**	-1.20	-0.54	-0.15	-1.51	**2.10**		-1.17		-0.34	0.98	**-7.03**	0.01			0.67
21	-1.04	**-2.51**		1.64	0.28	0.81	0.71				0.00	**-6.69**		0.65		0.35
22		**-2.31**		-1.88	1.96	0.61	-0.11				0.05	-1.64				0.09
23		-0.06	0.33	-0.31	0.15	-0.18		0.57		1.02	-0.64	0.18	1.98			0.27
25	0.48	-0.07		-0.56	-0.72		-0.18				1.69	-0.43	**-2.80**			-0.10
26			**-7.87**	**224.42**	**-2.21**	**-7.59**		**-7.88**		**-7.98**		**11.79**				**-7.65**
27			-0.58		1.37	-1.28		-0.91		-0.73	0.47					-1.13
28	**-3.96**	-0.43	0.49	**66.41**	**-3.49**	1.59	-1.21	**-7.19**		1.15	-0.39	**-2.63**	-0.15	-0.43	1.04	-0.06
29				-1.22	**5.49**	-0.30	-0.70				-1.60	-0.20				

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

Lab. Code	Ag	As	Ca	Cd	Cu	Fe	Hg	K	MeHg	Mg	Mn	Pb	Se	Sr	V	Zn
30			-1.40		1.23	-0.25	0.18	**-7.99**		**-7.99**	-0.79			0.08		-0.17
31	0.16	0.09	0.37	0.02	1.85	0.34	1.65	-0.01		-0.35	0.44	0.93	-0.43	0.63	-0.82	0.06
35	-1.21	**2.32**	-0.43	-0.21	-0.28	0.61	-0.67	0.56		0.39	0.36	-0.59	0.43	0.76	1.29	0.68
36	-1.64	0.08	-0.25	-1.18	-1.34	0.12	-0.98	0.16		-0.45	0.37	-1.27	-0.16		-0.01	-0.55
38								0.28					-0.05			**3.16**
42	0.69	-0.32		**4.24**	1.15	1.07	0.91				0.08		0.65	0.24	-0.78	0.19
43	**4.93**	0.31	1.72	-0.31	**-2.34**	-0.49	0.41	1.50		0.83	-0.75	**-2.59**	0.22	-0.33		-0.37
44				**3.08**	0.34	0.47					0.25					
45		-0.50	1.88		**7.43**	0.71		0.90			**-2.47**			**-2.18**		-1.40
46		0.04	0.68		0.09	-0.72	-0.08	0.89		1.21	0.20	1.28	-0.27	-0.02	**-2.71**	-0.42
47		0.54		-1.88	1.17	-0.78	0.13		-1.11		-1.39	0.58				0.07
48				**-3.04**			-0.49					**-2.29**				
49		-0.68	-0.33			-0.37	**7340**			-0.36	-0.87		-1.14	-0.49		-0.68
52			-0.04	**44.09**	**-2.50**	-1.46		-0.32		-1.83		**4.24**				-1.71
53	**22.30**	**18.51**	-1.00	**140**	**25.51**	1.78	1.33	-1.32		-0.60	**3.97**	**108**	**10.40**	-1.45	**4652.50**	1.40
54		0.47		-0.81	-0.24		-0.51				1.32	0.27				0.16
55	**84.93**	0.34	0.83	**48.22**	-0.20	-1.24	-0.13	-0.51		-0.79	1.02		0.12	0.69	**-3.48**	0.05
56							**8112**		**8450.52**							
57	-0.95	0.99	0.46	-0.77	-0.91	0.46	0.59	0.74	0.82	0.97	0.25	1.19	0.52	0.04	0.16	1.61
58	-1.01	-0.27	1.00	-1.63	1.18	-0.24		0.93		**2.13**	0.77	1.50	-1.93			-0.12
59	-0.81	1.35	-0.43	0.02	-0.50	0.13	-0.69	0.11	0.80	0.99	0.03	0.70	1.59	-0.10	**-2.68**	0.76
60		-1.74		**2.17**	0.34	0.55	-0.27				0.48	-0.39				-0.27
62				-1.39			-0.98					0.49				

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

Lab. Code	Ag	As	Ca	Cd	Cu	Fe	Hg	K	MeHg	Mg	Mn	Pb	Se	Sr	V	Zn
1																
2	0.20		**-4.41**	**-2.98**	-0.05	-0.84	**-2.72**	-1.82		-1.34	**-2.13**	**-2.40**	-1.21	-1.00	-0.88	-0.07
4																
5		0.11	-0.84			-0.50	**-3.28**	0.00					-0.41	-1.02		-1.22
6		0.83	0.93	-0.13	-0.41	-0.27	**2.66**	1.21		1.23	1.16	-1.17	**3.55**	1.04	0.93	**4.04**
7				-0.16	**-3.74**	**4.87**						-0.08				
8																
10	**2.19**	-0.12	0.32	-1.89	-1.53	-0.16	-0.77	-0.07		0.74	0.54	0.06	-0.55	0.29	**2.46**	-1.73
11		0.71	0.66	-1.53	-0.80	-0.93	0.19	0.28		0.65	0.41	0.24	-0.16	0.70	**-2.98**	-0.72
12		**-4.59**	0.91	1.72	**5.43**	0.17	0.52	1.07		0.94		**3.74**				-1.40
13		1.32	1.13	0.98	-1.21	0.15		-0.87		1.34	-0.50	0.54	-0.57	1.44		0.03
14		1.74		-0.08	0.78		-0.35		0.69		1.26	**2.13**	1.55		**2.13**	1.10
15		-0.16	**-2.06**		-1.50	**-4.02**		0.15		-0.18	**-3.03**	**-5.77**	-0.72	**4.67**	**5.25**	**3.13**
16	**2.16**			1.64	**-4.56**	**3.44**	**-31.37**				**-16.58**	**2.74**		-0.73		**45.13**
17																
18																
19			0.75	-1.93		-0.35	1.71	0.17	**-5.02**	0.50	-1.84			0.01		**-2.16**
20	**15.99**	**-3.83**	-0.75	-0.06	-1.72	**2.42**		-1.63		-0.28	1.26	**-15.16**	0.02			**2.56**
21	-1.57	**-7.75**		**2.37**	0.47	1.34	1.47				0.00	**-15.02**		0.81		0.68
22		**-9.38**		**-2.12**	**2.37**	0.84	-0.34				0.08	-1.69				0.25
23		-0.09	0.42	-0.35	0.18	-0.20		0.71		1.22	-0.94	0.20	1.87			0.40
25																
26			**-11.60**	**37.58**	**-3.77**	**-13.64**		**-11.57**		**-11.29**		**18.20**				**-33.72**
27			-0.68		0.97	-1.87		-1.08		-0.81	1.13					**-2.80**
28	**-3.03**	-1.83	0.66	**2.68**	**-5.90**	**2.39**	**-3.50**	**-10.47**		1.55	-0.59	**-5.26**	-0.35	-0.62	0.80	-0.27
29				-0.92	**2.69**	-0.44	-1.17				**-3.12**	-0.33				

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

Lab. Code	Ag	As	Ca	Cd	Cu	Fe	Hg	K	MeHg	Mg	Mn	Pb	Se	Sr	V	Zn
30			-1.86		1.82	-0.33	0.39	**-11.73**		**-11.30**	-1.13			0.10		-0.21
31	0.27	0.23	0.49	0.03	**2.51**	0.49	**2.66**	-0.01		-0.44	0.77	1.68	-0.83	0.84	-0.94	0.16
35	**-2.16**	**5.85**	-0.64	-0.29	-0.35	1.08	-1.59	0.75		0.54	0.88	-1.30	1.15	1.01	1.26	**2.98**
36																
38								0.33					-0.09			**3.96**
42	0.39	-1.10		**3.84**	1.52	1.61	**2.73**				0.20		1.02	0.34	-0.94	0.81
43	**9.09**	0.15	1.07	0.00	**-3.09**	-0.38	0.49	0.71		0.56	-0.67	**-3.30**	0.11	-0.24		-0.46
44				**3.48**	0.57	0.57					0.56					
45		-1.08	**2.77**		**3.58**	1.17		1.32			**-2.23**			**-3.21**		**-5.10**
46		0.02	0.46		0.09	-0.62	-0.06	0.47		0.78	0.16	1.02	-0.13	-0.01	**-2.58**	-0.53
47		0.41		-1.71	0.77	-0.64	0.11		-0.89		-1.29	0.42				0.06
48				-1.23			-1.41					**-3.94**				
49		-1.06	-0.45			-0.57	**108.81**				-1.83		-1.39	-0.72		**-2.84**
52			-0.05	**8.85**	**-4.16**	**-2.55**		-0.46		**-2.57**		**6.45**				**-7.02**
53	**6.08**	**11.24**	-1.47	**7.09**	**12.47**	**2.02**	1.19	-1.92		-0.85	**4.52**	**9.63**	**6.00**	-1.55	**11.50**	1.91
54		**2.01**		-1.49	-0.39		**-2.29**				**2.95**	0.58				0.71
55																
56							**6.11**		**12.54**							
57																
58	-1.67	-1.12	1.43	**-3.02**	1.61	-0.35		1.37		**2.99**	1.92	**2.39**	**-4.71**			-0.47
59	-0.92	1.62	-0.56	0.02	-0.57	0.13	-0.91	0.10	0.50	1.27	0.03	0.99	1.16	-0.12	**-3.04**	0.55
60		**-2.14**		**4.01**	0.45	0.96	-1.08				0.60	-0.75				-0.61
62				-1.81			**-2.39**					0.43				

5.3 ANALYTICAL METHODS

Analytical methods used by the participating in this ILC laboratories are presented on Figure 5. Generally, they can be divided to three groups: nondestructive techniques (NAA, XRF); plasma spectrometric methods (ICP-MS and ICP-OES) and atomic absorption spectrometry methods, representing 10%, 60% and 20% respectively. Abbreviation used in the figure 5 and appendix II are shown in Table 6.

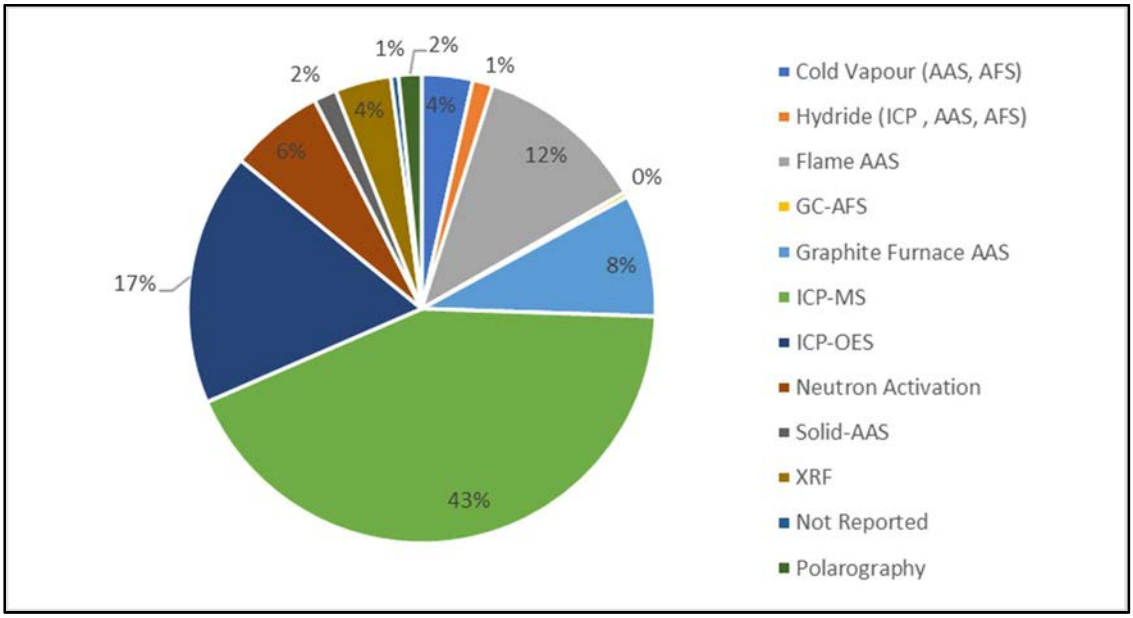


FIG. 5. Graphical distribution of instrumental techniques.

TABLE 6. ABBREVIATIONS OF INSTRUMENTAL TECHNIQUES USED IN THE INTERLABORATORY COMPARISON

Method code	Instrumental technique
AAS	Atomic Absorption Spectrometry
AFS	Atomic Fluorescence Spectrometry
GC	Gas Chromatography
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
ICP-OES	Inductively Coupled Plasma Optical Emission Spectrometry
NAA	Neutron Activation Analysis
XRF	X-Ray Fluorescence Spectrometry

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

Eleven participants (22%) didn't report the obtained for the CRM results as requested in the reporting form. Eight participating laboratories didn't provide QC results for all requested elements. An important principle for the selection of reference material by laboratories was the principle of matrix and concentration range matching. CRMs used in this ILC were appropriately selected as most of laboratories used biota matrices of marine origin (i.e. IAEA 407 Tuna fish and IAEA 461 Clam from the IAEA, SRM 2976 mussel from the NIST).

Sixteen participants (32%) claimed to be accredited, but only part of them were accredited for the determination of trace element in fish sample matrix. 4 participants (25%) from accredited laboratories didn't report results for QC sample. In general, results reported by accredited laboratories were comparable with results reported by non-accredited laboratories. Only one of accredited laboratory (6%) and 6 of non-accredited laboratories (36%) reported 100% of their results with $|z| \leq 2$.

Only 6 laboratories (12%) claimed implementing correction for recovery for at least part of their reported results, but 25 participants didn't provide results for recoveries. Most of recoveries reported were in the range of 100 ± 25%. High proportion of the laboratories that didn't perform correction for recovery have obtained satisfactory scorings, meaning that the laboratories have correctly estimated that the recovery achieved was not significantly different from 100%.

The ILC fish sample was subjected to freeze drying as part of its preparation process. At the time of bottling, the moisture content of the material was around 6.5%. Depending on local storage conditions and humidity levels the ILC sample might absorb moisture from the environment. Consequently, users were advised to make a separate determination of the moisture content of the material. As the moisture is operationally dependent parameter [5] procedure on moisture content determination in the test sample was provided to all participating laboratories in the accompanying letter. Only 27 participants (55%) claimed to report results corrected for moisture, 14 of them have used effectively the prescribed by the organizers protocol (85°C). Other 13 laboratories didn't provide their methodology for moisture determination. Inadequate determination of moisture can be a source of bias, especially for biological matrices, where the moisture content is often more than 5%. The moisture content reported by the laboratories that applied a correction factor was in the range from 0.05 to 11%.

It should be noted that out of 49 data sets received, 12 participants didn't fill the questionnaire as requested.

6 RECOMMENDATIONS

Participants are recommended to review their data element by element, appraising whether the *z*-scores 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 data quality.

Laboratories should investigate all unsatisfactory scores (i.e. |z| or |Zeta| > 3) and put in place the necessary corrective actions in order to prevent the problem reoccurring. This is also a requirement for accredited according to the ISO/IEC 17025 standard laboratories. [6].

Participants reporting total mercury in fish sample are strongly suggested to look at the implementation of methodologies for the measurement of mercury speciation's, when the obtained measurement results are used for risk assessment purposes.

Some laboratories still need to improve quality assurance / quality control procedures, to implement regular analysis of certified reference materials and the use of quality control chart in their daily laboratory practice. This way of work provides continuous feedback to the analyst and is an essential tool for the monitoring of data quality and for the production of reliable measurement results, used in the monitoring and risk assessment studies.

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

Although the overall performance of participating in this ILC laboratories is quite satisfactory, it must be pointed that for elements present at low to ultra-low concentration levels (i.e Cd, Pb) in fish matrix, there is clear danger of contamination problems. It is a subject of concern as these elements are toxics and the accurate determination of their content in seafood is of crucial importance.

The implementation of Minamata convention, especially article 19, should lead to increasing number of laboratories involved in the monitoring of mercury but also on mercury species, especially in fish samples. The need for improvement in this analytical field is obvious, as only 12% of participants in the ILC are in a position to report obtained measurement results for CH_3Hg.

An extra effort is needed for relevant evaluation of measurement uncertainties, associated with measurement results. There is still almost 20% of participants that do not report results with associated uncertainties. As a result, the number of unsatisfactory Zeta-scores was systematically higher than the number of unsatisfactory z-scores for the same trace elements. The uncertainty associated with measurement results is of paramount importance in the frame of different regulations and international agreements, and it is important for any analytical laboratory to report a complete uncertainty statement.

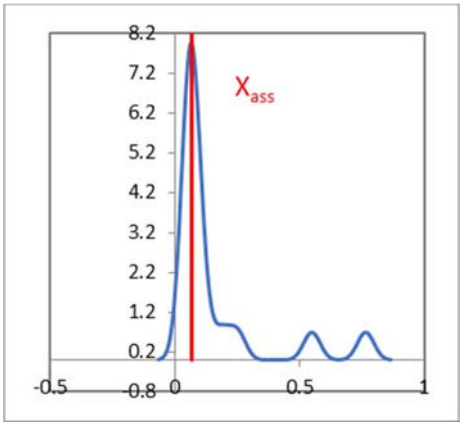
In general, it should be noted that uncertainty evaluations based only on the precision of measurement results are very often underestimated. In many cases, they do not include other major contributors, coming from uncertainties on the determination of recovery, procedural blank, moisture content etc.

APPENDIX I

PERFORMANCE EVALUATION BY ELEMENT IN IAEA-MESL-ILC-TE-BIOTA-2017

Evaluation of Reported data for Ag

Kernel density Plot



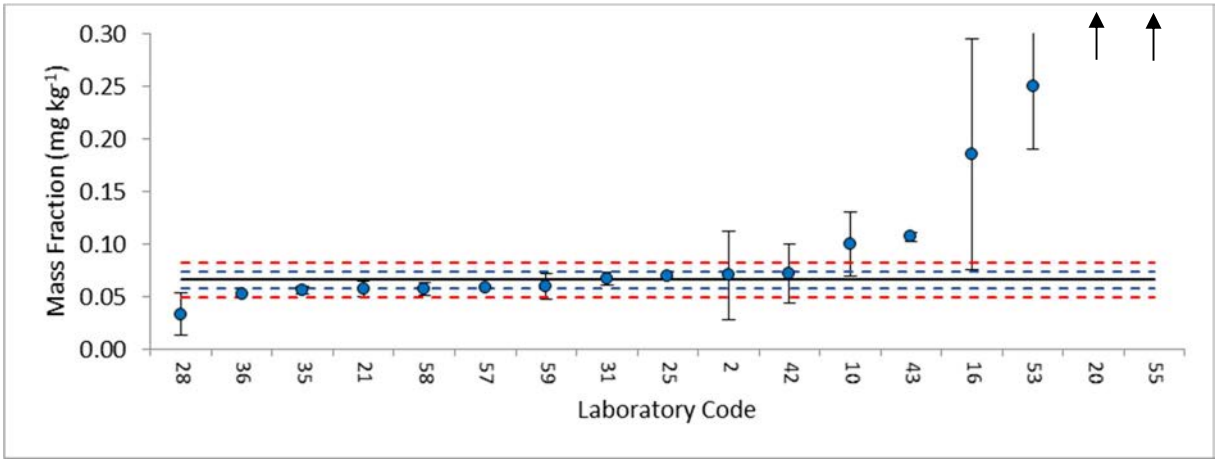
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	59%	0%	41%
Zeta-score	46%	23%	31%

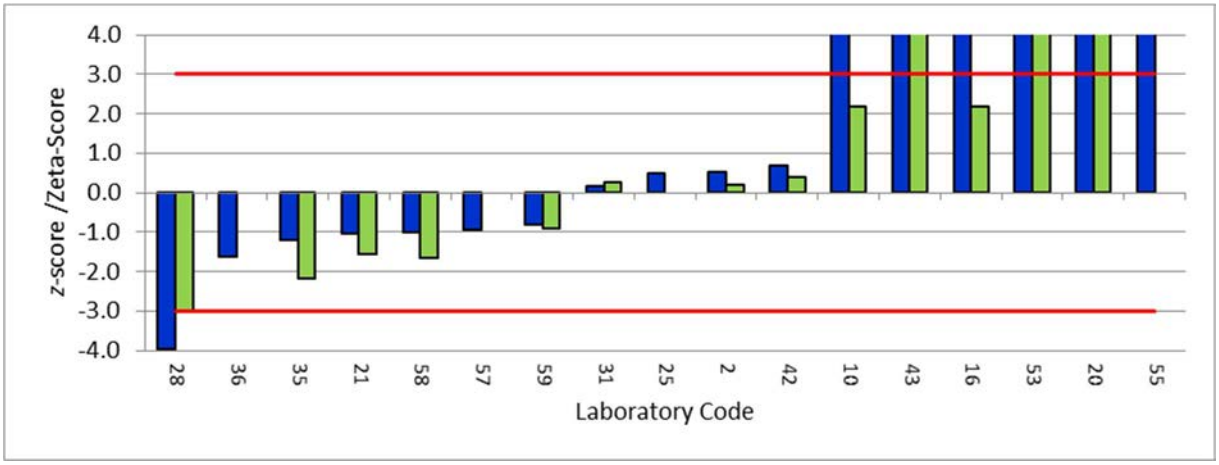
X_{ass}:	0.066 mg kg^{-1}
U_{ass} (k=2):	0.008 mg kg^{-1}
$2\sigma_p$:	0.017 mg kg^{-1}
Number of results:	17
Number of method:	3

Reported results and expanded uncertainties:

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

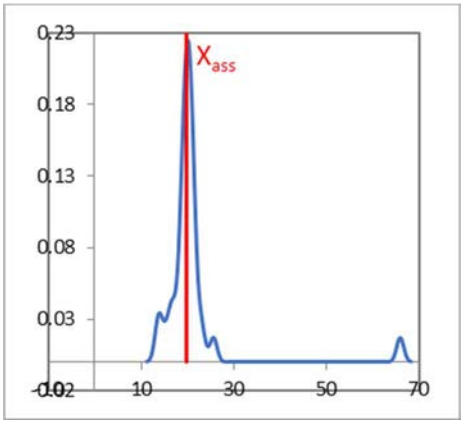


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for As

Kernel density Plot



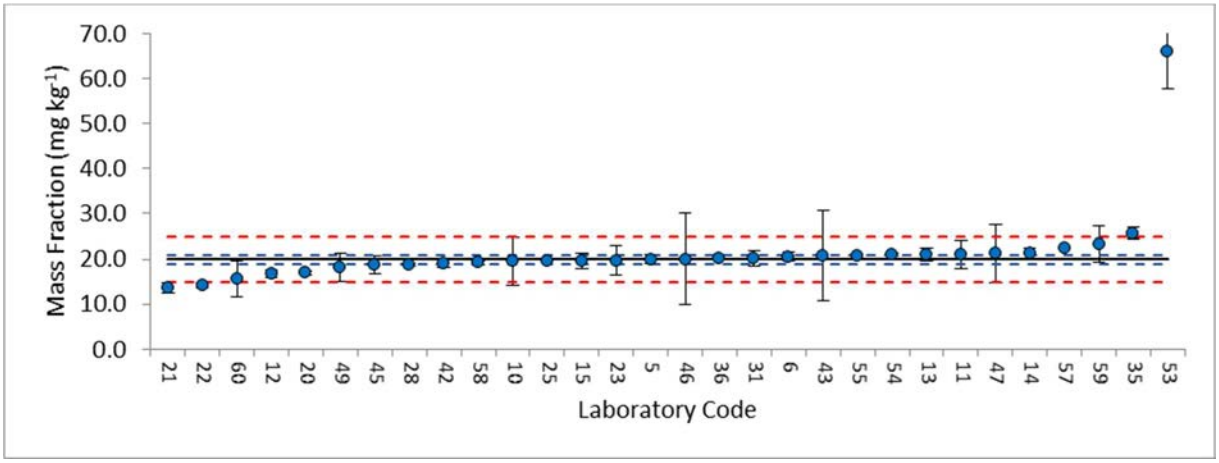
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	87%	10%	3%
Zeta-score	69%	8%	23%

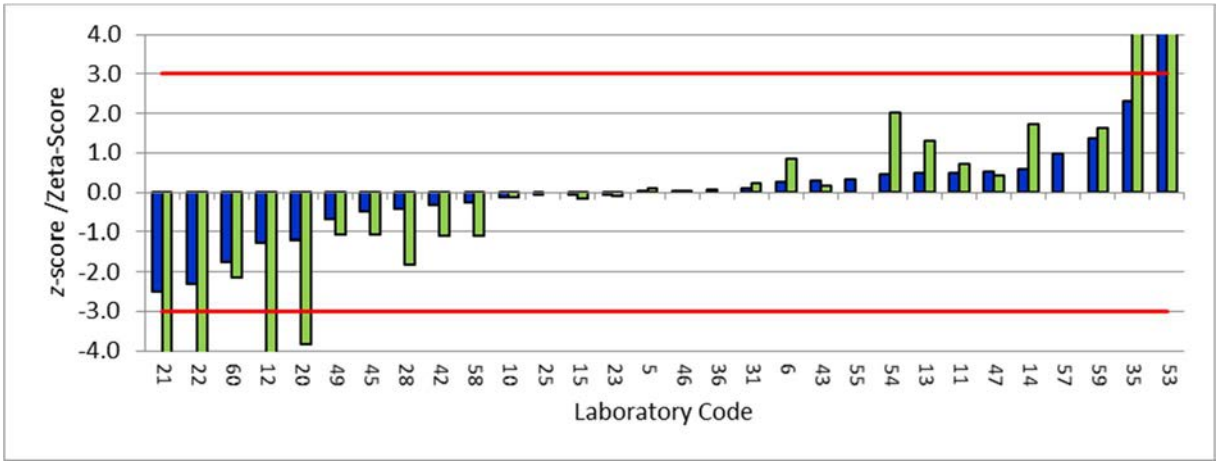
X_{ass}:	19.9 mg kg^{-1}
U_{ass} (k=2):	1.1 mg kg^{-1}
$2\sigma_p$:	5.0 mg kg^{-1}
Number of results:	30
Number of method:	6

Reported results and expanded uncertainties:

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

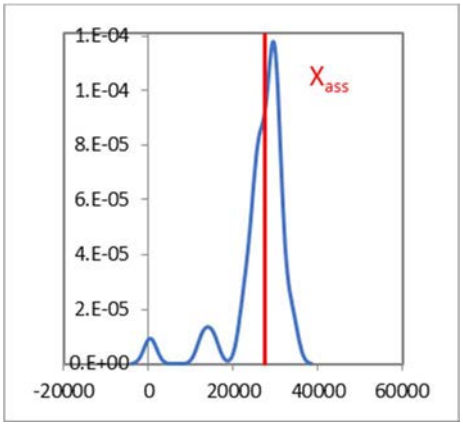


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for Ca

Kernel density Plot



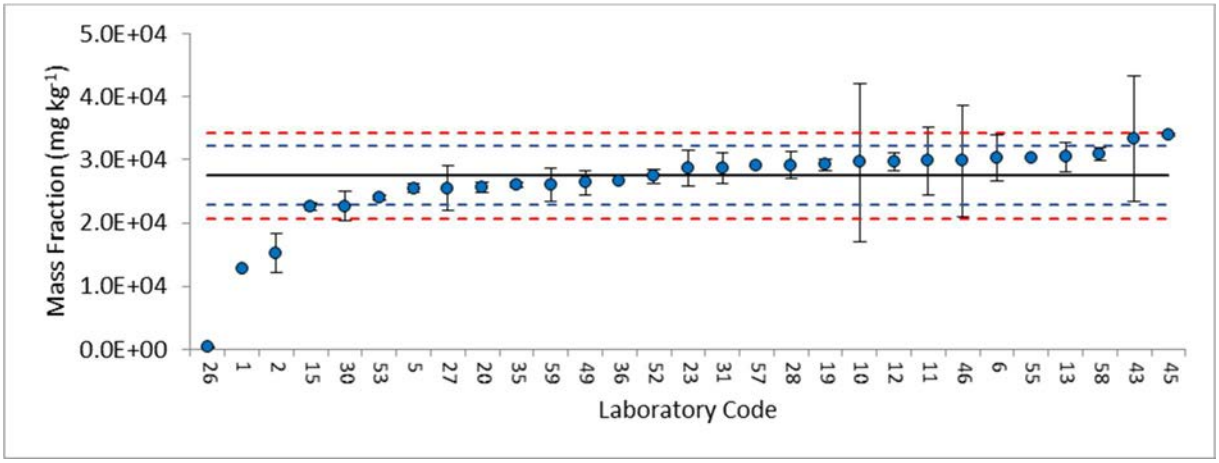
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	90%	0%	10%
Zeta-score	84%	8%	8%

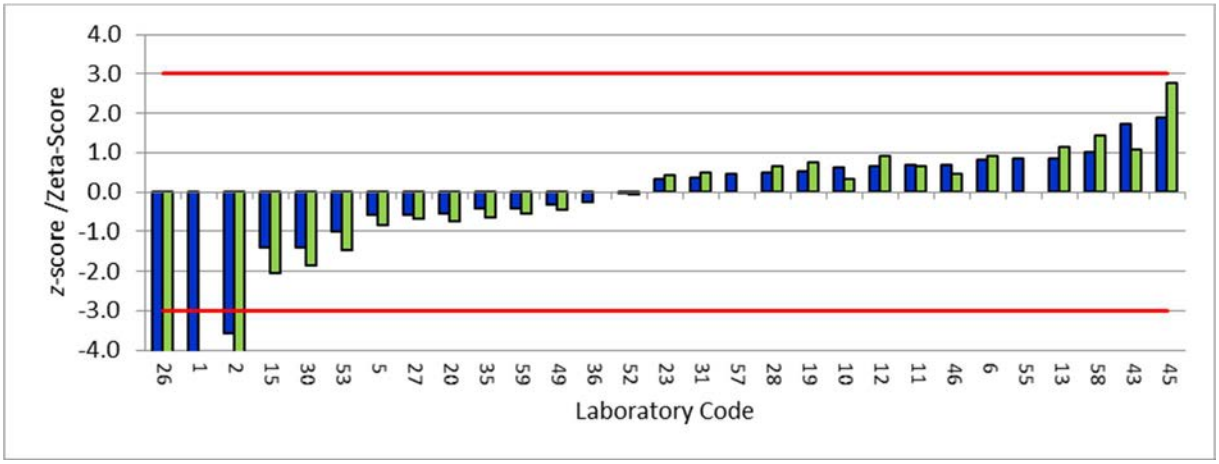
X_{ass}:	27.5×10^3 mg kg^{-1}
U_{ass} (k=2) :	4.6×10^3 mg kg^{-1}
$2\sigma_p$:	6.8×10^3 mg kg^{-1}
Number of results:	25
Number of method:	6

Reported results and expanded uncertainties:

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

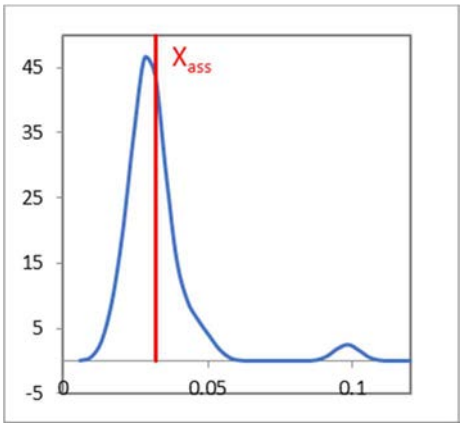


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for Cd

Kernel density Plot



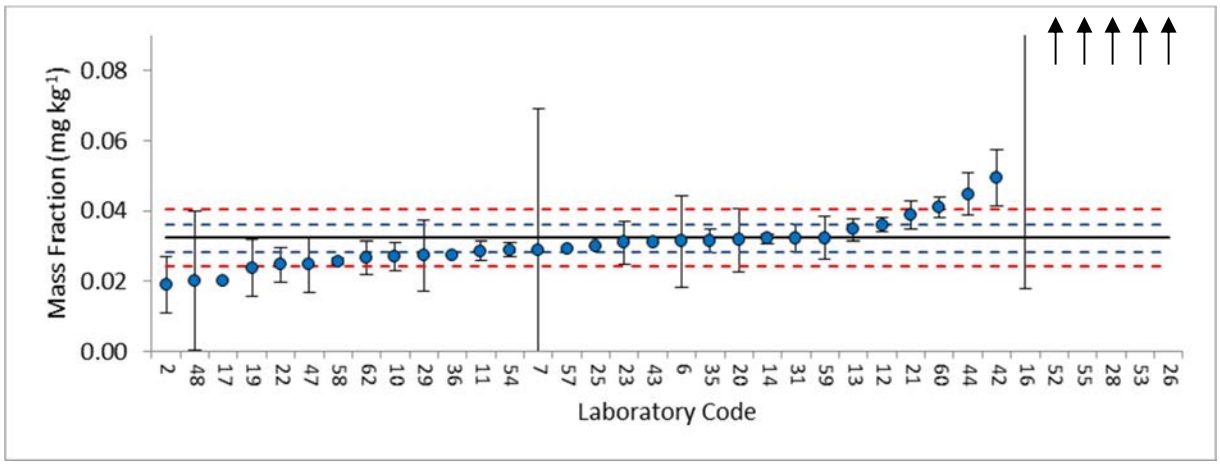
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	64%	6%	31%
Zeta-score	65%	13%	23%

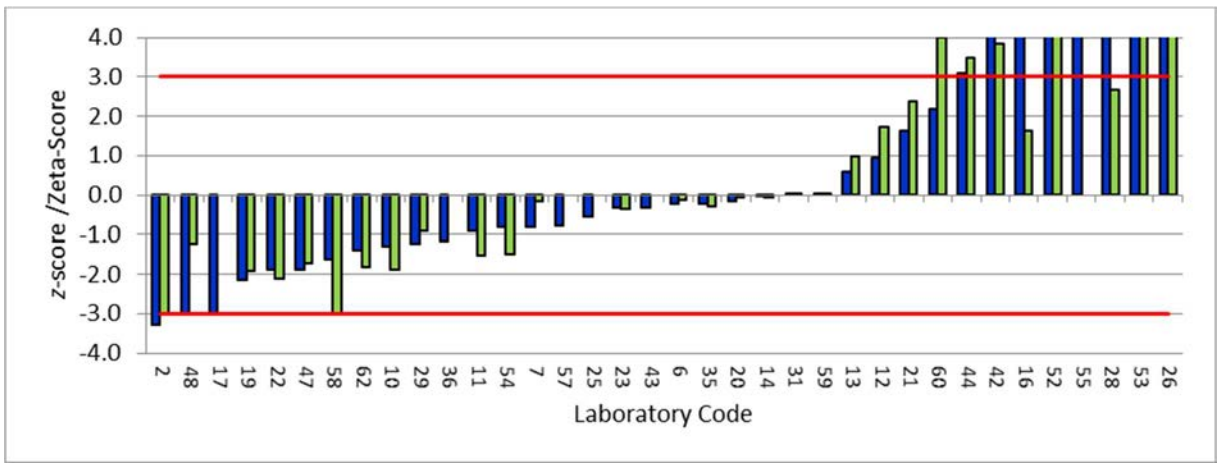
X_{ass}:	0.032 mg kg^{-1}
U_{ass} (k=2) :	0.004 mg kg^{-1}
$2\sigma_p$:	0.008 mg kg^{-1}
Number of results:	36
Number of method:	6

Reported results and expanded uncertainties:

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

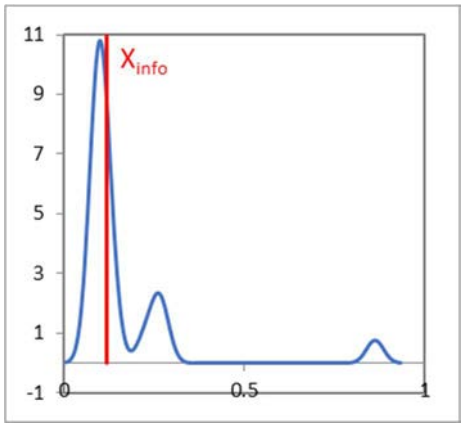


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for Co

Kernel density Plot

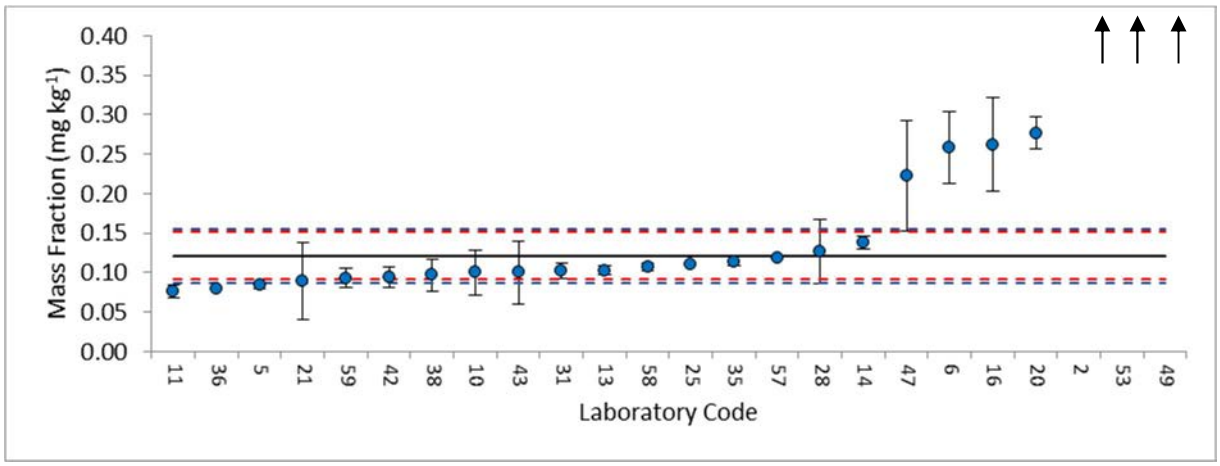


Summary of results:

X_{info}:	0.121 mg kg^{-1}
U_{info} (k=2) :	0.020 mg kg^{-1}
$2\sigma_p$:	0.030 mg kg^{-1}
Number of results:	24
Number of method:	5

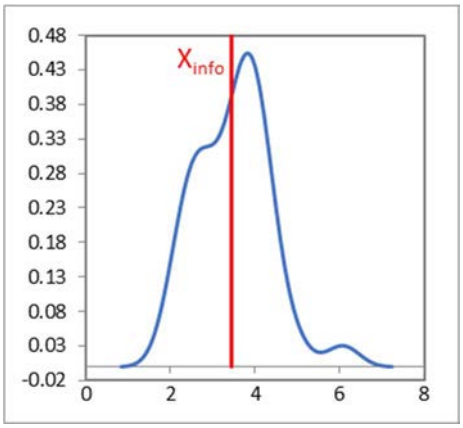
Reported results and expanded uncertainties:

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



Evaluation of Reported data for Cr

Kernel density Plot

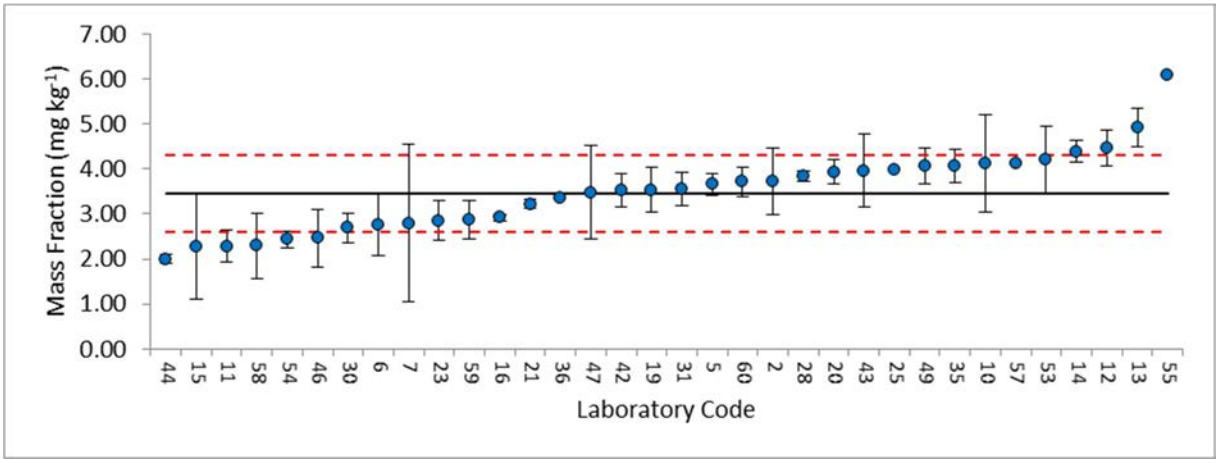


Summary of results:

X_{info}:	3.45 mg kg^{-1}
U_{info} (k=2) :	0.86 mg kg^{-1}
$2\sigma_p$:	0.86 mg kg^{-1}
Number of results:	34
Number of method:	6

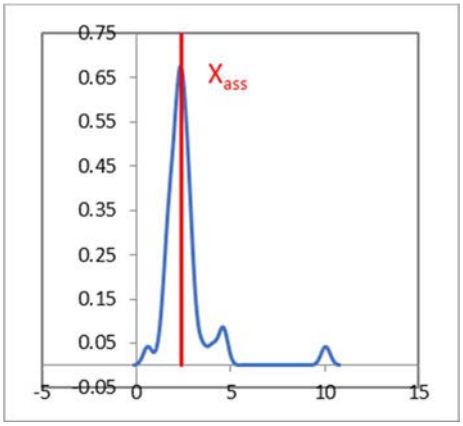
Reported results and expanded uncertainties:

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



Evaluation of Reported data for Cu

Kernel density Plot



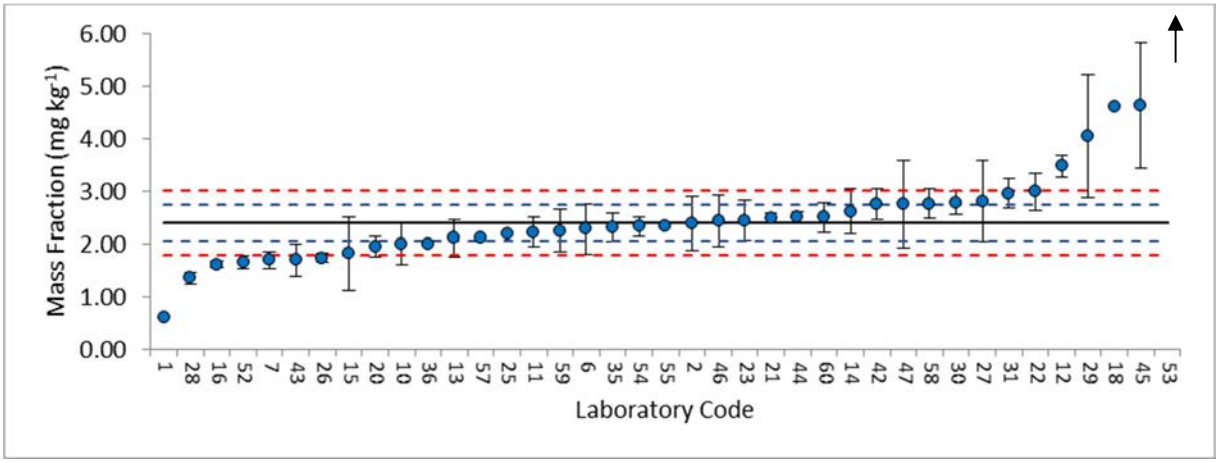
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	69%	13%	18%
Zeta-score	64%	9%	27%

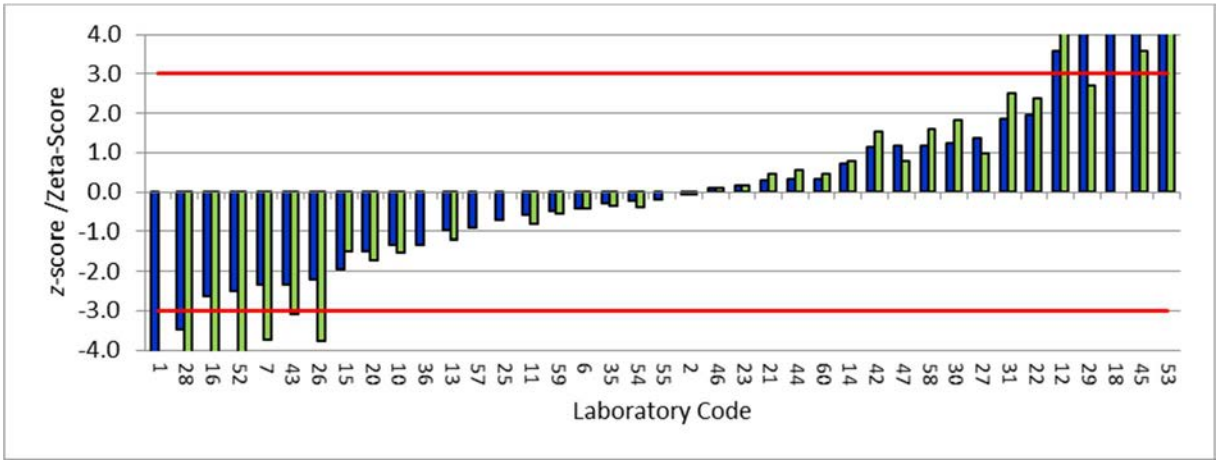
X_{ass}:	2.40 mg kg^{-1}
U_{ass} (k=2) :	0.34 mg kg^{-1}
$2\sigma_p$:	0.60 mg kg^{-1}
Number of results:	39
Number of method:	6

Reported results and expanded uncertainties:

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

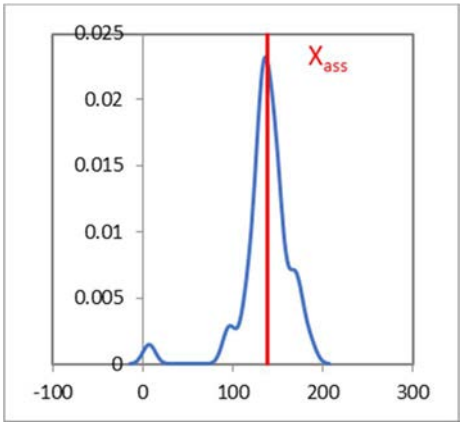


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for Fe

Kernel density Plot



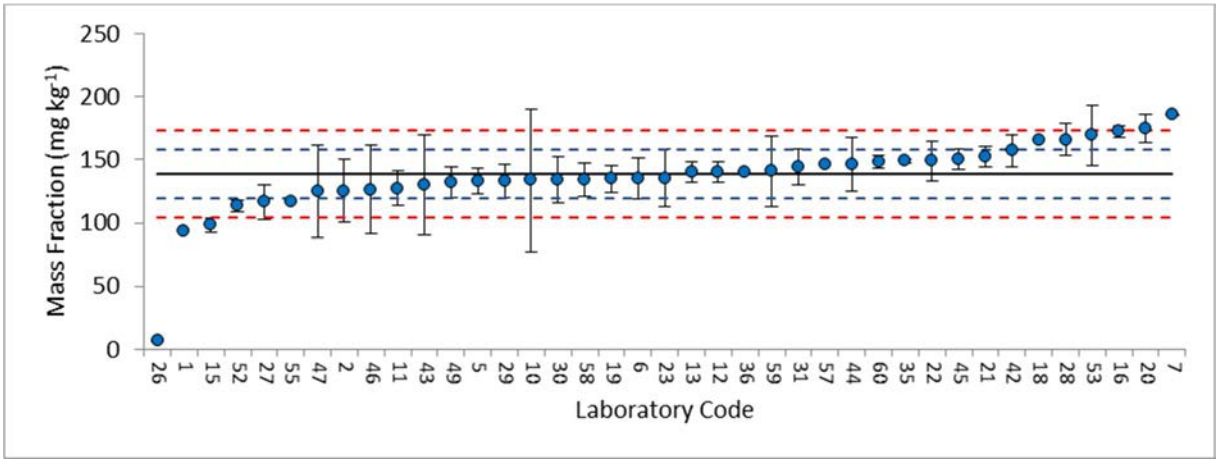
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	87%	10%	3%
Zeta-score	76%	12%	12%

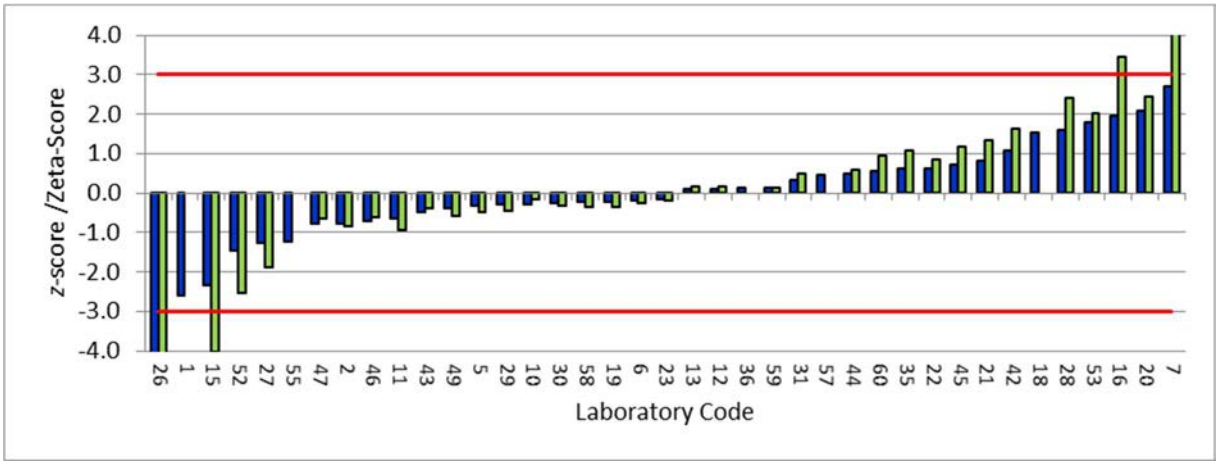
X_{ass}:	138 mg kg^{-1}
U_{ass} (k=2) :	19 mg kg^{-1}
$2\sigma_p$:	35 mg kg^{-1}
Number of results:	39
Number of method:	7

Reported results and expanded uncertainties:

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

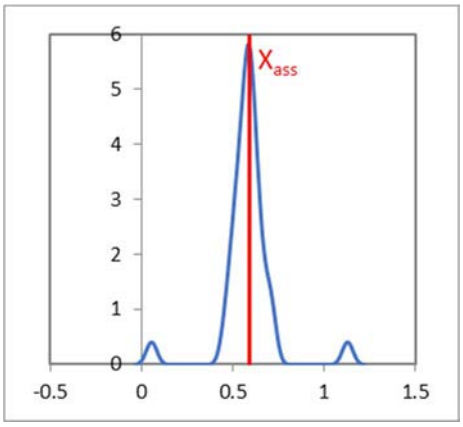


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for Hg

Kernel density Plot



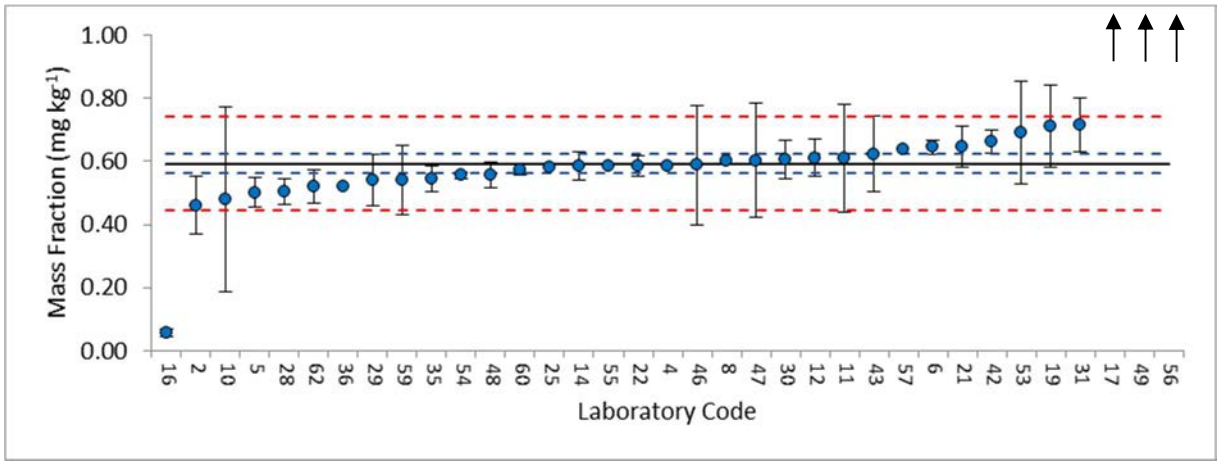
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	89%	0%	11%
Zeta-score	61%	21%	18%

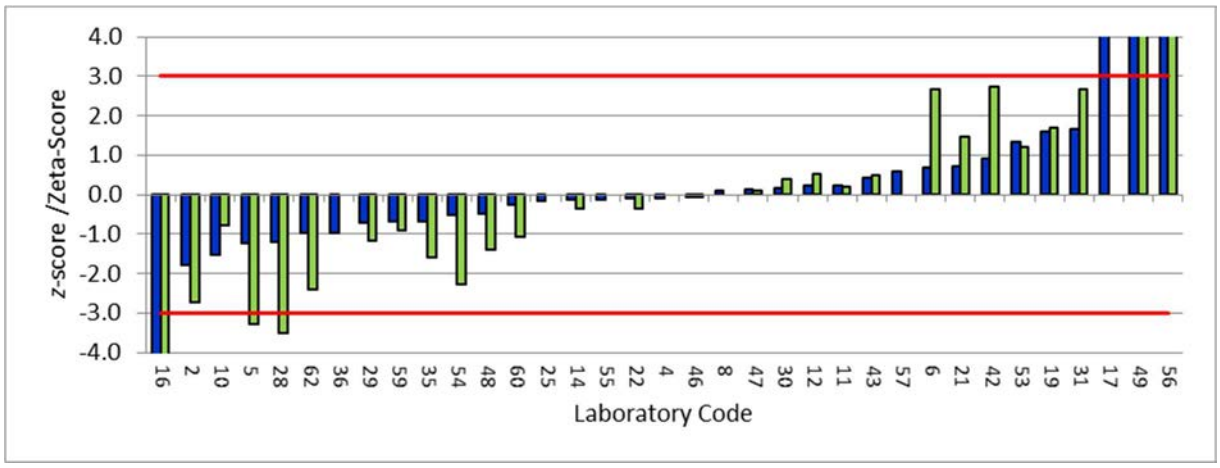
X_{ass}:	0.593 mg kg^{-1}
U_{ass} (k=2) :	0.032 mg kg^{-1}
$2\sigma_p$:	0.148 mg kg^{-1}
Number of results:	35
Number of method:	6

Reported results and expanded uncertainties:

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

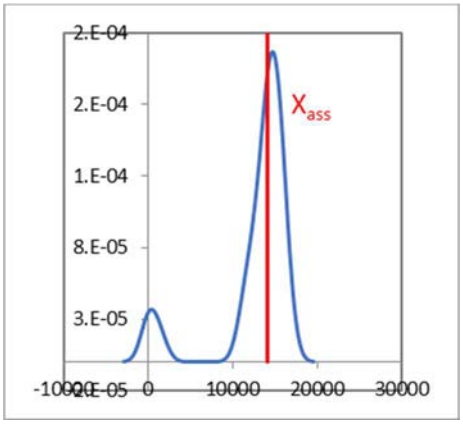


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for K

Kernel density Plot



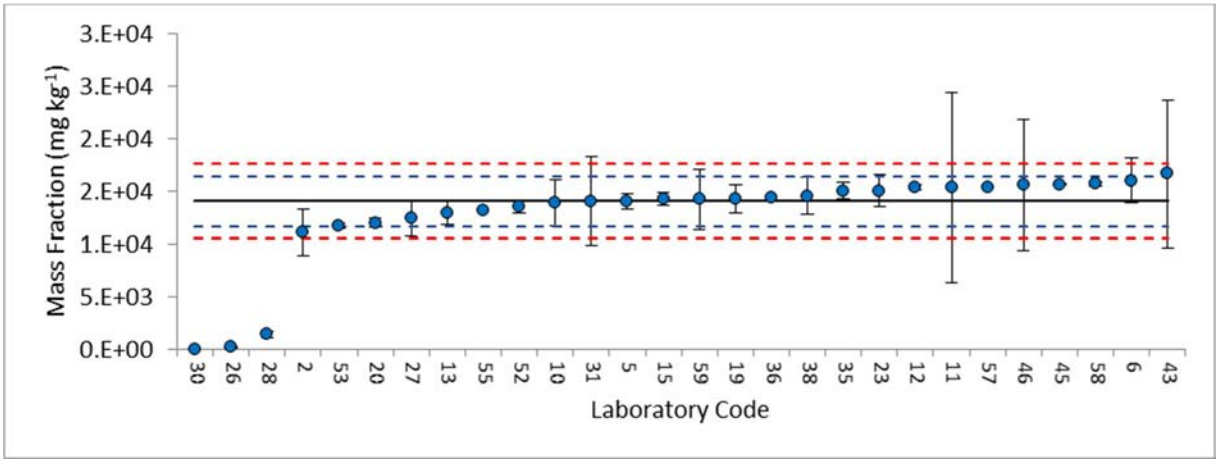
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	89%	0%	11%
Zeta-score	88%	0%	12%

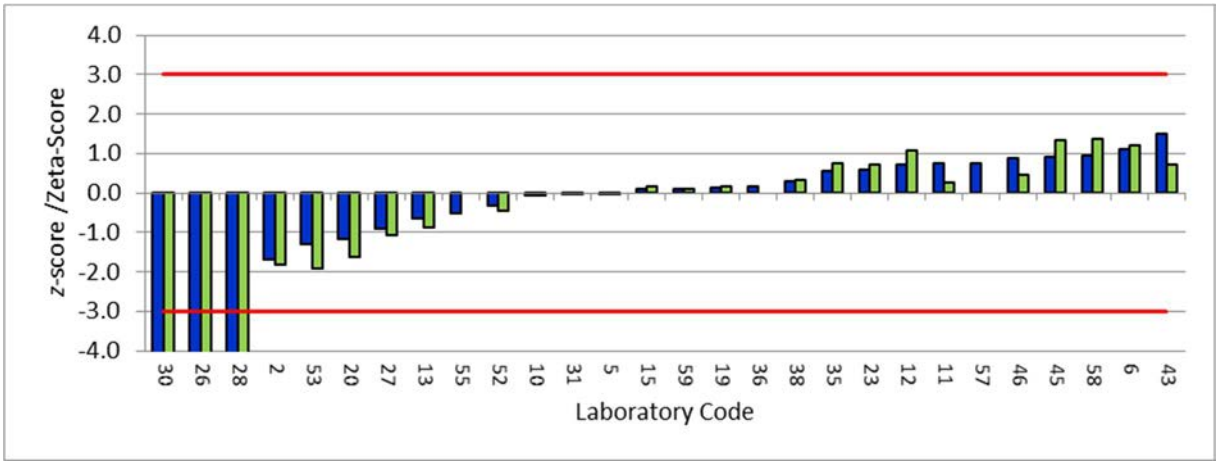
X_{ass}:	14.0×10^3 mg kg^{-1}
U_{ass} (k=2) :	2.4×10^3 mg kg^{-1}
$2\sigma_p$:	3.5×10^3 mg kg^{-1}
Number of results:	28
Number of method:	6

Reported results and expanded uncertainties:

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



Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for CH_3Hg

Kernel density Plot

< 8 results

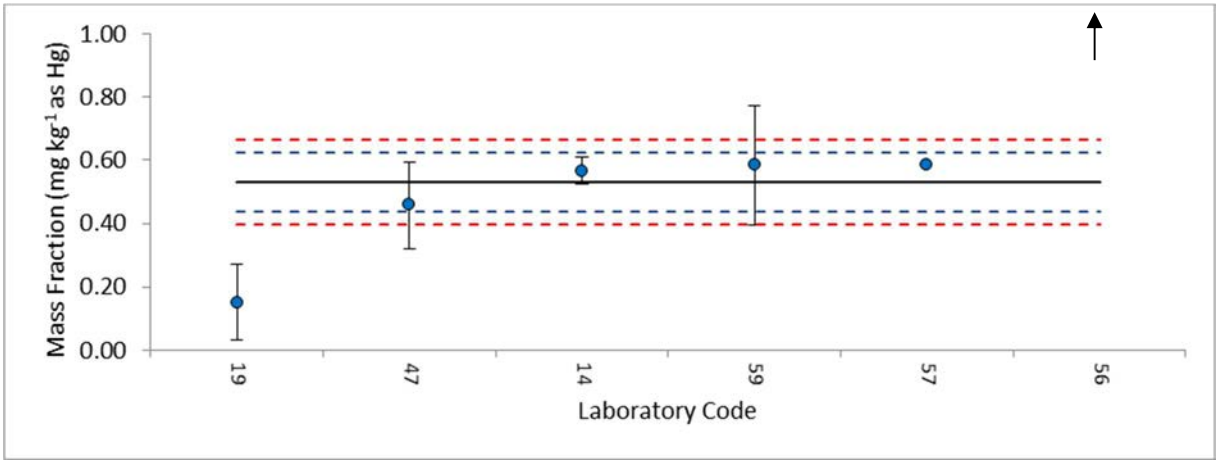
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	67%	0%	33%
Zeta-score	60%	0%	40%

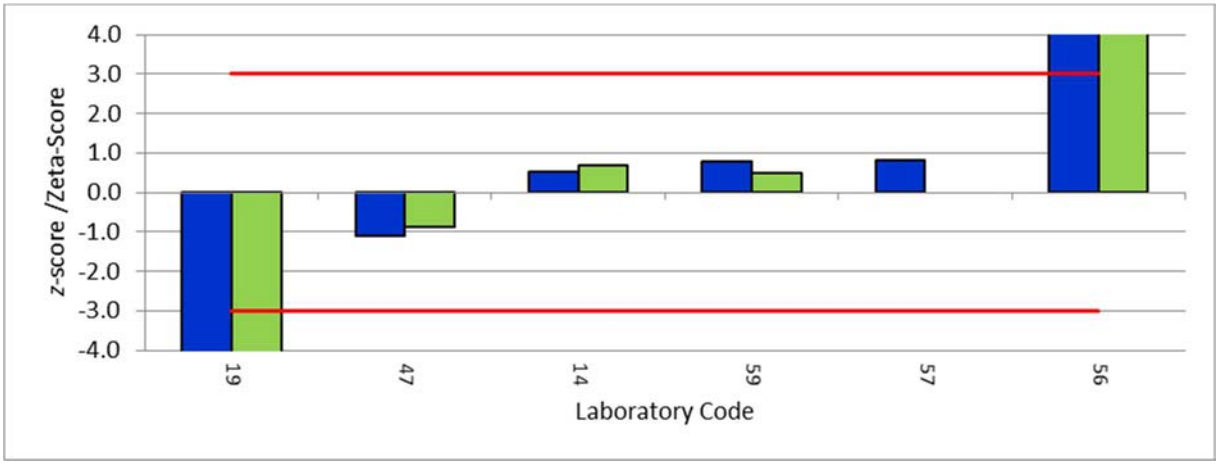
X_{ass}:	0.531 mg kg^{-1} as Hg
U_{ass} (k=2) :	0.092 mg kg^{-1} as Hg
$2\sigma_p$:	0.133 mg kg^{-1} as Hg
Number of results:	6
Number of method:	3

Reported results and expanded uncertainties:

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

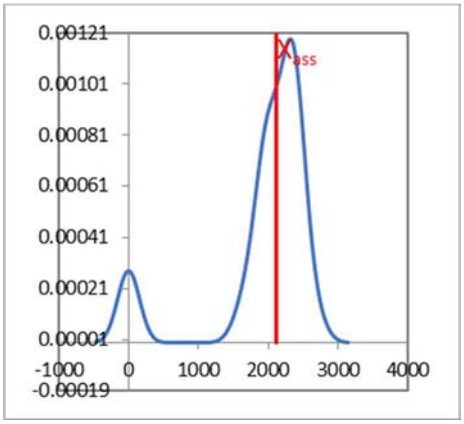


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for Mg

Kernel density Plot



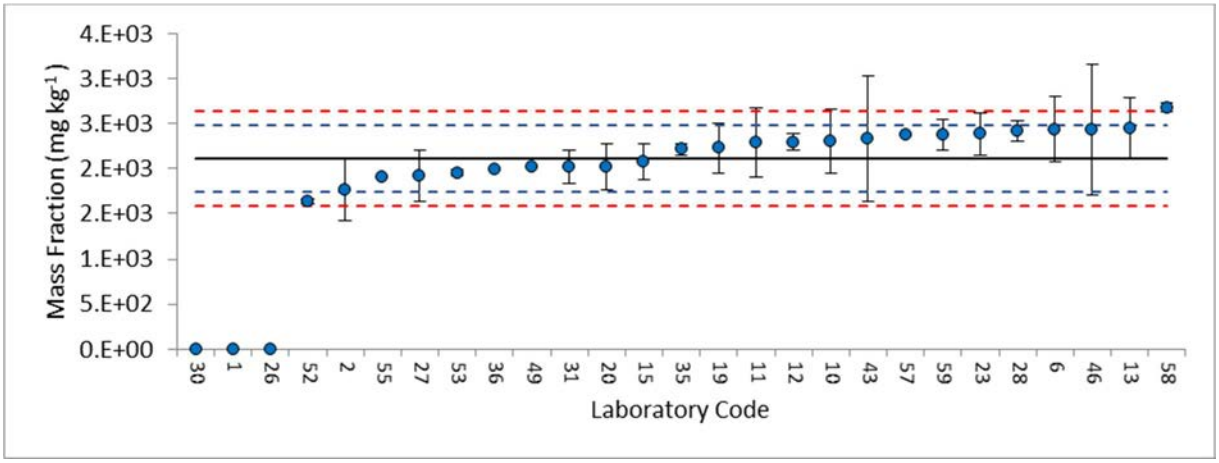
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	85%	4%	11%
Zeta-score	82%	9%	9%

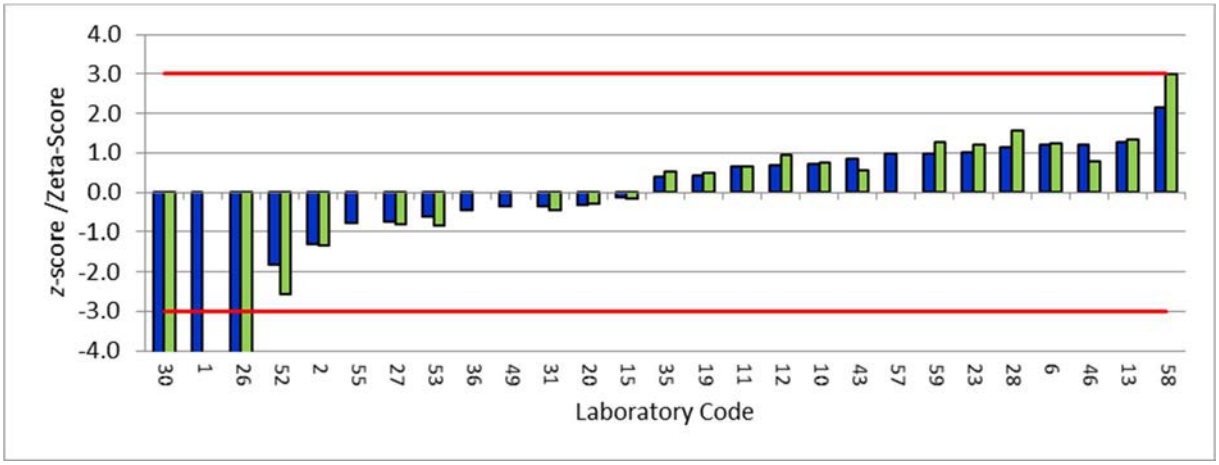
X_{ass}:	2.11×10^3 mg kg^{-1}
U_{ass} (k=2) :	0.37×10^3 mg kg^{-1}
$2\sigma_p$:	0.53×10^3 mg kg^{-1}
Number of results:	27
Number of method:	7

Reported results and expanded uncertainties:

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

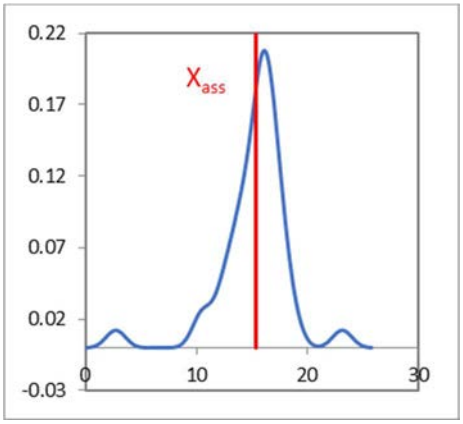


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for Mn

Kernel density Plot



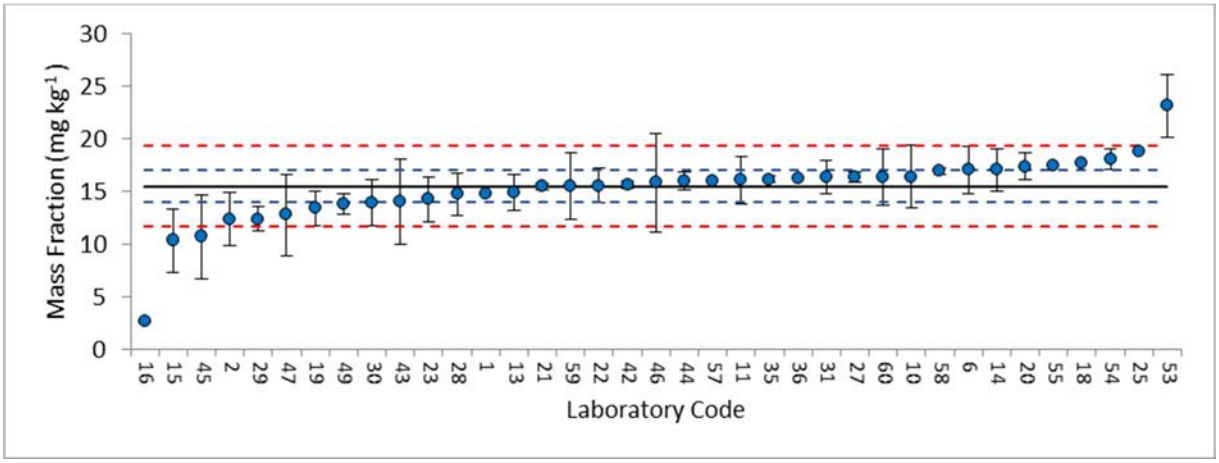
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	89%	5%	5%
Zeta-score	77%	10%	13%

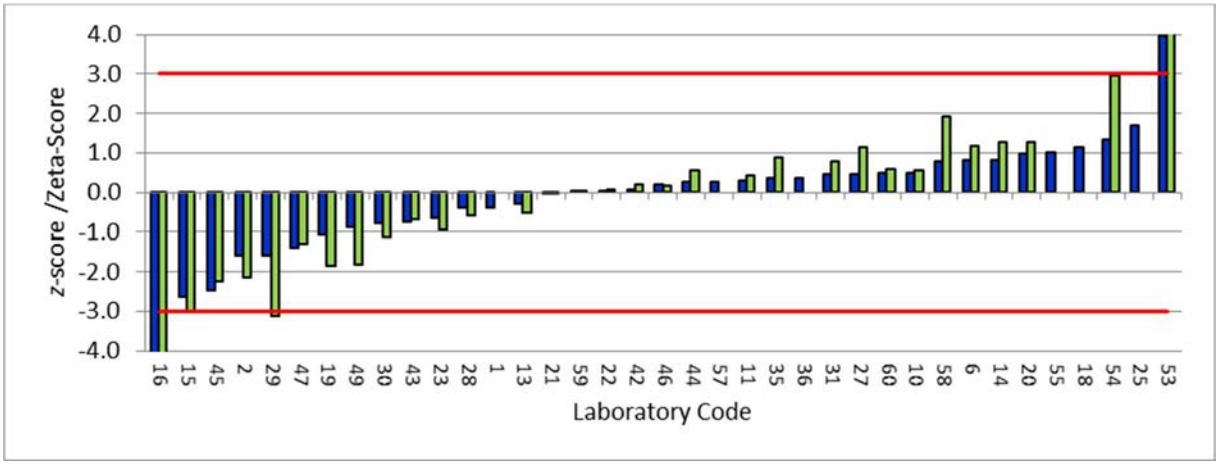
X_{ass}:	15.4×10^3 mg kg^{-1}
U_{ass} (k=2) :	1.5×10^3 mg kg^{-1}
$2\sigma_p$:	3.9×10^3 mg kg^{-1}
Number of results:	37
Number of method:	6

Reported results and expanded uncertainties:

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

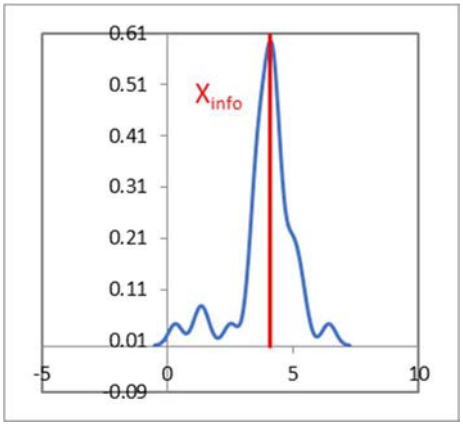


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for Ni

Kernel density Plot

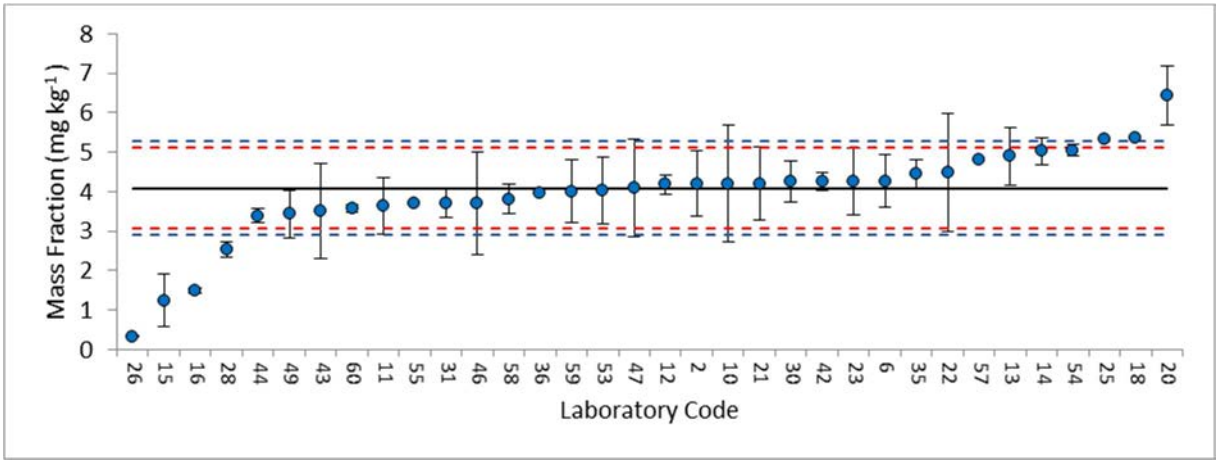


Summary of results:

X_{info}:	4.09 mg kg^{-1}
U_{info} (k=2) :	1.18 mg kg^{-1}
$2\sigma_p$:	1.02 mg kg^{-1}
Number of results:	34
Number of method:	6

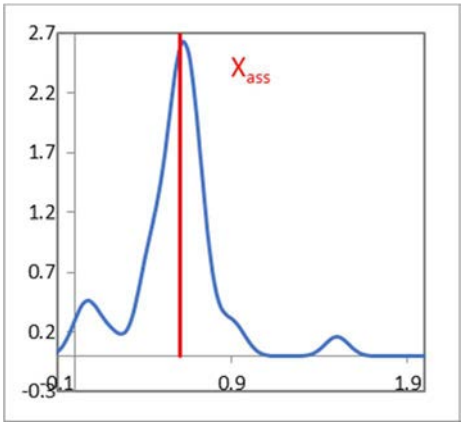
Reported results and expanded uncertainties:

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



Evaluation of Reported data for Pb

Kernel density Plot



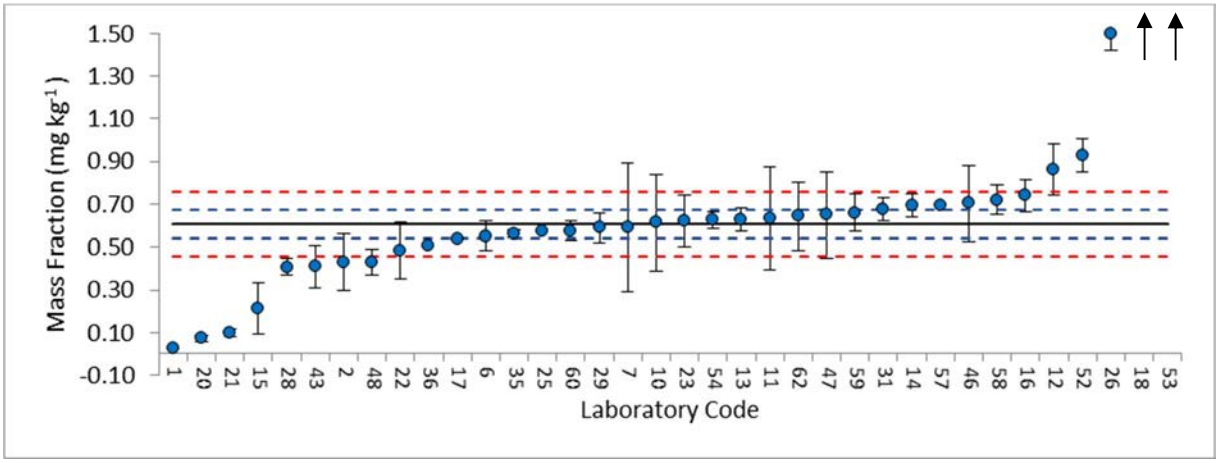
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	64%	11%	25%
Zeta-score	53%	13%	33%

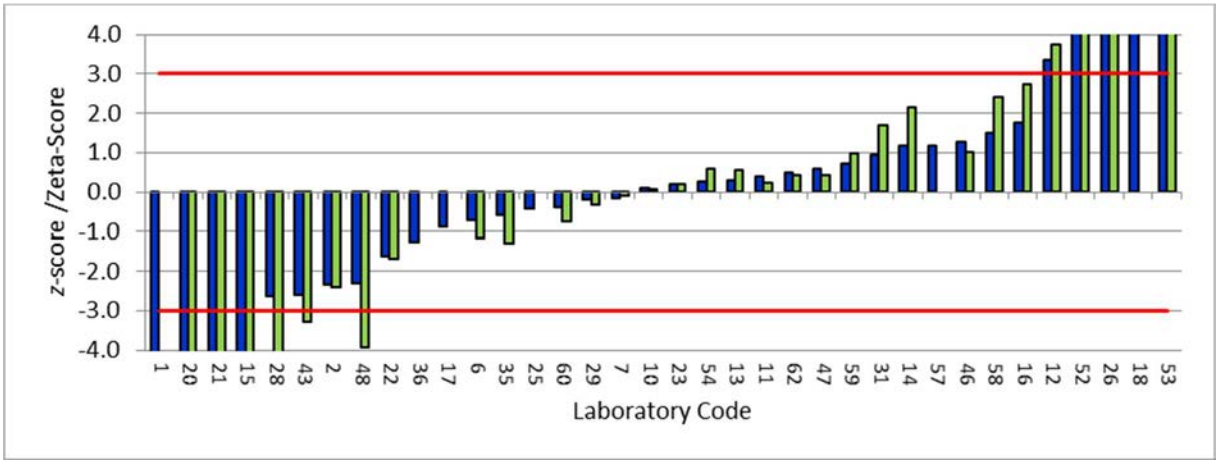
X_{ass}:	0.606 mg kg^{-1}
U_{ass} (k=2) :	0.064 mg kg^{-1}
$2\sigma_p$:	0.152 mg kg^{-1}
Number of results:	36
Number of method:	6

Reported results and expanded uncertainties:

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

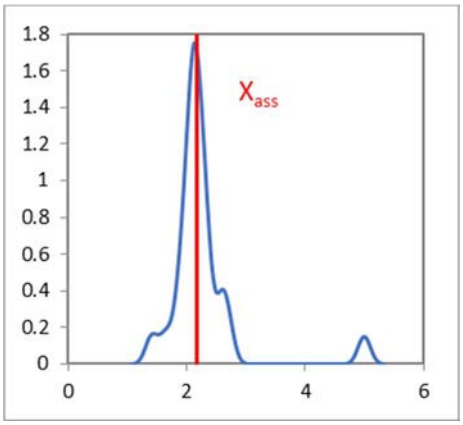


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for Se

Kernel density Plot



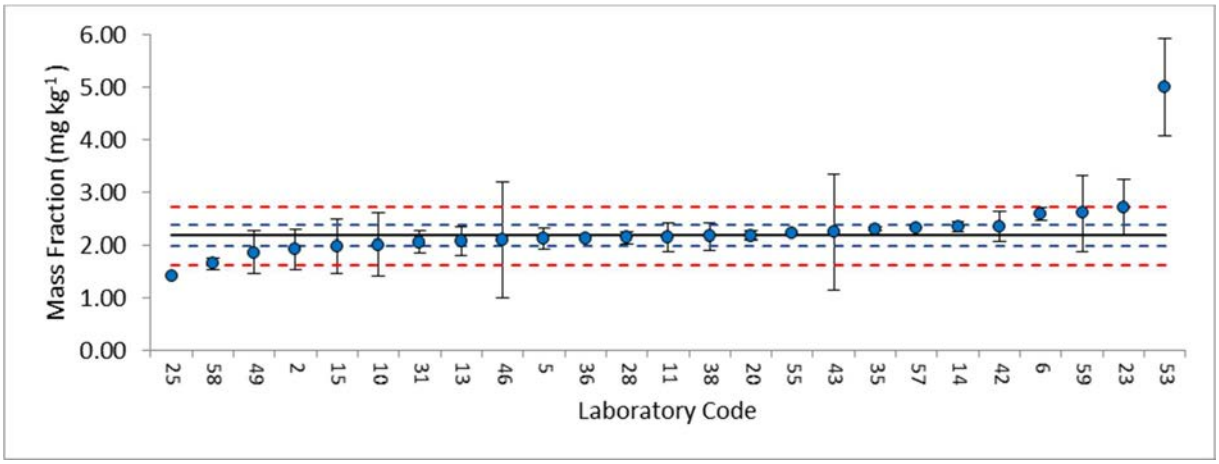
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	92%	4%	4%
Zeta-score	86%	0%	14%

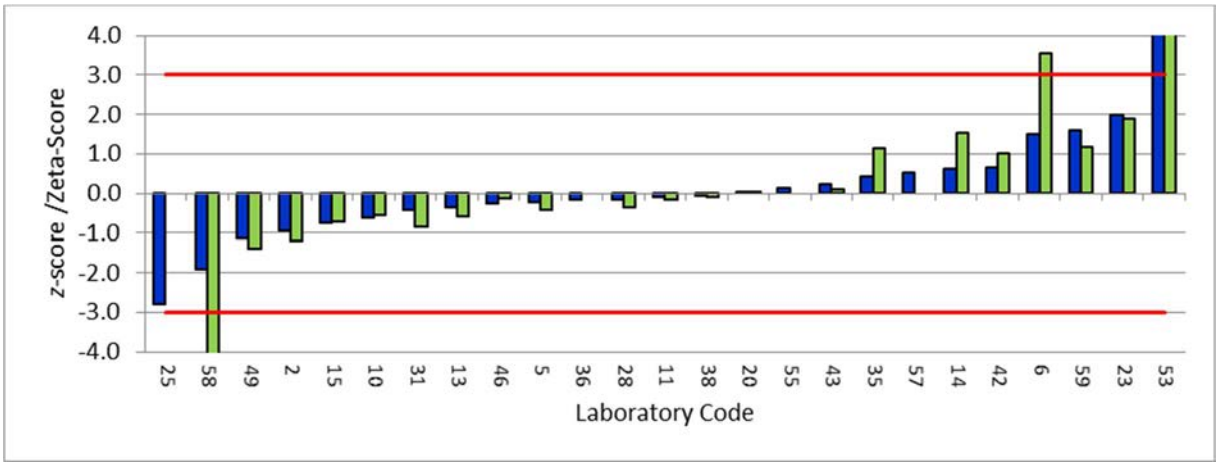
X_{ass}:	2.17 mg kg^{-1}
U_{ass} (k=2) :	0.20 mg kg^{-1}
$2\sigma_p$:	0.54 mg kg^{-1}
Number of results:	25
Number of method:	4

Reported results and expanded uncertainties:

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

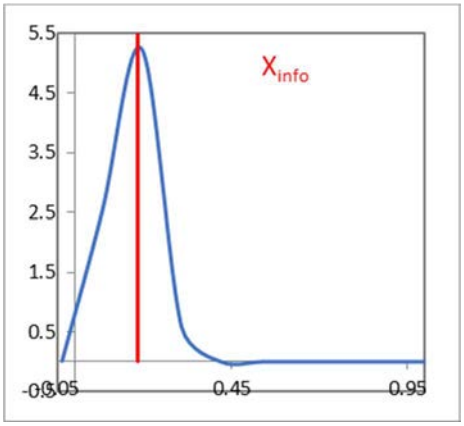


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for Sn

Kernel density Plot

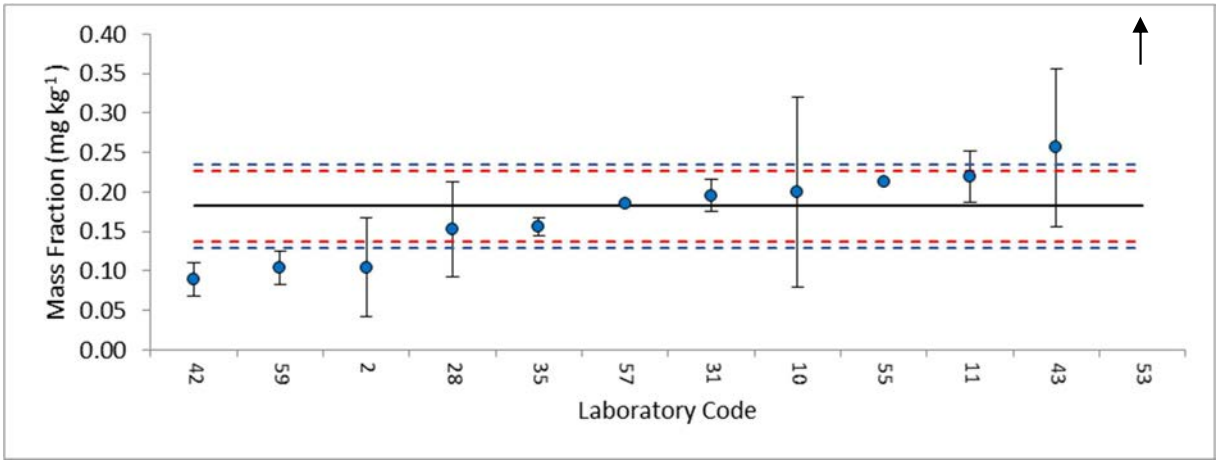


Summary of results:

X_{info}:	0.182 mg kg^{-1}
U_{info} (k=2) :	0.054 mg kg^{-1}
$2\sigma_p$:	0.045 mg kg^{-1}
Number of results:	12
Number of method:	2

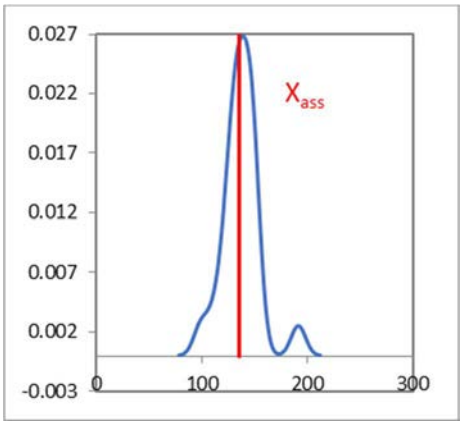
Reported results and expanded uncertainties:

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



Evaluation of Reported data for Sr

Kernel density Plot



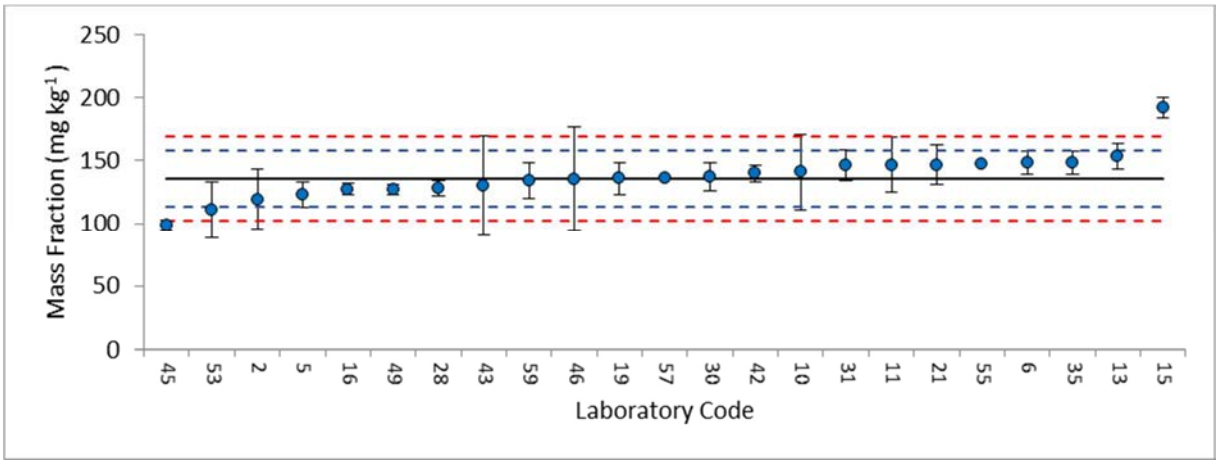
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	92%	4%	4%
Zeta-score	90%	0%	10%

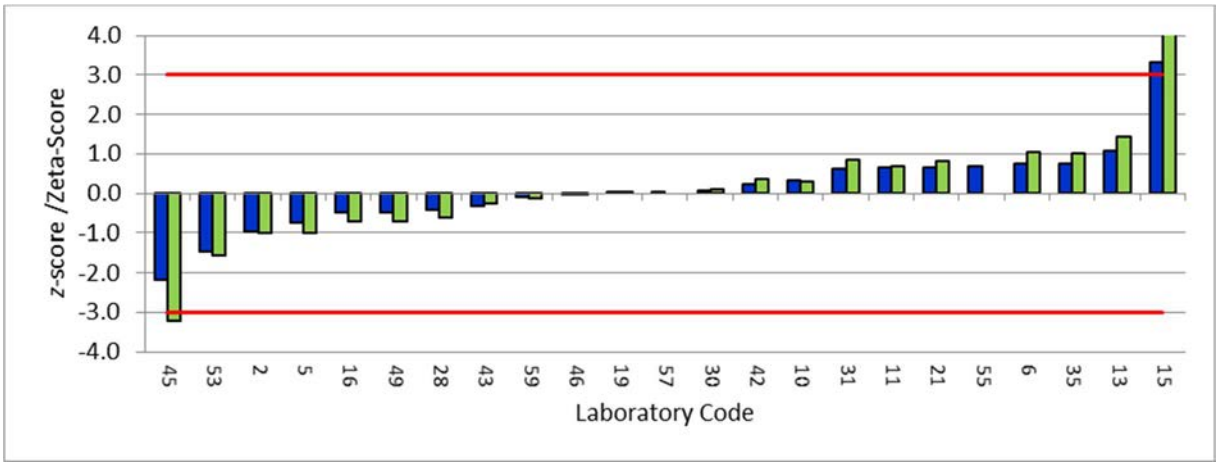
X_{ass}:	136 mg kg^{-1}
U_{ass} (k=2) :	23 mg kg^{-1}
$2\sigma_p$:	34 mg kg^{-1}
Number of results:	23
Number of method:	4

Reported results and expanded uncertainties:

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

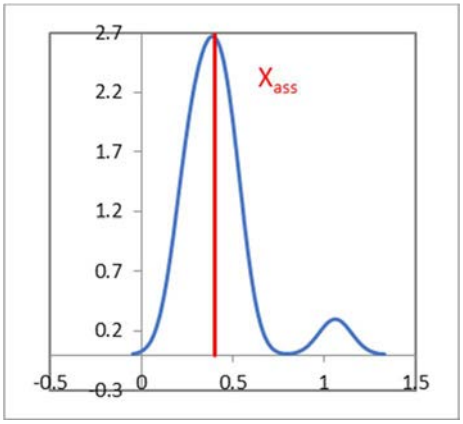


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for V

Kernel density Plot



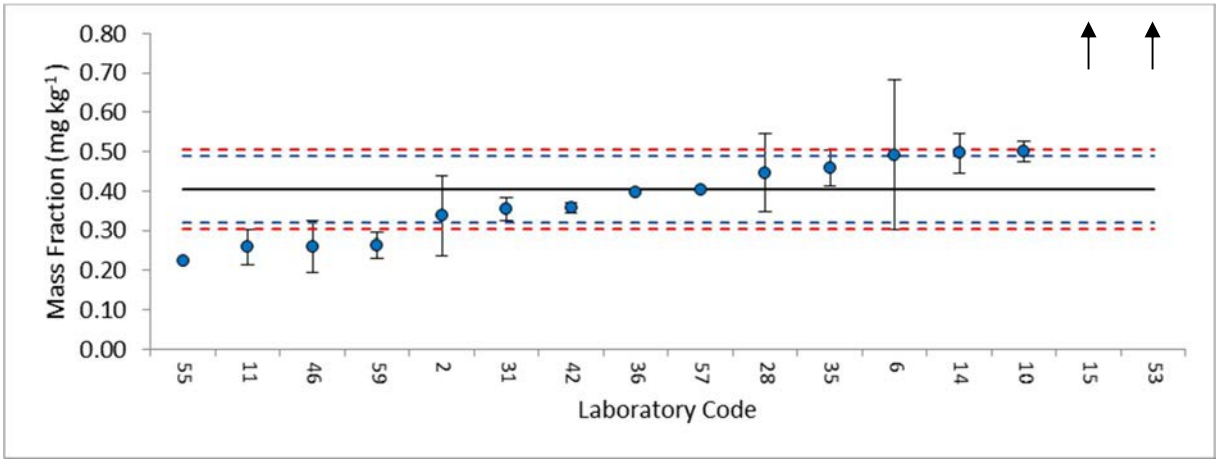
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	50%	31%	19%
Zeta-score	46%	31%	23%

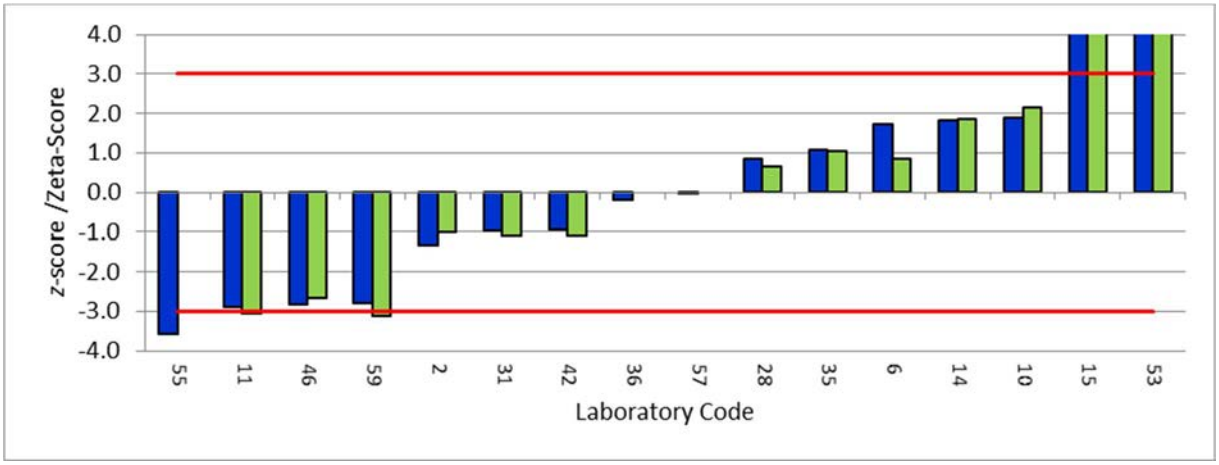
X_{ass}:	0.405 mg kg^{-1}
U_{ass} (k=2) :	0.085 mg kg^{-1}
$2\sigma_p$:	0.101 mg kg^{-1}
Number of results:	16
Number of method:	4

Reported results and expanded uncertainties:

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

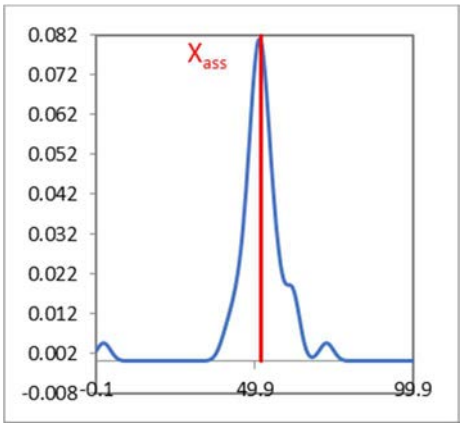


Performance evaluation: *z*-score Zeta-score



Evaluation of Reported data for Zn

Kernel density Plot



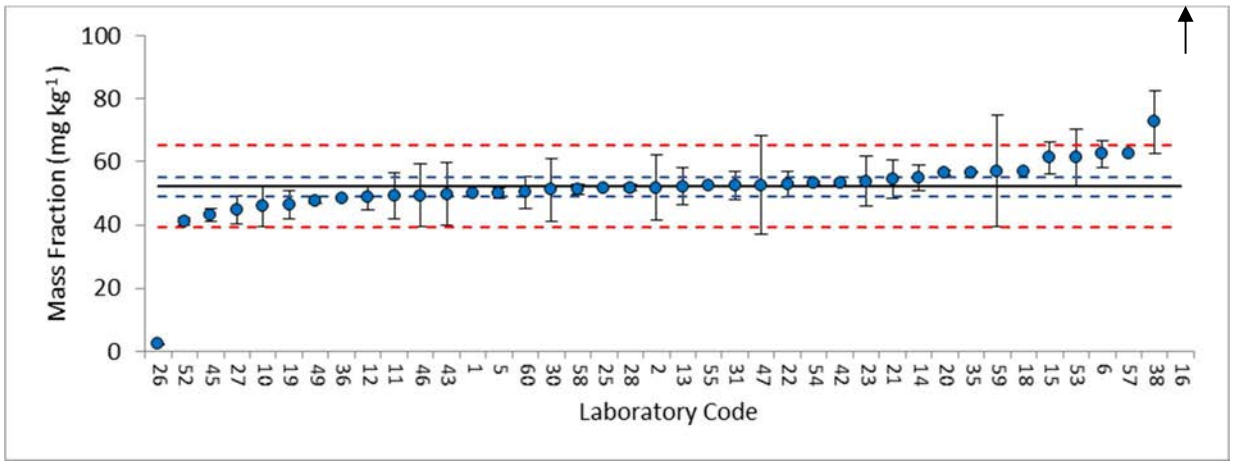
Summary of results:

	Satisfactory	Questionable	Unsatisfactory
z-score	93%	0%	8%
Zeta-score	65%	15%	21%

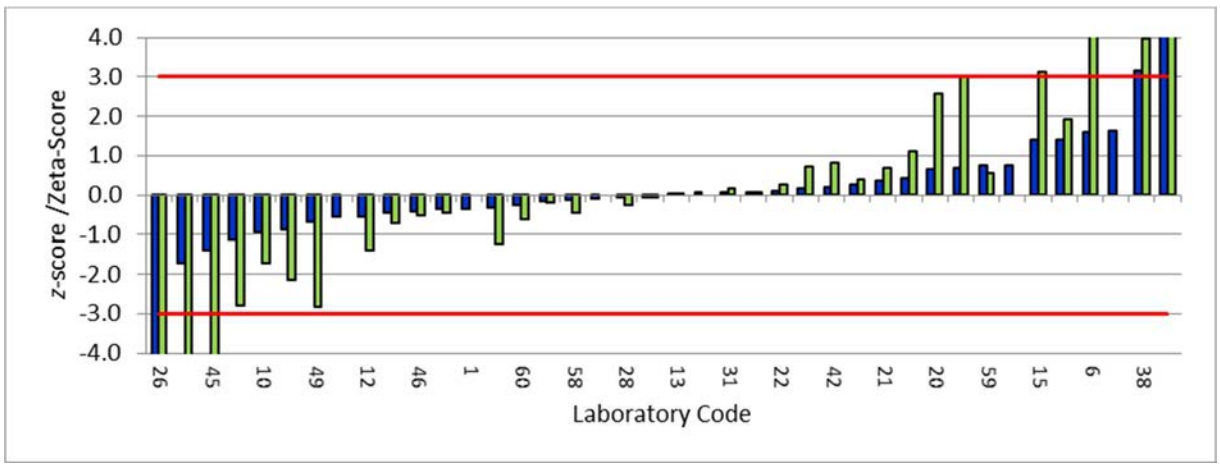
X_{ass}:	52.1 mg kg^{-1}
U_{ass} (k=2) :	3.0 mg kg^{-1}
$2\sigma_p$:	13.0 mg kg^{-1}
Number of results:	40
Number of method:	6

Reported results and expanded uncertainties:

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



Performance evaluation: *z*-score Zeta-score



APPENDIX II

REPORTED RESULTS BY PARTICIPANTS

TABLE 7. REPORTED RESULTS BY PARTICPANTS

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
2	Ag	mg kg^{-1}	ICP-MS	0.070	0.042	2	0.53	0.20	No QC Reported
10	Ag	mg kg^{-1}	ICP-MS	0.100	0.030	2	4.12	2.19	na
16	Ag	mg kg^{-1}	ICP-MS	0.185	0.110	2	14.46	2.16	DOLT 2
20	Ag	mg kg^{-1}	Neutron Activation	0.550	0.030	1	58.67	16.0	NIST 1566b
21	Ag	mg kg^{-1}	ICP-OES	0.057	0.007	2	-1.04	-1.57	IAEA 407
25	Ag	mg kg^{-1}	ICP-MS	0.070			0.48		NIST 2976
28	Ag	mg kg^{-1}	ICP-MS	0.033	0.020	2	-3.96	-3.03	No QC Reported
31	Ag	mg kg^{-1}	ICP-MS	0.067	0.006	2	0.16	0.27	IAEA 407
35	Ag	mg kg^{-1}	ICP-MS	0.056	0.003	2	-1.21	-2.16	No QC Reported
36	Ag	mg kg^{-1}	ICP-MS	0.053			-1.64		TORT
42	Ag	mg kg^{-1}	ICP-MS	0.072	0.028	1.96	0.69	0.39	IAEA 407
43	Ag	mg kg^{-1}	ICP-OES	0.107	0.004	2	4.93	9.09	No QC Reported
53	Ag	mg kg^{-1}	ICP-OES	0.250	0.060	2	22.30	6.08	No QC Reported
55	Ag	mg kg^{-1}	ICP-MS	0.767			84.93		No QC Reported
57	Ag	mg kg^{-1}	ICP-MS	0.058			-0.95		DORM 4
58	Ag	mg kg^{-1}	ICP-MS	0.058	0.006	2	-1.01	-1.67	NIST 2976
59	Ag	mg kg^{-1}	ICP-MS	0.059	0.012	2	-0.81	-0.92	IAEA 461
5	As	mg kg^{-1}	Neutron Activation	20.0	0.9	2	0.03	0.11	SRM 1566b
6	As	mg kg^{-1}	ICP-MS	20.5	1.0	2	0.25	0.83	No QC Reported
10	As	mg kg^{-1}	ICP-MS	19.6	5.3	2	-0.13	-0.12	TORT 3

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
11	As	mg kg^{-1}	ICP-MS	21.1	3.2	2	0.48	0.71	CUSTOM
12	As	mg kg^{-1}	Hydride AAS	16.7	0.8	2	-1.28	-4.59	IAEA 461
13	As	mg kg^{-1}	ICP-MS	21.1	1.4	2	0.48	1.32	NIST 2976
14	As	mg kg^{-1}	ICP-MS	21.3	1.2	2	0.58	1.74	DORM 4
15	As	mg kg^{-1}	XRF	19.7	1.7	2	-0.07	-0.16	NIST 2976
20	As	mg kg^{-1}	Neutron Activation	16.9	0.5	1	-1.20	-3.83	NIST 1566b
21	As	mg kg^{-1}	ICP-OES	13.7	1.2	2	-2.51	-7.75	IAEA 407
22	As	mg kg^{-1}	Graphite Furnace AAS	14.2	0.5	2	-2.31	-9.38	DORM 4
23	As	mg kg^{-1}	ICP-MS	19.7	3.4	2	-0.06	-0.09	No QC Reported
25	As	mg kg^{-1}	ICP-MS	19.7			-0.07		NIST 2976
28	As	mg kg^{-1}	Neutron Activation	18.8	0.3	2	-0.43	-1.83	NIST 1566b
31	As	mg kg^{-1}	ICP-MS	20.1	1.7	2	0.09	0.23	IAEA 407
35	As	mg kg^{-1}	ICP-MS	25.7	1.2	2	2.32	5.85	No QC Reported
36	As	mg kg^{-1}	ICP-MS	20.1			0.08		TORT
42	As	mg kg^{-1}	ICP-MS	19.1	0.9	1.96	-0.32	-1.10	IAEA 407
43	As	mg kg^{-1}	ICP-OES	20.7	10.0	2	0.31	0.15	No QC Reported
45	As	mg kg^{-1}	XRF	18.7	2.0	2	-0.50	-1.08	No QC Reported
46	As	mg kg^{-1}	ICP-MS	20.0	10.0	2	0.04	0.02	No QC Reported
47	As	mg kg^{-1}	Hydride AAS	21.2	6.4		0.54	0.41	DORM 4
49	As	mg kg^{-1}	ICP-OES	18.2	3.0		-0.68	-1.06	TORT 3

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
53	As	mg kg^{-1}	ICP-OES	66.0	8.1	2	18.51	11.2	No QC Reported
54	As	mg kg^{-1}	Hydride AAS	21.1	0.3		0.47	2.01	IAEA 407
55	As	mg kg^{-1}	ICP-MS	20.7			0.34		No QC Reported
57	As	mg kg^{-1}	ICP-MS	22.4			0.99		DORM 4
58	As	mg kg^{-1}	ICP-MS	19.2	0.4	2	-0.27	-1.12	NIST 2976
59	As	mg kg^{-1}	ICP-MS	23.3	4.0	2	1.35	1.62	IAEA 461
60	As	mg kg^{-1}	Graphite Furnace AAS	15.6	3.9	2.21	-1.74	-2.14	IAEA 407
1	Ca	mg kg^{-1}	Flame AAS	12823			-4.26		No QC Reported
2	Ca	mg kg^{-1}	Flame AAS	15187	3037	2	-3.57	-4.41	No QC Reported
5	Ca	mg kg^{-1}	Neutron Activation	25463	700	2	-0.58	-0.84	SRM 1515
6	Ca	mg kg^{-1}	ICP-OES	30193	3680	2	0.80	0.93	No QC Reported
10	Ca	mg kg^{-1}	ICP-MS	29567	12510	2	0.62	0.32	No QC Reported
11	Ca	mg kg^{-1}	ICP-MS	29767	5300	2	0.68	0.66	NIST 1547
12	Ca	mg kg^{-1}	Flame AAS	29673	1408	2	0.65	0.91	IAEA 461
13	Ca	mg kg^{-1}	ICP-MS	30373	2247	2	0.85	1.13	NIST 2976
15	Ca	mg kg^{-1}	XRF	22603	607	2	-1.41	-2.06	IAEA 413
19	Ca	mg kg^{-1}	ICP-OES	29230	920	2	0.52	0.75	NIST SRM 1566a
20	Ca	mg kg^{-1}	Neutron Activation	25609	766	1	-0.54	-0.75	NIST 1566b
23	Ca	mg kg^{-1}	ICP-MS	28590	2860	2	0.33	0.42	No QC Reported
26	Ca	mg kg^{-1}	POLAROGRAPHY	433	0	2	-7.87	-11.6	IAEA 407

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
27	Ca	mg kg^{-1}	Flame AAS	25465	3526	2	-0.58	-0.68	IAEA 407
28	Ca	mg kg^{-1}	Neutron Activation	29137	2180	2	0.49	0.66	NIST 1566b
30	Ca	mg kg^{-1}	ICP-OES	22635	2264		-1.40	-1.86	No QC Reported
31	Ca	mg kg^{-1}	ICP-OES	28725	2442	2	0.37	0.49	IAEA 407
35	Ca	mg kg^{-1}	ICP-OES	25958	393	2	-0.43	-0.64	No QC Reported
36	Ca	mg kg^{-1}	ICP-MS	26597			-0.25		Skimmed Milk Powder
43	Ca	mg kg^{-1}	ICP-OES	33333	10000	2	1.72	1.07	No QC Reported
45	Ca	mg kg^{-1}	XRF	33907	180	2	1.88	2.77	No QC Reported
46	Ca	mg kg^{-1}	ICP-OES	29767	8900	2	0.68	0.46	No QC Reported
49	Ca	mg kg^{-1}	ICP-OES	26317	2000		-0.33	-0.45	No QC Reported
52	Ca	mg kg^{-1}	Flame AAS	27326	1119	2	-0.04	-0.05	No QC Reported
53	Ca	mg kg^{-1}	ICP-OES	24000	420	2	-1.00	-1.47	No QC Reported
55	Ca	mg kg^{-1}	ICP-MS	30304			0.83		No QC Reported
57	Ca	mg kg^{-1}	ICP-OES	29025			0.46		DORM 4
58	Ca	mg kg^{-1}	ICP-MS	30866	1048	2	1.00	1.43	NIST 2976
59	Ca	mg kg^{-1}	ICP-MS	25967	2600	2	-0.43	-0.56	IAEA 461
2	Cd	mg kg^{-1}	Graphite Furnace AAS	0.019	0.008	2	-3.29	-2.98	IAEA 461
6	Cd	mg kg^{-1}	ICP-MS	0.031	0.013	2	-0.23	-0.13	No QC Reported
7	Cd	mg kg^{-1}	Graphite Furnace AAS	0.029	0.040	2	-0.81	-0.16	DORM 3
10	Cd	mg kg^{-1}	ICP-MS	0.027	0.004	2	-1.30	-1.89	TORT 3

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
11	Cd	mg kg^{-1}	ICP-MS	0.029	0.003	2	-0.91	-1.53	CUSTOM
12	Cd	mg kg^{-1}	Flame AAS	0.036	0.002	2	0.93	1.72	IAEA 461
13	Cd	mg kg^{-1}	ICP-MS	0.035	0.003	2	0.60	0.98	NIST 2976
14	Cd	mg kg^{-1}	ICP-MS	0.032	0.001	2	-0.04	-0.08	DORM 4
16	Cd	mg kg^{-1}	ICP-MS	0.098	0.080	2	16.31	1.64	NIST 2976
17	Cd	mg kg^{-1}	Graphite Furnace AAS	0.020			-3.04		No QC Reported
19	Cd	mg kg^{-1}	Graphite Furnace AAS	0.024	0.008	2	-2.13	-1.93	NIST SRM 1566a
20	Cd	mg kg^{-1}	Graphite Furnace AAS	0.032	0.009	1	-0.15	-0.06	NIST 1566b
21	Cd	mg kg^{-1}	Graphite Furnace AAS	0.039	0.004	2	1.64	2.37	IAEA 407
22	Cd	mg kg^{-1}	Graphite Furnace AAS	0.025	0.005	2	-1.88	-2.12	DORM 4
23	Cd	mg kg^{-1}	Hydride ICP-MS	0.031	0.006	2	-0.31	-0.35	No QC Reported
25	Cd	mg kg^{-1}	ICP-MS	0.030			-0.56		NIST 2976
26	Cd	mg kg^{-1}	POLAROGRAPHY	0.937	0.048	2	224.42	37.6	IAEA 407
28	Cd	mg kg^{-1}	ICP-MS	0.300	0.200	2	66.41	2.68	DOLT 4
29	Cd	mg kg^{-1}	Graphite Furnace AAS	0.027	0.010	2	-1.22	-0.92	QTM114BT
31	Cd	mg kg^{-1}	ICP-MS	0.032	0.004	2	0.02	0.03	IAEA 436
35	Cd	mg kg^{-1}	ICP-MS	0.031	0.003	2	-0.21	-0.29	No QC Reported
36	Cd	mg kg^{-1}	ICP-MS	0.028			-1.18		TORT
42	Cd	mg kg^{-1}	ICP-MS	0.049	0.008	1.96	4.24	3.84	IAEA 407
43	Cd	mg kg^{-1}	ICP-OES	0.031		2	-0.31		No QC Reported

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
44	Cd	mg kg^{-1}	Graphite Furnace AAS	0.045	0.006	2	3.08	3.48	IAEA 407
47	Cd	mg kg^{-1}	Graphite Furnace AAS	0.025	0.008		-1.88	-1.71	DORM 4
48	Cd	mg kg^{-1}	Graphite Furnace AAS	0.020	0.020	2	-3.04	-1.23	DORM 4
52	Cd	mg kg^{-1}	Graphite Furnace AAS	0.210	0.040	2	44.09	8.85	No QC Reported
53	Cd	mg kg^{-1}	ICP-OES	0.600	0.160	2	140.83	7.09	No QC Reported
54	Cd	mg kg^{-1}	Graphite Furnace AAS	0.029	0.002		-0.81	-1.49	IAEA 407
55	Cd	mg kg^{-1}	ICP-MS	0.227			48.22		No QC Reported
57	Cd	mg kg^{-1}	ICP-MS	0.029			-0.77		DORM 4
58	Cd	mg kg^{-1}	ICP-MS	0.026	0.001	2	-1.63	-3.02	NIST 2976
59	Cd	mg kg^{-1}	ICP-MS	0.032	0.006	2	0.02	0.02	IAEA 461
60	Cd	mg kg^{-1}	Graphite Furnace AAS	0.041	0.003	2	2.17	4.01	IAEA 407
62	Cd	mg kg^{-1}	ICP-MS	0.027	0.005	2	-1.39	-1.81	NIST 2976
14	CH_3Hg	mg kg^{-1} as Hg	GC-AFS	0.566	0.043	2	0.53	0.69	DORM 4
19	CH_3Hg	mg kg^{-1} as Hg	Cold Vapor AAS	0.151	0.120	2	-5.73	-5.02	ERM 464
47	CH_3Hg	mg kg^{-1} as Hg	Cold Vapor AAS	0.457	0.137		-1.11	-0.89	DORM 4
56	CH_3Hg	mg kg^{-1} as Hg	Cold Vapor AFS	561	88	1.96	8450.52	12.5	BCR 463
57	CH_3Hg	mg kg^{-1} as Hg	Hydride AFS	0.585			0.82		DORM 3
59	CH_3Hg	mg kg^{-1} as Hg	GC-AFS	0.583	0.188	2	0.80	0.50	IAEA 461
2	Co	mg kg^{-1}	Flame AAS	0.863	0.226	2			IAEA 461

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
5	Co	mg kg^{-1}	Neutron Activation	0.084	0.004	2			SRM 1566b
6	Co	mg kg^{-1}	ICP-MS	0.259	0.046	2			No QC Reported
10	Co	mg kg^{-1}	ICP-MS	0.100	0.028	2			No QC Reported
11	Co	mg kg^{-1}	ICP-MS	0.077	0.008	2			CUSTOM
13	Co	mg kg^{-1}	ICP-MS	0.103	0.006	2			NIST 2976
14	Co	mg kg^{-1}	ICP-MS	0.138	0.008	2			DORM 4
16	Co	mg kg^{-1}	ICP-MS	0.262	0.060	2			TORT 1
20	Co	mg kg^{-1}	Neutron Activation	0.277	0.020	1			NIST 1566b
21	Co	mg kg^{-1}	Graphite Furnace AAS	0.090	0.049	2			IAEA 407
25	Co	mg kg^{-1}	ICP-MS	0.110					NIST 2976
28	Co	mg kg^{-1}	Neutron Activation	0.127	0.040	2			NIST 1566b
31	Co	mg kg^{-1}	ICP-MS	0.102	0.010	2			IAEA 436
35	Co	mg kg^{-1}	ICP-MS	0.114	0.006	2			No QC Reported
36	Co	mg kg^{-1}	ICP-MS	0.080					TORT
38	Co	mg kg^{-1}	Neutron Activation	0.097	0.020	2			IAEA 452
42	Co	mg kg^{-1}	ICP-MS	0.094	0.013	1.96			IAEA 407
43	Co	mg kg^{-1}	ICP-OES	0.100	0.040	2			No QC Reported
47	Co	mg kg^{-1}	Graphite Furnace AAS	0.223	0.070				TORT 2
49	Co	mg kg^{-1}	ICP-MS	111	30				TORT 3
53	Co	mg kg^{-1}	ICP-OES	8.23	2.94	2			No QC Reported

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
57	Co	mg kg^{-1}	ICP-MS	0.119					DORM 4
58	Co	mg kg^{-1}	ICP-MS	0.107	0.005	2			NIST 2976
59	Co	mg kg^{-1}	ICP-MS	0.093	0.012	2			IAEA 461
2	Cr	mg kg^{-1}	Graphite Furnace AAS	3.73	0.75	2			IAEA 461
5	Cr	mg kg^{-1}	Neutron Activation	3.66	0.24	2			NONE
6	Cr	mg kg^{-1}	ICP-MS	2.75	0.68	2			No QC Reported
7	Cr	mg kg^{-1}	Graphite Furnace AAS	2.80	1.74	2			DORM 3
10	Cr	mg kg^{-1}	ICP-MS	4.11	1.08	2			TORT 3
11	Cr	mg kg^{-1}	ICP-MS	2.29	0.35	2			CUSTOM
12	Cr	mg kg^{-1}	Flame AAS	4.46	0.40	2			IAEA 461
13	Cr	mg kg^{-1}	ICP-MS	4.91	0.43	2			NIST 2976
14	Cr	mg kg^{-1}	ICP-MS	4.39	0.24	2			DORM 4
15	Cr	mg kg^{-1}	XRF	2.28	1.19	2			NIST 2976
16	Cr	mg kg^{-1}	ICP-MS	2.92	0.07	2			TORT 1
19	Cr	mg kg^{-1}	Graphite Furnace AAS	3.54	0.50	2			NIST SRM 1566a
20	Cr	mg kg^{-1}	Neutron Activation	3.93	0.27	1			No QC Reported
21	Cr	mg kg^{-1}	ICP-OES	3.22	0.09	2			IAEA 407
23	Cr	mg kg^{-1}	ICP-MS	2.86	0.43	2			No QC Reported
25	Cr	mg kg^{-1}	ICP-MS	3.97					NIST 2976
28	Cr	mg kg^{-1}	Neutron Activation	3.83	0.12	2			No QC Reported

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
30	Cr	mg kg^{-1}	ICP-OES	2.69	0.32				IAEA 436
31	Cr	mg kg^{-1}	ICP-MS	3.55	0.36	2			IAEA 407
35	Cr	mg kg^{-1}	ICP-MS	4.08	0.37	2			No QC Reported
36	Cr	mg kg^{-1}	ICP-MS	3.35					TORT
42	Cr	mg kg^{-1}	ICP-MS	3.52	0.37	1.96			IAEA 407
43	Cr	mg kg^{-1}	ICP-OES	3.97	0.80	2			No QC Reported
44	Cr	mg kg^{-1}	Graphite Furnace AAS	2.00	0.11	2			IAEA 407
46	Cr	mg kg^{-1}	ICP-MS	2.47	0.64	2			No QC Reported
47	Cr	mg kg^{-1}	Graphite Furnace AAS	3.48	1.04				DORM 4
49	Cr	mg kg^{-1}	ICP-OES	4.07	0.40				TORT 3
53	Cr	mg kg^{-1}	ICP-OES	4.21	0.75	2			No QC Reported
54	Cr	mg kg^{-1}	Graphite Furnace AAS	2.43	0.18				IAEA 407
55	Cr	mg kg^{-1}	ICP-MS	6.07					No QC Reported
57	Cr	mg kg^{-1}	ICP-OES	4.14					DORM 4
58	Cr	mg kg^{-1}	ICP-MS	2.30	0.72	2			NIST 2976
59	Cr	mg kg^{-1}	ICP-MS	2.88	0.42	2			IAEA 461
60	Cr	mg kg^{-1}	Graphite Furnace AAS	3.72	0.33	2			IAEA 407
1	Cu	mg kg^{-1}	Graphite Furnace AAS	0.610			-5.97		No QC Reported
2	Cu	mg kg^{-1}	Flame AAS	2.39	0.52	2	-0.05	-0.05	IAEA 461
6	Cu	mg kg^{-1}	ICP-MS	2.28	0.49	2	-0.41	-0.41	No QC Reported

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
7	Cu	mg kg^{-1}	Graphite Furnace AAS	1.70	0.16	2	-2.35	-3.74	DORM 3
10	Cu	mg kg^{-1}	ICP-MS	2.00	0.40	2	-1.34	-1.53	TORT 3
11	Cu	mg kg^{-1}	ICP-MS	2.23	0.28	2	-0.58	-0.80	NIST 1547
12	Cu	mg kg^{-1}	Flame AAS	3.48	0.20	2	3.58	5.43	IAEA 461
13	Cu	mg kg^{-1}	ICP-MS	2.11	0.35	2	-0.98	-1.21	NIST 2976
14	Cu	mg kg^{-1}	ICP-MS	2.61	0.42	2	0.71	0.78	DORM 4
15	Cu	mg kg^{-1}	XRF	1.82	0.69	2	-1.95	-1.50	IAEA 413
16	Cu	mg kg^{-1}	ICP-MS	1.61	0.06	2	-2.63	-4.56	TORT 1
18	Cu	mg kg^{-1}	Flame AAS	4.60			7.32		IAEA 461
20	Cu	mg kg^{-1}	Flame AAS	1.95	0.20	1	-1.51	-1.72	NIST 1566b
21	Cu	mg kg^{-1}	Flame AAS	2.49	0.11	2	0.28	0.47	IAEA 407
22	Cu	mg kg^{-1}	Flame AAS	2.99	0.36	2	1.96	2.37	DORM 4
23	Cu	mg kg^{-1}	ICP-MS	2.45	0.37	2	0.15	0.18	No QC Reported
25	Cu	mg kg^{-1}	ICP-MS	2.19			-0.72		NIST 2976
26	Cu	mg kg^{-1}	POLAROGRAPHY	1.74	0.09	2	-2.21	-3.77	IAEA 407
27	Cu	mg kg^{-1}	Flame AAS	2.81	0.76	1.970686	1.37	0.97	IAEA 407
28	Cu	mg kg^{-1}	ICP-MS	1.35	0.10	2	-3.49	-5.90	DOLT 4
29	Cu	mg kg^{-1}	Flame AAS	4.05	1.18	2	5.49	2.69	QTM114BT
30	Cu	mg kg^{-1}	ICP-OES	2.77	0.22		1.23	1.82	IAEA 436
31	Cu	mg kg^{-1}	ICP-MS	2.96	0.28	2	1.85	2.51	IAEA 436

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
35	Cu	mg kg^{-1}	ICP-OES	2.32	0.27	2	-0.28	-0.35	No QC Reported
36	Cu	mg kg^{-1}	ICP-MS	2.00			-1.34		TORT
42	Cu	mg kg^{-1}	Flame AAS	2.75	0.29	1.96	1.15	1.52	IAEA 407
43	Cu	mg kg^{-1}	ICP-OES	1.70	0.30	2	-2.34	-3.09	No QC Reported
44	Cu	mg kg^{-1}	Graphite Furnace AAS	2.50	0.10	2	0.34	0.57	IAEA 407
45	Cu	mg kg^{-1}	XRF	4.63	1.20	2	7.43	3.58	No QC Reported
46	Cu	mg kg^{-1}	ICP-MS	2.43	0.49	2	0.09	0.09	No QC Reported
47	Cu	mg kg^{-1}	Flame AAS	2.75	0.83		1.17	0.77	DORM 4
52	Cu	mg kg^{-1}	ICP-OES	1.65	0.12	2	-2.50	-4.16	No QC Reported
53	Cu	mg kg^{-1}	ICP-OES	10.1	1.2	2	25.51	12.5	No QC Reported
54	Cu	mg kg^{-1}	Flame AAS	2.33	0.19		-0.24	-0.39	IAEA 407
55	Cu	mg kg^{-1}	ICP-MS	2.34			-0.20		No QC Reported
57	Cu	mg kg^{-1}	ICP-OES	2.13			-0.91		DORM 4
58	Cu	mg kg^{-1}	ICP-MS	2.76	0.28	2	1.18	1.61	NIST 2976
59	Cu	mg kg^{-1}	ICP-MS	2.25	0.41	2	-0.50	-0.57	IAEA 461
60	Cu	mg kg^{-1}	Graphite Furnace AAS	2.50	0.29	2	0.34	0.45	NIST 2976
1	Fe	mg kg^{-1}	Flame AAS	93.6			-2.59		No QC Reported
2	Fe	mg kg^{-1}	Flame AAS	125	25	2	-0.77	-0.84	IAEA 461
5	Fe	mg kg^{-1}	Neutron Activation	133	10	2	-0.32	-0.50	SRM 1566b
6	Fe	mg kg^{-1}	ICP-OES	135	17	2	-0.20	-0.27	No QC Reported

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
7	Fe	mg kg^{-1}	Flame AAS	185	0	2	2.71	4.87	DORM 3
10	Fe	mg kg^{-1}	ICP-MS	134	56	2	-0.28	-0.16	TORT 3
11	Fe	mg kg^{-1}	ICP-MS	127	14	2	-0.64	-0.93	NIST 1547
12	Fe	mg kg^{-1}	Flame AAS	140	8	2	0.10	0.17	IAEA 436
13	Fe	mg kg^{-1}	ICP-MS	140	8	2	0.09	0.15	NIST 2976
15	Fe	mg kg^{-1}	XRF	98.0	5.9	2	-2.34	-4.02	IAEA 413
16	Fe	mg kg^{-1}	ICP-MS	172	5	2	1.96	3.44	DOLT 2
18	Fe	mg kg^{-1}	Flame AAS	165			1.54		IAEA 461
19	Fe	mg kg^{-1}	ICP-OES	135	11	2	-0.22	-0.35	NIST SRM 1566a
20	Fe	mg kg^{-1}	Neutron Activation	175	11	1	2.10	2.42	INST 1566b
21	Fe	mg kg^{-1}	Flame AAS	152	8	2	0.81	1.34	IAEA 407
22	Fe	mg kg^{-1}	Flame AAS	149	16	2	0.61	0.84	NIST 1566b
23	Fe	mg kg^{-1}	ICP-MS	135	23	2	-0.18	-0.20	No QC Reported
26	Fe	mg kg^{-1}	POLAROGRAPHY	7.09	0.39	2	-7.59	-13.6	IAEA 407
27	Fe	mg kg^{-1}	Flame AAS	116	13	1.970686	-1.28	-1.87	IAEA 407
28	Fe	mg kg^{-1}	Neutron Activation	166	13	2	1.59	2.39	NIST 1566b
29	Fe	mg kg^{-1}	Flame AAS	133	13	2	-0.30	-0.44	QTM114BT
30	Fe	mg kg^{-1}	ICP-OES	134	19		-0.25	-0.33	IAEA 436
31	Fe	mg kg^{-1}	ICP-MS	144	14	2	0.34	0.49	IAEA 407
35	Fe	mg kg^{-1}	ICP-OES	149	2	2	0.61	1.08	No QC Reported

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
36	Fe	mg kg^{-1}	ICP-MS	141			0.12		TORT
42	Fe	mg kg^{-1}	Flame AAS	157	12	1.96	1.07	1.61	IAEA 407
43	Fe	mg kg^{-1}	ICP-OES	130	40	2	-0.49	-0.38	No QC Reported
44	Fe	mg kg^{-1}	Graphite Furnace AAS	147	21	2	0.47	0.57	IAEA 407
45	Fe	mg kg^{-1}	XRF	151	8	2	0.71	1.17	No QC Reported
46	Fe	mg kg^{-1}	ICP-OES	126	35	2	-0.72	-0.62	No QC Reported
47	Fe	mg kg^{-1}	Flame AAS	125	37		-0.78	-0.64	DORM 4
49	Fe	mg kg^{-1}	ICP-OES	132	12		-0.37	-0.57	TORT 3
52	Fe	mg kg^{-1}	ICP-OES	113	5	2	-1.46	-2.55	No QC Reported
53	Fe	mg kg^{-1}	ICP-OES	169	24	2	1.78	2.02	No QC Reported
55	Fe	mg kg^{-1}	ICP-MS	117			-1.24		No QC Reported
57	Fe	mg kg^{-1}	ICP-OES	146			0.46		DORM 4
58	Fe	mg kg^{-1}	ICP-MS	134	13	2	-0.24	-0.35	NIST 2976
59	Fe	mg kg^{-1}	ICP-MS	141	28	2	0.13	0.13	IAEA 461
60	Fe	mg kg^{-1}	Flame AAS	148	5	2	0.55	0.96	IAEA 407
2	Hg	mg kg^{-1}	Cold Vapor AAS	0.460	0.092	2	-1.79	-2.72	No QC Reported
4	Hg	mg kg^{-1}	Solid-AAS	0.587			-0.08		DORM 4
5	Hg	mg kg^{-1}	Neutron Activation	0.501	0.046	2	-1.24	-3.28	NONE
6	Hg	mg kg^{-1}	Cold Vapor AAS	0.645	0.022	2	0.70	2.66	No QC Reported
8	Hg	mg kg^{-1}	Cold Vapor AAS	0.601			0.10		MESS 4

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
10	Hg	mg kg^{-1}	Cold Vapor AFS	0.479	0.292	2	-1.53	-0.77	TORT 3
11	Hg	mg kg^{-1}	Cold Vapor AAS	0.611	0.170	2	0.24	0.19	NIST 1547
12	Hg	mg kg^{-1}	Cold Vapor AAS	0.611	0.060	2	0.24	0.52	IAEA 436
14	Hg	mg kg^{-1}	Cold Vapor AFS	0.583	0.045	2	-0.13	-0.35	DORM 4
16	Hg	mg kg^{-1}	ICP-MS	0.058	0.012	2	-7.22	-31.4	TORT 1
17	Hg	mg kg^{-1}		1.13			7.24		No QC Reported
19	Hg	mg kg^{-1}	Cold Vapor AAS	0.711	0.130	2	1.59	1.71	ERM 464
21	Hg	mg kg^{-1}	Solid-AAS	0.646	0.064	2	0.71	1.47	IAEA 407
22	Hg	mg kg^{-1}	Cold Vapor AFS	0.585	0.034	2	-0.11	-0.34	DORM 4
25	Hg	mg kg^{-1}	Cold Vapor AFS	0.580			-0.18		NIST 2976
28	Hg	mg kg^{-1}	Neutron Activation	0.503	0.040	2	-1.21	-3.50	IAEA MA-A-2
29	Hg	mg kg^{-1}	solid-AAS	0.541	0.081	2	-0.70	-1.17	ERM 278k
30	Hg	mg kg^{-1}	Solid-AAS	0.606	0.060		0.18	0.39	No QC Reported
31	Hg	mg kg^{-1}	Solid-AAS	0.715	0.086	2	1.65	2.66	IAEA 436
35	Hg	mg kg^{-1}	ICP-MS	0.544	0.040	2	-0.67	-1.59	No QC Reported
36	Hg	mg kg^{-1}	ICP-MS	0.520			-0.98		TORT
42	Hg	mg kg^{-1}	Cold Vapor AAS	0.661	0.037	1.96	0.91	2.73	IAEA 407
43	Hg	mg kg^{-1}	Solid-AAS	0.623	0.120	2	0.41	0.49	No QC Reported
46	Hg	mg kg^{-1}	Cold Vapor AAS	0.587	0.190	2	-0.08	-0.06	No QC Reported
47	Hg	mg kg^{-1}	Cold Vapor AAS	0.603	0.181		0.13	0.11	DORM 4

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
48	Hg	mg kg^{-1}	Cold Vapor AAS	0.557	0.040	2	-0.49	-1.41	DORM 4
49	Hg	mg kg^{-1}	solid-AAS	545	10		7340.00	109	TORT 3
53	Hg	mg kg^{-1}	Hydride AAS	0.691	0.162	2	1.33	1.19	No QC Reported
54	Hg	mg kg^{-1}	Cold Vapor AAS	0.555	0.010		-0.51	-2.29	IAEA 407
55	Hg	mg kg^{-1}	ICP-MS	0.583			-0.13		No QC Reported
56	Hg	mg kg^{-1}	Cold Vapor AFS	602	193	1.96	8112.38	6.11	BCR 463
57	Hg	mg kg^{-1}	Solid-AAS	0.637			0.59		DORM 3
59	Hg	mg kg^{-1}	Cold Vapor AFS	0.542	0.110	2	-0.69	-0.91	IAEA 461
60	Hg	mg kg^{-1}	Hydride AAS	0.573	0.017	2	-0.27	-1.08	IAEA MA-A-2
62	Hg	mg kg^{-1}	Solid-AAS	0.520	0.053	2	-0.98	-2.39	IAEA 407
2	K	mg kg^{-1}	Flame AAS	11083	2217	2	-1.69	-1.82	No QC Reported
5	K	mg kg^{-1}	Neutron Activation	14040	720	2	0.00	0.00	SRM 1566b
6	K	mg kg^{-1}	ICP-OES	15980	2130	2	1.10	1.21	No QC Reported
10	K	mg kg^{-1}	ICP-MS	13933	2193	2	-0.06	-0.07	No QC Reported
11	K	mg kg^{-1}	ICP-MS	15333	9000	2	0.74	0.28	NIST 1547
12	K	mg kg^{-1}	Flame AAS	15327	220	2	0.73	1.07	IAEA 436
13	K	mg kg^{-1}	ICP-MS	12895	1110	2	-0.65	-0.87	NIST 2976
15	K	mg kg^{-1}	XRF	14224	607	2	0.10	0.15	IAEA 413
19	K	mg kg^{-1}	ICP-OES	14280	1320	2	0.14	0.17	NIST SRM 1566a
20	K	mg kg^{-1}	Neutron Activation	11980	402	1	-1.17	-1.63	INST 1566b

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
23	K	mg kg^{-1}	ICP-MS	15047	1510	2	0.57	0.71	No QC Reported
26	K	mg kg^{-1}	POLAROGRAPHY	204	0	2	-7.88	-11.6	IAEA 407
27	K	mg kg^{-1}	Flame AAS	12453	1679	1.970686	-0.91	-1.08	IAEA 407
28	K	mg kg^{-1}	Neutron Activation	1427	300	2	-7.19	-10.5	NIST 1566b
30	K	mg kg^{-1}	ICP-OES	12.3	1.2		-7.99	-11.7	No QC Reported
31	K	mg kg^{-1}	ICP-OES	14024	4206	2	-0.01	-0.01	IAEA 407
35	K	mg kg^{-1}	ICP-OES	15017	783	2	0.56	0.75	No QC Reported
36	K	mg kg^{-1}	ICP-MS	14328			0.16		Skimmed milk powder
38	K	mg kg^{-1}	Neutron Activation	14533	1750	2	0.28	0.33	IAEA 436
43	K	mg kg^{-1}	ICP-OES	16667	7000	2	1.50	0.71	No QC Reported
45	K	mg kg^{-1}	XRF	15623	60	2	0.90	1.32	No QC Reported
46	K	mg kg^{-1}	ICP-MS	15600	6200	2	0.89	0.47	No QC Reported
52	K	mg kg^{-1}	Flame AAS	13477	543	2	-0.32	-0.46	No QC Reported
53	K	mg kg^{-1}	ICP-OES	11733	260	2	-1.32	-1.92	No QC Reported
55	K	mg kg^{-1}	ICP-MS	13150			-0.51		No QC Reported
57	K	mg kg^{-1}	ICP-OES	15342			0.74		DORM 4
58	K	mg kg^{-1}	ICP-MS	15680	204	2	0.93	1.37	NIST 2976
59	K	mg kg^{-1}	ICP-MS	14233	2850	2	0.11	0.10	IAEA 461
1	Mg	mg kg^{-1}	Flame AAS	2.28			-7.99		No QC Reported
2	Mg	mg kg^{-1}	Flame AAS	1769	354	2	-1.30	-1.34	No QC Reported

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
6	Mg	mg kg^{-1}	ICP-OES	2433	364	2	1.21	1.23	No QC Reported
10	Mg	mg kg^{-1}	ICP-MS	2303	356	2	0.72	0.74	No QC Reported
11	Mg	mg kg^{-1}	ICP-MS	2287	380	2	0.66	0.65	NIST 1547
12	Mg	mg kg^{-1}	Flame AAS	2293	94	2	0.68	0.94	IAEA 461
13	Mg	mg kg^{-1}	ICP-MS	2449	333	2	1.27	1.34	NIST 2976
15	Mg	mg kg^{-1}	XRF	2076	200	2	-0.14	-0.18	NIST 2976
19	Mg	mg kg^{-1}	ICP-OES	2229	280	2	0.44	0.50	NIST SRM 1566a
20	Mg	mg kg^{-1}	Neutron Activation	2024	254	1	-0.34	-0.28	INST 1566b
23	Mg	mg kg^{-1}	Hydride ICP-MS	2383	240	2	1.02	1.22	No QC Reported
26	Mg	mg kg^{-1}	POLAROGRAPHY	4.40	0.23	2	-7.98	-11.3	IAEA 407
27	Mg	mg kg^{-1}	Flame AAS	1920	291	1.97	-0.73	-0.81	IAEA 407
28	Mg	mg kg^{-1}	Neutron Activation	2417	120	2	1.15	1.55	NIST 1566b
30	Mg	mg kg^{-1}	ICP-OES	2.13	0.30		-7.99	-11.3	No QC Reported
31	Mg	mg kg^{-1}	ICP-OES	2021	182	2	-0.35	-0.44	IAEA 407
35	Mg	mg kg^{-1}	ICP-OES	2216	64	2	0.39	0.54	No QC Reported
36	Mg	mg kg^{-1}		1995			-0.45		Skimmed milk powder
43	Mg	mg kg^{-1}	ICP-OES	2333	700	2	0.83	0.56	No QC Reported
46	Mg	mg kg^{-1}	ICP-MS	2433	730	2	1.21	0.78	No QC Reported
49	Mg	mg kg^{-1}	ICP-OES	2018			-0.36		No QC Reported
52	Mg	mg kg^{-1}	ICP-OES	1631	28	2	-1.83	-2.57	No QC Reported

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
53	Mg	mg kg^{-1}	ICP-OES	1953	40	2	-0.60	-0.85	No QC Reported
55	Mg	mg kg^{-1}	ICP-MS	1905			-0.79		No QC Reported
57	Mg	mg kg^{-1}	ICP-OES	2368			0.97		DORM 4
58	Mg	mg kg^{-1}	ICP-MS	2676	51	2	2.13	2.99	NIST 2976
59	Mg	mg kg^{-1}	ICP-MS	2373	171	2	0.99	1.27	IAEA 461
1	Mn	mg kg^{-1}	Flame AAS	14.7			-0.38		No QC Reported
2	Mn	mg kg^{-1}	Flame AAS	12.3	2.5	2	-1.61	-2.13	IAEA 461
6	Mn	mg kg^{-1}	ICP-MS	17.0	2.3	2	0.82	1.16	No QC Reported
10	Mn	mg kg^{-1}	ICP-MS	16.4	3.0	2	0.48	0.54	No QC Reported
11	Mn	mg kg^{-1}	ICP-MS	16.0	2.3	2	0.31	0.41	NIST 1547
13	Mn	mg kg^{-1}	ICP-MS	14.9	1.7	2	-0.30	-0.50	NIST 2976
14	Mn	mg kg^{-1}	ICP-MS	17.0	2.0	2	0.82	1.26	DORM 4
15	Mn	mg kg^{-1}	XRF	10.3	3.0	2	-2.65	-3.03	IAEA 413
16	Mn	mg kg^{-1}	ICP-MS	2.69	0.10	2	-6.61	-16.6	TORT 1
18	Mn	mg kg^{-1}	Flame AAS	17.6			1.13		IAEA 461
19	Mn	mg kg^{-1}	ICP-OES	13.4	1.7	2	-1.08	-1.84	NIST SRM 1566a
20	Mn	mg kg^{-1}	Neutron Activation	17.3	1.3	1	0.98	1.26	INST 1566b
21	Mn	mg kg^{-1}	Flame AAS	15.4	0.3	2	0.00	0.00	IAEA 407
22	Mn	mg kg^{-1}	Flame AAS	15.5	1.7	2	0.05	0.08	NIST 1566b
23	Mn	mg kg^{-1}	ICP-MS	14.2	2.1	2	-0.64	-0.94	No QC Reported

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
25	Mn	mg kg^{-1}	ICP-MS	18.7			1.69		NIST 2976
27	Mn	mg kg^{-1}	Flame AAS	16.4	0.5	2	0.47	1.13	IAEA 407
28	Mn	mg kg^{-1}	Neutron Activation	14.7	2.0	2	-0.39	-0.59	NIST 1566b
29	Mn	mg kg^{-1}	Flame AAS	12.4	1.2	2	-1.60	-3.12	QTM114BT
30	Mn	mg kg^{-1}	ICP-OES	13.9	2.2		-0.79	-1.13	IAEA 436
31	Mn	mg kg^{-1}	ICP-MS	16.3	1.6	2	0.44	0.77	IAEA 407
35	Mn	mg kg^{-1}	ICP-OES	16.1	0.3	2	0.36	0.88	No QC Reported
36	Mn	mg kg^{-1}	ICP-MS	16.2			0.37		TORT
42	Mn	mg kg^{-1}	ICP-MS	15.6	0.4	1.96	0.08	0.20	IAEA 407
43	Mn	mg kg^{-1}	ICP-OES	14.0	4.0	2	-0.75	-0.67	No QC Reported
44	Mn	mg kg^{-1}	Graphite Furnace AAS	15.9	0.9	2	0.25	0.56	IAEA 407
45	Mn	mg kg^{-1}	XRF	10.7	4.0	2	-2.47	-2.23	No QC Reported
46	Mn	mg kg^{-1}	ICP-MS	15.8	4.7	2	0.20	0.16	No QC Reported
47	Mn	mg kg^{-1}	Flame AAS	12.8	3.8		-1.39	-1.29	TORT 2
49	Mn	mg kg^{-1}	ICP-OES	13.8	1.0		-0.87	-1.83	TORT 3
53	Mn	mg kg^{-1}	ICP-OES	23.1	3.0	2	3.97	4.52	No QC Reported
54	Mn	mg kg^{-1}	Flame AAS	18.0	1.0		1.32	2.95	IAEA 407
55	Mn	mg kg^{-1}	ICP-MS	17.4			1.02		No QC Reported
57	Mn	mg kg^{-1}	ICP-OES	15.9			0.25		DORM 4
58	Mn	mg kg^{-1}	ICP-MS	16.9	0.3	2	0.77	1.92	NIST 2976

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
59	Mn	mg kg^{-1}	ICP-MS	15.5	3.2	2	0.03	0.03	IAEA 461
60	Mn	mg kg^{-1}	Flame AAS	16.4	2.7	2	0.48	0.60	NIST 2976
2	Ni	mg kg^{-1}	Flame AAS	4.20	0.84	2			IAEA 461
6	Ni	mg kg^{-1}	ICP-MS	4.27	0.66	2			No QC Reported
10	Ni	mg kg^{-1}	ICP-MS	4.21	1.47	2			TORT 3
11	Ni	mg kg^{-1}	ICP-MS	3.64	0.72	2			CUSTOM
12	Ni	mg kg^{-1}	Flame AAS	4.18	0.24	2			IAEA 461
13	Ni	mg kg^{-1}	ICP-MS	4.89	0.74	2			NIST 2976
14	Ni	mg kg^{-1}	ICP-MS	5.03	0.34	2			DORM 4
15	Ni	mg kg^{-1}	XRF	1.25	0.68	2			IAEA 413
16	Ni	mg kg^{-1}	ICP-MS	1.48	0.07	2			TORT 1
18	Ni	mg kg^{-1}	Flame AAS	5.37					IAEA 461
20	Ni	mg kg^{-1}	Flame AAS	6.44	0.74	1			Waste water CRM
21	Ni	mg kg^{-1}	ICP-OES	4.21	0.92	2			IAEA 407
22	Ni	mg kg^{-1}	Graphite Furnace AAS	4.48	1.50	2			DORM 4
23	Ni	mg kg^{-1}	ICP-MS	4.26	0.85	2			No QC Reported
25	Ni	mg kg^{-1}	ICP-MS	5.33					NIST 2976
26	Ni	mg kg^{-1}	POLAROGRAPHY	0.336	0.017	2			IAEA 407
28	Ni	mg kg^{-1}	ICP-MS	2.53	0.20	2			DOLT 4
30	Ni	mg kg^{-1}	ICP-OES	4.26	0.51				IAEA 436

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
31	Ni	mg kg^{-1}	ICP-MS	3.71	0.36	2			IAEA 407
35	Ni	mg kg^{-1}	ICP-MS	4.45	0.35	2			No QC Reported
36	Ni	mg kg^{-1}	ICP-MS	3.95					TORT
42	Ni	mg kg^{-1}	ICP-MS	4.26	0.24	1.96			IAEA 407
43	Ni	mg kg^{-1}	ICP-OES	3.50	1.20	2			No QC Reported
44	Ni	mg kg^{-1}	Graphite Furnace AAS	3.39	0.19	2			IAEA 407
46	Ni	mg kg^{-1}	ICP-MS	3.71	1.30	2			No QC Reported
47	Ni	mg kg^{-1}	Graphite Furnace AAS	4.09	1.23				DORM 4
49	Ni	mg kg^{-1}	ICP-OES	3.43	0.60				TORT 3
53	Ni	mg kg^{-1}	ICP-OES	4.04	0.85	2			No QC Reported
54	Ni	mg kg^{-1}	Flame AAS	5.05	0.15				IAEA 407
55	Ni	mg kg^{-1}	ICP-MS	3.69					No QC Reported
57	Ni	mg kg^{-1}	ICP-MS	4.81					DORM 4
58	Ni	mg kg^{-1}	ICP-MS	3.82	0.38	2			NIST 2976
59	Ni	mg kg^{-1}	ICP-MS	4.01	0.80	2			IAEA 461
60	Ni	mg kg^{-1}	Graphite Furnace AAS	3.58	0.09	2			IAEA MA-A-2
1	Pb	mg kg^{-1}	Graphite Furnace AAS	0.029			-7.62		No QC Reported
2	Pb	mg kg^{-1}	Graphite Furnace AAS	0.430	0.132	2	-2.32	-2.40	IAEA 461
6	Pb	mg kg^{-1}	ICP-MS	0.551	0.068	2	-0.72	-1.17	No QC Reported
7	Pb	mg kg^{-1}	Graphite Furnace AAS	0.593	0.300	2	-0.17	-0.08	DORM 3

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
10	Pb	mg kg^{-1}	ICP-MS	0.613	0.224	2	0.10	0.06	TORT 3
11	Pb	mg kg^{-1}	ICP-MS	0.636	0.240	2	0.39	0.24	NIST 1547
12	Pb	mg kg^{-1}	Flame AAS	0.861	0.120	2	3.36	3.74	IAEA 461
13	Pb	mg kg^{-1}	ICP-MS	0.629	0.053	2	0.30	0.54	NIST 2976
14	Pb	mg kg^{-1}	ICP-MS	0.695	0.052	2	1.17	2.13	DORM 4
15	Pb	mg kg^{-1}	XRF	0.213	0.120	2	-5.18	-5.77	IAEA 413
16	Pb	mg kg^{-1}	ICP-MS	0.740	0.074	2	1.77	2.74	NIST 2976
17	Pb	mg kg^{-1}	Graphite Furnace AAS	0.540			-0.87		No QC Reported
18	Pb	mg kg^{-1}	Flame AAS	3.37			36.44		IAEA 461
20	Pb	mg kg^{-1}	Graphite Furnace AAS	0.074	0.014	1	-7.03	-15.2	Waste water CRM
21	Pb	mg kg^{-1}	Graphite Furnace AAS	0.099	0.020	2	-6.69	-15.0	IAEA 407
22	Pb	mg kg^{-1}	Graphite Furnace AAS	0.482	0.133	2	-1.64	-1.69	NIST 1566b
23	Pb	mg kg^{-1}	ICP-MS	0.620	0.120	2	0.18	0.20	No QC Reported
25	Pb	mg kg^{-1}	ICP-MS	0.573			-0.43		NIST 2976
26	Pb	mg kg^{-1}	POLAROGRAPHY	1.50	0.08	2	11.79	18.2	IAEA 407
28	Pb	mg kg^{-1}	ICP-MS	0.407	0.040	2	-2.63	-5.26	Mussel Tissue
29	Pb	mg kg^{-1}	Graphite Furnace AAS	0.591	0.069	2	-0.20	-0.33	QTM114BT
31	Pb	mg kg^{-1}	ICP-MS	0.677	0.054	2	0.93	1.68	IAEA 407
35	Pb	mg kg^{-1}	ICP-MS	0.561	0.018	2	-0.59	-1.30	No QC Reported
36	Pb	mg kg^{-1}	ICP-MS	0.510			-1.27		TORT

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
43	Pb	mg kg^{-1}	ICP-OES	0.410	0.100	2	-2.59	-3.30	No QC Reported
46	Pb	mg kg^{-1}	ICP-MS	0.703	0.180	2	1.28	1.02	No QC Reported
47	Pb	mg kg^{-1}	Graphite Furnace AAS	0.650	0.200		0.58	0.42	DORM 4
48	Pb	mg kg^{-1}	Graphite Furnace AAS	0.433	0.060	2	-2.29	-3.94	DORM 4
52	Pb	mg kg^{-1}	Graphite Furnace AAS	0.927	0.077	2	4.24	6.45	No QC Reported
53	Pb	mg kg^{-1}	ICP-OES	8.80	1.70	2	108.11	9.63	No QC Reported
54	Pb	mg kg^{-1}	Graphite Furnace AAS	0.627	0.038		0.27	0.58	IAEA 407
57	Pb	mg kg^{-1}	ICP-MS	0.696			1.19		DORM 4
58	Pb	mg kg^{-1}	ICP-MS	0.720	0.070	2	1.50	2.39	NIST 2976
59	Pb	mg kg^{-1}	ICP-MS	0.659	0.086	2	0.70	0.99	IAEA 461
60	Pb	mg kg^{-1}	Graphite Furnace AAS	0.577	0.044	2	-0.39	-0.75	NIST 2976
62	Pb	mg kg^{-1}	ICP-MS	0.643	0.160	2	0.49	0.43	NIST 2976
2	Se	mg kg^{-1}	ICP-MS	1.91	0.38	2	-0.96	-1.21	No QC Reported
5	Se	mg kg^{-1}	Neutron Activation	2.12	0.20	2	-0.21	-0.41	SRM 1566b
6	Se	mg kg^{-1}	ICP-MS	2.58	0.12	2	1.50	3.55	No QC Reported
10	Se	mg kg^{-1}	ICP-MS	2.00	0.60	2	-0.63	-0.55	TORT 3
11	Se	mg kg^{-1}		2.15	0.27	2	-0.10	-0.16	CUSTOM
13	Se	mg kg^{-1}	ICP-MS	2.08	0.27	2	-0.35	-0.57	NIST 2976
14	Se	mg kg^{-1}	ICP-MS	2.34	0.09	2	0.63	1.55	DORM 4
15	Se	mg kg^{-1}	XRF	1.97	0.52	2	-0.74	-0.72	NIST 2976

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
20	Se	mg kg^{-1}	Neutron Activation	2.18	0.09	1	0.01	0.02	INST 1566b
23	Se	mg kg^{-1}	ICP-MS	2.71	0.54	2	1.98	1.87	No QC Reported
25	Se	mg kg^{-1}	ICP-MS	1.41			-2.80		NIST 2976
28	Se	mg kg^{-1}	Neutron Activation	2.13	0.12	2	-0.15	-0.35	NIST 1566b
31	Se	mg kg^{-1}	ICP-MS	2.06	0.20	2	-0.43	-0.83	IAEA 407
35	Se	mg kg^{-1}	ICP-MS	2.29	0.04	2	0.43	1.15	No QC Reported
36	Se	mg kg^{-1}	ICP-MS	2.13			-0.16		TORT
38	Se	mg kg^{-1}	Neutron Activation	2.16	0.26	2	-0.05	-0.09	IAEA 452
42	Se	mg kg^{-1}	ICP-MS	2.35	0.28	1.96	0.65	1.02	IAEA 407
43	Se	mg kg^{-1}	ICP-OES	2.23	1.10	2	0.22	0.11	No QC Reported
46	Se	mg kg^{-1}	ICP-MS	2.10	1.10	2	-0.27	-0.13	No QC Reported
49	Se	mg kg^{-1}	ICP-OES	1.86	0.40		-1.14	-1.39	TORT 3
53	Se	mg kg^{-1}	ICP-OES	5.00	0.92	2	10.40	6.00	No QC Reported
55	Se	mg kg^{-1}	ICP-MS	2.21			0.12		No QC Reported
57	Se	mg kg^{-1}	ICP-MS	2.32			0.52		DORM 4
58	Se	mg kg^{-1}	ICP-MS	1.65	0.11	2	-1.93	-4.71	NIST 2976
59	Se	mg kg^{-1}	ICP-MS	2.61	0.72	2	1.59	1.16	IAEA 461
2	Sn	mg kg^{-1}	ICP-MS	0.105	0.063	2			No QC Reported
10	Sn	mg kg^{-1}	ICP-MS	0.200	0.120	2			DORM 4
11	Sn	mg kg^{-1}	ICP-MS	0.219	0.033	2			CUSTOM

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
28	Sn	mg kg^{-1}	ICP-MS	0.153	0.060	2			Mussel Tissue
31	Sn	mg kg^{-1}	ICP-MS	0.196	0.020	2			IAEA 407
35	Sn	mg kg^{-1}	ICP-MS	0.156	0.011	2			No QC Reported
42	Sn	mg kg^{-1}	ICP-MS	0.090	0.021	1.96			IAEA 407
43	Sn	mg kg^{-1}	ICP-OES	0.257	0.100	2			No QC Reported
53	Sn	mg kg^{-1}	ICP-OES	28.9	6.0	2			No QC Reported
55	Sn	mg kg^{-1}	ICP-MS	0.213					No QC Reported
57	Sn	mg kg^{-1}	ICP-MS	0.186					DORM 4
59	Sn	mg kg^{-1}	ICP-MS	0.104	0.021	2			IAEA 461
2	Sr	mg kg^{-1}	ICP-MS	119	24	2	-0.97	-1.00	No QC Reported
5	Sr	mg kg^{-1}	Neutron Activation	123	10	2	-0.74	-1.02	SRM 1515
6	Sr	mg kg^{-1}	ICP-MS	148	9	2	0.75	1.04	No QC Reported
10	Sr	mg kg^{-1}	ICP-MS	141	30	2	0.32	0.29	No QC Reported
11	Sr	mg kg^{-1}	ICP-MS	147	22	2	0.65	0.70	NIST 1547
13	Sr	mg kg^{-1}	ICP-MS	154	10	2	1.06	1.44	NIST 2976
15	Sr	mg kg^{-1}	XRF	192	8	2	3.31	4.67	NIST 2976
16	Sr	mg kg^{-1}	ICP-MS	127	4	2	-0.50	-0.73	TORT 1
19	Sr	mg kg^{-1}	ICP-OES	136	12	2	0.00	0.01	NIST SRM 1566a
21	Sr	mg kg^{-1}	ICP-OES	147	16	2	0.65	0.81	IAEA 407
28	Sr	mg kg^{-1}	ICP-MS	128	6	2	-0.43	-0.62	No QC Reported

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
30	Sr	mg kg^{-1}	ICP-OES	137	11		0.08	0.10	IAEA 436
31	Sr	mg kg^{-1}	ICP-MS	146	12	2	0.63	0.84	IAEA 407
35	Sr	mg kg^{-1}	ICP-MS	149	9	2	0.76	1.01	No QC Reported
42	Sr	mg kg^{-1}	ICP-MS	140	6	1.96	0.24	0.34	IAEA 407
43	Sr	mg kg^{-1}	ICP-OES	130	40	2	-0.33	-0.24	No QC Reported
45	Sr	mg kg^{-1}	XRF	98.7	4.0	2	-2.18	-3.21	No QC Reported
46	Sr	mg kg^{-1}	ICP-OES	135	41	2	-0.02	-0.01	No QC Reported
49	Sr	mg kg^{-1}	ICP-OES	127	4		-0.49	-0.72	TORT 3
53	Sr	mg kg^{-1}	ICP-OES	111	22	2	-1.45	-1.55	No QC Reported
55	Sr	mg kg^{-1}	ICP-MS	147			0.69		No QC Reported
57	Sr	mg kg^{-1}	ICP-OES	136			0.04		DORM 4
59	Sr	mg kg^{-1}	ICP-MS	134	14	2	-0.10	-0.12	IAEA 461
2	V	mg kg^{-1}	ICP-MS	0.338	0.101	2	-1.32	-1.00	No QC Reported
6	V	mg kg^{-1}	ICP-MS	0.492	0.190	2	1.72	0.84	No QC Reported
10	V	mg kg^{-1}	ICP-MS	0.500	0.026	2	1.89	2.14	No QC Reported
11	V	mg kg^{-1}	ICP-MS	0.258	0.044	2	-2.89	-3.05	NIST 1547
14	V	mg kg^{-1}	ICP-MS	0.497	0.050	2	1.82	1.86	DORM 4
15	V	mg kg^{-1}	XRF	1.06	0.24	2	12.96	5.15	No QC Reported
28	V	mg kg^{-1}	Neutron Activation	0.447	0.100	2	0.83	0.64	NIST 1566b
31	V	mg kg^{-1}	ICP-MS	0.355	0.030	2	-0.98	-1.10	IAEA 407

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
35	V	mg kg^{-1}	ICP-MS	0.459	0.046	2	1.08	1.04	No QC Reported
36	V	mg kg^{-1}	ICP-MS	0.395			-0.19		TORT
42	V	mg kg^{-1}	ICP-MS	0.357	0.013	1.96	-0.94	-1.10	IAEA 407
46	V	mg kg^{-1}	ICP-MS	0.261	0.065	2	-2.83	-2.67	No QC Reported
53	V	mg kg^{-1}	ICP-OES	230	40	2	4546.98	11.5	No QC Reported
55	V	mg kg^{-1}	ICP-MS	0.223			-3.58		No QC Reported
57	V	mg kg^{-1}	ICP-OES	0.403			-0.03		DORM 4
59	V	mg kg^{-1}	ICP-MS	0.263	0.032	2	-2.80	-3.11	IAEA 461
1	Zn	mg kg^{-1}	Flame AAS	49.8			-0.35		No QC Reported
2	Zn	mg kg^{-1}	Flame AAS	51.7	10.3	2	-0.05	-0.07	IAEA 461
5	Zn	mg kg^{-1}	Neutron Activation	50.0	1.6	2	-0.32	-1.22	SRM 1566b
6	Zn	mg kg^{-1}	ICP-MS	62.5	4.2	2	1.59	4.04	No QC Reported
10	Zn	mg kg^{-1}	ICP-MS	45.9	6.5	2	-0.95	-1.73	TORT 3
11	Zn	mg kg^{-1}	ICP-MS	49.1	7.5	2	-0.45	-0.72	NIST 1547
12	Zn	mg kg^{-1}	Flame AAS	48.6	4.0	2	-0.54	-1.40	IAEA 461
13	Zn	mg kg^{-1}	ICP-MS	52.2	5.9	2	0.02	0.03	NIST 2976
14	Zn	mg kg^{-1}	ICP-MS	54.8	4.0	2	0.42	1.10	DORM 4
15	Zn	mg kg^{-1}	XRF	61.2	5.0	2	1.39	3.13	NIST 2976
16	Zn	mg kg^{-1}	ICP-MS	191	5	2	21.33	45.1	TORT 1
18	Zn	mg kg^{-1}	Flame AAS	57.1			0.76		IAEA 461

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
19	Zn	mg kg^{-1}	ICP-OES	46.3	4.5	2	-0.89	-2.16	NIST SRM 1566a
20	Zn	mg kg^{-1}	Neutron Activation	56.4	0.8	1	0.67	2.56	NIST 1566b
21	Zn	mg kg^{-1}	Flame AAS	54.4	6.0	2	0.35	0.68	IAEA 407
22	Zn	mg kg^{-1}	Flame AAS	52.7	4.0	2	0.09	0.25	DORM 4
23	Zn	mg kg^{-1}	ICP-MS	53.8	8.1	2	0.27	0.40	No QC Reported
25	Zn	mg kg^{-1}	ICP-MS	51.4			-0.10		NIST 2976
26	Zn	mg kg^{-1}	POLAROGRAPHY	2.26	0.12	2	-7.65	-33.7	IAEA 407
27	Zn	mg kg^{-1}	Flame AAS	44.7	4.4	2	-1.13	-2.80	IAEA 407
28	Zn	mg kg^{-1}	Neutron Activation	51.7	1.0	2	-0.06	-0.27	NIST 1566b
30	Zn	mg kg^{-1}	ICP-OES	51.0	10.0		-0.17	-0.21	IAEA 436
31	Zn	mg kg^{-1}	ICP-MS	52.5	4.4	2	0.06	0.16	IAEA 407
35	Zn	mg kg^{-1}	ICP-OES	56.5	0.2	2	0.68	2.98	No QC Reported
36	Zn	mg kg^{-1}	ICP-MS	48.5			-0.55		TORT
38	Zn	mg kg^{-1}	Neutron Activation	72.7	10.0	2	3.16	3.96	IAEA 436
42	Zn	mg kg^{-1}	Flame AAS	53.3	0.5	1.96	0.19	0.81	IAEA 407
43	Zn	mg kg^{-1}	ICP-OES	49.7	10.0	2	-0.37	-0.46	No QC Reported
45	Zn	mg kg^{-1}	XRF	43.0	2.0	2	-1.40	-5.10	No QC Reported
46	Zn	mg kg^{-1}	ICP-OES	49.3	10.0	2	-0.42	-0.53	No QC Reported
47	Zn	mg kg^{-1}	Flame AAS	52.6	15.8		0.07	0.06	DORM 4
49	Zn	mg kg^{-1}	ICP-OES	47.7	1.0		-0.68	-2.84	TORT 3

TABLE 7. REPORTED RESULTS BY PARTICPANTS (cont.)

Lab code	Analyte	Unit	Instrumental Method	Lab Mean	Lab U	*k*	*z*-score	Zeta-score	QC
52	Zn	mg kg^{-1}	ICP-OES	40.9	1.2	2	-1.71	-7.02	No QC Reported
53	Zn	mg kg^{-1}	ICP-OES	61.2	9.1	2	1.40	1.91	No QC Reported
54	Zn	mg kg^{-1}	Flame AAS	53.1	0.4		0.16	0.71	IAEA 407
55	Zn	mg kg^{-1}	ICP-MS	52.4			0.05		No QC Reported
57	Zn	mg kg^{-1}	ICP-OES	62.6			1.61		DORM 4
58	Zn	mg kg^{-1}	ICP-MS	51.3	1.7	2	-0.12	-0.47	NIST 2976
59	Zn	mg kg^{-1}	ICP-MS	57.0	17.8	2	0.76	0.55	IAEA 461
60	Zn	mg kg^{-1}	Flame AAS	50.3	5.0	2	-0.27	-0.61	NIST 2976

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