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Multi-Element Analysis of Drinking Water Following ISO 17294-2 Using the NexION 1100 ICP-MS

Introduction

Elemental analysis is critical to ensuring the quality and safety of drinking water. While mineral elements like calcium, magnesium, and iron are essential nutrients for the health of humans and

animals, the adverse effects imposed by heavy metals like mercury, cadmium, arsenic, and lead, usually at trace levels, cannot be neglected.

The international standard method ISO 17294 outlines the analysis of elements using inductively coupled plasma mass spectrometry (ICP-MS). ISO 17294-1:2004¹ provides the general directions for the use of the ICP-MS technique; and ISO 17294-2:2023² describes the determination of trace and major elements in water samples such as drinking water, surface water, groundwater, wastewater, and eluates. In drinking water and relatively unpolluted waters, the limit of quantification (LOQ) lies between 0.002 µg/L and 1.0 µg/L for most elements.

In comparison to other analytical techniques, ICP-MS has the advantages of multi-element detection, low detection limits, high speed of analysis, wide dynamic range, etc. However, it is affected by plasma and matrix-based polyatomic interferences and doubly charged species, which need to be accounted for by applying mathematical corrections and/or using collision/reaction mechanisms. The NexION® 1100 ICP-MS is equipped with Universal Cell Technology (UCT) that can be operated in both Collision mode with kinetic energy discrimination (KED) and Reaction mode with dynamic reaction cell (DRC) to tackle the polyatomic interferences.

In this work, we reported a method for the elemental analysis of drinking water using ICP-MS in accordance with the guidelines of ISO 17294-2. The method used here is included in the Syngistix™ for ICP-MS software.

Experimental

Sample Preparation

All sample and calibration solution preparations were performed volumetrically. Ultrapure water (Resistivity >18.2MΩ.cm), high-purity acids HNO₃ (55% w/w, Tama Chemicals, Moses Lake, Washington, USA) and HCl (20% w/w, Tama Chemicals) were used for all samples, blanks, standards, and wash solutions unless otherwise specified. Diluted acid solutions were prepared via the dilution of the concentrated acid(s) with ultrapure water. The concentrations of the diluted acid solutions were based on concentrated HNO₃ with 70% (w/w) and concentrated HCl with 37% (w/w). Water samples included a tap water, a coffee-maker water supply line, a local well water (underground water), two bottled pure waters and three bottled spring waters, covering a wide

range of hardness. The water samples were acidified to 1% HNO₃ and measured directly without prior dilution.

Calibration Standards

The calibration standards were prepared by diluting ICP-MS grade single-element standards and multi-element standards (see the *Consumables Used* table) in a diluent made of 2% HNO₃ and 0.5% HCl and spiked with 200 µg/L of Au. The addition of HCl helps with the long-term stability of elements like Hg, Ag, Sn, Sb, and Mo, and Au facilitates the washout of mercury (Hg). This diluent was also used as the calibration blank, the continuing calibration blank (CCB) and the High Throughput System (HTS) carrier solution. The concentrations of the calibration standards are shown in Table 1. Standard 3 was used as the continuing calibration verification (CCV) standards. The CCBs and CCVs were measured periodically throughout the sequence.

Table 1. List of The Concentrations of Analytes in the Calibration Standards.

Analytes	Standard 1 (µg/L)	Standard 2 (µg/L)	Standard 3 (µg/L)	Standard 4 (µg/L)	Standard 5 (µg/L)	Standard 6 (µg/L)
Na, Ca	50	500	5,000	10,000	25,000	50,000
Mg, K	10	100	1,000	2,000	5,000	10,000
Li, B, Fe, Ba, Sr	1	10	100	200	500	1,000
Ag, Al, As, Be, Bi, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Rb, Sb, Se, Sn, Te, Th, Ti, U, V, W and Zn	0.1	1	10	20	50	100
Hg	0.002	0.02	0.2	0.4	1	2
P, S	25	250	2,500	5,000	12,500	25,000

Wash Solution

The wash solution consists of 1.5% HCl (v/v) and 0.5% HNO₃ (v/v) spiked with 200 µg/L of Au.

Internal Standard (ISTD)

The internal standard solution contains 1,000 µg/L of Sc, 50 µg/L of In, Ir, and Rh and was prepared by 200-fold dilution of an Internal Standard Mix (see the *Consumables Used* table) in 1% of HNO₃. The internal standard solution was introduced into the designated port of the High Throughput System (HTS) switching valve and mixed inline continuously with the carrier solution/sample flow.

QC Samples

QC samples include:

- two CRMs: NIST1643f fresh water (NIST, Gaithersburg, Maryland, USA) and CRM-TMDW-B-250 B (HPS, North Charleston, South Carolina, USA) synthetic drinking water
- two standard spiked water samples: a tap water and a well water
- and CCVs

Rare earth elements (REEs) don't have a significant presence in drinking water. But with the increased use of REEs in the

industrial processes and products, their influence on the environment should not be neglected. Due to their low second ionization potentials, REE elements are easy to form doubly charged ions that interfere with the middle mass elements, e.g., ¹⁵⁰Nd²⁺ and ¹⁵⁰Sm²⁺ on ⁷⁵As⁺, and ¹⁵⁶Gd²⁺ and ¹⁵⁶Dy²⁺ on ⁷⁸Se⁺. To evaluate the effect of the REEs, a recovery test was also performed on the two CRMs that were spiked with 10 µg/L of Nd, Sm, Gd, and Dy single-element standards.

Instrumentation

All measurements were performed with a NexION 1100 ICP-MS (PerkinElmer, Shelton, Connecticut, USA) equipped with an S20 series autosampler and a High Throughput System (HTS, optional). HTS features a high-flow vacuum pump, a 7-port switching valve, and a sample loop. Using a metal-free fluid path, the vacuum pump can quickly deliver the sample into the sample loop. The sample probe is rinsed with solution drawn by the vacuum pump while the sample is analyzed. The post-run washout is also performed using the vacuum pump. The overall analysis time per sample is drastically shortened compared to the peristaltic-based sample delivery system. The instrument components/parameters were shown in Table 2.

Table 2. NexION 1100 ICP-MS Instrument Parameters and Operating Conditions.

Instrument Component/Parameter	Type/Value	
ICP-MS	NexION 1100	
Nebulizer	Concentric Type CT Q + Quartz	
Spray Chamber	Quartz Cyclonic with AMS (All Matrix System) gas port	
Torch	One-piece Quartz Torch, 2 mm injector	
Interface	Standard Ni Sampler and Skimmer AI Hyper-Skimmer	
Peripump Tubing	Carrier: Orange/Green (0.38 mm i.d.) ISTD: Orange/Green (0.38 mm i.d.) Waste: Gray/Gray Santoprene (1.30 mm i.d.)	
Operating Conditions	Type/Value	
RF Power	1600 W	
Plasma Gas Flow	15 L/min	
Auxiliary Gas Flow	1.2 L/min	
Nebulizer Gas Flow	As optimized	
Cell Gas	Premixed 7% Hydrogen/Helium (He+H)	
Cell Gas Flow	Collision (KED) mode	Reaction (DRC) mode
	3.6 - 5.4 mL/min	12 mL/min
Sample Uptake Rate	0.24 mL/min	
Data Acquisition	Type/Value	
Sweeps	15	
Dwell Time	10 - 150 ms	
Replicates	3	
Autosampler and HTS	Type/Value	
Autosampler	S23	
Sample Loop Size	1.5 mL	
Autosampler Probe	1.0 mm i.d.	
Flush Delay	8 s	
Rinse Mode	Dual	
Read Delay	25 s	
Probe Rinse	5 s	
Wash 1	2 s	
Wash 2	33 s	
Peripump Speed	89 rpm	

Instrument Optimization

The instrument was tuned for optimal sensitivity and oxide, as well as doubly charged ion ratios. Using the instrument components and conditions, as shown in Table 2, the oxide level as measured by CeO^+/Ce^+ was < 2.5%, and the doubly charged ion ratio as measured by Ce^{2+}/Ce^+ was < 1.5% in Standard mode. In the Collision (KED) mode, the oxide level is typically 0.5%. Newly cleaned cones need to be conditioned prior to sample analysis. In this method, the cones were conditioned by aspirating a 50 ppm calcium single-element

standard solution in 2% HNO_3 /0.5% HCl and monitoring the internal standards until the signals stabilized. The system was then washed by aspirating 2% HNO_3 /0.5% HCl followed by ultrapure water before starting the sample runs.

Compared to its prior generation, the NexION 1100 ICP-MS allows a higher cell gas flow, which can be utilized to mitigate the argon dimer interference on the measurement of Se in Reaction (DRC) mode using a premixed helium-hydrogen gas mixture (He-H): 7% hydrogen-helium. In this method, Reaction (DRC) mode was used to measure ^{78}Se , and Collision (KED)

mode was used for the rest of the elements. The cell gas flows were optimized for best detection limits following the instrument operation manual³. A default RPq (cell rejection parameter) was used for the analytes measured in Collision mode to simplify the method development. For the Reaction

mode, RPq was optimized to maximize the sensitivity of ⁷⁸Se. The elements, their isotopes, and modes of analysis are listed in Table 3. Nd, Sm, Gd, and Dy were monitored for evaluating the doubly charged interferences on ⁷⁵As and ⁷⁸Se.

Table 3. Method Setup and Instrument Performance.

Analyte	Isotope	Cell Mode	Gas	Cell Flow (mL/min)	RPq	Internal Standard	R ²	ISO 17294-2 (LOQ) (µg/L)	This Method (LOQ) (µg/L)
Li	7	KED	He+H	3.6	0.25	Sc	1.0000	1	0.08
Be	9	KED	He+H	3.6	0.25	Sc	1.0000	0.1	0.003
B	11	KED	He+H	3.6	0.25	Sc	1.0000	1	0.4
Na	23	KED	He+H	4.8	0.25	Sc	1.0000	10	0.4
Mg	24	KED	He+H	4.8	0.25	Sc	1.0000	1	0.2
Al	27	KED	He+H	3.6	0.25	Sc	1.0000	1	0.08
P	31	KED	He+H	3.6	0.25	Sc	1.0000	5	1.9
K	39	KED	He+H	4.8	0.25	Sc	0.9999	5	4.3
Ca	44	KED	He+H	4.8	0.25	Sc	1.0000	50	4.4
Ti	47	KED	He+H	4.8	0.25	Sc	1.0000	1	0.02
V	51	KED	He+H	5.4	0.25	Sc	0.9998	0.1	0.07
Cr	52	KED	He+H	5.4	0.25	Rh	0.9996	0.1	0.03
Mn	55	KED	He+H	4.8	0.25	Sc	1.0000	0.1	0.02
Fe	56	KED	He+H	5.4	0.25	Sc	1.0000	5	0.3
Co	59	KED	He+H	4.8	0.25	Sc	1.0000	0.2	0.008
Ni	60	KED	He+H	4.8	0.25	Sc	1.0000	0.1	0.05
Cu	63	KED	He+H	4.8	0.25	In	1.0000	0.1	0.01
Zn	66	KED	He+H	4.8	0.25	In	1.0000	1	0.4
As	75	KED	He+H	4.8	0.25	Ir	1.0000	0.1	0.1
Se	78	DRC	He+H	12.0	0.45	Ir	0.9999	0.1	0.01
Rb	85	KED	He+H	4.8	0.25	In	0.9999	0.1	0.10
Sr	88	KED	He+H	4.8	0.25	In	0.9999	0.3	0.03
Mo	95	KED	He+H	4.8	0.25	Sc	0.9999	0.5	0.03
Ag	107	KED	He+H	3.6	0.25	Rh	1.0000	0.5	0.004
Cd	111	KED	He+H	3.6	0.25	Rh	1.0000	0.1	0.006
Sn	118	KED	He+H	3.6	0.25	In	1.0000	1	0.02
Sb	121	KED	He+H	3.6	0.25	In	1.0000	0.2	0.005
Te	125	KED	He+H	3.6	0.25	Rh	0.9995	2	0.2
Ba	138	KED	He+H	3.6	0.25	In	1.0000	3	0.02
W	182	KED	He+H	4.8	0.25	Ir	0.9998	0.3	0.004
Hg	201	KED	He+H	4.8	0.25	Ir	1.0000	0.05	0.004

Table 3. Method Setup and Instrument Performance continued...

Analyte	Isotope	Cell Mode	Gas	Cell Flow (mL/min)	RPq	Internal Standard	R ²	ISO 17294-2 (LOQ) (µg/L)	This Method (LOQ) (µg/L)
Tl	205	KED	He+H	4.8	0.25	Ir	1.0000	0.1	0.002
Pb*	208+207+206	KED	He+H	4.8	0.25	Ir	1.0000	0.1	0.006
Bi	209	KED	He+H	4.8	0.25	Ir	1.0000	0.5	0.01
Th	232	KED	He+H	4.8	0.25	Ir	1.0000	0.1	0.002
U	238	KED	He+H	4.8	0.25	Ir	1.0000	0.1	0.003
Nd	146	KED	He+H	4.8	0.25	In	--	--	--
Sm	147	KED	He+H	4.8	0.25	In	--	--	--
Gd	157	KED	He+H	4.8	0.25	In	--	--	--
Dy	163	KED	He+H	4.8	0.25	In	--	--	--

* Three Pb isotopes are measured and summed to address the natural abundance variation.

Results and Discussion

Limits of Quantification

Limits of quantification (LOQs) were calculated as 10 times the standard deviation of 10 replicated measurements of the blank. The LOQs of this method for all elements were well below the specifications from ISO 17294-2, as shown in Table 3.

Linearity

Calibration curves were plotted following internal standard correction and blank subtraction. A coefficient of correlation (R²) higher than 0.9995 was obtained for all elements in the calibrated ranges, as shown in Table 3.

Accuracy

The accuracy of the method was validated via the recoveries of the CRMs, with and without REEs spiking, and the standard spiked water samples.

Recoveries of CRMs

Each CRM sample was measured three times, and the mean concentration was calculated for each analyte. Recoveries between 90% and 110% were obtained for all certified analytes, as shown in Table 4. With the presence of 10 µg/L REEs, the recoveries for As and Se were comparable with those non-REE spiked samples. Note that the interferences from REEs may become significant at sufficiently high concentrations when correcting measures must be invoked for the affected samples.

Table 4. Recoveries for the Certified Elements in Water CRMs NIST1643f and TMDW-B-250 with and without REEs Spiking.

Element	NIST1643f			NIST1643f+REE		TMDW			TMDW+REE	
	Certified (µg/L)	Measured (µg/L)	Recovery (%)	Measured (µg/L)	Recovery (%)	Certified (µg/L)	Measured (µg/L)	Recovery (%)	Measured (µg/L)	Recovery (%)
Li	16.59	16.07	97	15.53	94	15	14.47	96	13.7	91
Be	13.67	13.42	98	12.57	92	15	14.42	96	13.7	91
B	152.3	139.5	92	139.6	92	150	140.8	94	136.8	91
Na	18,830	18,590	99	18,670	99	22,000	21,460	98	21,400	97
Mg	7,454	7,216	97	7,198	97	8,000	7,681	96	7,676	96
Al	133.8	133.9	100	132.7	99	125	122.2	98	121.1	97
K	1,933	1,873	97	1,876	97	2,500	2,427	97	2,457	98
Ca	29,430	27,870	95	27,800	94	31,000	29,650	96	29,640	96
V	36.07	34.39	95	34.3	95	35	33.31	95	33.79	97
Cr	18.5	16.97	92	16.9	91	20	18.41	92	18.16	91

Table 4. Recoveries for the Certified Elements in Water CRMs NIST1643f and TMDW-B-250 with and without REEs Spiking continued...

Element	NIST1643f			NIST1643f+REE		TMDW			TMDW+REE	
	Certified (µg/L)	Measured (µg/L)	Recovery (%)	Measured (µg/L)	Recovery (%)	Certified (µg/L)	Measured (µg/L)	Recovery (%)	Measured (µg/L)	Recovery (%)
Mn	37.14	37.98	102	37.84	102	40	40.75	102	41.27	103
Fe	93.44	92.53	99	92.61	99	90	88.9	99	89.94	100
Co	25.3	26.16	103	26.23	104	25	25.27	101	25.37	101
Ni	59.8	61.48	103	61.96	104	60	61.43	102	62.02	103
Cu	21.66	19.55	90	19.69	91	20	18.33	92	18.55	93
Zn	74.4	69.83	94	70.50	95	75	70.41	94	70.70	94
As	57.42	57.17	100	57.33	100	10	9.93	99	10.37	104
Se	11.7	10.83	93	11.13	95	11	9.99	91	10.33	94
Rb	12.64	12.89	102	13.31	105	--	--	--	--	--
Sr	314.0	307.2	98	309.6	99	300	290.3	97	292.4	97
Mo	115.3	123.6	107	125.5	109	110	118.4	108	121.4	110
Ag	0.970	0.910	94	0.910	94	2	1.80	90	1.800	90
Cd	5.89	5.81	99	5.80	99	10	9.98	100	10.08	101
Sb	55.45	55.04	99	55.27	100	55	54.93	100	55.00	100
Te	0.977	1.010	104	1.030	106	--	--	--	--	--
Ba	518.2	511.3	99	514.1	99	500	504.4	101	493.9	99
Tl	6.892	6.64	96	6.74	98	10	9.77	98	9.77	98
Pb	18.49	18.31	99	18.46	100	20	19.86	99	20.05	100
Bi	12.62	12.69	101	12.85	102	--	--	--	--	--

Standard Spike Recoveries

The spike recovery test was performed on two water samples, a tap water (TW) and a well water (WW). To perform this test, the unspiked water sample was measured six times, and the mean concentration of each analyte was used as the

subtrahend to calculate the spiked concentration. The mean concentrations of the unspiked and the spiked samples and spike recoveries are listed in Table 5. Recoveries between 90% and 110% were obtained for all spiked standards, further validating the accuracy of the analysis of the trace elements that were not certified by the CRMs.

Table 5. Spike Recovery Results.

Element	Spike Concentration (µg/L)	TW Concentration (µg/L)	TW + Spike Concentration (µg/L)	TW Spike Recovery (%)	WW Concentration (µg/L)	WW + Spike Concentration (µg/L)	WW Spike Recovery (%)
Li	200	1.57	197.3	98	3.15	194.9	96
Be	10	< LOQ	10.52	105	< LOQ	10.20	102
B	100	20.43	117.2	97	8.32	104.7	96
Na	10,000	15,740	25,850	101	19,170	28,920	98
Mg	2,000	7,591	9,442	93	17,090	19,120	102
Al	10	21.01	31.85	108	0.407	10.11	97
P	23,000	147.0	22,030	95	1.226	21,570	94
K	2,000	1,507	3,452	97	1,098	3,016	96
Ca	10,000	28,030	37,130	91	69,330	79,280	99
Ti	10	< LOQ	10.01	100	< LOQ	9.742	97

Table 5. Spike Recovery Results continued...

Element	Spike Concentration (µg/L)	TW Concentration (µg/L)	TW + Spike Concentration (µg/L)	TW Spike Recovery (%)	WW Concentration (µg/L)	WW + Spike Concentration (µg/L)	WW Spike Recovery (%)
V	10	< LOQ	9.672	97	0.219	9.554	93
Cr	10	0.079	9.292	92	0.207	9.447	92
Mn	10	0.223	10.22	100	0.465	10.25	98
Fe	200	6.44	199.6	97	9.98	197.1	94
Co	10	0.011	10.21	102	0.039	9.921	99
Ni	10	0.493	10.73	102	0.430	10.29	99
Cu	10	22.88	32.26	94	11.51	21.17	97
Zn	10	0.923	11.57	106	54.26	64.15	99
As	10	0.499	11.03	105	0.043	10.65	106
Se	10	0.125	10.72	106	0.136	10.89	108
Rb	10	0.93	10.65	97	0.75	10.63	99
Sr	200	150.5	340.8	95	191.9	383.3	96
Mo	10	1.10	11.54	104	0.096	10.48	104
Ag	10	< LOQ	9.874	99	< LOQ	9.584	96
Cd	10	< LOQ	10.35	103	< LOQ	10.18	102
Sn	10	< LOQ	9.916	99	< LOQ	9.792	98
Sb	10	0.13	10.63	105	0.012	10.17	102
Te	10	< LOQ	11.71	117	< LOQ	10.30	103
Ba	200	17.78	220.7	101	28.85	229.5	100
W	10	0.062	10.09	100	< LOQ	10.00	100
Hg	0.2	< LOQ	0.202	100	< LOQ	0.193	96
Tl	10	< LOQ	10.15	101	< LOQ	9.909	99
Pb	10	0.010	10.11	101	0.144	9.939	98
Bi	10	< LOQ	10.29	103	< LOQ	9.844	98
Th	20	0.023	19.76	99	0.006	19.47	97
U	10	0.302	10.15	98	0.311	9.897	96

Stability

To assess the long-term stability, a variety of drinking water samples, including tap water, local well water and bottled pure and spring waters, were analyzed repeatedly over an extended period of 12 hours and the CCV recoveries and the internal standards were monitored.

CCV Recovery: The CCV recoveries were normalized to Standard 3 (Table 1). The recoveries for all the analytes were within $\pm 10\%$ of the original reading, as shown in Figure 1, and there was no apparent trending through the runs, which demonstrates the validity of the calibration over the 12-hour sample run. This performance is important for high-throughput laboratories in terms of overall efficiency and productivity by avoiding the frequent reruns of the calibration standards.

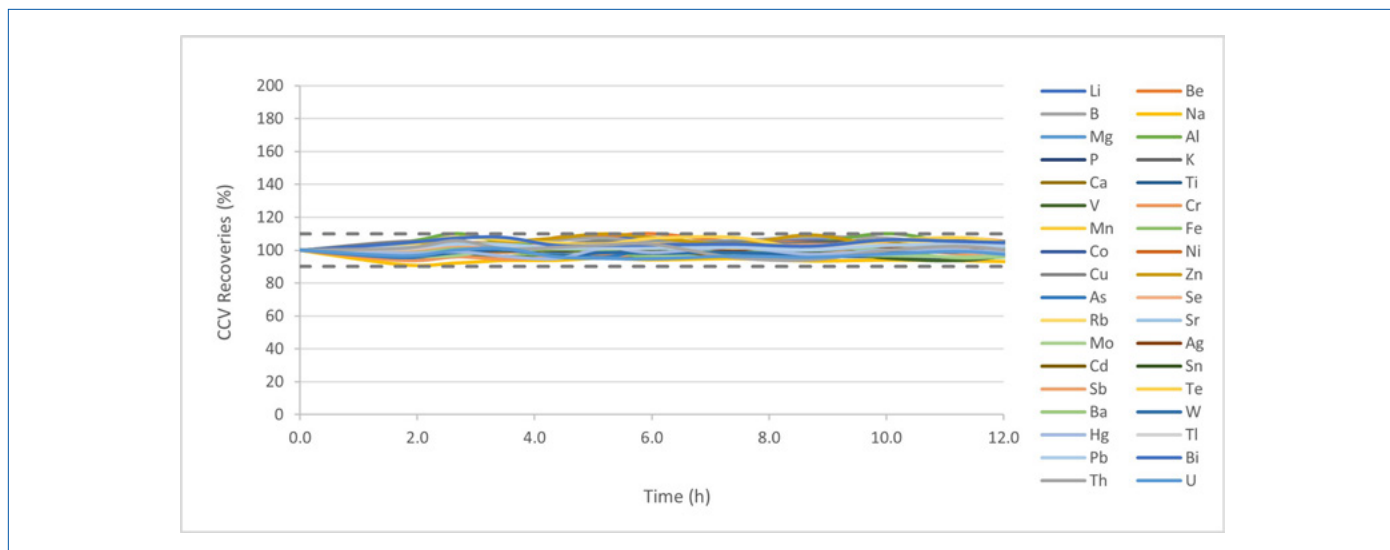


Figure 1. CCV recoveries over a 12-hour period of analysis of a variety of drinking water samples.

Internal Standard Recovery: The internal standards (IS) were normalized to the calibration blank, and the time resolved plot was shown in Figure 2. The overall IS recoveries were within the 80% - 120% range, demonstrating the outstanding stability and robustness of this method and system as well as their suitability for extended sample runs.

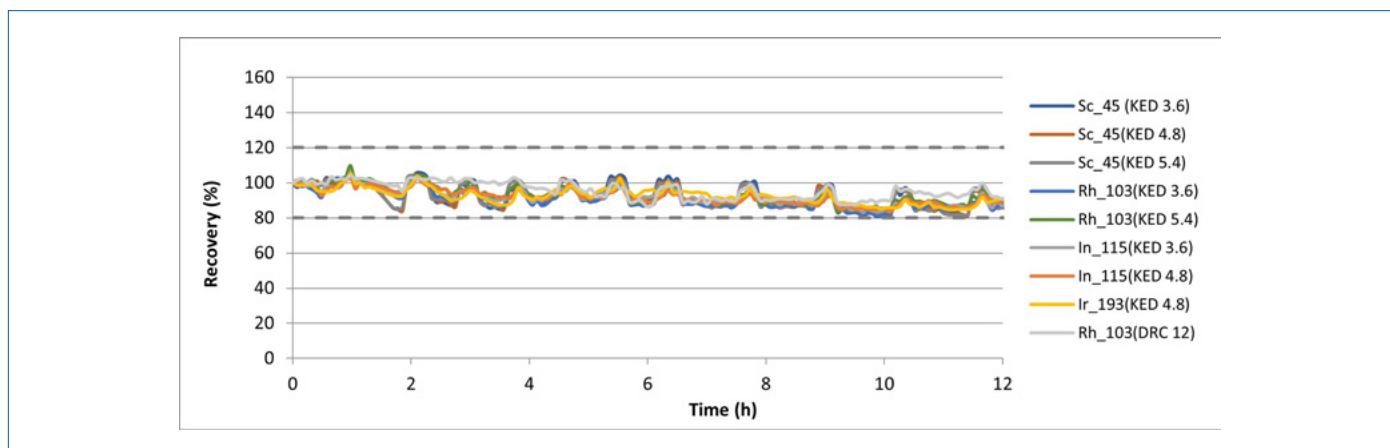


Figure 2. Internal standard recoveries (normalized to the calibration blank) during a 12-hour sequence of analysis of a variety of drinking water samples. The numbers in parentheses represent the gas flow rate in mL/min.

Conclusion

The NexION 1100 ICP-MS was used for the analysis of a variety of drinking water samples in accordance with ISO 17294-2:2023. Compared to its prior generation, the Universal Cell of the NexION 1100 ICP-MS allows a higher cell gas flow, which was leveraged to tackle the interference of the argon dimer on the analysis of Se. With the premixed 7% hydrogen-helium gas as the cell gas, ^{76}Se was measured in Reaction (DRC) mode and the rest of the elements were measured in Collision (KED) mode.

The limits of quantification (LOQs) of all elements achieved in this work were lower than recommended in ISO 17294-2. The accuracy was validated by recoveries of drinking water CRMs with and without REEs spiking and the standard spiked water samples. Recoveries within $\pm 10\%$ were achieved for all the target elements in each category. The stability was validated by the consistent recoveries of the internal standards and the CCVs over a 12-hour run of a variety of water samples.

This work demonstrated that the NexION 1100 ICP-MS has the capability to meet and/or exceed the specifications recommended by the ISO 17294-2:2023 for the analysis of drinking water.

References

1. ISO 17294-1:2004 Water quality - Application of inductively coupled plasma mass spectrometry (ICP-MS)-Part 1: General guidelines.
2. ISO 17294-2:2023 Water quality - Application of inductively coupled plasma mass spectrometry (ICP-MS)-Part 2: Determination of selected elements including uranium isotopes.
3. NexION® Software Guide, PerkinElmer.

Consumables Used

Part A: Instrument Components


Component	Description	Part Number
Nebulizer	Concentric Type CT Q + Quartz Nebulizer	N8152372
Nebulizer line	ST Nebulizer line, 0.25 mm i.d.	N0812026
Spray Chamber	Cyclonic High-Sensitivity Quartz Spray Chamber with Matrix Gas Port	N8152383
Torch	One-Piece Quartz Torch with 2.0 mm Injector	N8152472
Cones	Ni Sampler Cone Ni Skimmer Cone (0.9 mm) Al Hyper-Skimmer Cone	W1033612 W1026356 W1033995
Peripump Tubing	Carrier/Internal Standard: Orange/Green (0.38 mm i.d.) Waste: Gray/Gray Santoprene (1.30 mm i.d.)	N8152403 N8152415
Internal Standard Probe Carrier Sample Probe	Carbon Fiber Autosampler Probe for ST Nebulizers	N0777225
Autosampler Probe used with HTS	Carbon Probe 1.0 mm i.d. 2 Blue Bands	N0811956
HTS Sample Loop	Sample Loop 1.5 mL; 1.0 mm i.d.	N0777665
Tubes for Calibration and QC Solutions	50 mL Graduated Conical Bottom MetalFree Tubes with White Flat Caps, Qty. 500 – Racked	N0776116
Tubes for Sample Solutions	15 mL Graduated Conical Bottom MetalFree Tubes with White Flat Caps, Qty. 500 – Racked	N0776118

Part B: Stock Standards

Standard ID	Description	Part Number
Multi-Element Standard 1	10 µg/mL of Ag, Al, As, Be, Bi, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Rb, Sb, Se, Sn, Te, Tl, U, V, W and Zn in 5% HNO ₃ /Trace Tartaric Acid/Trace HF	N8145600
Multi-Element Standard 2	5000 µg/mL of Ca and Na 1000 µg/mL of K and Mg 100 µg/mL of Ba, Fe, Li, and Sr 10 µg/mL of Th in 5% HNO ₃	N8145601
Multi-Element Standard 3	500 µg/mL of P, S in H ₂ O	N8145602
Internal Standard Mix	200 µg/mL of Sc 10 µg/mL of In, Rh and Ir in 5% HNO ₃ /Trace HCl	N9307738
Single-Element Standards	1000 µg/mL B in H ₂ O	N9303760
	1000 µg/mL Hg in 10% HNO ₃	N9303740
	1000 µg/mL Au in 10% HCl	N9303759
	1000 µg/mL Ti in H ₂ O/Tr. HF	N9303754*

* The standards listed in Part B are included in PerkinElmer's TruQ MS Calibration Std Kit ISO 17294 (Part Number N8140581) except for Ti. Ti is added to address the specification of the 3rd edition of ISO 17294-2: 2023.

Part C: Calibration Preparation Scheme (For Information Only)

TruQ MS Calibration Std Kit ISO 17294		Working Calibration Standards						
Part Number N8140581		Calib Blank	Std 1	Std 2	Std 3	Std 4	Std 5	Std 6
Part Number	Elements				CCV			
Intermediate Dilution	Concentration of Stock Solution	Aliquot in mL						
Mix 1 N8145600 undiluted	Ag, Al, As, Be, Bi, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Rb, Sb, Se, Sn, Te, Tl, U, V, W, Zn 10 mg/L		4 mL of Std 2	4 mL of Std 3	4 mL of Std 6	0.080	0.200	0.400
Mix 2 N8145601 undiluted	Ca, Na - 5000 mg/L K, Mg - 1000 mg/L Ba, Fe, Li, Sr - 100 mg/L Th - 10 mg/L					0.080	0.200	0.400
Mix 3 N8145602 undiluted	P, S - 500 mg/L					0.400	1.000	2.000
Mix 4 N9307742 1:10	B - 100 mg/L					0.080	0.200	0.400
Hg N9303740 1:1000	Hg - 1 mg/L					0.016	0.040	0.080
Final Volume in mL								
Diluent 2% HNO ₃ (v/v), 0.5% HCl (v/v) 200 µg/L Au (N9303759)	40	40	40	40	40	40	40	40
50 mL Graduated MetalFree Tubes N0776116	Final Concentration in µg/L							
Ag, Al, As, Be, Bi, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Rb, Sb, Se, Sn, Te, Tl, U, V, W, Zn	0	0.1	1	10	20	50	100	
Ca, Na	0	50	500	5,000	10,000	25,000	50,000	
K, Mg	0	10	100	1,000	2,000	5,000	10,000	
Ba, Fe, Li, Sr	0	1	10	100	200	500	1,000	
Th	0	0.1	1	10	20	50	100	
P, S	0	25.0	250	2,500	5,000	12,500	25,000	
B	0	1	10	100	200	500	1,000	
Hg	0	0.002	0.020	0.200	0.400	1.000	2.000	