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Application News

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Inductively Coupled Plasma Mass Spectrometry

Analysis of Tap Water and Drinking Water by ICPMS-2030

Introduction

The normal daily water consumption of adults is thought to be around 2 liters, almost all of which consist of drinking water such as tap water or mineral water. Each country has regulations that require testing of the safety and condition of drinking water. Items tested for include high concentration elements such as sodium and calcium that are present at 10 mg/L or higher, and trace elements such as arsenic and lead that are present at 10 µg/L or lower. Consequently, analytical instruments are required to perform a wide range of measurements with high sensitivity, where it is preferred the items to be tested are done so simultaneously. We describe using Shimadzu's ICPMS-2030 inductively coupled plasma mass spectrometer to analyze tap water and mineral water.

Sample

- Tap water (Kanagawa Prefecture, Kyoto Prefecture)
- Commercial mineral water

Sample Preparation

A water sample (100 mL) was placed in a fluororesin beaker, to which high purity nitric acid (1 mL) was added. The beaker was heated for approximately two hours on a hot plate covered with a watch glass at a temperature just below boiling. After leaving it to cool to room temperature, it was transferred to a plastic container, made up to 100 mL with ultrapure water, and used for analysis.
The elements to be measured were also added to tap water from Kanagawa Prefecture to create a spike-and-recovery test solution. For elements present in high concentration, dilution test solutions were prepared by diluting 10-fold with 1 % nitric acid solution.
Calibration curve samples were prepared by diluting and mixing appropriate amounts of mixed standard solution and single element standard solution (1000 mg/L). Calibration curve samples were prepared so their acid concentration was equivalent to that present in samples used for analysis.

Instrument and Analytical Conditions

Shimadzu's ICPMS-2030 inductively coupled plasma mass spectrometer was used for analysis. Analytical conditions are shown in Table 1. In addition to being highly sensitive, the ICPMS-2030 uses a helium gas collision system that greatly reduces the spectral interference caused by argon and chlorine. Use of Eco mode and a mini-torch also reduces argon gas consumption compared to previous ICP-MS systems, and greatly reduces running costs.

Analysis

Parameters in Japanese water quality standards, water quality targets, and water quality items for consideration were analyzed simultaneously by the calibration curve method. Internal standard elements (Be, Co, Ga, Y, In, Tl) were each added to samples at a concentration of 5 µg/L.

Analytical Results

Table 2 shows the results of tap water and mineral water analysis. The results show that good spike and recovery and dilution test results were obtained with little interference.

Discussion

Removal of Spectral Interference

The sensitivity of ICP-MS is reduced by spectral interferences arising from polyatomic ions and errors in results are found. For water quality analysis, these polyatomic ions include $^{40}Ar^{16}O$ that interferes with measurement of ^{56}Fe, $^{40}Ar^{35}Cl$ that interferes with measurement of ^{75}As, and $^{40}Ar^{38}Ar$ that interferes with measurement of ^{78}Se. This kind of interference is removed, however, by using a helium gas collision system.

Measurement of High Concentration Elements

Measuring elements present at high concentrations reduces the lifespan of detectors. Deterioration of detectors can be lessened with a collision system that reduces the high concentration element count.
Using high temperature plasma also results in good ionization efficiency for even high concentration analytes, providing good linearity.
Fig. 1 shows the calibration curves for sodium and calcium. Good linearity was obtained up to Ca 100 mg/L and Na 200 mg/L, and alkali and alkaline-earth elements were measured with good accuracy simultaneous to the measurement of other trace elements.

[References]

- Ministerial ordinance on water quality standards (Ministry of Health, Labour and Welfare ordinance No. 101, May 30, 2003; Revised by Ministry of Health, Labour and Welfare ordinance No. 15, February 28, 2014) [In Japanese]
- Methods determined by Minister of Health, Labour and Welfare based on regulations of the ministerial ordinance on water quality standards (Ministry of Health, Labour and Welfare notification No. 261, July 22, 2003; Revised by Ministry of Health, Labour and Welfare notification No. 56, March 12, 2015) [In Japanese]

Table 1 Analytical Conditions

Instrument	: ICPMS-2030
High-frequency output	: 1.2 kW
Plasma gas flowrate	: 8.0 L/min
Auxiliary gas flowrate	: 1.1 L/min
Carrier gas flowrate	: 0.70 L/min
Sampling depth	: 6.0 mm
Sample introduction	: Nebulizer 10
Pump rotation speed	: 15 rpm
Chamber	: Cyclone chamber (electronic cooling)
Plasma torch	: Mini-torch
Sampling cone/Skimmer	: Copper

Table 2 Tap Water and Mineral Water Quantitative Results

Element	Reference Value		Detection Limit	Kanagawa Tap Water		Kyoto Tap Water	Mineral Water
	Units (μg/L)			Quantitative Results	Spike and Recovery (%)		
As	10	Water quality standard	0.006	0.12	104	0.30	6.64
B	1000	Water quality standard	0.05	15.9	103	15.1	46.6
Cd	3	Water quality standard	0.001	0.003	104	0.013	N.D.
Cr	50	Water quality standard	0.003	0.61	106	0.031	0.011
Cu	1000	Water quality standard	0.02	2.63	103	2.18	N.D.
Fe	300	Water quality standard	0.04	8.7	103	28.0	0.004
Pb	10	Water quality standard	0.0005	0.089	105	0.67	N.D.
Se	10	Water quality standard	0.06	N.D.	103	N.D.	N.D.
Zn	1000	Water quality standard	0.003	4.7	99	108	0.026
Al	200 (100)	Water quality standard (target)	0.005	11.2	103	16.0	1.28
Mn	50 (10)	Water quality standard (target)	0.003	0.11	104	1.16	N.D.
Ni	20	Water quality target	0.006	2.56	102	1.29	N.D.
Sb	20	Water quality target	0.001	0.010	102	0.116	1.25
U	2	Water quality target	0.00005	0.0163	108	0.0003	0.77
Mo	70	Water quality consideration	0.003	1.10	92	1.44	1.44
	Units (mg/L)				Dilution Test Result (%)		
Na	200	Water quality standard	-	5.5	108	10.6	10.0
Ca	10～100	Water quality standard (target)	-	19.8	91	12.5	72.3
Mg	10～100	Water quality standard (target)	-	6.4	91	2.04	24.2
K			-	0.67	91	1.55	5.78

* N.D.: Not detected
* Spike and recovery (%) = { (Quantitative result for spiked sample - Quantitative result for sample) / Spiked concentration} × 100
* Dilution test result (%) = Quantitative result for sample × 100 / (Quantitative result for 10-fold dilution sample × Dilution ratio)

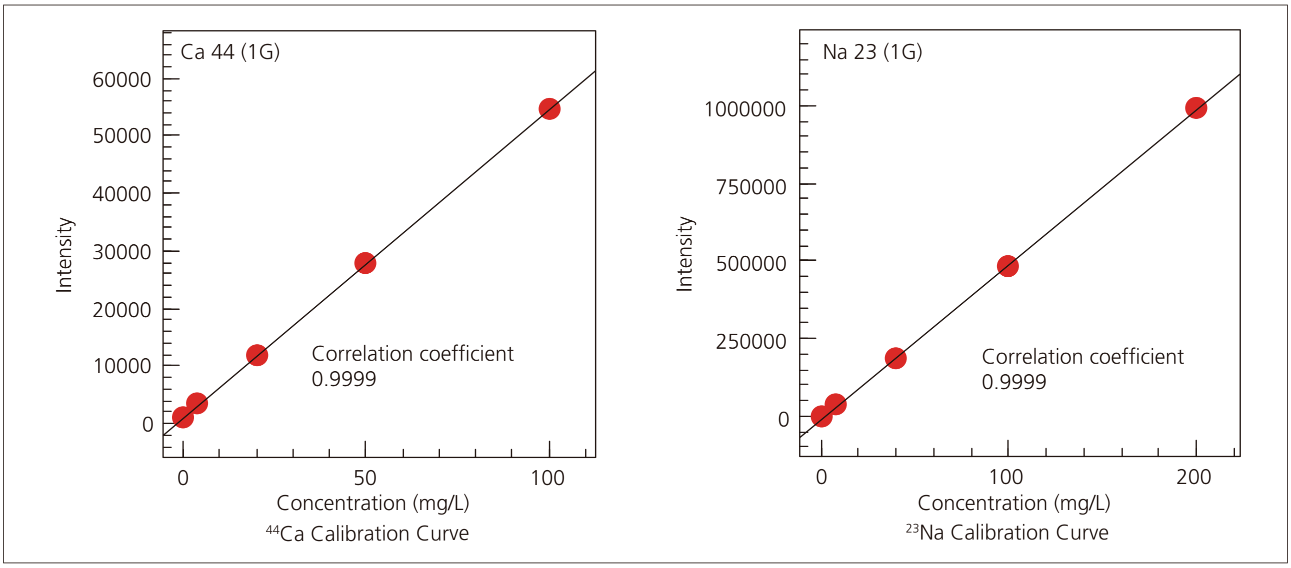

Fig. 1 Calibration Curves for ^{44}Ca and ^{23}Na

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