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Application News

No.J104

Inductively Coupled Plasma Atomic Emission Spectrometry

Analysis of Multiple Elements in Drinking Water by ICPE-9820

Introduction

The amount of water typically consumed by an adult is said to be about two liters per day, and nearly all of this is tap water or mineral water, generally referred to as "drinking water." Conducting safety inspections are the responsibility of each country according to their respective regulations. Typically, there are many target elements included in the test, such as sodium (Na), calcium (Ca), etc. which are present at the mg/L level or greater, and toxic trace elements such as lead (Pb) and cadmium (Cd), which are normally present at the µg/L level or less.

Here, using the Shimadzu ICPE-9820 multi-type ICP atomic emission spectrometer and an ultrasonic nebulizer, we conducted analysis of river water, typically the source of tap water.

The ICPE-9820, with its auto-switching of axial/radial viewing which permits total overall measurement from trace to high concentrations, in addition to the newest CCD detector which allows acquisition of all elements over the entire wavelength region, greatly improves analysis throughput for multiple elements and multiple samples. Moreover, as a system designed to reduce running costs, it increases lab productivity.

Sample

The river water certified reference materials JSAC 0301-1 (unspiked), 0302 (spiked) (Japan Society for Analytical Chemistry certification) were used as the samples.

Sample Preparation

5 mL of nitric acid was added to 50 mL of test water, and the mixture was then heated to complete dissolution. After cooling, the internal standard element Y (yttrium) was added to obtain a concentration of 0.5 mg/L, and the test solution volume was adjusted to 50 mL.

Instrument and Analytical Conditions

For measurement, the Shimadzu ICPE-9820 multi-type ICP atomic emission spectrometer and UAG-1 ultrasonic nebulizer were used. The measurement conditions are shown in Table 1.

Table 1 Analytical Conditions

Instrument	:ICPE-9820
Radio frequency power	:1.2 kW 1.0 kW (UAG-1)
Plasma gas Flowrate	:10 L/min
Auxiliary gas Flowrate	:0.6 L/min
Carrier gas Flowrate	:0.7 L/min
Sample introduction	:Nebulizer 10 Ultrasonic Nebulizer (UAG-1)
Misting chamber	:Cyclone chamber
Plasma torch	:Mini Torch
Observation	:Axial (AX) / Radial (RD)

With its echelle spectrometer and CCD detector, ICPE-9820 permits simultaneous analysis of all elements, at all wavelengths, and high-throughput analysis is possible even when there are many target elements and samples.

Also, thanks to the automatic switching between axial viewing (AX) for high sensitivity, and radial viewing (RD) for high-concentration analysis, simultaneous analysis of both trace- and high-concentration elements is possible using the same solution, without conducting dilution.

Example) In the measurement of high-concentration Na using the axial view, the sample must be diluted because a linear calibration curve cannot be obtained. On the other hand, using the radial view, good linearity can be obtained up to the high-concentration region, permitting analysis to be conducted without dilution. Fig. 1 shows the calibration curve for Na (maximum 200 mg/L = water quality standard value for drinking water).

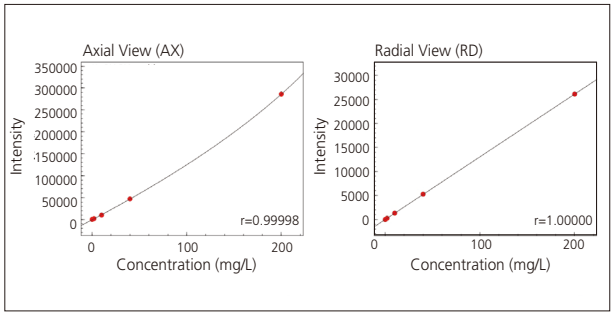

Fig. 1 Calibration Curves for Na 588.592 nm Using Axial View and Radial View (Maximum Concentration 200 mg/L)

In addition, the mini-torch which limits Ar gas consumption, the Eco mode which keeps standby gas and electrical power consumption to a minimum, in addition to the use of a vacuum-type spectrometer which eliminates the need for purge gas, all serve to significantly reduce running costs compared to existing ICP instruments.

Analysis

We conducted quantitative analysis using the calibration curve – internal standard method. For measurement of B, K, Na, Ca, and Mg, the Nebulizer 10 was used, and for sample introduction of other trace elements, the ultrasonic nebulizer UAG-1 was used.

[References]

1) National Primary Drinking Water Regulations: US-EPA (2012)
2) Guidelines for Drinking-Water Quality – 4th ed. ©WHO2011

Analytical Results

Table 2 shows the analytical results. In addition, the drinking water maximum limit (MCL) according to the US-EPA, and the drinking water guideline values according to WHO are also shown. Fig. 2 shows the spectral profiles of Cd, Cr, and Pb. As for the quantitation values, good results matching the guaranteed values were obtained, even at trace concentrations. Regarding the detection limits, all of the elements were detected at less than 1/10 the limit values and guideline values, indicating excellent sensitivity.

Conclusion

The ICPE-9820 can be used for accurate, low-cost measurement of the many elements in drinking water, from those present at trace levels to those at high concentrations.

Table 2 Analytical Results for River Water

Element	EPA Drinking Water Maximum Limit	WHO Drinking Water Guideline Value	Detection Limit	Introduction Method	Sample: JSAC0301-1		Sample: JSAC0302	
					Quantitation Value	Certified Value	Quantitation Value	Certified Value
Unit (µg/L)								
Al	200		0.1	UAG	19.8	19.0 ± 0.9	66.3	67 ± 1
B		2400	0.2	STD	8.8	8.6 ± 0.3	59.6	59 ± 1
Ba	2000	700	0.002	UAG	0.62	0.60 ± 0.02	0.60	0.60 ± 0.01
Be	4		0.004	UAG	<		0.98	0.99 ± 0.04
Cd	5	3	0.02	UAG	<	0.002 ± 0.0007	1.02	1.01 ± 0.01
Cr^{6+}	100	50	0.04	UAG	0.2	0.15 ± 0.01	10.2	10.1 ± 0.2
Cu	1300	2000	0.1	UAG	0.6	0.57 ± 0.07	10.4	10.3 ± 0.2
Fe	300		0.02	UAG	4.9	4.7 ± 0.3	56.3	56 ± 1
Mn	50*		0.006	UAG	0.12	0.125 ± 0.007	5.1	5.0 ± 0.1
Mo		70	0.1	UAG	0.4	0.38 ± 0.01	0.4	0.38 ± 0.01
Ni		20	0.05	UAG	<		10.1	9.9 ± 0.2
Pb	15	10	0.3	UAG	<	0.005 (Reference value)	10.2	10.1 ± 0.2
Zn	5000*		0.04	UAG	0.2	0.19 ± 0.03	10.1	10.2 ± 0.3
Unit (mg/L)								
K			0.001	STD	0.56	0.57 ± 0.02	0.58	0.57 ± 0.01
Na			0.0005	STD	4.35	4.4 ± 0.1	4.35	4.33 ± 0.07
Mg			0.00001	STD	2.82	2.85 ± 0.04	2.84	2.83 ± 0.03
Ca	250*		0.00001	STD	12.2	12.0 ± 0.2	12.3	12.2 ± 0.2

Cr^{6+}: Measured as total chromium
EPA Drinking Water Standard: EPA Maximum Contaminant Levels of Drinking Water Contaminant
*: National Secondary Drinking Water Regulations
WHO Drinking Water Guidelines: Guidelines for Drinking-Water Quality - 4th ed. ©WHO 2011
Detection Limit: 10 repeat measurements of calibration curve blank are conducted, and 3 times the concentration of the standard deviation is obtained.
<: Below the detection limit
UAG: Ultrasonic nebulizer (UAG-1), STD: Nebulizer 10

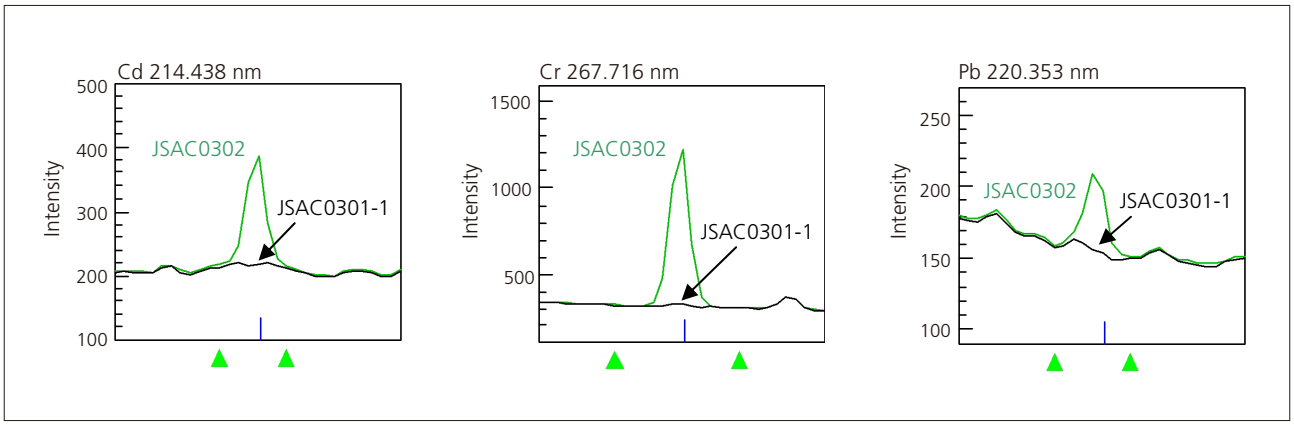

Fig. 2 Spectral Profiles of River Water

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