

# **EPA Method 200.8 and 6020B - Performance Comparison of Elemental Analysis with Advanced ICP-MS Technology -**

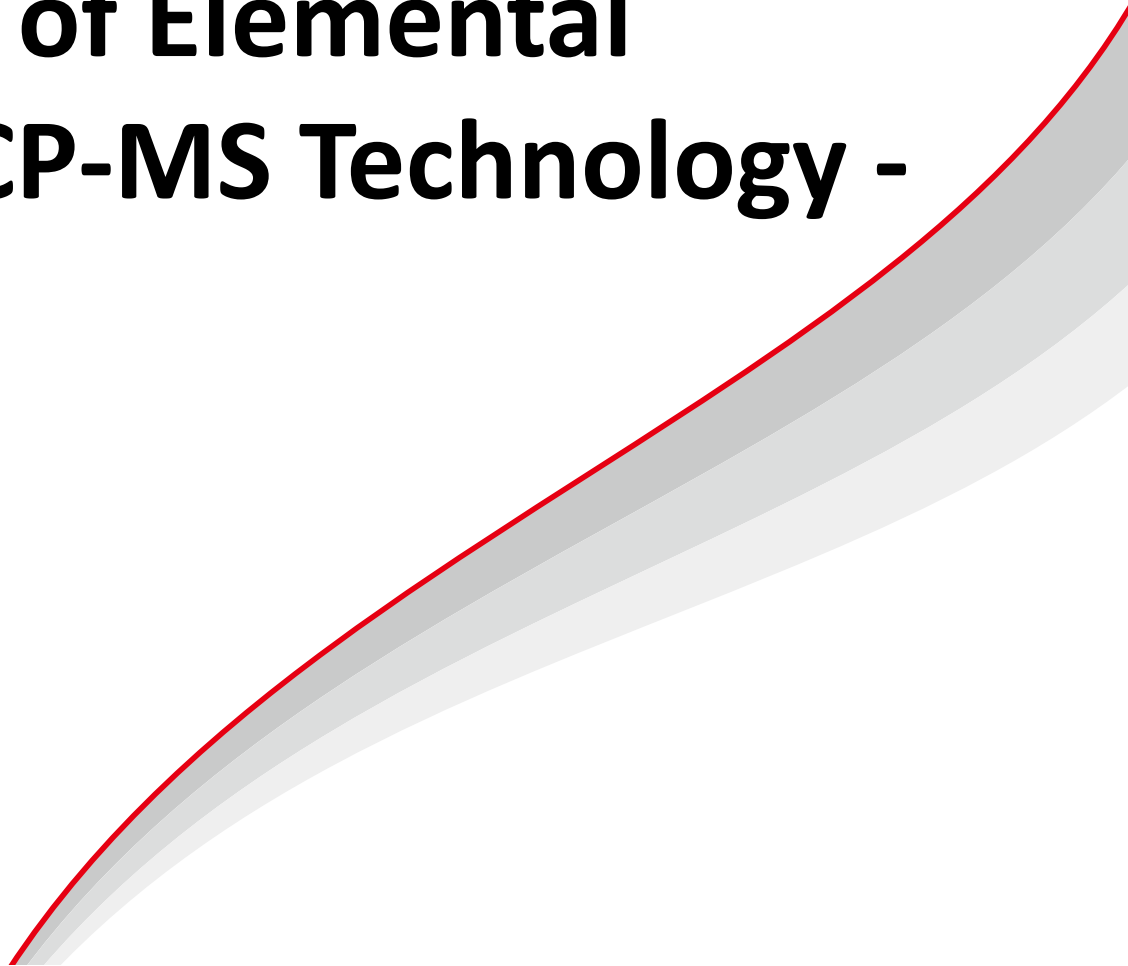
August 2025

**Yujing Jiang**

Shimadzu Corporation

Analytical & Measuring Instruments Division

Solutions COE



# Today's Presentation

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- **Background**

- Introduction of ICP-MS and U. S. Environmental Protection Agency (EPA) methods of water analysis

- **Advanced ICP-MS Technologies & Optimized Analytical Conditions**

- **Results of EPA Method 200.8 and 6020B**

- Quality control (QC) requirements in EPA method and experimental data

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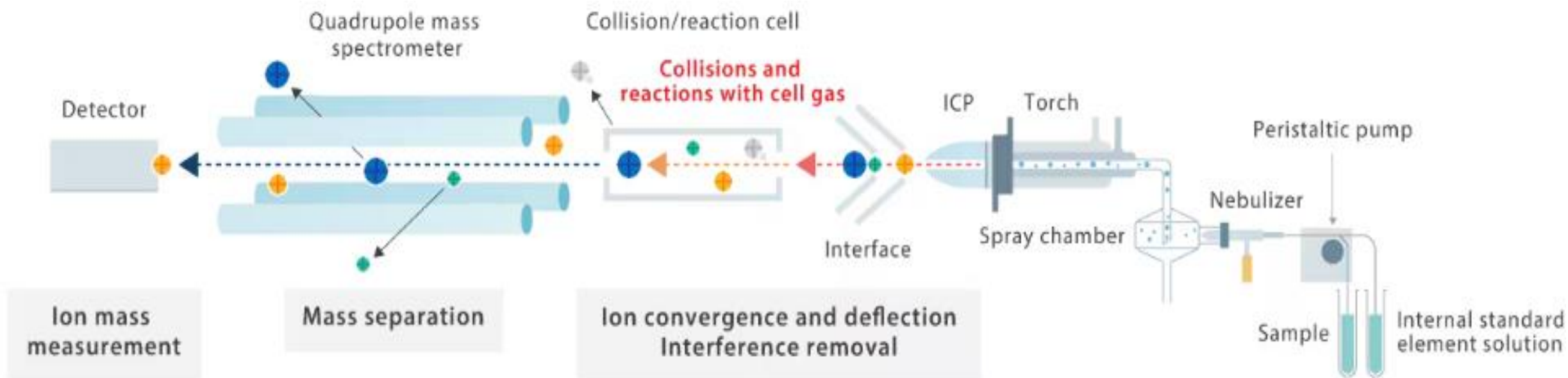
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# What is ICP-MS

ICP-MS is the instrument for **elemental analysis**

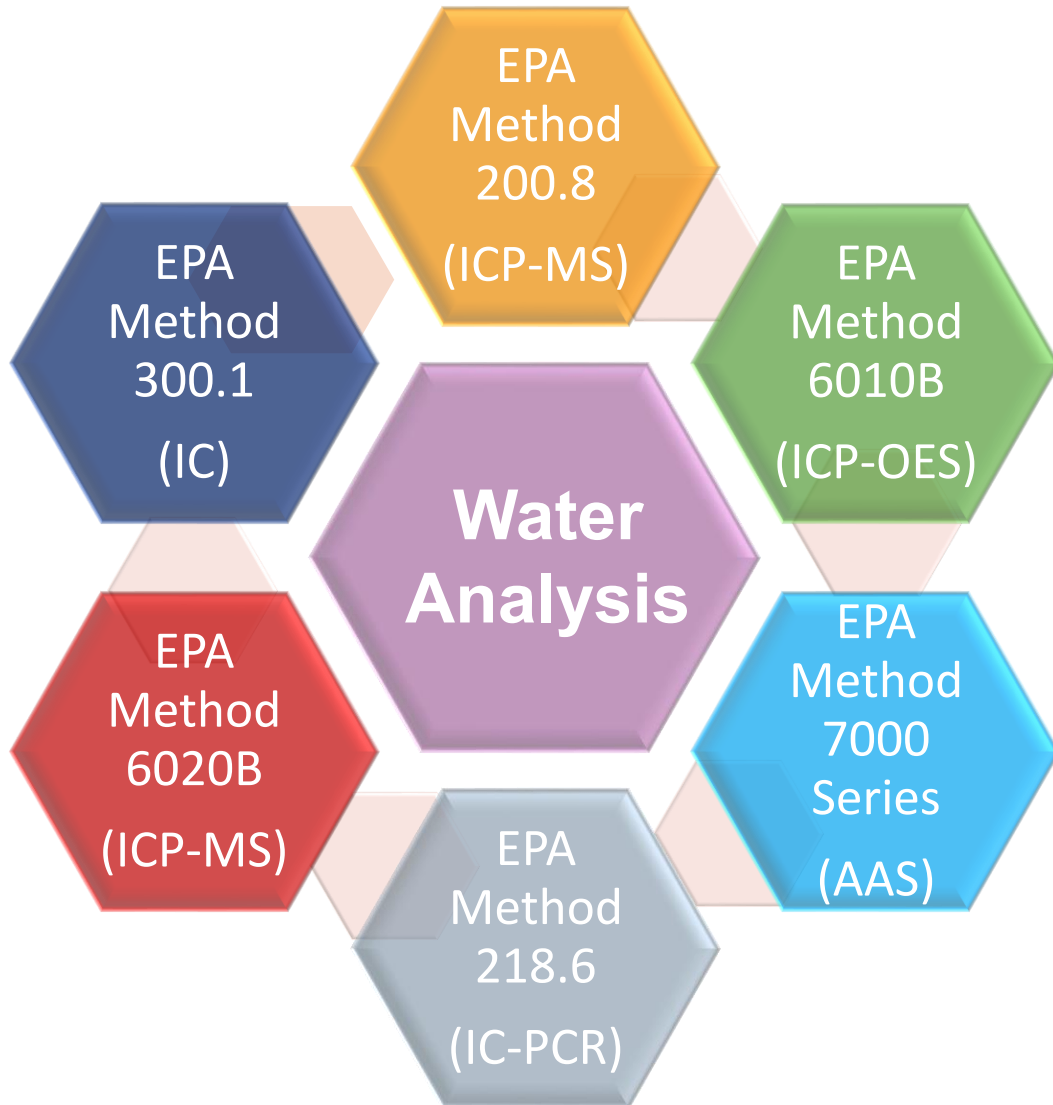
|     |    |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|-----|----|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1   | 2  | 3   | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| H   |    |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    | He |
| Li  | Be |     |    |    |    |    |    |    |    |    |    | B  | C  | N  | O  | F  | Ne |
| Na  | Mg |     |    |    |    |    |    |    |    |    |    | Al | Si | P  | S  | Cl | Ar |
| K   | Ca | Sc  | Ti | V  | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br | Kr |
| Rb  | Sr | Y   | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I  | Xe |
| Cs  | Ba | *L  | Hf | Ta | W  | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn |
| Fr  | Ra | **A |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| *L  | La | Ce  | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |    |    |
| **A | Ac | Th  | Pa | U  | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr |    |    |

# What is ICP-MS



ICP-MS is an analytical technique that measures the concentrations of elements and their isotopes by ionizing samples with high-temperature Ar plasma and using a mass spectrometer to analyze the ions based on their mass-to-charge ratio ( $m/z$ ).

# Elemental analysis of water in EPA method



- **Purpose of water analysis:**

Water quality assessment, environmental monitoring, and regulatory compliance

- **Analysis methods:**

Key methods include Atomic Absorption Spectrometer (AAS), ICP-OES, ICP-MS, and Ion Chromatography (IC).

- **Target:**

The elemental analysis of water typically measures the following metals and non-metals.

Metals: As, Ba, Cd, Cr, Cu, Hg, Pb, Sb, Se, U, etc.

Non-metals:  $\text{ClO}_2$ ,  $\text{ClO}_3$ ,  $\text{NO}_2\text{-N}$ ,  $\text{NO}_3\text{-N}$ , etc.

# EPA method 200.8 & 6020B

|          |                      | EPA Method 200.8                                                                                                                                       | EPA Method 6020B                                                                                                                                                             |
|----------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Outline  |                      | Determination of <u>trace elements</u> in waters and wastes by ICP-MS.                                                                                 | Focus on a <u>broader range of elements</u> and is designed for more complex matrices.                                                                                       |
| Analytes |                      | Applies to the determination of the <u>21 listed elements</u> in ground water, surface waters, and drinking water ( <u>→Drinking water analysis</u> ). | Applies to the determination of the <u>23 listed elements</u> in groundwater, aqueous samples, industrial wastes, soils, sludges, sediments ( <u>→Wastewater analysis</u> ). |
| QC       | Precision & Accuracy | 70~130% of spike recovery                                                                                                                              | 75 ~ 125% of the recovery and 20% of the %RPD                                                                                                                                |
|          | Long-term stability  | 60 ~ 125% of internal standard recovery<br>90 ~110% of CCV fluctuation                                                                                 | internal standard recoveries within 70 ~ 130%<br>90 ~110% of CCV fluctuation                                                                                                 |

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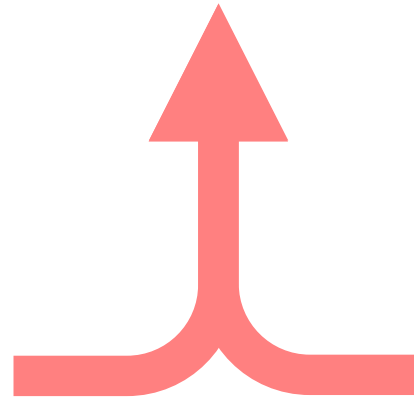


# Instrument Configuration -Plasma Condition-

## • Drinking water

|                  |                            |
|------------------|----------------------------|
| Instrument       | Shimadzu ICPMS-2040 / 2050 |
| Nebulizer        | Nebulizer DC04             |
| Chamber          | Cyclone Chamber            |
| Torch            | Mini-Torch                 |
| Skimmer Cone     | Nickel                     |
| Autosampler      | AS-20                      |
| RF               | 1.20 kW                    |
| Sampling Depth   | 5.0 mm                     |
| Plasma Gas       | 9.0 L/min                  |
| Auxiliary Gas    | 1.10 L/min                 |
| Carrier Gas      | 0.45 L/min                 |
| Dilution Gas     | 0.40 L/min                 |
| Peristaltic Pump | 15 r.p.m.                  |

**Low Running Costs**



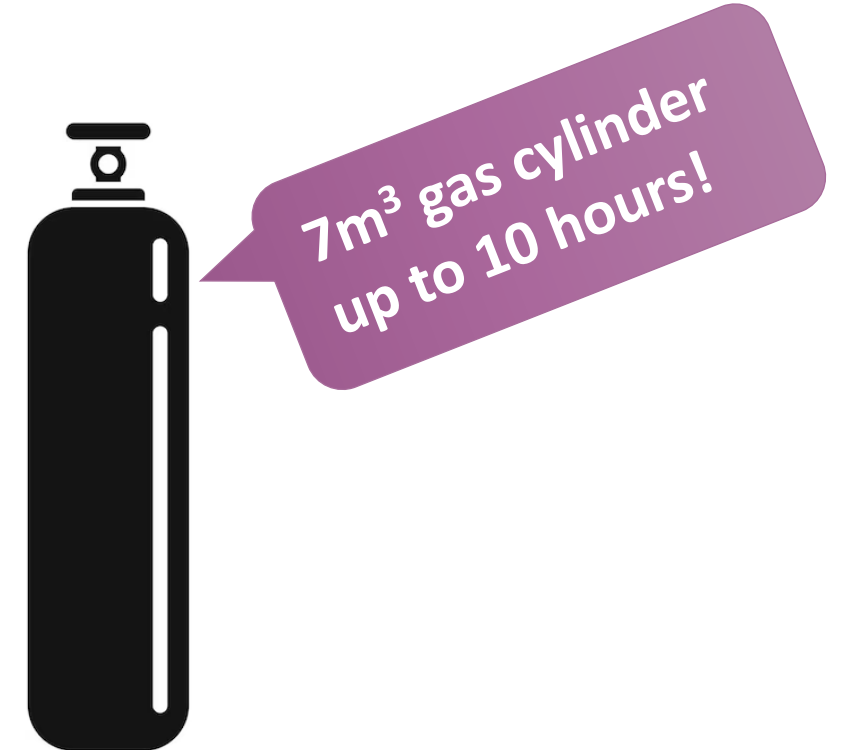
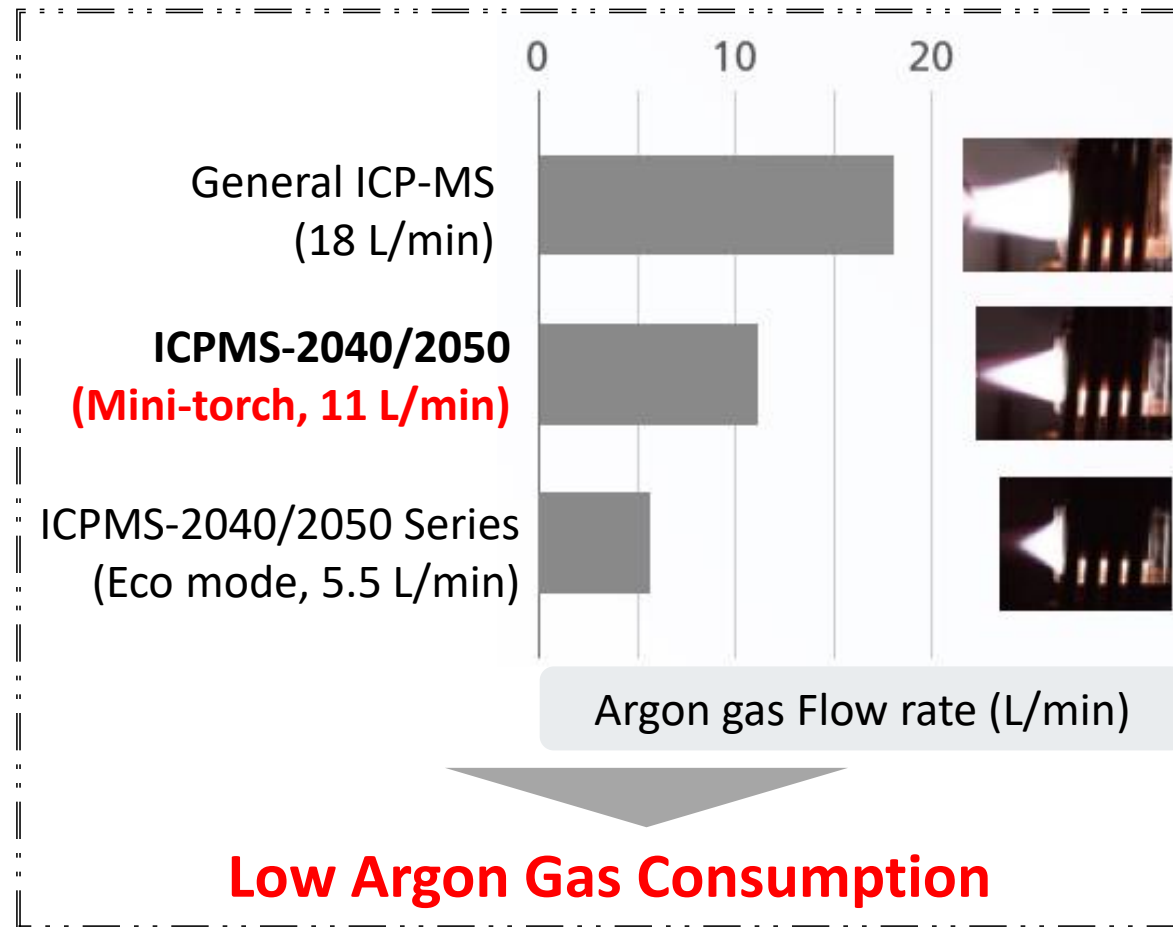
## • Wastewater

|                  |                            |
|------------------|----------------------------|
| Instrument       | Shimadzu ICPMS-2040 / 2050 |
| Nebulizer        | Nebulizer DC04             |
| Chamber          | Cyclone Chamber            |
| Torch            | Mini-Torch                 |
| Skimmer Cone     | Nickel                     |
| Autosampler      | AS-20                      |
| RF               | 1.20 kW                    |
| Sampling Depth   | 10.0 mm                    |
| Plasma Gas       | 9.0 L/min                  |
| Auxiliary Gas    | 1.10 L/min                 |
| Carrier Gas      | 0.45 L/min                 |
| Dilution Gas     | 0.40 L/min                 |
| Peristaltic Pump | 10 r.p.m.                  |

# New Technologies: for minimizing running cost

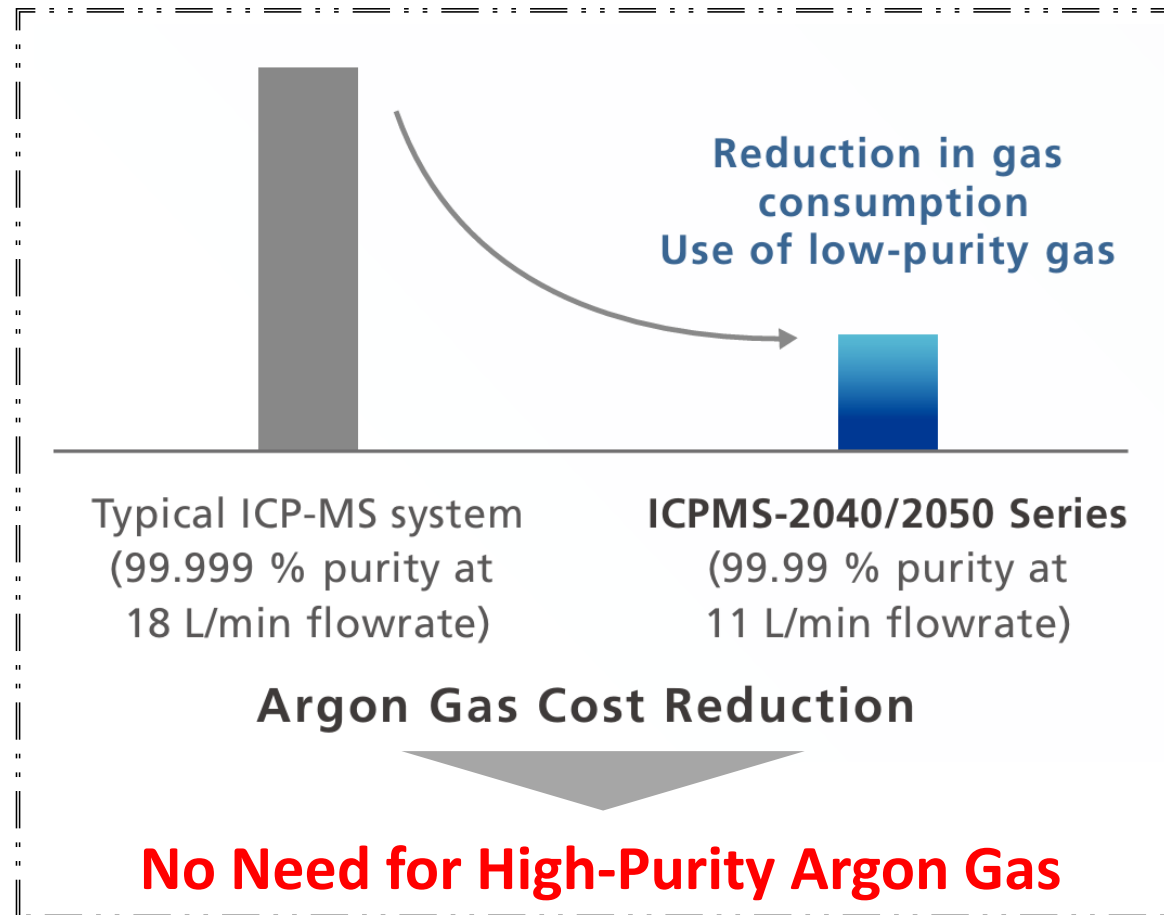
**Mini-torch system** enables a decrease in argon gas consumption.

→ **Low running cost!!**



# New Technologies: for minimizing running cost

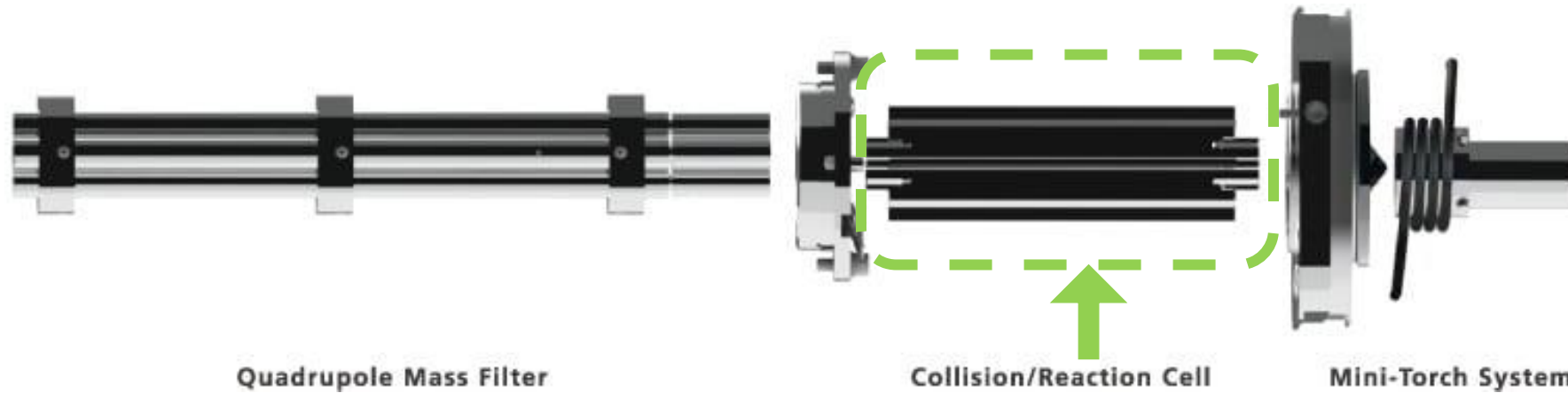
**Mini-torch system** retains its unique feature of **reducing argon gas consumption**.  
→ **Low running cost!!**



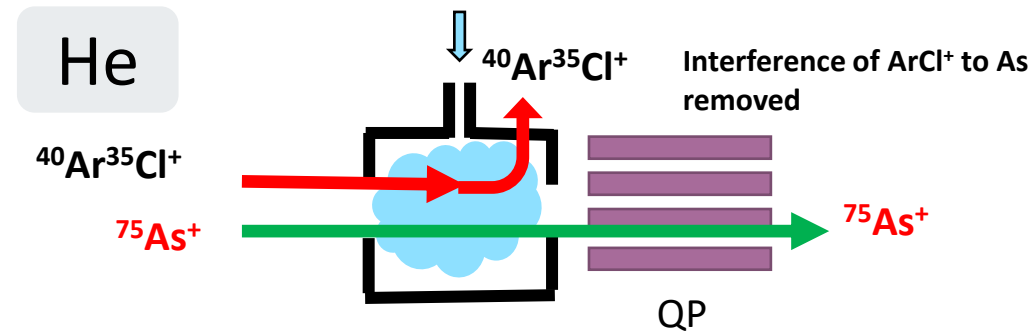
# New Technologies: updated cell design

## Collision & reaction cell

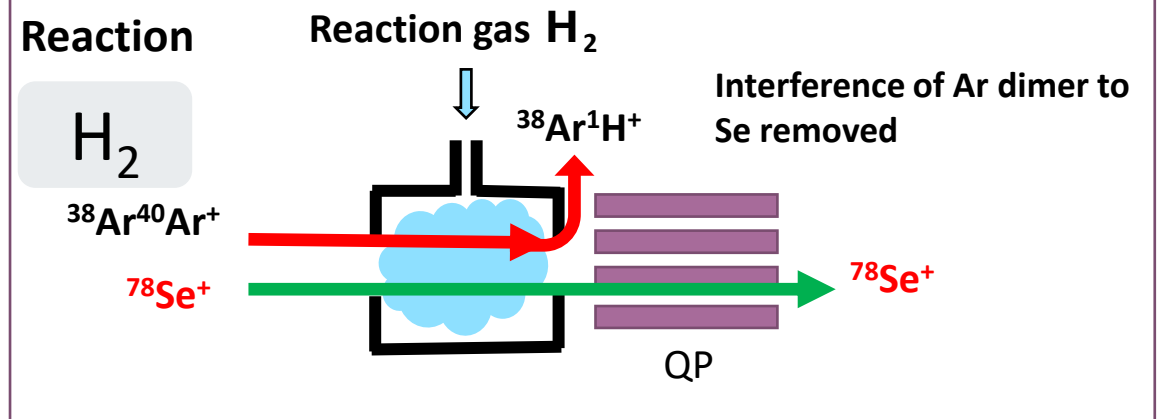
Collision/Reaction cell is used to remove the spectral interference from polyatomic and doubly charged ions.



### Collision

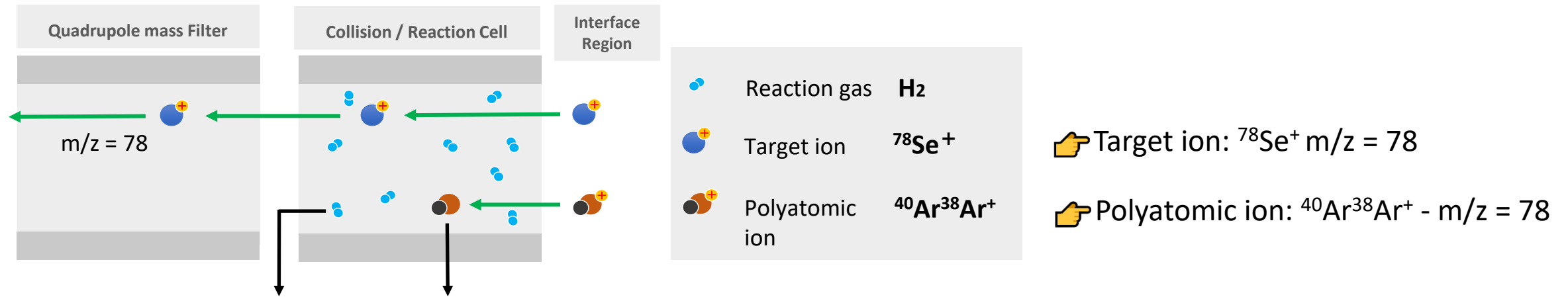


### Reaction



# $^{78}\text{Se}^+$ Analysis / Interference with $^{40}\text{Ar}^{38}\text{Ar}^+=78$

$^{78}\text{Se}$  has a  $^{40}\text{Ar}^{38}\text{Ar}^+$  background. Removal of  $^{40}\text{Ar}^{38}\text{Ar}^+$  can measure Se with higher sensitivity.



| Cell condition       | No Gas | He collision | $\text{H}_2$ reaction |
|----------------------|--------|--------------|-----------------------|
| BEC (ppb)            | 0.82   | 0.01         | 0.001                 |
| Intensity (kcps/ppb) | 24.5   | 0.66         | 2.43                  |

BEC: Background Equivalent Concentration

- $^{40}\text{Ar}^{38}\text{Ar}^+$  interference can be removed in both He collision and  $\text{H}_2$  reaction mode.
- More sensitive for Se in  $\text{H}_2$  reaction mode.

# $^{111}\text{Cd}$ Analysis / Interference with $^{95}\text{Mo}^{16}\text{O}^+=111$

$^{111}\text{Cd}$  has the interference caused by  $^{95}\text{Mo}^{16}\text{O}^+$  when Mo is present in large quantities. Removal of  $^{95}\text{Mo}^{16}\text{O}^+$  is important to measure Cd with high accuracy.

[ Target ion:  $^{111}\text{Cd}^+$  -  $m/z = 111$   
Polyatomic ion:  $^{95}\text{Mo}^{16}\text{O}^+$  -  $m/z = 111$

## • Wastewater

| Cell Gas Type              | H <sub>2</sub> -Reaction | He-Collision |
|----------------------------|--------------------------|--------------|
| Cd intensity (kcps)        | 16.9                     | 7.7          |
| MoO Interference (μg/L) *1 | < LOQ                    | 0.206        |

\*1: Cd concentration affected by MoO interference in a 2 mg/L Mo standard solution

|               |                         |
|---------------|-------------------------|
| Cell Gas      | H <sub>2</sub> (for Cd) |
| Cell Gas      | 6.5 mL/min              |
| Cell Voltage  | -20 V                   |
| Energy Filter | 7 V                     |

**$^{95}\text{Mo}^{16}\text{O}^+$  interference on  $^{111}\text{Cd}$  can be removed by H<sub>2</sub> reaction mode.**

# Instrument Configuration -Cell Condition-

- **Drinking water**

| Cell Gas Type | No Gas | He         | H <sub>2</sub> (for Se) |
|---------------|--------|------------|-------------------------|
| Cell Gas      |        | 7.0 mL/min | 7.0 mL/min              |
| Cell Voltage  |        | -40 V      | -30 V                   |
| Energy Filter |        | 7.0 V      |                         |

- **Wastewater**

| Cell Gas Type | No Gas | He         | H <sub>2</sub> | He (for V) | H <sub>2</sub> (for Cd) |
|---------------|--------|------------|----------------|------------|-------------------------|
| Cell Gas      |        | 5.5 mL/min | 6.5 mL/min     | 5.5 mL/min | 6.5 mL/min              |
| Cell Voltage  |        | -30 V      | -30 V          | -17 V      | -20 V                   |
| Energy Filter |        | 7 V        | 7 V            | 7 V        | 7 V                     |

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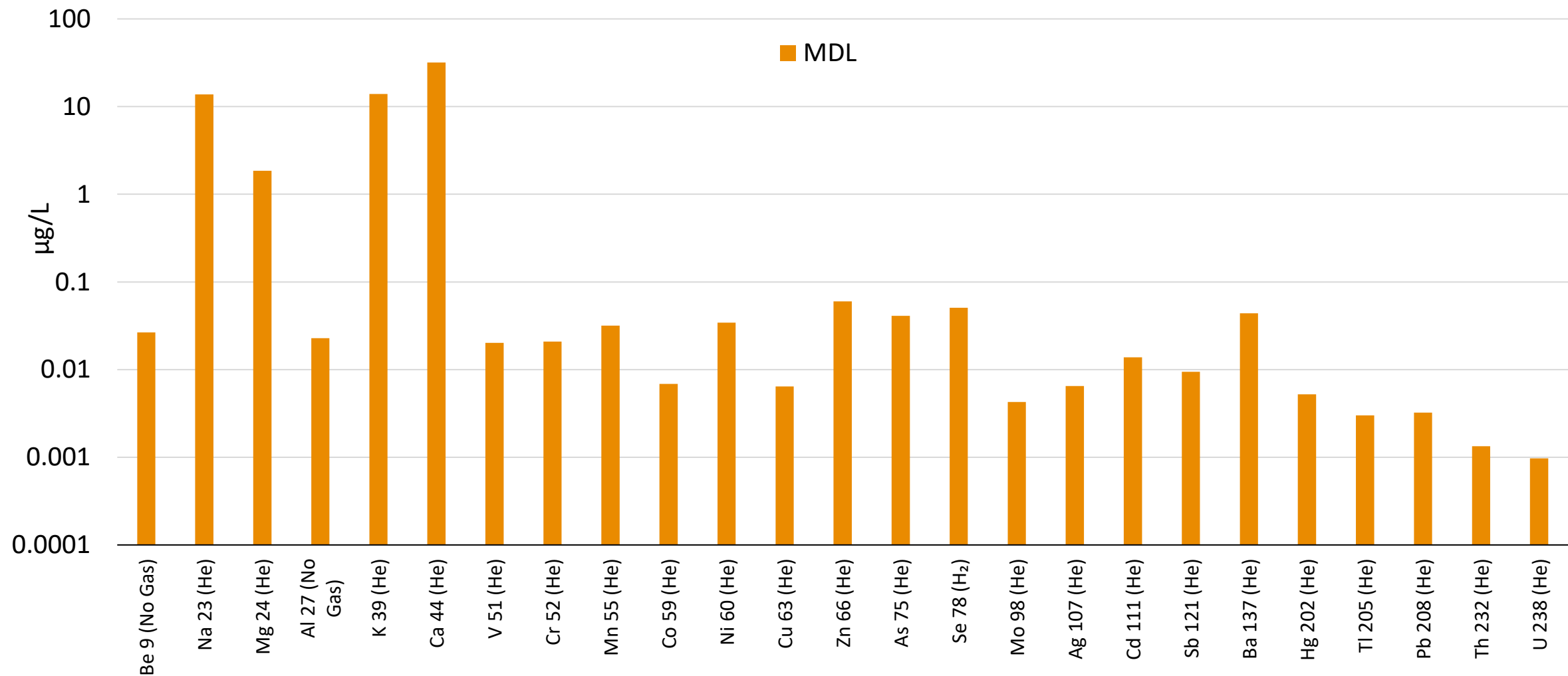
# Elements and Samples

|                                                   | Drinking Water Analysis<br>(EPA 200.8)                                                          | Wastewater Analysis<br>(EPA 6020B)                                                           |
|---------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| <b>Elements</b>                                   | Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Hg, K, Na, Mg, Mn, Mo, Ni, Pb, Sb, Se, Th, Tl, U, V, Zn | Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, Zn     |
| <b>Internal Standards</b>                         | Bi, Ga, Sc                                                                                      | Bi, Ga, Sc, In                                                                               |
| <b>Spectral Interference Check (SIC) solution</b> | ---                                                                                             | 10 times diluted ICP-MS Interferents A1 in 5% HNO <sub>3</sub> /tr. HF, 125 mL from SPEX     |
| <b>Certified Reference Material (CRM)</b>         | JSAC 0302-4a<br>(The Japan Society for Analytical Chemistry)                                    | ---                                                                                          |
| <b>Reference Material (RM)</b>                    | ---                                                                                             | JEMCA 0001-6, JEMCA 0001-7<br>(The Japan Environmental Measurement and Analysis Association) |
| <b>Analysis Sample</b>                            | Bottled water                                                                                   | 2 types of factory wastewater                                                                |

# Elements and Samples

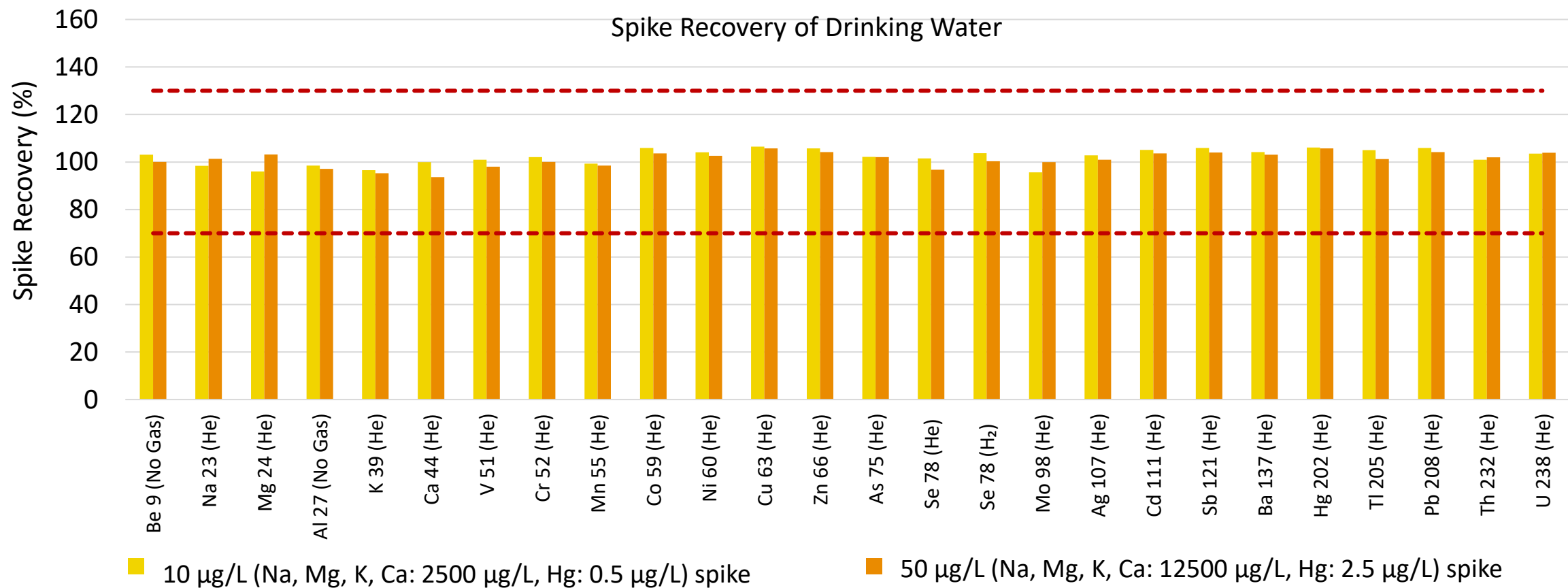
|                                                   | Drinking Water Analysis<br>(EPA 200.8)                                                          | Wastewater Analysis<br>(EPA 6020B)                                                           |
|---------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| <b>Elements</b>                                   | Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Hg, K, Na, Mg, Mn, Mo, Ni, Pb, Sb, Se, Th, Tl, U, V, Zn | Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, Zn     |
| <b>Internal Standards</b>                         | Bi, Ga, Sc                                                                                      | Bi, Ga, Sc, In                                                                               |
| <b>Spectral Interference Check (SIC) solution</b> | ---                                                                                             | 10 times diluted ICP-MS Interferents A1 in 5% HNO <sub>3</sub> /tr. HF, 125 mL from SPEX     |
| <b>Certified Reference Material (CRM)</b>         | JSAC 0302-4a<br>(The Japan Society for Analytical Chemistry)                                    | ---                                                                                          |
| <b>Reference Material (RM)</b>                    | ---                                                                                             | JEMCA 0001-6, JEMCA 0001-7<br>(The Japan Environmental Measurement and Analysis Association) |
| <b>Analysis Sample</b>                            | Tap water                                                                                       | 2 types of factory wastewater                                                                |

# Sensitivity (MDL) - EPA Method 200.8 - Drinking Water -



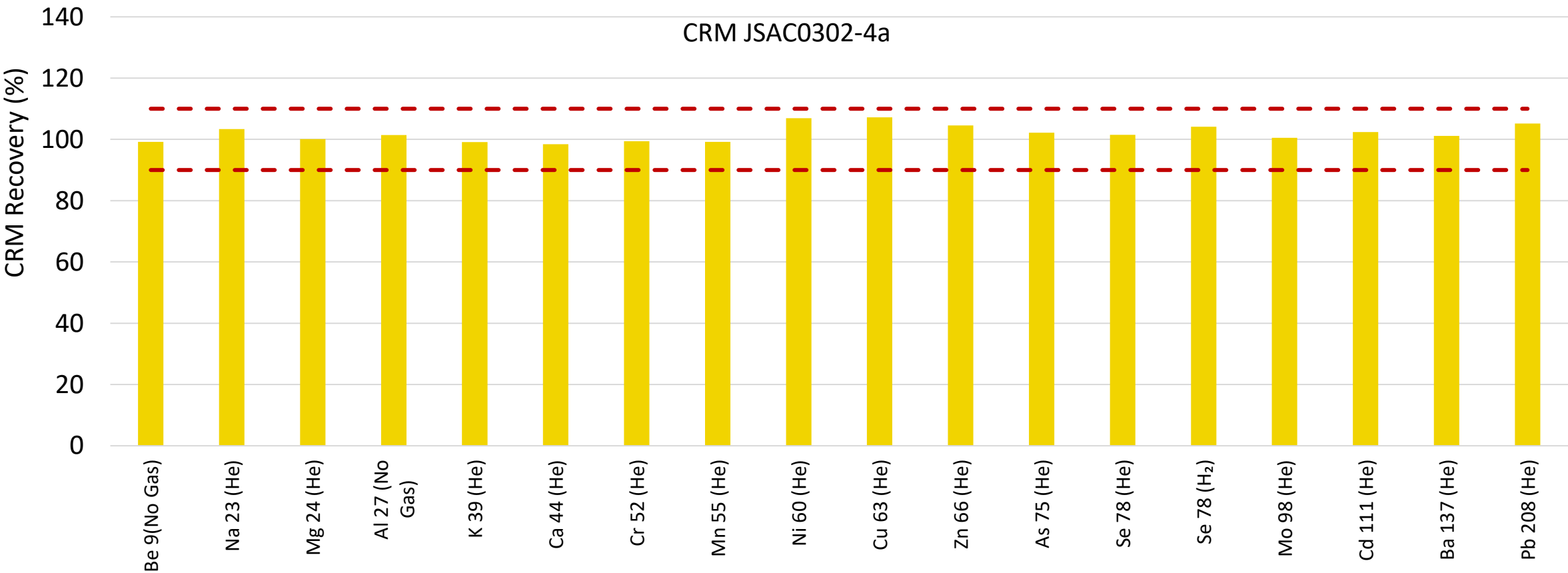
**Shimadzu ICP-MS is sensitive enough to analyze trace elements in drinking water.**

# Accuracy - EPA Method 200.8 - Drinking Water -



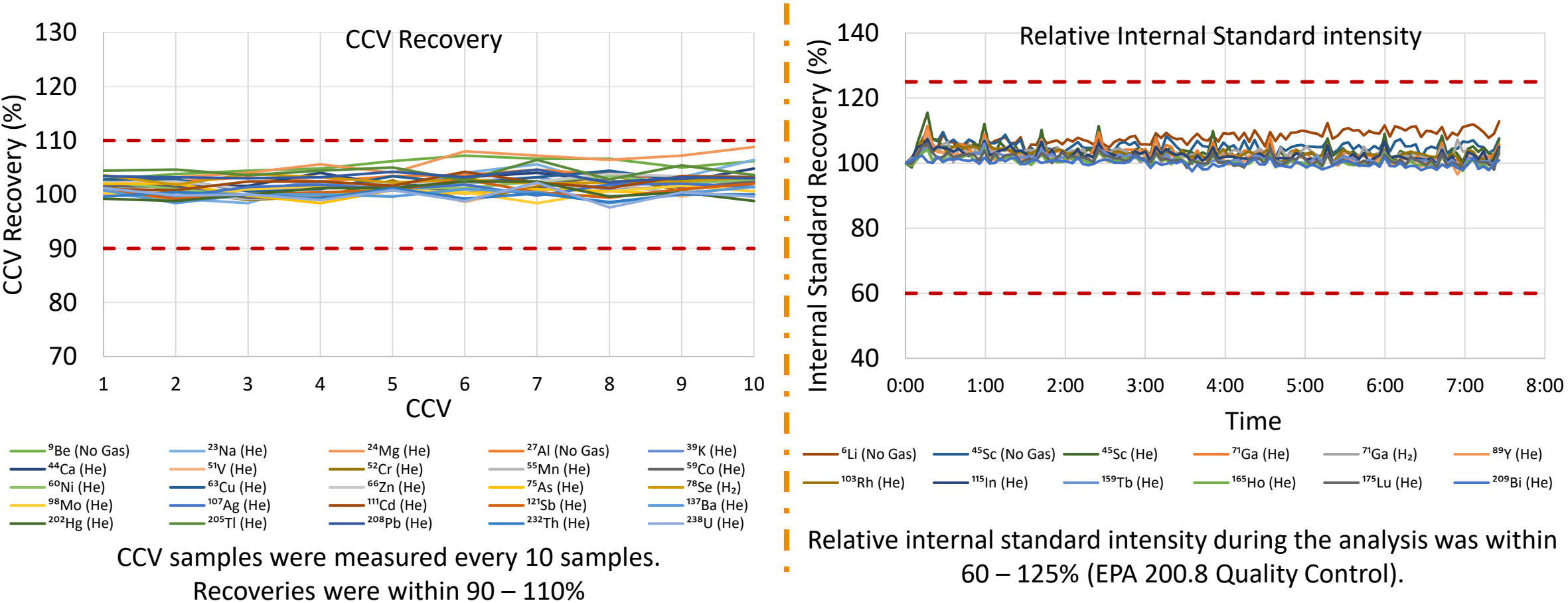
**Recovery of spiked samples was within 90 – 110%,  
demonstrating the accuracy of the Shimadzu ICP-MS analysis.**

# Accuracy - EPA Method 200.8 - Drinking Water -



**Recovery of CRM was within 90 – 110% of the certified values, demonstrating the accuracy of the Shimadzu ICP-MS analysis.**

# Precision / Stability - EPA Method 200.8 - Drinking Water -

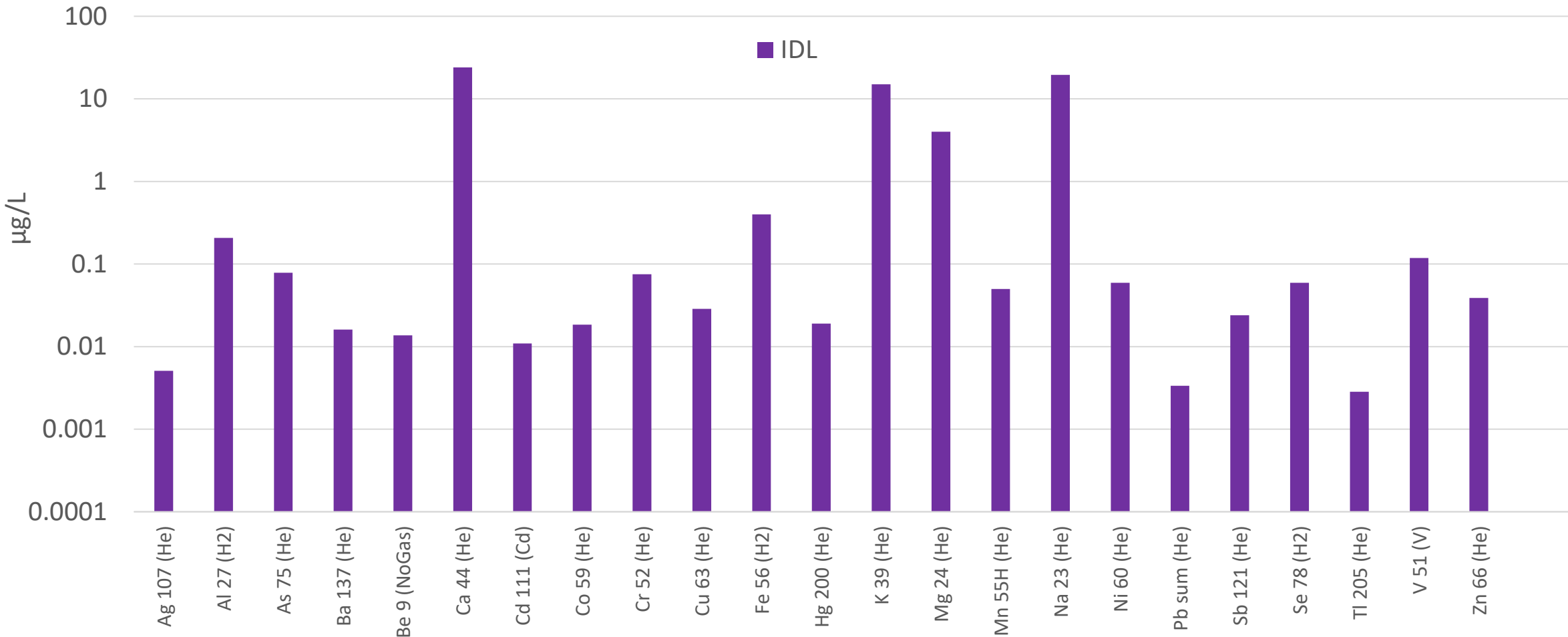


**CCV and internal standard recovery showed good long-term stability (7 hours) of the Shimadzu ICP-MS analysis.**

# Elements and Samples

|                                                   | Drinking Water Analysis<br>(EPA 200.8)                                                          | Wastewater Analysis<br>(EPA 6020B)                                                           |
|---------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| <b>Elements</b>                                   | Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Hg, K, Na, Mg, Mn, Mo, Ni, Pb, Sb, Se, Th, Tl, U, V, Zn | Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, Zn     |
| <b>Internal Standards</b>                         | Bi, Ga, Sc                                                                                      | Bi, Ga, Sc, In                                                                               |
| <b>Spectral Interference Check (SIC) solution</b> | ---                                                                                             | 10 times diluted ICP-MS Interferents A1 in 5% HNO <sub>3</sub> /tr. HF, 125 mL from SPEX     |
| <b>Certified Reference Material (CRM)</b>         | JSAC 0302-4a<br>(The Japan Society for Analytical Chemistry)                                    | ---                                                                                          |
| <b>Reference Material (RM)</b>                    | ---                                                                                             | JEMCA 0001-6, JEMCA 0001-7<br>(The Japan Environmental Measurement and Analysis Association) |
| <b>Analysis Sample</b>                            | Tap water                                                                                       | 2 types of factory wastewater                                                                |

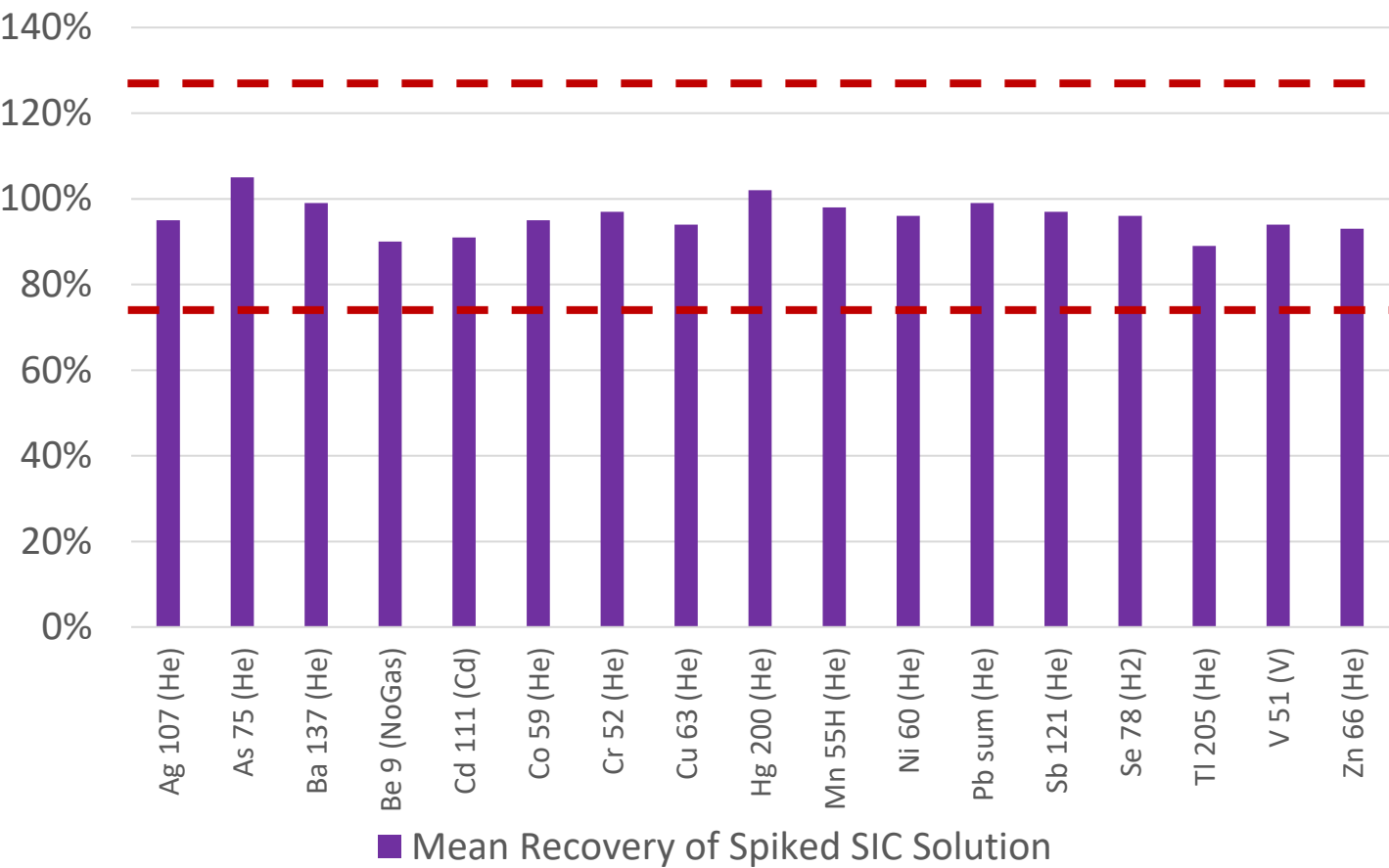
# Sensitivity (IDL) - EPA Method 6020B - Wastewater-



**Shimadzu ICP-MS is sensitive enough to analyze trace elements in wastewater.**



# Accuracy (recovery) of SIC - EPA Method 6020B – Wastewater -

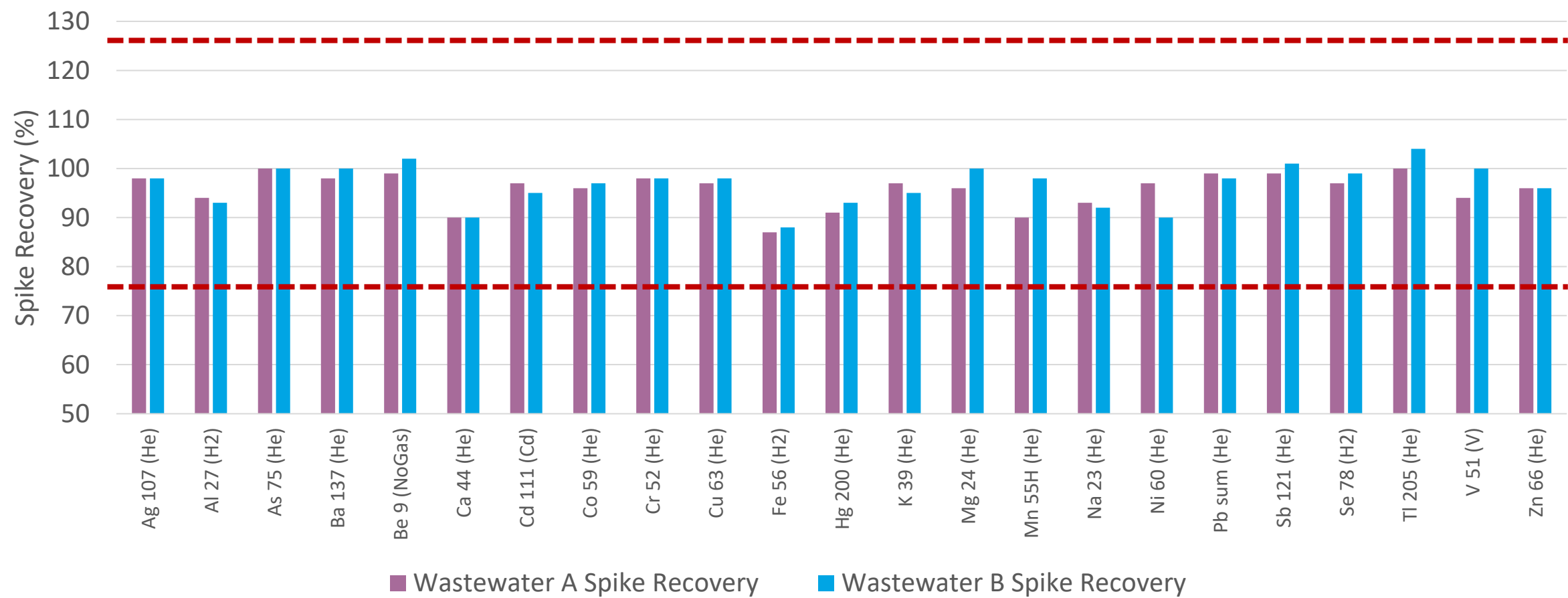


Concentration of analytes and interferents in SIC Solution and Spiked SIC Solution

| Analyte / Interferent                 | SIC Solution (µg/L) | Spiked SIC Solution (µg/L) |
|---------------------------------------|---------------------|----------------------------|
| Ag, Hg, Tl                            | 0                   | 1                          |
| As, Be, Cd, Co, Cr, Ni, Pb, Sb, Se, V | 0                   | 10                         |
| Ba, Cu, Fe, Mn, Zn                    | 0                   | 100                        |
| Mo, Ti                                | 2,000               | 2,000                      |
| Al, K, Mg, P, S                       | 100,000             | 100,000                    |
| C                                     | 200,000             | 200,000                    |
| Fe, Na                                | 250,000             | 250,000                    |
| Ca                                    | 300,000             | 300,000                    |

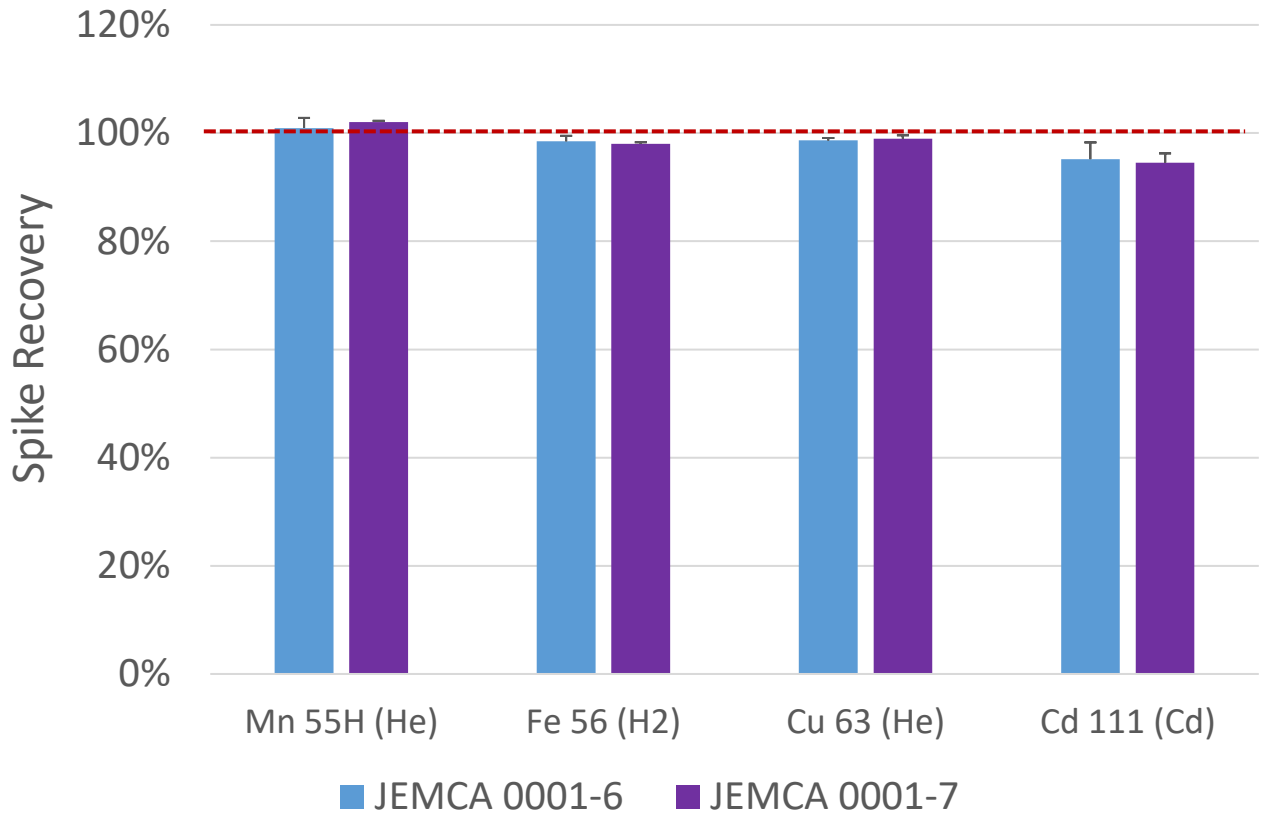
The mean recoveries are 89 ~ 105%, which met EPA QC requirements (100±25%), demonstrating the accuracy of the Shimadzu ICP-MS analysis.

# Accuracy (recovery) of Sample - EPA Method 6020B – Wastewater -



The spike recoveries were 87 ~ 104% for all measured elements. This result satisfied the QC requirements of EPA Method 6020B, which is within 75 ~ 125% of the recovery rate.

# Accuracy (recovery) of RM - EPA Method 6020B – Wastewater -



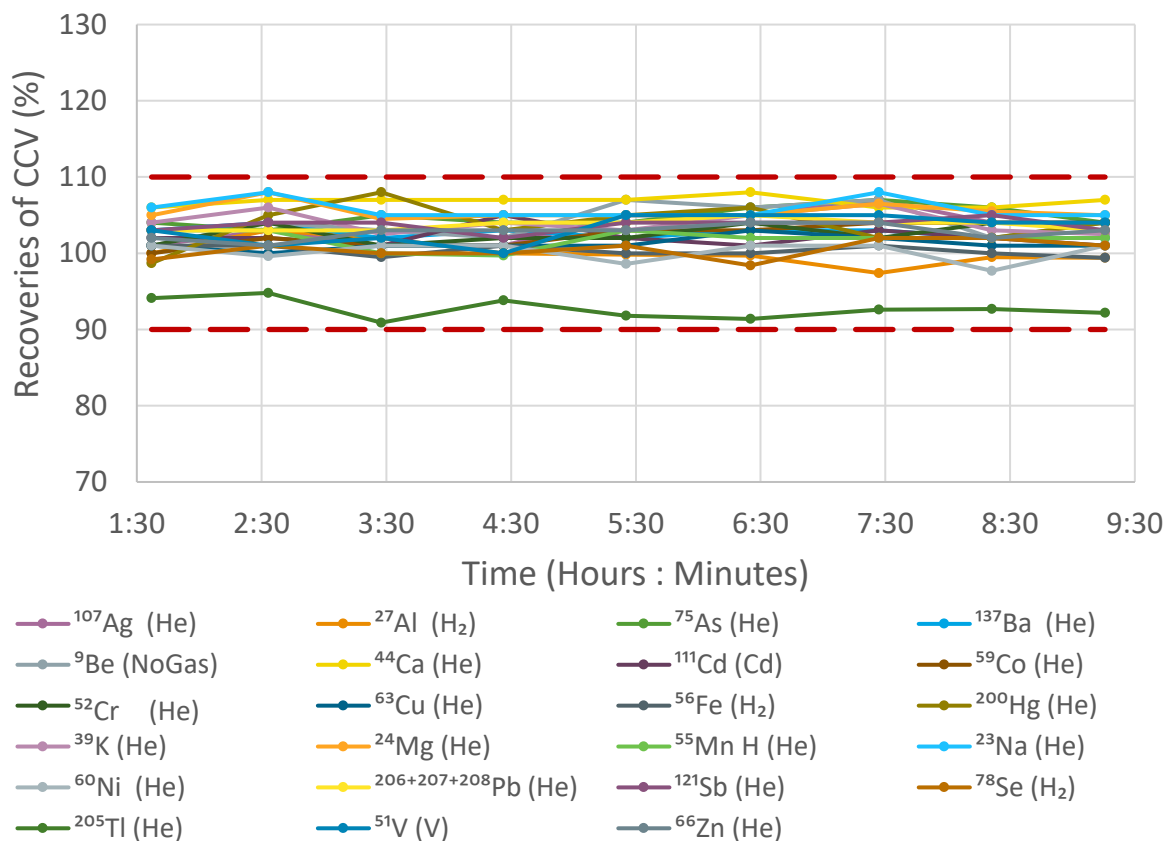
**The recoveries of all elements were within 100±5%, demonstrating the accuracy of the Shimadzu ICP-MS analysis.**

Analysis Results of JEMCA 0001-6 and 0001-7 (N=2)

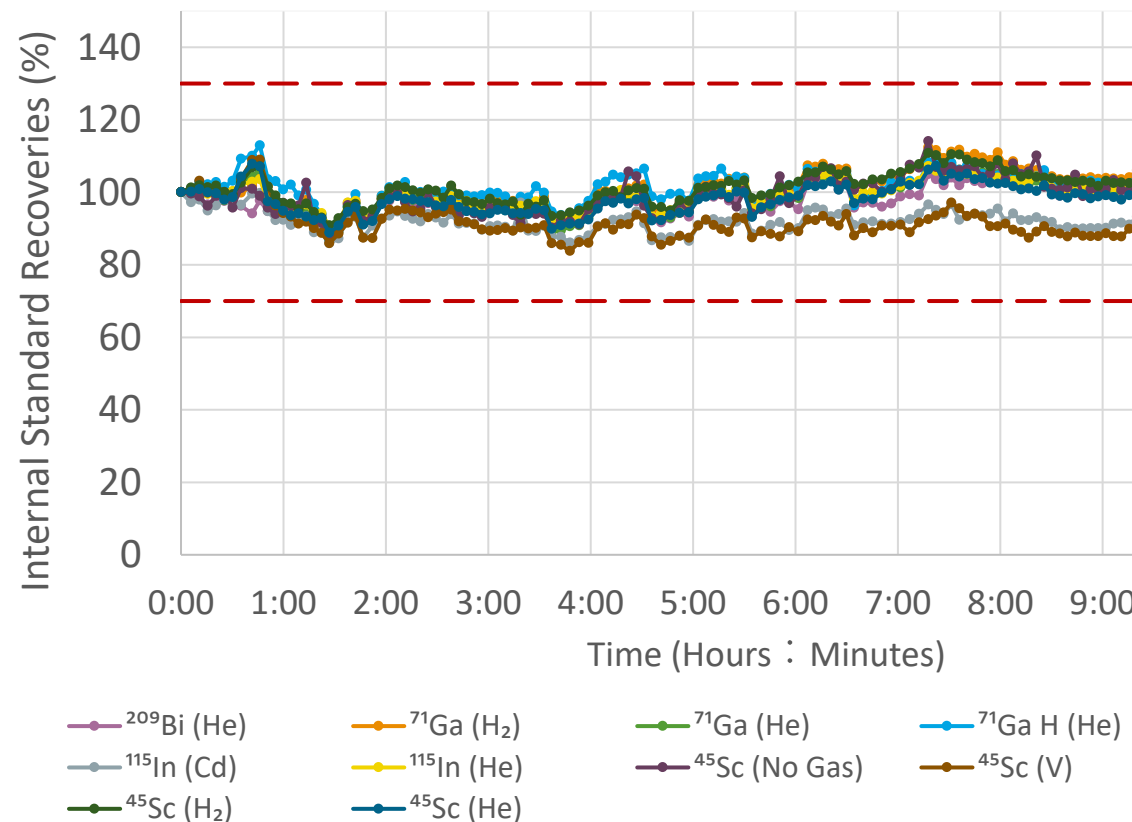
| Element      | Certification value (mg/L) | Mean Analysis Value (mg/L) | Recovery |
|--------------|----------------------------|----------------------------|----------|
| JEMCA 0001-6 |                            |                            |          |
| Mn           | 0.107                      | 0.108                      | 101%     |
| Fe           | 1.97                       | 1.94                       | 98%      |
| Cu           | 0.44                       | 0.43                       | 98%      |
| Cd           | 0.0029                     | 0.0028                     | 95%      |
| JEMCA 0001-7 |                            |                            |          |
| Mn           | 0.097                      | 0.099                      | 102%     |
| Fe           | 1.77                       | 1.74                       | 98%      |
| Cu           | 0.49                       | 0.49                       | 100%     |
| Cd           | 0.0032                     | 0.0030                     | 95%      |

JEMCA 0001-6 and 0001-7:  
Simulated wastewater reference material for metal component analysis by Japan Environmental Measurement and Analysis Association

# Precision / Stability - EPA Method 6020B – Wastewater -



CCV Recoveries over 9 Hours Analysis



Internal Standard Recoveries over 9 Hours Analysis

The CCV recoveries during the analysis were 90 ~ 110% and internal standard recoveries were 70 ~ 130% (red dotted line) showed good long-term stability of Shimadzu ICP-MS.

# Summary

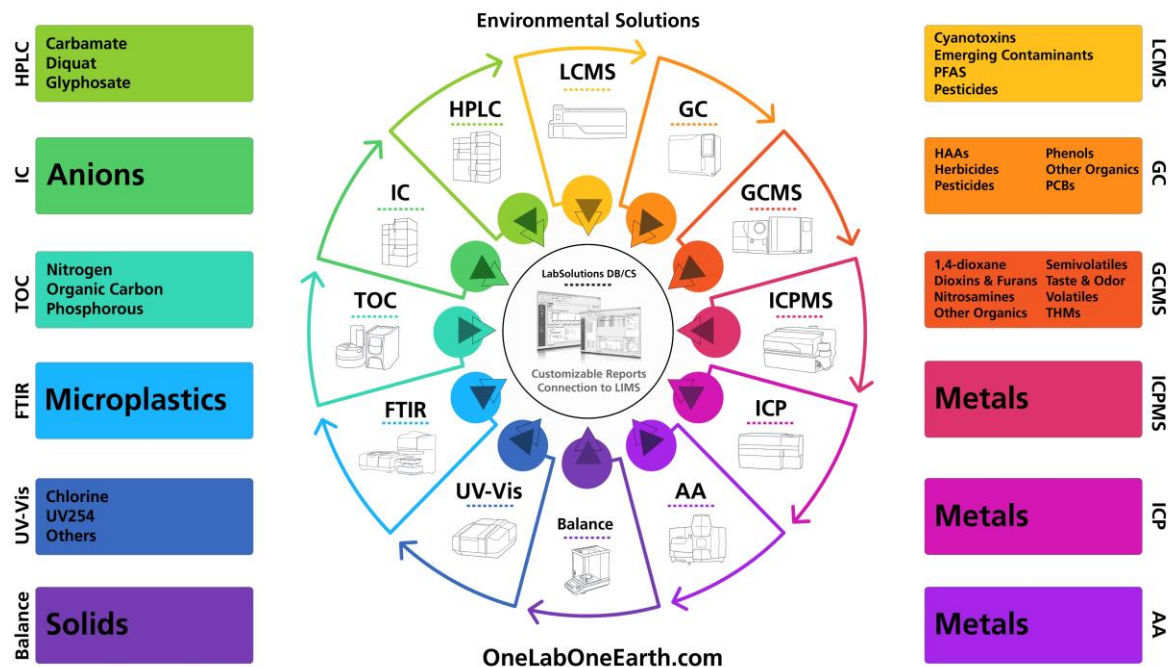
## Drinking water

| Requirement                        | Acceptance criteria                                                                                                                      | Result           |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| MDL                                | Seven replicate aliquots of the fortified reagent water.<br>MDL = (t) X (s)                                                              | High Sensitivity |
| Laboratory Fortified Matrix (LFM)  | The recovery range of LFM for each analyte within $\pm 30\%$ .                                                                           | PASSED!!         |
| Instrument performance (CCB & CCV) | Verify the calibration blank and calibration standards after every ten analyses. All analytes within $\pm 10\%$ of calibration.          | PASSED!!         |
| Internal standards                 | The absolute response of any one internal standard must not deviate more than 60-125% of the original response in the calibration blank. | PASSED!!         |

## Wastewater

| Requirement                                               | Acceptance criteria                                                                                                             | Result           |
|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|------------------|
| IDLs                                                      | The blank result plus three times the SD of 10 replicate analyses of the reagent blank.                                         | High Sensitivity |
| Recovery of the matrix sample                             | The recovery fall within a $\pm 25\%$ acceptance range.                                                                         | PASSED!!         |
| Continuing Calibration Blank and Verification (CCB & CCV) | Verify the ongoing validity after every 10 samples. The CCV within $\pm 10\%$ of its true value and the CCB below the LLOQ.     | PASSED!!         |
| Internal standards                                        | The intensities of each internal standard not decrease below 30%, with respect to its intensity during the initial calibration. | PASSED!!         |

**The analysis of environmental water can be performed using the Shimadzu ICP-MS system.  
The mini-torch system reduces argon gas consumption and offers low operating costs.**



# Thank you for your attention!

Yujing Jiang  
Shimadzu Corporation  
Jiang.yujing.au9@shimadzu.co.jp

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