



### Challenge

Meeting regulations for trace element concentrations in drinking water

### Solution

PlasmaQuant® MS with high throughput sample introduction system, ultrafast data acquisition and sub ng/L detection

## Monitoring Drinking Water Quality with the PlasmaQuant MS

### Introduction

Fresh drinking water is needed for life as well as being a valuable source of vital minerals for health. Water for consumption is sourced from various resources including surface fresh waters, ground water and even seawater. The source often dictates the level of pre-treatment required before it is considered safe for consumption. While groundwater is naturally filtered and may only require minimal pre-treatment, converting seawater to potable water involves a much more complex and intrusive process including desalination, disinfection, water conditioning and remineralization. Through the course of any water treatment, contaminants and nutrients will either be removed or added and those not demineralized may still undergo significant changes in their mineral content due to the treatment processes. Corrosion of plumbing material can also be a source of toxic metal contamination that can have adverse effects on human health.

ICP-MS has become the technique of choice for the monitoring of drinking waters. The fast, multi-element capability allows large numbers of samples to be routinely analyzed. While the ability to accurately quantify from ultra-trace to major levels means toxic metals, minerals and other contaminants can be determined within a single measurement.

The analysis of drinking water by ICP-MS is an uncomplicated application where regulated limits are easily reached. The various interference management systems available today remove many common spectroscopic interferences providing simple and routine analysis. Demand from water quality testing laboratories is for faster turnaround times, greater productivity and reduced operating costs.

The PlasmaQuant MS offers fast, multi-element and interference-free analysis although with one noticeable difference. Robust plasma conditions suitable for drinking water analysis are achieved with only 7.5 L/min of plasma (coolant) gas. The integrated Collision Reaction Cell (iCRC) provides fast and effective removal of spectroscopic interferences using the optimum collision or reaction gas for the job. Allowing the lowest possible detection limits to be achieved for each element. The high pressure/low volume reaction zone also means switching between gas modes takes only seconds.

### Instrumentation

A PlasmaQuant MS with Cetac ASX-520 autosampler and ASXpress rapid sample introduction system was used for the analysis. The Aspect MS software allows automatic optimization of the ion optics, iCRC and plasma gas flows and offers comprehensive quality control protocols, developed to meet the requirements of important regulated methodology including USEPA 200.8.

Table 1: PlasmaQuant MS operating conditions

| Parameter           | Settings                                 |
|---------------------|--|
| Plasma Gas Flow     | 7.5 L/min                                |
| Auxiliary Gas Flow  | 1.00 L/min                               |
| Nebulizer Gas Flow  | 1.05 L/min                               |
| iCRC Gas Flow       | 75 mL/min H <sub>2</sub> , 110 mL/min He |
| Plasma RF Power     | 1.10 kW                                  |
| Dwell Time          | 20 ms                                    |
| Scans per Replicate | 15 (peak hopping, 1pt/peak)              |
| No. of replicates   | 3  |
| Pump Rate           | 8 rpm - black/black PVC pump tubing      |
| Sample loading time | 4 s (1mL loop volume)                    |
| Stabilization delay | 10 s (5 s between gas modes)             |
| Ion Optics          | Auto-optimized                           |

Table 2: Analyte mass, iCRC gas mode and potential interferences

| Element               | Gas Mode       | Potential Interference   |
|-----------------------|----------------|--|
| <sup>9</sup> Be       | None           |  |
| <sup>11</sup> B       | None           |  |
| <sup>23</sup> Na      | None           |  |
| <sup>25</sup> Mg      | None           |  |
| <sup>27</sup> Al      | None           |  |
| <sup>39</sup> K       | None           |  |
| <sup>44</sup> Ca      | None           |  |
| <sup>51</sup> V       | He             | <sup>16</sup> O <sup>35</sup> Cl                                     |
| <sup>52</sup> Cr      | He             | <sup>40</sup> Ar <sup>12</sup> C                                     |
| <sup>55</sup> Mn      | He             | <sup>40</sup> Ar <sup>15</sup> N, <sup>39</sup> K <sup>16</sup> O    |
| <sup>56</sup> Fe      | H <sub>2</sub> | <sup>40</sup> Ar <sup>16</sup> O, <sup>40</sup> Ca <sup>16</sup> O   |
| <sup>59</sup> Co      | He             | <sup>43</sup> Ca <sup>16</sup> O                                     |
| <sup>60</sup> Ni      | He             | <sup>44</sup> Ca <sup>16</sup> O                                     |
| <sup>63</sup> Cu      | He             | <sup>40</sup> Ar <sup>23</sup> Na                                    |
| <sup>66</sup> Zn      | He             | <sup>40</sup> Ar <sup>26</sup> Mg                                    |
| <sup>75</sup> As      | H <sub>2</sub> | <sup>40</sup> Ar <sup>35</sup> Cl, <sup>40</sup> Ca <sup>35</sup> Cl |
| <sup>78</sup> Se      | H <sub>2</sub> | <sup>40</sup> Ar <sup>38</sup> Ar                                    |
| <sup>107</sup> Ag     | None           |  |
| <sup>111</sup> Cd     | None           |  |
| <sup>121</sup> Sb     | None           |  |
| <sup>138</sup> Ba     | None           |  |
| <sup>206,7,8</sup> Pb | None           |  |

### Samples and Reagents

The following high purity reagents were used for all solution preparations:

- Deionized water (>18.2 MΩ/cm, Millipore MiliQ)
- Suprapur 65 % nitric acid (Merck)

### Calibration standards

Calibration solutions were prepared from high-purity, multi-element solutions in 1 % HNO<sub>3</sub> covering the concentration range from 0 to 100 µg/L for trace elements and 0 to 100 mg/L for major elements.

### Sample preparation

NIST Certified Reference Materials 1640; Trace Elements in Natural Water and 1643e; Trace Elements in Water were analyzed directly.

### Internal standard

Internal standard contained 1 µg/L of Sc, Rh, Ir in 1 % HNO<sub>3</sub> and was added online via the 3rd channel on the peristaltic pump.

### Results and Discussion

Tables 3a and 3b list the average result of triplicate measurements of NIST Certified Reference Materials 1643e and 1640 Trace Elements in Water. Excellent recoveries were recorded and typically fell in the range of ±5 %.

Analysis times were less than 1.5 minutes per sample using three optimized gas modes: He, no-gas and H<sub>2</sub>. Stabilization time between gas modes was <5 seconds.

Total argon consumption was 9.55 L/min which is half the amount typically required on competitive ICP-MS instruments.

Table 3a: Average result of major elements from triplicate analyses of NIST 1643e and 1640

| Element          | NIST 1643e       |                 |            | NIST 1640        |                 |            |
|------------------|------------------|-----------------|------------|------------------|-----------------|------------|
|                  | Certified (mg/L) | Measured (mg/L) | Recovery % | Certified (mg/L) | Measured (mg/L) | Recovery % |
| <sup>44</sup> Ca | 31.5             | 30.7            | 98         | 7.05             | 6.89            | 98         |
| <sup>25</sup> Mg | 7.84             | 8.06            | 103        | 5.82             | 5.92            | 102        |
| <sup>23</sup> Na | 20.2             | 20.9            | 103        | 29.4             | 28.9            | 99         |
| <sup>39</sup> K  | 1.98             | 2.08            | 105        | 0.99             | 0.92            | 93         |

Table 3b: Average result of trace elements from triplicate analyses of NIST 1643e and 1640

| Element               | NIST 1643e       |                 |            | NIST 1640        |                 |            |
|-----------------------|------------------|-----------------|------------|------------------|-----------------|------------|
|                       | Certified (µg/L) | Measured (µg/L) | Recovery % | Certified (µg/L) | Measured (µg/L) | Recovery % |
| <sup>9</sup> Be       | 13.6             | 13.2            | 97         | 34.9             | 34.8            | 100        |
| <sup>11</sup> B       | 154.0            | 157.8           | 102        | 301.1            | 303.6           | 101        |
| <sup>27</sup> Al      | 138.3            | 144.8           | 105        | 52.0             | 53.4            | 103        |
| <sup>51</sup> V       | 36.9             | 38.0            | 103        | 13.0             | 12.8            | 99         |
| <sup>52</sup> Cr      | 19.9             | 21.0            | 106        | 38.6             | 39.0            | 101        |
| <sup>55</sup> Mn      | 38.0             | 38.7            | 102        | 121.5            | 114.6           | 94         |
| <sup>56</sup> Fe      | 95.7             | 96.5            | 101        | 34.3             | 35.6            | 104        |
| <sup>59</sup> Co      | 26.4             | 26.3            | 100        | 20.3             | 19.4            | 96         |
| <sup>60</sup> Ni      | 60.9             | 60.0            | 99         | 27.4             | 27.0            | 98         |
| <sup>63</sup> Cu      | 22.2             | 22.8            | 103        | 85.2             | 83.9            | 98         |
| <sup>66</sup> Zn      | 76.5             | 79.3            | 104        | 53.2             | 51.4            | 97         |
| <sup>75</sup> As      | 59.0             | 56.8            | 96         | 26.7             | 25.9            | 97         |
| <sup>78</sup> Se      | 11.7             | 11.1            | 95         | 22.0             | 23.0            | 105        |
| <sup>107</sup> Ag     | 1.04             | 0.99            | 96         | 7.62             | 7.76            | 102        |
| <sup>111</sup> Cd     | 6.41             | 6.30            | 98         | 22.8             | 22.8            | 100        |
| <sup>121</sup> Sb     | 56.9             | 57.1            | 100        | 13.8             | 14.1            | 102        |
| <sup>205</sup> Tl     | 7.26             | 7.06            | 97         | -                | 0.009           |            |
| <sup>206,7,8</sup> Pb | 19.2             | 18.4            | 96         | 27.9             | 26.9            | 97         |

## Conclusion

This work demonstrates that the PlasmaQuant MS provides fast and accurate analysis for monitoring the quality of drinking water. The advancement of sample introduction accessories reduces analysis times to less than 1.5 minutes while iCRC technology eliminates problematic interferences quickly and without compromise.

A new RF generator design provides robust plasma conditions with only half the argon gas typically required of competitive systems, greatly reducing operating costs and instrument downtime.

The capability of the all-digital detector to measure all analyte concentrations from ultra-trace to majors levels in a single 'pulse-counting' mode is a major benefit in the analysis of waters. It eliminates the need for performing inaccurate analog measurements when measuring strong signals.

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### Headquarters

Analytik Jena GmbH+Co. KG  
Konrad-Zuse-Strasse 1  
07745 Jena · Germany

Phone +49 3641 77 70  
Fax +49 3641 77 9279

info@analytik-jena.com  
www.analytik-jena.com

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