Using ICP Instrumentation for Fast and Accurate Determination of Trace and Major Metallic and Elemental Components in Drinking Water Samples

The availability of clean and safe water, free from dangerous chemicals and contaminants is imperative for the health and safety of the public. Increased concerns about water quality due to over-use, climate change and pollution have highlighted the importance of drinking water quality. In the UK, all water supplied to the public must be monitored to ensure strict compliance with water quality guidelines set out by the British Government. It is therefore crucial to analyse water samples in order to identify any harmful chemicals or micro-organism, ensuring the fitness for consumption of drinking water.

Regulatory Framework

The UK water industry is strictly regulated by government agencies including the Environment Agency and the Drinking Water Inspectorate (DWI). The British Government has set legal standards for drinking water in the Water Quality Regulations which provide a regulatory framework for the quality of drinking water supplied in England and Wales. These regulations are based on the European Council Directive 98/83/EC which sets out a list of parameters for monitoring and the maximum permissible concentrations for many parameters and guideline values for many others which are enforce-able throughout member states. In England and Wales, the Environment Agency is responsible for maintaining or improving the quality of fresh, marine, surface and underground water. The DWI monitors and enforces regulations on behalf of the Secretary of State for the Department of the Environment, Food and Rural Affairs (DEFRA) and the National Assembly for Wales. The DWI's remit is to ensure the safety of drinking water by ensuring that water companies meet the standards set in the Water Quality Regulations.

The DWI imposes stringent standards on water companies, whose laboratories must test for over 50 different parameters to assess the quality of supplied drinking water. These parameters cover aesthetic, chemical, microbiological, physical and health-related aspects of water quality. Since many harmful chemicals and organisms pose a potential health threat, they need to be accurately detected. The presence of trace and major elements in supplied drinking water is an important class of chemicals requiring continuous monitoring. At least 14 chemical elements must be monitored across a wide concentration range as some elements are naturally present at moderately high concentrations and may be nutritionally important or essential, while others are indicative of anthropogenic pollution and may represent a toxicity threat even at low concentrations.

Methods and Instrumentation for the Analysis of Elemental Components in Water

Traditionally, trace and major elemental determinations were carried out by wet chemical methods such as volumetric-, gravimetric-, or colorimetric-based assays, however the development of atomic spectroscopy techniques produced vastly greater sensitivity and flexibility in trace element analyses. Trace element detection capability, flexibility and automation has dramatically improved with each advancement in atomic spectrometry, from flame photometry to flame atomic absorption spectrophotometry (FAAS), through the advent of electrothermal atomization (ETA) techniques, and then with the introduction of inductively coupled plasma optical emission spectrometry (ICP-OES) and inductively coupled plasma mass spectrometry (ICP-MS).(1)

Today the use of inductively coupled plasma (ICP) techniques is standard in most high-throughput water analysis laboratories thanks to their ability to measure multiple elements within a single analytical run. ICP techniques have become increasingly accepted as powerful techniques for the analysis and quantification of trace elements in liquid samples. This technique is capable of determining the concentrations of around 70 elements across an extremely wide range of concentrations, from parts per trillion (ppt) in the case of ICP-MS up to percent levels using ICP-OES. ICP-OES uniquely offers high sample throughput thanks to truly simultaneous multi-element measurements, a robustness to dirty sample matrices and simplicity of operation because of its optical spectrometry character. For over a decade, ICP instruments have offered two plasma viewing modes: the traditional radial plasma view, with excellent freedom from interference and tolerance to sample matrix; and axial view which offers improved detection capability by increasing the viewing path length. Echelle-based optical designs, featuring two-dimensional spectra that are projected onto solid state detector technologies, similar to those found in digital cameras have also been introduced. The very latest generation instruments now combine the latest iterations of these technologies with compact, user-focused designs and analytical productivity-enhancing features.

Thames Water

The latest advances in elemental analysis using ICP instrumentation are being applied by Thames Water, the UK's largest water and wastewater services company. Every day the company supplies 2,600 million litres of tap water to 8.5 million customers across London and the Thames Valley region via a network of 31,100 kilometers of water mains and 99 water treatment works. To confirm the quality of its water for supply to the general public, Thames Water carries out a wide-ranging monitoring program of sampling and laboratory analysis. Samples are regularly collected from its treatment works, service reservoirs and supply points to monitor water quality. In addition to this close scrutiny, the company also collects samples from randomly selected customer properties, allowing the company to monitor the quality of the water consumed at source.

Regulatory Standards

Like all water and wastewater treatment facilities within England and Wales, Thames Water is independently regulated by the DWI. Thames Water carries out over half a million water quality tests per year to ensure its drinking water meets the standards set in the Water Quality Regulations. The company employs highly trained staff with extensive analytical skills in microbiology, organic and inorganic chemistry, materials testing and metals analysis. Its advanced metals analysis laboratory, based at Spencer House in Reading in the UK employs eight laboratory scientists focused on analysing potable water to ensure it meets all relevant standards for elemental content.

Metals Analysis

Headed by Graham Coe, analytical manager at Thames Water, the advanced metals analysis laboratory analyzes 500-600 samples per day for metals content which are then compared with regulatory consent levels. With such a high analytical throughput, the company requires highly reliable analytical instrumentation for its routine analysis of potable water and a comprehensive Laboratory Information Management System (LIMS) for managing and reporting generated data. Among its arsenal of analytical equipment, Thames Water uses the Thermo Scientific iCAP 6000 Series ICP emission spectrometer to analyse water samples for elemental content. This is coupled to the Thermo Scientific SampleManager LIMS to capture, store, interpret and report data. The iCAP 6000 Series is suitable for the measurement of many metals and elements in potable water and has helped Thames Water to ensure water quality in compliance with the strict regulations governing the UK water industry.

ICP Selection

On average, the Reading laboratory receives a quarter of a million samples for various analyses each year, 25% of which require metals analysis by ICP. As a result, Thames Water sought an ICP instrument that would be sufficiently fast and powerful to allow the team to analyse in excess of 240 samples per day. It needed a rugged, reliable ICP that would cope with the analysis of many environmental sample types day in, day out and that would help improve its analytical process, reduce laboratory costs and provide accurate, precise results that could be relied upon to enable the company to comply with the strict standards set out by the DWI.

Thames Water required an instrument that would provide accurate routine analysis 24 hours a day, seven days a week, 365 days a year with

a minimum amount of down time. A key advantage of the iCAP 6000 Series in a high throughput laboratory is that it offers excellent stability. This enhanced stability is directly translated into a higher frequency of QC checks being within limits, resulting in fewer samples needing to be retested.

By using the latest generation ICP, sample analysis times are reduced thanks to advancements in the design of optical components of modern ICP instruments, such as the iCAP 6000 Series, which enhance the efficiency of light transfer to the detector, resulting in reduced measurement times without compromising detection capability, as well as time saving features within the software and hardware. For Thames Water, ICP provides efficient measurement of all elements of interest and these time savings can result in significant running cost reductions, enabling the laboratory to lower its costs per analysis and to run more samples per hour.

The company particularly wanted to find an instrument that was easy to understand and use so that training staff and rapidly getting the instrument productive would be as simple as possible. Faced with space-efficiency issues, Thames Water also looked to the iCAP 6000 Series due to its compact footprint. As bench space is at a premium in many modern laboratories, a small instrument footprint is important. Compact instrument size, reduced running costs and improved ease of operation are key requirements for many modern laboratories.

For Thames Water, a solution that would guarantee the analysis of a large number of water samples and facilitate efficient reporting of the data to clients was crucial. By integrating the ICAP 6000 Series with a Laboratory Information Management System (LIMS), the time from sample reception to the reporting of results was reduced and data was effectively and securely managed.

Results

Thames Water publishes all its water quality results online in postcodal area reports which are available to download from the official Thames Water website. Many metals results detailed in the water quality reports are obtained via ICP analysis. In 2007, Thames Water performed around 470,000 analyses and in samples collected from customers' taps. 99.98 per cent of tests met the standards for water quality specified within UK regulations.

Thames Water uses ICP analysis to test for many different elemental parameters, including iron, sodium, calcium, magnesium, potassium and manganese. The prescribed concentration or value (PCV) is the maximum amount of each parameter permitted in drinking water under UK regulations. The results Thames Water attain from water sample analyses are compared with the PCV. Each water quality report details the number of samples that contravened the PCV compared to the total number of samples taken, expressed as a percentage.

By using ICP, Thames Water is able to carry out extremely accurate analyses of water samples in addition to helping the company operate efficiently. Given the high sample load in Thames Water's laboratory, ICP in combination with a LIMS provides an end-to-end solution that improves the overall efficiency and cost effectiveness of the laboratory workflow and ensures that quality data is reported to the client.

Conclusion

ICP is the ideal and accepted general analytical technique for trace and major elemental analyses for high throughput laboratories. For Thames Water, the integration of modern instrumentation and LIMS provide a solution that achieves the shortest sample turnaround time and optimum sample throughput, while ensuring the highest standards of data quality and integrity. The result of this is greater efficiency and confidence in evaluating water quality. By utilising a comprehensive end-to-end portfolio of laboratory solutions for water analysis, Thames Water has been able to improve productivity, reliability and management of their laboratory data, all while ensuring compliance with regulations. For more information on the Thermo Scientific ICP emission spectrometers, please call +1 800-532-4752, email analyze@thermofisher.com or alternatively visit www.thermo.com/icp

References

1. Prospects in analytical atomic spectrometry, A A Bol'shakov, A A Ganeev, V M Nemets, Russian Chemical Reviews 75 (4) 289 – 302 (2006) http://arxiv.org/ftp/physics/papers/0607/0607078.pdf

AUTHOR DETAILS

Graham Coe
Analytical manager,
Thames Water, UK

Matthew Cassap
Applications Specialist
Thermo Fisher Scientific

Martin Nash,
ICP Product Manager
Thermo Fisher Scientific

Bill Spence, Marketing Manager of ICP Products
Thermo Fisher Scientific

CONTACT DETAILS

Thermo Fisher Scientific
Tel: +1 800 532 4752
E-mail:
analyze@thermofisher.com
Web:
www.thermo.com/icap