

**Soils, sludges, Sediments and treated bio-wastes — trace elements —  
Method by inductively coupled plasma - mass spectrometry (ICP MS)**

Boden, Schlamm Sedimente und behandelte Bio-Abfälle — Spuren Elementen — Methode mit induktiv gekoppeltes Plasma mit Massen- Spectrometer (ICP-MS)

Sols, boues, Sediment et bio déchets traités — Éléments trace — Méthode de spectromètre de masse à source plasma (ICP-MS)

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## Foreword

This document has been prepared in the framework of the project Horizontal.

This document is a working document.

The following TC's have been involved in the preparation of the standard:

This standard is applicable and validated for several types of matrices. The table below indicates which ones.

[table to be filled and amended by the standards writer]

Material	Validated	Document
Soil	<input type="checkbox"/>	[reference]
Sludge	<input type="checkbox"/>	
Biowaste	<input type="checkbox"/>	
Soil improvers	Not validated yet	

## Introduction

This document is developed in the framework of the project 'Horizontal'. It is the result of a desk study "Determination of elements by ICP-AES and ICP-MS" in Phase I and "Trace elements with ICP-MS: ruggedness test" in Phase II and aims at evaluation of the latest developments in assessing measurement of trace elements in sludge, soil, treated biowaste and neighbouring fields. After discussion with all parties concerned in GEN and selection of a number of test methods described in this study the standard has been developed further as an modular horizontal method and has been validated within in the project 'Horizontal' .

## 1 Scope

This standard specifies a method for the determination of the dissolved elements aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, cesium, calcium, cerium, chromium, cobalt, copper, dysprosium, erbium, europium, gadolinium, gallium, germanium, gold, hafnium, holmium, indium, iridium, iron, lanthanum, lead, lithium, lutetium, magnesium, manganese, mercury, molybdenum, neodymium, nickel, palladium, phosphorus, platinum, potassium, praseodymium, rubidium, rhenium, rhodium, ruthenium, samarium, scandium, selenium, silicon, silver, sodium, strontium, sulfur, terbium, tellurium, thorium, thallium, thulium, tin, titanium, tungsten, uranium, vanadium, yttrium, ytterbium, zinc, and zirconium in water (e.g. filtered drinking water, surface water, groundwater, wastewater, eluates) and *aqua regia* and nitric acid digests of water, eluates, industrial and organic wastes, soils, sludges, sediments, and other solid wastes.

The working range depends on the matrix and the interferences encountered.

In drinking water and relatively unpolluted waters, the detection limit is between 0,1 µg/l and 1,0 µg/l for most elements (see Table 1).

In soil, sludge and biowaste, the detection limit is between 0,1 mg/kg dry weight and 2,0 mg/kg dry weight for most elements (see Table 1).

The detection limits of most elements will be affected by blank contamination and this will depend predominantly on the laboratory air-handling facilities available.

The detection limit will be higher in cases where the determination is likely to be interfered (see clause 4) or in case of memory effects (see clause 8.2 of ISO 17294-1).

## 2 Normative references

The following normative documents contain provisions, which, through reference in this text, constitute provisions of <standard number>. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on <standard number> are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

ISO 3696:1987, Water for analytical laboratory use. Specification and test methods.

<Aqua regia horizontal standard> . Digestion for the determination of selected elements . Part 1: Aqua regia digestion.

<Nitric acid horizontal standard>. Digestion for the determination of selected elements . Part 2: Nitric acid digestion.

EN - ISO 17294-1, Water quality . Application of inductively coupled plasma mass spectrometry (ICP-MS) . Part 1: General guideline.

### 3 Definitions

For the purposes of this **Error! Reference source not found.**, the following terms and definitions apply.

#### 3.1 Instrumental limit of detection (IDL):

Three times the repeatability standard deviation ( $3 * Sr$ ) calculated from multiple readings ( $n > 8$ ) of a (matrix) solution within a single run.

#### 3.2 Method detection limit (MDL):

Three times the within laboratory reproducibility standard deviation ( $3 * Sw$ ) calculated from multiple measurements ( $n > 8$ ) on different days of a relevant matrix solution.

### 4 Symbols and abbreviations

#### 4.1 ICS: Interference check solution

### 5 Principle

This international standard describes the multi-elemental determination of analytes by ICP-MS in aqueous and nitric acid or *aqua regia* digests. The method measures ions produced by a radio-frequency inductively coupled plasma. Analyte species originating in a liquid are nebulized and the resulting aerosol is transported by argon gas into the plasma torch. The ions produced by high temperatures are entrained in the plasma gas and introduced, by means of an interface, into a mass spectrometer.

The ions produced in the plasma are sorted according to their mass-to-charge ratios and quantified with a channel electron multiplier. Interferences must be assessed and valid corrections applied. Interference correction must include compensation for background ions contributed by the plasma gas, reagents, and constituents of the sample matrix.

### 6 Interferences

#### 6.1 General

Detailed information on spectral and non-spectral interferences is given in clause 6.1 of EN ISO 17294-1.

#### 6.2 Spectral interferences

##### 6.2.1 Isobaric elemental interferences

Isobaric elemental interferences are caused by isotopes of different elements of the same nominal mass-to-charge-ratio and which cannot be separated due to an insufficient resolution of the mass spectrometer in use (e.g.  $^{114}\text{Cd}$  and  $^{114}\text{Sn}$ ).

Element interferences from isobars may be corrected for taking into account the influence from the interfering element (see Table 1). The isotopes used for correction shall be free of interference. Correction options are often included in the instrument software. Common isobaric interferences are given in Table 2.

### 6.2.2 Isobaric molecular and doubly charged ion interferences

Isobaric molecular and doubly-charged ion interferences in ICP-MS are caused by ions consisting of more than one atom or charge, respectively. Examples include  $^{40}\text{Ar}^{35}\text{Cl}^+$  and  $^{40}\text{Ca}^{35}\text{Cl}^+$  ion on the  $^{75}\text{As}$  signal and  $^{98}\text{Mo}^{16}\text{O}^+$  ions on the  $^{114}\text{Cd}^+$  signal. Natural isotope abundances are available from the literature. However, the most precise coefficients for an instrument will be determined from the ratio of the net isotope signals observed for a standard solution.

The accuracy of these types of equations is based upon the constancy of the observed isotopic ratios for the interfering species. Corrections that presume a constant fraction of a molecular ion relative to the "parent" ion have not been found to be reliable, e.g., oxide levels can vary with operating conditions. If a correction for an oxide ion is based upon the ratio of parent-to-oxide ion intensities, the correction must be adjusted for the degree of oxide formation by the use of an appropriate oxide internal standard previously demonstrated to form a similar level of oxide as the interferent.

The magnitude of isobaric molecular and doubly charged interferences shall be corrected for if their impact can be higher than three times the instrumental detection limit.

### 6.3 Non spectral interferences

Physical interferences are associated with the sample nebulization and transport processes as well as with ion-transmission efficiencies. Nebulization and transport processes can be affected if a matrix component causes a change in surface tension or viscosity. Changes in matrix composition can cause significant signal suppression or enhancement. Dissolved solids can deposit on the nebulizer tip of a pneumatic nebulizer and on the interface skimmers.

A total solid level below 0.2% (2,000 mg/L) is recommended to minimize solid deposition. An internal standard can be used to correct for physical interferences, if it is carefully matched to the analyte so that the two elements are similarly affected by matrix changes. When intolerable physical interferences are present in a sample, a significant suppression of the internal standard signals (to less than 30 % of the signals in the calibration solution) will be observed. Dilution of the sample fivefold will usually eliminate the problem.

## 7 Reagents

### 7.1 General

For the determination of elements at trace and ultra trace level, the reagents shall be of adequate purity. The concentration of the analyte or interfering substances in the reagents and the water should be negligible compared to the lowest concentration to be determined.

Preferably, nitric acid preservation and digestion should be applied in order to minimize interferences by polyatoms. Bi, Mo, Sn, Sb, Te, W, Hf and Zr may need hydrochloric acid for preservation and digestion.

### 7.2 Water

Use water according to Grade 1 of ISO 3696 for all sample preparation and dilutions.

### 7.3 Nitric acid, $c(\text{HNO}_3) = 1,4 \text{ g/ml}$ .

NOTE Nitric acid is available both as  $\rho(\text{HNO}_3) = 1,40 \text{ g/ml}$  ( $w(\text{HNO}_3) = 650 \text{ g/kg}$ ) and  $\rho(\text{HNO}_3) = 1,42 \text{ g/ml}$  ( $w(\text{HNO}_3) = 690 \text{ g/kg}$ ). Both are suitable for use in this method provided there is minimal content of the interesting analytes.

#### 7.4 Hydrochloric acid, $c(\text{HCl}) = 1,16 \text{ g/ml}$ .

#### 7.5 Element stock solutions

Ag, Al, As, Au, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Hg, Ho, In, Ir, K, La, Li, Lu, Mg, Mn, Mo, Na, Nd, Ni, P, Pb, Pd, Pr, Pt, Rb, Re, Rh, Ru, S, Sb, Sc, Se, Si, Sm, Sn, Sr, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn, Zr,  $\rho = 1\,000 \text{ mg/l}$  each.

Both single-element stock solutions and multi-element stock solutions with adequate specification stating the acid used and the preparation technique are commercially available.

These solutions are considered to be stable for more than one year, but in reference to guaranteed stability, the recommendations of the manufacturer should be considered.

#### 7.6 Anion stock solutions

Cl,  $\text{PO}_4\text{-P}$ ,  $\text{SO}_4\text{-S}$ ,  $\rho = 1\,000 \text{ mg/l}$  each.

Prepare these solutions from the respective acids. The solutions are as well commercially available.

These solutions are considered to be stable for more than one year, but in reference to guaranteed stability, the recommendations of the manufacturer should be considered.

#### 7.7 Multi-element standard solutions

Depending on the scope, different multi-element standard solutions may be necessary. In general, when combining multi-element standard solutions, their chemical compatibility and the possible hydrolysis of the components shall be regarded. Care must be taken to prevent chemical reactions (e.g. precipitation).

The multi-element standard solutions are considered to be stable for several months, if stored in the dark.

This does not apply to multi-element standard solutions that are prone to hydrolysis, in particular solutions of Bi, Mo, Sn, Sb, Te, W, Hf and Zr.

Multi-element standard solution A at the mg/l level may contain the following elements:

Ag, Al, As, B, Ba, Be, Bi, Cd, Ce, Co, Cr, Cs, Cu, La, Li, Mn, Ni, Pb, Rb, Sr, Th, Tl, U, V, Se, Zn. Use nitric acid for stabilization of standard solution A.

Multi-element standard solution B at the mg/l level may contain the following elements:

Au, Mo, Sb, Sn, W, Zr.

Standard solution B needs hydrochloric acid for stabilization.

Mercury standard solutions can be stabilized by adding 1 ppm Au in nitric acid or by adding hydrochloric acid.

Multi-element standard solutions with more elements are allowed provided that these solutions are stable.

#### 7.8 Multi-element calibration solutions

Prepare in one or more steps calibration solutions at the highest concentration of interest.

If more concentration levels are needed prepare those similarly.

Add acids (7.3 – 7.4) to match the acid concentration of samples closely.

If traceability of the values is not established check the validity by comparison with a (traceable) independent standard.

Check the stability of the calibration solutions.



## 7.9 Internal standard solution

The choice of elements for the internal standard solution depends on the analytical problem. The solution of this/these internal standard(s) should cover the mass range of interest. The concentrations of the selected elements in samples should be negligibly low. The elements In, Lu, Re, Rh and Y have been found suitable for this purpose.

Generally, a suitable concentration of the internal standard in samples and calibration solutions is 50 µg/l.

## 7.10 Calibration blank

Prepare the calibration blank by acidifying water (7.2) to the same concentrations of the acids found in the calibration solutions and samples.

## 7.11 Method blank

The method blank must contain all of the reagents in the same volumes as used in the processing of the samples. The method blank must be carried through the complete procedure and contain the same acid concentration in the final solution as the sample solution used for analysis.

## 7.12 Optimization solution

The optimization solution serves for mass calibration and for optimization of the apparatus conditions, e.g. adjustment of maximal sensitivity with respect to minimal oxide formation rate and minimal formation of doubly charged ions.

It should contain elements covering the total mass range, as well as elements prone to a high oxide formation rate or to the formation of doubly charged ions. An optimization solution containing Mg, Cu, Rh, In, Ba, La, Ce, U and Pb is suitable. Li, Be and Bi are less suitable because they tend to cause memory effects. The mass concentrations of the elements used for optimization should allow count rates of more than  $10^4$  counts per second.

## 7.13 Interference check solution

The interference check solutions serve to determine the correction factors for the corresponding equations. High demands are made concerning the purity of the basic reagents due to the high mass concentrations.

Interference check solutions shall contain all the interferents of practical relevance given in Table 1, at a concentration level that is at least as high as in samples.

Leaving out an interferent of Table 1 is permitted if it can be demonstrated that its impact is negligible and lasting.

In extreme situations also the other interferents of Table 1 shall be investigated for relevance.

### NOTE

An example of the composition of an interferent check solution is:

$\rho(\text{Ca}) = 200 \text{ mg/l}$ ;  $\rho(\text{Cl}^-) = 300 \text{ mg/l}$ ;  $\rho(\text{P-PO}_4) = 25 \text{ mg/l}$  and  $\rho(\text{S-SO}_4) = 100 \text{ mg/l}$  and for digests also  $\rho(\text{C}) = 200 \text{ mg/l}$ ;  $\rho(\text{Fe}) = 100 \text{ mg/l}$ ;  $\rho(\text{Na}) = 100 \text{ mg/l}$  and  $\rho(\text{AL}) = 100 \text{ mg/l}$ .

## 8 Apparatus

### 8.1 General requirements

The stability of samples, measuring, and calibration solutions depends to a high degree on the container material.

The material shall be checked according to the specific purpose. For the determination of elements in a very low concentration range, glass or polyvinyl chloride (PVC) should not be used. Instead, it is recommended to use perfluoroalkoxy (PFA), hexafluoroethene propene (FEP) or quartz containers, cleaned with hot, concentrated nitric acid in a closed system. For the determination of elements in a higher concentration range, HDPE or PTFE containers are also allowed for the collection of samples.

Immediately before use, all glassware should be washed thoroughly with warm diluted nitric acid (e.g.  $w(\text{HNO}_3) = 10\%$ ), and then rinsed several times with water (7.2).

The use of piston pipettes is permitted and also enables the preparation of lower volumes of calibration solutions.

The application of dilutors is also allowed. Every charge of pipette tips and single-use plastics vessels shall be tested for impurities.

For more detailed information on the instrumentation see clause 5 of ISO 17294-1.

### 8.2 Mass spectrometer

A mass spectrometer with inductively coupled plasma (ICP) suitable for multi-element and isotope analysis is required. The spectrometer should be capable of scanning a mass range from 5  $m/z$  (AMU) to 240  $m/z$  (AMU) with a resolution of at least 1  $m_r/z$  peak width at 5 % of peak height ( $m_r$  = relative mass of an atom species;  $z$  = charge number). The instrument may be fitted with a conventional or extended dynamic range detection system.

Most quadrupole ICP-MS, high-resolution ICP-MS and collision/reaction cell ICP-MS instrumentation is fit for purpose.

### 8.3 Mass-flow controller

A mass-flow controller on the nebulizer gas supply is required. Mass-flow controllers for the plasma gas and the auxiliary gas are also useful. A water-cooled spray chamber may be of benefit in reducing some types of interferences (e.g. from polyatomic oxide species).

NOTE The plasma is very sensitive to variations in the gas flow rate.

### 8.4 Nebulizer with variable speed peristaltic pump

### 8.5 Argon gas supply

Argon gas with high purity grade, i.e. > 99,99 %

### 8.6 Glassware

Volumetric flasks, 50 ml, 100 ml, 500 ml and 1 000 ml;

Erlenmeyer flasks, 100 ml;

Pipettes, 1 ml, 2,5 ml, 10 ml, 20 ml and 25 ml.

### 8.7 Storage bottles for the stock, standard, calibration and sample solutions

Preferably made from perfluoroalkoxy (PFA) or hexafluoroethene propene (FEP). For the determination of elements in a higher concentration range, HDPE or PTFE bottles may be sufficient for the storage of samples.

## 9 Procedure

### 9.1 Test sample

The test sample is an acidified aqueous sample ( $\text{pH} \leq 1$ ) free of particles or the digest obtained by *<Horizontal standard nitric acid digestion>* or *<Horizontal standard aqua regia digestion>*.

### 9.2 Test portion

The test portion may be directly obtained for the test sample or may be diluted from the test sample to accommodate the measurement range or to dilute the matrix.

The acidity of the test portion must match the acidity of calibration solutions.

Ensure that all elements are present in a non-volatile form. Volatile species must be converted to non-volatile ones e.g. sulfide oxidation by hydrogen peroxide.

### 9.3 Instrument set up

Adjust the instrumental parameters of the ICP-MS system in accordance with the manufacturer's manual.

About 30 min prior to measurement, adjust the instrument to working condition.

Before each series of measurement check the sensitivity and the stability of the system and minimize interference e.g. by using the optimization solution (7.12).

Check the resolution and the mass calibration as often as required by the manufacturer.

Define the relative atomic masses and the corresponding corrections. Alternatively, apply multivariate calibration procedures.

Define the rinsing times depending on the length of the flow; in the case of largely varying mass concentrations in the measuring solutions, allow for longer rinsing periods.

The use of an internal standard is recommended. Add the internal standard solution (7.9) to the interference check solution (7.13), to all multi-element calibration solutions (7.8), to the blank calibration solutions (7.10), and to all measuring solutions.

The mass concentration of the reference-elements shall be the same in all solutions. A mass concentration of  $\rho(Y, \text{Re}) = 50 \mu\text{g/l}$  is often suitable.

NOTE ICP-MS has excellent multi-element capability. Nevertheless it does not mean, that all elements can be analyzed during one measurement run. The sensitivity of determination depends on plenty of parameters (nebulizer flow, radio-frequency power, lens voltage, lens voltage mode etc.). The optimal instrument settings can not be reached for all elements at once.

### 9.4 Calibration

#### 9.4.1 Linear calibration function

If more than two concentration levels, including zero, are used apply weighted linear regression to obtain the linear calibration function.

NOTE ICP-MS provides a large measurement range. The dispersion of blank measurements is usually much smaller than the dispersion at full scale. Ordinary linear regression assumes that the dispersion is constant over the entire range. As a consequence a much higher percentage of the calculated intercepts is out of the range expected from the spread of blanks: a non-zero blank value is calculated that is actually not there. Weighted linear regression forces the line through points of low dispersion, resulting in the expected intercept dispersion. Unfortunately, many data systems cannot handle weighted regression. An alternative, but less efficient, approach is ordinary linear regression where the line is forced through the blank

value or through zero.

The most inexpensive way however is a (single or multiple) two point calibration. If calibration lines are linear, as they are usually in ICP-MS, this procedure is valid and efficient.

If weighted linear regression is not possible apply linear regression forced through the blank value or through zero. In the latter case check regularly by running a blank whether the assumption on the absence of a blank value is justified.

A two point calibration is allowed if the calibration function is linear, which usually is the case. Check regularly with a calibration solution of known dilution whether the assumption on linearity is justified. Instead of one measurement per level more measurements can be performed to reduce the uncertainty of the calibration line.

#### **9.4.2 Standard addition calibration**

Add a known amount of analyte to the known amount of the sample portion, or its dilution. Calculate the corresponding concentration change. Measure the difference in concentration between the original and the spiked sample portion. Use the ratio 'true spike concentration' versus 'measured spike concentration' as a correction factor for the initially measured concentration of the sample portion. Minimise dilution or correct for spike dilution.

#### **9.4.3 Determination of correction factors**

In order to evaluate and to update the correction factors, measure the interference check solutions (7.13) at regular intervals within a measuring cycle. Subsequent correction factors shall not change more than 20%.

#### **9.4.4 Variable isotope ratio**

Take into account the possible discrepancies in the isotope composition between the calibration solutions and the measuring solutions (e.g. relevant for Li, Pb, U).

### **9.5 Sample measurement**

Run one or more calibration solutions and a calibration blank.

Run the interference check solution(s) to establish interference correction or to check presence of interference.

Run all samples including one or more method blanks.

Every 25 samples or less and at the end, run a calibration blank and a calibration check solution.

Every (e.g.) 50 samples and at the end of a run, analyze a interference check solution.

Run at least one spiked sample (digest or aqueous sample) from the series to check recovery.

NOTE 1 If standard addition calibration is applied to all samples leave out recovery check.

Some elements (for example Ag, B, Be, Hg, Li, Th) are rinsed very slowly from the sample inlet system. Check whether a high sample count rate has an effect on the next measurement result.

Whenever a new or usual sample matrix is encountered check:

- matrix effects by running the spike sample or
- matrix effects by running a fivefold diluted sample and

- inter-element interference analysing a different isotope.

## 10 Calculation

Calculate the element concentration in the aqueous sample:

$$\rho = (\rho_1 - \rho_0)f_d \cdot f_a$$

Calculate the element concentration in the digested solid sample:

$$w = (\rho_1 - \rho_0)f_a \cdot V \cdot 100 / (m \cdot dw)$$

where:

$\rho$	is the concentration of the element in the aqueous sample in $\mu\text{g/l}$ ;
$\rho_1$	is the concentration of the element in the test sample in $\mu\text{g/l}$ ;
$\rho_0$	is the concentration of the element in the blank in $\mu\text{g/l}$ ;
$f_d$	is the dilution factor due to digestion of an aqueous sample; in all other cases $f_d = 1$ ;
$f_a$	is the dilution factor of the test portion;
$w$	is the mass fraction of the element in the solid sample in $\mu\text{g/g}$ or $\text{mg/kg}$ ;
$V$	is the volume of the test sample (digest) in litres;
$m$	is the mass of the digested sample in g.
$dw$	is the dry weight percentage of the sample.

## 11 Expression of results

State as many significant figures as are acceptable according to the precision of the measuring values, but not more than three significant figures.

## 12 Performance characteristics

### 12.1 Blank

Result of the calibration blank check shall be less than 3 times the instrumental limit of detection.

### 12.2 Sensitivity

Result of the calibration check standard shall not deviate more than 10%.

### 12.3 Internal standard response

Internal standard response of a sample shall be more than 30% of the response of a calibration solution.

### 12.4 Interference

The contribution of corrected and uncorrected isobaric molecular and doubly charged shall not be higher than three times the instrumental detection limit in trace analysis or lower than halve the value of the lowest concentration to be reported.

In high matrix measurements the detection limit of analytes of interest should be determined in ICS containing relevant interferences.

**Note:** Assume that the concentration for calcium in an interference check solution (ICS) is 200 mg/L. If the contribution of interference of Ca on the interfered isotope (Ni60) is lower than three times the instrumental detection limit or lower than 0.5 times the lowest concentration to be reported ( or if the concentration of the Ca interferent in the testsample is LOWER than 200 mg/L) the concentration of the interfered isotope (Ni60) can be reported. If the concentration of the interference on the interfered isotope is higher than 200 mg/L, Ni60 can NOT be reported prior to further investigation of the interference.

Successive values of a correction factor shall not differ more than 20% within one sequence.

## **12.5 Recovery**

Spike recovery shall be between 75% and 125% or difference between results for the original sample and the fivefold-diluted sample shall be less than 20% when the concentration in fivefold-diluted sample is higher than three times the instrumental detection limit or twice the lowest concentration to be reported. Spike concentration should be within 0.4 an 2.5 times the analyte concentration.

## 12.6 Limit of Detection

Table 1: Method Limit of detection:

Element	Method Limit of detection (in mg/kg dw)											
	Blank Aqua Regia			ICS1			ICS2			ICS1+2		
	1 gram 50 mL	5 gram 100 mL	5 gram 200 mL	1 gram 50 mL	5 gram 100 mL	5 gram 200 mL	1 gram 50 mL	5 gram 100 mL	5 gram 200 mL	1 gram 50 mL	5 gram 100 mL	5 gram 200 mL
Be / 9 [He]	0.09	0.03	0.07	0.07	0.03	0.06	0.08	0.03	0.06	0.09	0.03	0.07
V / 51 [He]	0.23	0.09	0.18	0.39	0.15	0.31	0.29	0.12	0.23	0.32	0.13	0.26
Cr / 52 [He]	0.25	0.10	0.20	0.20	0.08	0.16	0.20	0.08	0.16	0.20	0.08	0.16
Cr / 53 [He]	0.90	0.36	0.72	0.98	0.39	0.78	1.00	0.40	0.80	0.85	0.34	0.68
Ni / 58 [He]	0.18	0.07	0.14	7.24	2.89	5.79	0.13	0.05	0.10	4.51	1.80	3.61
Co / 59 [He]	0.09	0.03	0.07	0.08	0.03	0.06	0.06	0.02	0.05	0.04	0.02	0.03
Ni / 60 [He]	0.13	0.05	0.11	0.15	0.06	0.12	0.08	0.03	0.07	0.09	0.04	0.07
Ni / 61 [He]	0.47	0.19	0.37	0.79	0.32	0.63	1.72	0.69	1.38	1.16	0.46	0.93
Cu / 63 [He]	1.37	0.55	1.10	1.58	0.63	1.26	1.51	0.61	1.21	1.58	0.63	1.27
Zn / 64 [He]	0.31	0.12	0.25	0.31	0.13	0.25	0.22	0.09	0.17	0.23	0.09	0.19
Cu / 65 [He]	1.32	0.53	1.06	1.49	0.60	1.19	1.47	0.59	1.17	1.54	0.61	1.23
Zn / 66 [He]	0.32	0.13	0.26	0.27	0.11	0.21	0.26	0.11	0.21	0.29	0.12	0.23
Zn / 68 [He]	0.46	0.18	0.37	0.42	0.17	0.33	0.29	0.12	0.23	0.28	0.11	0.23
As / 75 [He]	0.17	0.07	0.14	0.23	0.09	0.18	0.13	0.05	0.11	0.11	0.04	0.09
Se / 77 [He]	2.51	1.00	2.01	1.87	0.75	1.49	1.25	0.50	1.00	2.54	1.01	2.03
Se / 78 [He]	1.91	0.76	1.53	1.57	0.63	1.26	2.12	0.85	1.69	2.17	0.87	1.73
Se / 82 [He]	1.07	0.43	0.86	1.00	0.40	0.80	0.83	0.33	0.66	0.95	0.38	0.76
Mo / 95 [He]	0.28	0.11	0.22	0.81	0.32	0.65	0.77	0.31	0.61	0.90	0.36	0.72
Mo / 98 [He]	0.28	0.11	0.23	0.84	0.33	0.67	0.80	0.32	0.64	0.93	0.37	0.74
Cd / 111 [He]	0.09	0.04	0.07	0.07	0.03	0.06	0.08	0.03	0.07	0.06	0.02	0.05
Cd / 114 [He]	0.08	0.03	0.07	0.05	0.02	0.04	0.07	0.03	0.05	0.04	0.02	0.03
Sn / 118 [He]	0.19	0.08	0.15	0.15	0.06	0.12	0.11	0.04	0.09	0.14	0.06	0.11
Sn / 120 [He]	0.19	0.08	0.15	0.14	0.06	0.11	0.12	0.05	0.09	0.14	0.06	0.11
Sb / 121 [He]	0.10	0.04	0.08	0.13	0.05	0.10	0.11	0.04	0.08	0.13	0.05	0.11
Sb / 123 [He]	0.10	0.04	0.08	0.13	0.05	0.11	0.16	0.06	0.13	0.14	0.06	0.11
Te / 125 [He]	0.12	0.05	0.09	0.09	0.04	0.08	0.14	0.06	0.12	0.15	0.06	0.12
Te / 126 [He]	0.08	0.03	0.06	0.08	0.03	0.06	0.05	0.02	0.04	0.06	0.02	0.05
Ba / 135 [He]	0.18	0.07	0.15	0.14	0.06	0.11	0.14	0.06	0.11	0.10	0.04	0.08
Ba / 137 [He]	0.15	0.06	0.12	0.11	0.04	0.09	0.09	0.04	0.07	0.08	0.03	0.06
Hg / 200 [He]	0.01	0.00	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
Hg / 201 [He]	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.02
Hg / 202 [He]	0.01	0.00	0.01	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.01
Tl / 203 [He]	0.22	0.09	0.17	0.24	0.10	0.19	0.16	0.06	0.13	0.14	0.06	0.12
Tl / 205 [He]	0.25	0.10	0.20	0.24	0.10	0.19	0.17	0.07	0.13	0.13	0.05	0.10
Pb / 206 [He]	0.11	0.04	0.08	0.06	0.02	0.05	0.07	0.03	0.06	0.07	0.03	0.05
Pb / 207 [He]	0.12	0.05	0.09	0.06	0.02	0.05	0.10	0.04	0.08	0.09	0.04	0.07
Pb / 208 [He]	0.10	0.04	0.08	0.05	0.02	0.04	0.07	0.03	0.06	0.06	0.03	0.05
Se / 77 [H2]	0.50	0.20	0.40	0.84	0.34	0.68	0.91	0.36	0.73	1.04	0.42	0.83
Se / 78 [H2]	0.07	0.03	0.06	0.12	0.05	0.10	0.10	0.04	0.08	0.14	0.06	0.12
Be / 9 [St]	0.05	0.02	0.04	0.05	0.02	0.04	0.04	0.01	0.03	0.05	0.02	0.04
V / 51 [St]	1.16	0.46	0.93	2.52	1.01	2.01	1.44	0.58	1.15	1.84	0.74	1.47
Cr / 52 [St]	0.29	0.12	0.23	0.20	0.08	0.16	0.29	0.12	0.23	0.16	0.06	0.13

Cr / 53 [St]	3.95	1.58	3.16	8.32	3.33	6.66	5.01	2.00	4.01	6.12	2.45	4.90
Ni / 58 [St]	0.19	0.08	0.15	17.22	6.89	13.77	0.12	0.05	0.10	8.63	3.45	6.90
Co / 59 [St]	0.08	0.03	0.06	0.06	0.02	0.05	0.05	0.02	0.04	0.05	0.02	0.04
Ni / 60 [St]	0.17	0.07	0.14	0.14	0.05	0.11	0.20	0.08	0.16	0.14	0.06	0.11
Ni / 61 [St]	0.56	0.22	0.45	3.13	1.25	2.51	13.24	5.30	10.59	9.54	3.82	7.64
Cu / 63 [St]	1.36	0.54	1.09	1.58	0.63	1.26	1.77	0.71	1.42	1.75	0.70	1.40
Zn / 64 [St]	0.26	0.10	0.21	0.33	0.13	0.27	0.55	0.22	0.44	0.37	0.15	0.29
Cu / 65 [St]	1.28	0.51	1.03	1.50	0.60	1.20	1.45	0.58	1.16	1.54	0.61	1.23
Zn / 66 [St]	0.30	0.12	0.24	0.29	0.12	0.23	0.30	0.12	0.24	0.22	0.09	0.17
Zn / 68 [St]	0.30	0.12	0.24	0.27	0.11	0.21	0.20	0.08	0.16	0.18	0.07	0.15
As / 75 [St]	0.85	0.34	0.68	2.72	1.09	2.17	1.99	0.79	1.59	1.98	0.79	1.58
Se / 77 [St]	7.61	3.04	6.09	17.90	7.16	14.32	13.98	5.59	11.18	12.69	5.08	10.15
Se / 78 [St]	3.07	1.23	2.46	6.69	2.68	5.36	8.00	3.20	6.40	7.79	3.11	6.23
Se / 82 [St]	0.50	0.20	0.40	0.32	0.13	0.25	0.56	0.22	0.45	0.38	0.15	0.31
Mo / 95 [St]	0.22	0.09	0.18	0.41	0.17	0.33	0.37	0.15	0.30	0.44	0.18	0.35
Mo / 98 [St]	0.24	0.10	0.19	0.41	0.16	0.33	0.38	0.15	0.31	0.48	0.19	0.38
Cd / 111 [St]	0.09	0.04	0.07	0.04	0.02	0.03	0.04	0.02	0.04	0.06	0.02	0.05
Cd / 114 [St]	0.07	0.03	0.05	0.02	0.01	0.02	0.03	0.01	0.03	0.04	0.01	0.03
Sn / 118 [St]	0.17	0.07	0.13	0.17	0.07	0.13	0.16	0.06	0.12	0.20	0.08	0.16
Sn / 120 [St]	0.17	0.07	0.14	0.15	0.06	0.12	0.13	0.05	0.10	0.16	0.07	0.13
Sb / 121 [St]	0.07	0.03	0.06	0.13	0.05	0.10	0.10	0.04	0.08	0.14	0.05	0.11
Sb / 123 [St]	0.08	0.03	0.06	0.14	0.06	0.12	0.10	0.04	0.08	0.12	0.05	0.10
Te / 125 [St]	0.08	0.03	0.06	0.04	0.02	0.04	0.05	0.02	0.04	0.03	0.01	0.03
Te / 126 [St]	0.05	0.02	0.04	0.02	0.01	0.01	0.03	0.01	0.02	0.02	0.01	0.02
Ba / 135 [St]	0.15	0.06	0.12	0.08	0.03	0.06	0.09	0.04	0.07	0.06	0.02	0.04
Ba / 137 [St]	0.14	0.06	0.11	0.10	0.04	0.08	0.12	0.05	0.10	0.09	0.04	0.07
Hg / 200 [St]	0.03	0.01	0.02	0.02	0.01	0.01	0.03	0.01	0.02	0.02	0.01	0.02
Hg / 201 [St]	0.03	0.01	0.02	0.03	0.01	0.02	0.02	0.01	0.02	0.03	0.01	0.02
Hg / 202 [St]	0.02	0.01	0.02	0.01	0.00	0.01	0.02	0.01	0.01	0.02	0.01	0.02
Tl / 203 [St]	0.21	0.08	0.17	0.24	0.10	0.19	0.19	0.08	0.15	0.16	0.06	0.13
Tl / 205 [St]	0.21	0.09	0.17	0.22	0.09	0.17	0.17	0.07	0.14	0.16	0.06	0.13
Pb / 206 [St]	0.12	0.05	0.09	0.08	0.03	0.07	0.08	0.03	0.07	0.05	0.02	0.04
Pb / 207 [St]	0.11	0.04	0.09	0.07	0.03	0.05	0.06	0.02	0.05	0.05	0.02	0.04
Pb / 208 [St]	0.09	0.04	0.08	0.05	0.02	0.04	0.06	0.02	0.05	0.04	0.02	0.03

[St] Standard mode

[He] He mode

[H2] Hydrogen mode

#### Legenda:

Component	ICS 1	ICS 2
Aluminium	1000 mg/L	-
Iron	1000 mg/L	-
Potassium	2000 mg/L	-
Sodium	1000 mg/L	-
Phosphorus	-	1000 mg/L
Calcium	1000 mg/L	4000 mg/L
Magnesium	1000 mg/L	-
Sulphur	-	1000 mg/L
Carbon	-	2000 mg/L
Chlorine	2000 mg/L	2000 mg/L

Cl: can interfere on V, Cr 53, As, Se77



Precision

Tabel 2: Measurement of precision (in VC<sub>w</sub> %):

Element	Rep. limit Limit	CRM145R	FeNeLab	LKSD-1	STSD	CRM7001	CRM144R	CRM141R	AMBWB	AMBSZ	AMB COMP	Average
Be / 9 [He]	0.1	30.1	4.9	25.1	2.1	4.9	54.3	3.5	7.7	<r.l.	<r.l.	16.6
V / 51 [He]	1	6.2	7.9	5.3	7.4	4.7	6.4	4.1	5.1	10.7	10.9	6.9
Cr / 52 [He]	15	5.6	5.2	5.5	4.3	6.4	5.0	4.7	5.6	<r.l.	6.9	5.5
Cr / 53 [He]	15	5.9	5.0	9.0	4.3	5.7	5.3	4.6	5.8	<r.l.	8.4	6.0
Ni / 58 [He]	3	5.5	4.7	4.4	2.9	4.2	4.2	4.4	4.8	<r.l.	7.5	4.7
Co / 59 [He]	1	5.0	5.0	4.5	3.8	5.0	4.7	4.6	5.3	<r.l.	8.2	5.1
Ni / 60 [He]	3	5.4	5.3	5.0	3.9	5.4	4.6	4.5	5.4	<r.l.	7.2	5.2
Ni / 61 [He]	3	4.8	5.6	7.7	4.1	5.4	6.8	5.5	5.9	<r.l.	17.0	7.0
Cu / 63 [He]	5	4.4	4.5	4.6	3.7	5.1	3.9	4.3	5.2	<r.l.	6.4	4.7
Zn / 64 [He]	17	3.7	3.7	3.4	2.7	4.3	3.1	2.7	4.1	<r.l.	5.0	3.6
Cu / 65 [He]	5	4.5	4.8	4.7	4.1	5.5	4.0	4.6	5.5	<r.l.	7.0	5.0
Zn / 66 [He]	1	3.6	3.9	3.6	3.1	3.9	3.1	3.7	4.2	4.0	5.0	3.8
Zn / 68 [He]	17	3.5	3.9	3.4	3.0	4.0	3.3	3.4	4.2	<r.l.	4.4	3.7
As / 75 [He]	4	5.1	3.2	3.0	2.5	3.2	<r.l.	2.8	3.8	<r.l.	<r.l.	3.4
Se / 77 [He]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.
Se / 78 [He]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.
Se / 82 [He]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.
Mo / 95 [He]	1.5	23.7	<r.l.	7.0	4.1	<r.l.	18.3	<r.l.	<r.l.	<r.l.	<r.l.	13.2
Mo / 98 [He]	1.5	22.8	<r.l.	7.5	4.6	<r.l.	18.6	<r.l.	<r.l.	<r.l.	<r.l.	13.4
Cd / 111 [He]	0.17	2.6	3.6	4.6	3.9	7.4	5.2	2.7	<r.l.	<r.l.	8.3	4.8
Cd / 114 [He]	0.17	5.0	4.0	3.8	5.0	8.1	4.9	3.6	<r.l.	<r.l.	8.2	5.3
Sn / 118 [He]	6	4.1	5.4	<r.l.	<r.l.	11<r.l.	5.2	<r.l.	<r.l.	<r.l.	<r.l.	4.9
Sn / 120 [He]	6	4.1	5.3	<r.l.	<r.l.	<r.l.	5.3	<r.l.	<r.l.	<r.l.	<r.l.	4.9
Sb / 121 [He]	1	4.6	9.4	<r.l.	12.7	<r.l.	8.0	<r.l.	<r.l.	<r.l.	<r.l.	8.7
Sb / 123 [He]	1	4.7	8.5	<r.l.	13.4	<r.l.	7.3	<r.l.	<r.l.	<r.l.	<r.l.	8.5
Te / 125 [He]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.
Te / 126 [He]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.
Ba / 135 [He]	15	11.4	4.1	2.9	3.2	4.3	3.7	3.3	13.8	<r.l.	3.9	5.6
Ba / 137 [He]	15	13.0	4.8	3.8	4.3	5.8	4.5	4.2	15.9	<r.l.	4.9	6.8
Hg / 200 [He]	0.05	1.4	2.0	8.1	8.2	5.4	3.0	3.2	3.2	<r.l.	<r.l.	4.3
Hg / 201 [He]	0.05	3.0	1.9	10.1	<r.l.	9.8	2.9	4.7	3.4	<r.l.	<r.l.	5.1
Hg / 202 [He]	0.05	2.7	1.8	5.2	7.4	3.7	1.8	2.8	2.9	<r.l.	<r.l.	3.5
Tl / 203 [He]	3	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.
Tl / 205 [He]	3	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.
Pb / 206 [He]	13	2.5	2.3	1.5	2.7	2.3	2.8	1.8	<r.l.	<r.l.	6.7	2.8
Pb / 207 [He]	13	2.4	2.4	1.7	2.4	2.7	2.7	1.7	<r.l.	<r.l.	6.3	2.8
Pb / 208 [He]	13	3.6	2.2	1.5	2.6	2.5	2.6	1.7	<r.l.	<r.l.	6.1	2.9
Se / 77 [H2]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.
Se / 78 [H2]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.
Be / 9 [St]	0.1	21.5	2.9	15.6	2.2	3.9	25.8	3.3	4.1	<r.l.	<r.l.	9.9
V / 51 [St]	1	15.5	7.5	12.2	6.3	6.3	24.5	6.5	6.9	76.7	61.8	22.4
Cr / 52 [St]	15	5.0	6.6	6.2	5.0	4.5	7.6	5.4	5.4	<r.l.	6.7	5.8
Cr / 53 [St]	15	8.0	8.0	<r.l.	9.6	7.8	13.6	6.7	9.5	<r.l.	24.1	10.9
Ni / 58 [St]	3	5.2	6.2	5.1	5.1	5.4	4.9	4.9	4.7	<r.l.	7.3	5.4
Co / 59 [St]	1	5.6	6.3	5.5	4.7	5.1	4.7	4.6	5.0	<r.l.	6.0	5.3
Ni / 60 [St]	3	5.4	6.5	5.8	4.7	4.8	4.8	4.8	5.0	<r.l.	8.0	5.5
Ni / 61 [St]	3	5.9	7.0	12.0	4.9	4.8	10.8	6.2	5.7	<r.l.	18.6	8.4
Cu / 63 [St]	5	4.5	5.4	5.0	4.5	5.1	4.3	4.7	5.0	<r.l.	6.3	5.0
Zn / 64 [St]	17	2.1	3.5	2.7	2.6	5.7	2.7	2.7	3.2	<r.l.	3.5	3.2
Cu / 65 [St]	5	4.3	5.2	4.8	4.6	4.9	4.6	4.7	4.6	<r.l.	6.0	4.9
Zn / 66 [St]	1	2.1	3.2	3.4	2.4	2.8	2.9	2.4	2.5	3.3	3.3	2.8
Zn / 68 [St]	17	2.1	3.1	2.3	2.7	3.1	2.7	2.4	2.9	<r.l.	3.0	2.7
As / 75 [St]	4	58.6	5.1	6.1	5.0	9.9	<r.l.	16.0	7.8	<r.l.	<r.l.	15.5
Se / 77 [St]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.
Se / 78 [St]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.
Se / 82 [St]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.

Mo / 95 [St]	1.5	14.3	<r.l.	4.6	3.3	<r.l.	10.9	12.7	14.2	<r.l.	<r.l.	<b>10.0</b>
Mo / 98 [St]	1.5	13.5	<r.l.	4.5	3.4	<r.l.	10.3	12.4	13.7	<r.l.	<r.l.	<b>9.6</b>
Cd / 111 [St]	0.17	4.5	1.7	3.5	3.0	6.3	4.1	1.6	<r.l.	<r.l.	3.5	<b>3.5</b>
Cd / 114 [St]	0.17	2.0	1.5	1.9	2.4	4.2	4.3	1.7	<r.l.	<r.l.	3.2	<b>2.7</b>
Sn / 118 [St]	6	2.5	1.5	<r.l.	<r.l.	<r.l.	3.2	<r.l.	<r.l.	<r.l.	<r.l.	<b>2.4</b>
Sn / 120 [St]	6	2.1	1.3	<r.l.	<r.l.	<r.l.	2.5	<r.l.	<r.l.	<r.l.	<r.l.	<b>2.0</b>
Sb / 121 [St]	1	3.0	5.4	<r.l.	11.4	<r.l.	4.8	<r.l.	<r.l.	<r.l.	<r.l.	<b>6.1</b>
Sb / 123 [St]	1	3.2	5.8	<r.l.	11.0	<r.l.	5.1	<r.l.	<r.l.	<r.l.	<r.l.	<b>6.3</b>
Te / 125 [St]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<b>&lt;r.l.</b>
Te / 126 [St]	10	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<b>&lt;r.l.</b>
Ba / 135 [St]	15	9.5	1.8	1.5	2.4	2.8	2.5	2.2	13.1	<r.l.	2.2	<b>4.2</b>
Ba / 137 [St]	15	8.8	1.5	1.7	1.8	2.9	2.3	2.5	12.9	<r.l.	1.8	<b>4.0</b>
Hg / 200 [St]	0.05	2.5	3.7	14.2	20.1	7.2	4.8	4.2	4.7	<r.l.	<r.l.	<b>7.7</b>
Hg / 201 [St]	0.05	2.5	2.9	8.7	<r.l.	10.0	2.2	6.3	4.0	<r.l.	<r.l.	<b>5.2</b>
Hg / 202 [St]	0.05	4.1	4.5	7.8	11.3	7.5	4.2	7.9	4.6	<r.l.	<r.l.	<b>6.5</b>
Tl / 203 [St]	3	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<b>&lt;r.l.</b>
Tl / 205 [St]	3	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<r.l.	<b>&lt;r.l.</b>
Pb / 206 [St]	13	2.2	3.7	1.9	3.5	2.1	3.0	2.5	<r.l.	<r.l.	2.4	<b>2.7</b>
Pb / 207 [St]	13	2.0	3.4	1.8	3.2	2.0	2.8	2.3	<r.l.	<r.l.	2.2	<b>2.5</b>
Pb / 208 [St]	13	2.0	3.6	2.5	3.7	2.1	2.9	1.5	<r.l.	<r.l.	2.2	<b>2.6</b>
Average:												<b>6.1</b>

### Legenda

1. CRM 145R: sewage sludge.
2. FeNeLab: internal reference material, river clay.
3. Lksd-1: lake sediment.
4. Stsd-2: stream sediment.
5. CRM 7001: light sandy soil.
6. CRM 144R: sewage sludge from domestic origin.
7. CRM 141R: Calcareous loam soil.
8. AMB WB: internal reference material: lake sediment.
9. AMB SZ: internal reference material: 'playground sand'.
10. AMB Compost: internal reference material; biowaste/garden waste.
11. Average: averaged precision of the 10 testsamples.

### **13 Test report**

The test report shall make reference to this international standard and contain the following details:

- a) Complete identification of the sample;
- b) Expression of results as indicated in clause 9;
- c) Sample pre-treatment, if appropriate;
- d) Any deviations from this method, and details of all circumstances which could have affected the result.

## Annex A Informative

Table 1. Selected isotopes, spectral interferences and detection limits for quadrupole ICP-MS instruments

Element	Isotope	Abundance (%)	Det. lim <sup>a</sup> µg/l	Potential interferences		Interference with practical relevance	Best usable isotopes	
				Interelement	Polyatomic ions		Preference	Reason
Ag	107	51,8	1		ZrO YO	<sup>91</sup> Zr <sup>16</sup> O	x	least interference
	109	48,2	1		ZrO ZrOH NbO			
Al	27	100	5		BeO BO CN HCN		x	
As	75	100	1	Sm <sup>2+</sup> Eu <sup>2+</sup> Nd <sup>2+</sup>	ArCl CoO Ar <sub>2</sub> H ArK CaO <sub>2</sub> NaCAr CPO <sub>2</sub> CaCl	<sup>40</sup> Ar <sup>35</sup> Cl	x	
Au	197	100	0,5		HfO TaO		x	
B	10	19,9	10				x	free of interference, low background
	11	80,1	10		BH			
Ba	135	6,6	3					
	137	11,2	3				x	highest abundance, least interference
	138	71,7	0,5	La Ce		La, Ce		
Be	9	100	0,5				x	
Bi	209	100	0,5				x	
Ca	43	0,14	100	Sr <sup>2+</sup>	MgO BO <sub>2</sub> AlO CaH CNO CO <sub>2</sub>	Sr <sup>2+</sup>	x	low background, least interference
	44	2,1	50	Sr <sup>2+</sup>	CaH MgO AlO BO <sub>2</sub> CNO SiO CO <sub>2</sub> N <sub>2</sub> O	Sr <sup>2+</sup> , <sup>12</sup> C <sup>16</sup> O <sub>2</sub>	x	lowest det. limit
Cd	111	12,8	0,5		MoO MoOH ZrOH K <sub>2</sub> O <sub>2</sub> H	<sup>94</sup> Zr <sup>16</sup> O <sup>1</sup> H, <sup>95</sup> Mo <sup>16</sup> O		
	113	12,2	0,5	In	MoO ZrOH Ca <sub>2</sub> O <sub>2</sub> H Ar <sub>2</sub> O <sub>2</sub> H RuO	In, <sup>97</sup> Mo <sup>16</sup> O	x	for high Sn
	114	28,7	0,3	Sn	MoO MoOH RuO	Sn, <sup>98</sup> Mo <sup>16</sup> O	x	lowest det. limit, least interference
Ce	140	88,5	0,1				x	
Co	59	100	0,2	Sn <sup>2+</sup>	CaO CaOH MgCl ArNa ArOH ArF	<sup>43</sup> Ca <sup>16</sup> O	x	
Cr	52	83,8	1		SO ArO ArC ArN ClO HClO ClN ArNH	<sup>40</sup> Ar <sup>12</sup> C	x	for low C and high Cl
	53	9,5	5		HSO ArC HClO ClO ArOH ArN ArNH SO	<sup>37</sup> Cl <sup>16</sup> O	x	for high C and low Cl
Cs	133	100	0,1		RuO <sub>2</sub>		x	
Cu	63	69,2	1		TiO PO <sub>2</sub> ArNa MgCl NaCa CaOH ArCNH NCCI ClO	<sup>47</sup> Ti <sup>16</sup> O, <sup>40</sup> Ar <sup>23</sup> Na	x	for low Na and Ti, lowest det. limit
	65	30,8	2	Ba <sup>2+</sup>	TiO PO <sub>2</sub> SO <sub>2</sub> SO <sub>2</sub> H ArMg CaOH ArN <sub>2</sub> H S <sub>2</sub> COCl	<sup>49</sup> Ti <sup>16</sup> O, <sup>32</sup> S <sup>16</sup> O <sub>2</sub> <sup>1</sup> H, <sup>40</sup> Ar <sup>25</sup> Mg	x	for medium Mg, S and Ti and high Na
Dy	163	24,9	0,1		NdO SmO		x	
Er	166	33,6	0,1		SmO NdO		x	
Eu	151	47,8	0,1		BaO			
	153	52,2	0,1		BaO		x	
Fe	54	5,8	20	Cr	HClO ArO ArN ArNH ArOH SO ClO	ArN Cr	x	abundance and background determine choice
	57	2,2	50		CaO ArO ArOH CaC CaN CaOH MgO <sub>2</sub> ArF	<sup>40</sup> Ar <sup>16</sup> O <sup>1</sup> H <sup>40</sup> Ca <sup>16</sup> O <sup>1</sup> H	x	
Ga	69	60,1	0,3	Ce <sup>2+</sup> Ba <sup>2+</sup> La <sup>2+</sup>	ClO <sub>2</sub> ArP VO ArS SO <sub>2</sub> S <sub>2</sub>	Ba <sup>2+</sup>		
	71	39,9	0,3	Nd <sup>2+</sup> Ce <sup>2+</sup>	ArP ClO <sub>2</sub> ArCl SO <sub>2</sub> ArS CrO		x	least interference
Gd	157	15,7	0,1		CeO PrO LaO BF		x	least interference
	158	24,8	0,1	Dy	CeO PrO NdO	Dy		

## Annex B Informative

Element	Isotope	Abundance (%)	Det. lim <sup>A</sup> µg/l	Potential interferences		Interference with practical relevance	Best usable isotopes	
				Interelement	Polyatomic ions		Preference	Reason
Ge	74	35,9	0,3	Se Sm <sup>2+</sup> Nd <sup>2+</sup>	ArS Cl <sub>2</sub> Ar <sub>2</sub>	Se	x	
Hf	178	27,3	0,1		GdO DyO ErO		x	
Hg	200	23,1	5		WO	<sup>184</sup> W <sup>16</sup> O		
	201	13,2	10		WO	<sup>184</sup> W <sup>17</sup> O	x	least interference of WO
	202	29,9	5		WO	<sup>186</sup> W <sup>16</sup> O		
Ho	165	100	0,1		SmO		x	
In	115	95,7	0,1	Sn	RuO	Sn	x	
Ir	193	62,7	0,1		HfO LuO		x	
K	39	93,3	50		ArH		x	
La	139	99,9	0,1				x	
Li	6	7,5	10					
	7	92,5	1				x	lowest det. limit
Lu	175	97,4	0,1	Hf	GdO TbO	Hf	x	
Mg	24	79,0	1	Ti <sup>2+</sup> Ca <sup>2+</sup>	LiO NaH C <sub>2</sub>		x	lowest det. limit, least interference
	25	10,0	10	Ti <sup>2+</sup>	LiO BeO C <sub>2</sub> C <sub>2</sub> H			
	26	11,0	10		BeO BO CN C <sub>2</sub> H <sub>2</sub> C <sub>2</sub> H		x	for higher Mg concentrations
Mn	55	100	3		HClO ArN ClO NaS ArOH ArNH KO ArN ArO ArF	ArNH	x	
Mo	95	15,9	0,5		ArKO BrO			
	98	24,1	0,3	Ru	BrO K <sub>2</sub> O	Ru	x	lowest det. limit
Na	23	100	10	Ti <sup>2+</sup> Ca <sup>2+</sup>	LiO		x	
Nd	146	17,2	0,1		BaO RuO <sub>3</sub>		x	
Ni	58	68,1	1	Fe	CaO ArO CaN NaCl MgS CaOH Si <sub>2</sub> ArOH	Fe	x	for low Fe
	60	26,2	3	Sn <sup>2+</sup>	CaO CaOH MgCl NaCl	<sup>44</sup> Ca <sup>16</sup> O	x	least interference
	61	1,1	5	Sn <sup>2+</sup>	CaOH ScO	<sup>44</sup> Ca <sup>16</sup> O <sup>1</sup> H, <sup>45</sup> Sc <sup>16</sup> O		
P	31	100	2		SiH NO NOH N <sub>2</sub> H CO COH	NO	x	
Pb	206 <sup>B</sup> )	24,1	0,2		PtO		x	Sum of 206, 207 and 208
	207 <sup>B</sup> )	22,1	0,2		IrO		x	Sum of 206, 207 and 208
	208 <sup>B</sup> )	52,4	0,1		PtO		x	Sum of 206, 207 and 208
Pd	105	22,3	0,5		YO ArCu			
	108	26,5	0,5	Cd	MoO ZrO	Cd	x	
Pr	141	100	0,1				x	
Pt	195	33,8	0,5		HfO		x	
Rb	85	72,2	0,1	Yb <sup>2+</sup> Er <sup>2+</sup>			x	
Re	185	37,4	0,1		TmO ErO		x	least interference
	187	62,6	0,1	Os	TmO YbO	Os	x	highest abundance
Rh	103	100	0,1	Pb <sup>2+</sup>	SrO ArCu RbO		x	
Ru	101	17,0	0,2		ArNi NiCl			
	102	31,6	0,1	Pd	SrO	Pd	x	lowest det. limit, least interference

Element	Isotope	Abundance (%)	Det. lim <sup>A</sup> µg/l	Potential interferences		Interference with practical relevance	Best usable isotopes	
				Interelement	Polyatomic ions		Preference	Reason
S	34	4,2	100		O <sub>2</sub> SH NOH O <sub>2</sub> H	O <sub>2</sub>	x	
Sb	121	57,4	0,2		PdO		x	least interference
	123	47,6	0,2	Te	ZrO	Te		
Sc	45	100	5	Zr <sup>2+</sup>	CO <sub>2</sub> SiO BO <sub>2</sub> AlO CaH CHO <sub>2</sub> SiOH N <sub>2</sub> OH	<sup>13</sup> C <sup>16</sup> O <sub>2</sub> , <sup>29</sup> Si <sup>16</sup> O	x	
Se	77	7,6	10	Sm <sup>2+</sup> Gd <sup>2+</sup>	ArCl Ar <sub>2</sub> H CaCl CFNO <sub>2</sub>	<sup>40</sup> Ar <sup>37</sup> Cl	x	for low Cl
	78	23,8	10	Kr Gd <sup>2+</sup> Dy <sup>2+</sup>	Ar <sub>2</sub> CaCl ArCa	<sup>36</sup> Ar <sup>40</sup> Ar	x	for high Cl and Br
	82	8,7	10	Kr Ho <sup>2+</sup> Er <sup>2+</sup> Dy <sup>2+</sup>	Ar <sub>2</sub> H BrH CCl <sub>2</sub> SO <sub>3</sub> Ar <sub>2</sub> H <sub>2</sub> ArCa	Kr, <sup>81</sup> Br <sup>1</sup> H	x	for low Br
Si	29	4,7	10		CO N <sub>2</sub> BO SiH AlH COH N <sub>2</sub> H		x	
Sm	147	15,0	0,1		RuO <sub>3</sub>		x	
Sn	118	24,2	1	U <sup>2+</sup>	MoO RuO PdO		x	least interference
	120	32,6	1	Te	RuO PdO	Te		
Sr	86	9,9	0,5	Kr Yb <sup>2+</sup>	RbH			
	88	82,6	0,3	Yb <sup>2+</sup> Lu <sup>2+</sup>			x	lowest det. limit, least interference
Tb	159	100	0,1		NdO PrO		x	
Te	125	7,1	5				x	least interference
Te	126	19,0	2	Xe	PdO	Xe	x	lowest det. limit
Th	232	100	0,1				x	
Ti	47	7,3	10	Zr <sup>2+</sup>	NO <sub>2</sub> PO SiO CCl SNH SiOH SN N <sub>2</sub> NO <sub>2</sub> H	<sup>31</sup> P <sup>16</sup> O	x	least interference
	48	73,8	1	Ca Zr <sup>2+</sup>	ArC CCl SO NO <sub>2</sub> PO SN NN <sub>2</sub> C4	Ca, <sup>32</sup> S <sup>16</sup> O		
	49	5,5			SOH	<sup>32</sup> S <sup>16</sup> O1H		
Tl	203	29,5	0,2		WO ReO WHO			
	205	70,5	0,1				x	lowest det. limit, least interference
Tm	169	100	0,1		EuO		x	
U	238	99,3	0,1				x	
V	51	99,8	1		HSO ClO ClN ArNH ArC ArN SN SO	<sup>35</sup> Cl <sup>16</sup> O	x	
W	182	26,3	0,3		HoO DyO ErO		x	least interference
	184	30,7	0,3	Os	ErO YbO	Os		
Y	89	100	0,1				x	
Yb	172	21,9	0,2		DyO SmO GdO		x	least interference
	174	31,8	0,2	Hf	DyO GdO	Hf		
Zn	64	48,6	1	Ni	TiO CaO PO <sub>2</sub> SO <sub>2</sub> AlCl S <sub>2</sub> PO <sub>2</sub> H ArN <sub>2</sub> ArMg	Ni, <sup>48</sup> Ti <sup>16</sup> O, <sup>32</sup> S <sup>16</sup> O <sub>2</sub> , <sup>40</sup> Ar <sup>24</sup> Mg		
	66	27,9	2	Ba <sup>2+</sup>	TiO VO SO <sub>2</sub> PCI FeC S <sub>2</sub> SO <sub>2</sub> H	<sup>50</sup> Ti <sup>16</sup> O, <sup>34</sup> S <sup>16</sup> O <sub>2</sub>	x	for medium Ti ans S
	68	18,8	3	Ba <sup>2+</sup> Ce <sup>2+</sup>	VO ClO <sub>2</sub> SO <sub>2</sub> TiO ArS FeN PCI FeC S <sub>2</sub> ArN <sub>2</sub> ArSi	Ba <sup>2+</sup> , <sup>40</sup> Ar <sup>28</sup> Si	x	for low Ba and Si
Zr	90	51,5	0,2				x	

<sup>A</sup> Detection limits are dependent on the matrix element concentration. Detection limits relate to higher levels of matrix elements in water samples.

<sup>B</sup> Signals of three isotopes summed because of natural variation of individual abundancies

**Annex B**  
**Informative**

Table 2. Examples of equations for correcting spectral interferences

Element	Recommended isotope and inter-element correction
As	$^{75}\text{As} - 3,127(^{77}\text{Se} - 0,815^{82}\text{Se})$ or $^{75}\text{As} - 3,127(^{77}\text{Se} + 0,3220^{78}\text{Se})$
Ba	$^{138}\text{Ba} - 0,0009008^{139}\text{La} - 0,002825^{140}\text{Ce}$
Cd	$^{114}\text{Cd} - 0,02684^{118}\text{Sn}$
Ge	$^{74}\text{Ge} - 0,1385^{82}\text{Se}$
In	$^{115}\text{In} - 0,01486^{118}\text{Sn}$
Mo	$^{98}\text{Mo} - 0,1106^{101}\text{Ru}$
Ni	$^{58}\text{Ni} - 0,04825^{54}\text{Fe}$
Pb	$^{208}\text{Pb} + ^{207}\text{Pb} + ^{206}\text{Pb}$
Se	$^{82}\text{Se} - 1,009^{83}\text{Kr}$
Sn	$^{120}\text{Sn} - 0,01344^{125}\text{Te}$
V	$^{51}\text{V} - 3,127(^{53}\text{Cr} - 0,1134^{52}\text{Cr})$
W	$^{184}\text{W} - 0,001242^{189}\text{Os}$

**Annex B  
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**Validation**

To be done