Environmental Laboratory Services

Testing the Waters

Metals Analysis

Table of Contents

Cover Photo: Pure tin granules

Introduction

Environmental Laboratory Services is one of New Zealand's leading experts in the areas of:

- Air quality monitoring
- Boiler water
- Environmental water
- Landfills
- Meat industry services
- Potable water for councils
- Sample Integrity
- Swimming pools
- Biological fluids
- Ceramicware and metal food containers
- Food and Dairy Products
- Legionella
- Metals
- Potable water for small communities
- Sewage and effluent
- Trade waste

The company has its origin as part of the Hutt City Council Laboratory and became a private enterprise in 1994. In 1998 the laboratory acquired the Wellington City Council Laboratory. In September 2001, ELS further expanded with the purchase of the Inorganic Chemistry section of AgriQuality New Zealand. This section was previously part of ESR, which before that was the DSIR.

We are based in a purpose built facility of 1450 m^2 at 85 Port Road, Lower Hutt. ELS is comprised of four separate laboratory areas – Instrumental Chemistry, General Chemistry, Biological Fluids, and Microbiology. The latter is further split into three separate rooms with clean, cleaner and ultra clean capabilities. The ultra clean lab is used for pathogenic bacteria determinations.

ELS is privately owned by scientific people committed to the science industry in New Zealand. We continue to be one of the few major laboratories in the country with such a broad microbiological and chemical analysis capability. We provide high quality, fast turnaround analyses at competitive prices.

Who should read this brochure?

Anybody interested in determining metal levels in a wide range of matrices should contact ELS.

This includes routine monitoring for such samples types and landfills, potable water, surface and ground water, through to foodstuffs.

We also determine metal levels in lesser know matrices such as human blood, wood, cement and plaster, crayons and coffee cups.

Instruments used at ELS

Inductively Coupled Plasma – Mass Spectroscopy

An ICP-MS is an instrument capable of determining the concentrations of around 70 elements simultaneously. The sample is introduced into the plasma, where it is vaporised, atomised, and ionised then passed through a magnetic quadrupole to the detector. The instrument is capable of ultra low detection limits of parts per trillion (ppt) for some elements.

Please remember that 1% is equivalent to 10,000,000,000 ppt.

Inductively Coupled Plasma – Optical Emission Spectroscopy

The analytical principle used in the ICP-OES systems is optical emission spectroscopy. A liquid is nebulised and then vaporised within the argon plasma in the same way as the ICP-MS. Unlike the MS however, the atoms and ions contained in the plasma vapour are excited into a state of radiated light (photon) emission. The radiation emitted can be passed to the spectrometer optics, where it is dispersed into its spectral components. From the specific wavelengths emitted by each element, the most suitable line for the application is measured by means of a CCD (charge coupled device).

The instrument is capable of determining the concentrations of 40 to 70 elements simultaneously to very low detection limits (ppm to ppb).

Cold Vapour Atomic Absorption Analyser

Cold Vapour Atomic Absorption spectrometry is used to analyse mercury and operates by reducing the element to the gaseous state, then passing it through a glass chamber where the concentration is measured by the absorption of light passing through the chamber. We use this instrument mainly for analysing mercury in blood and urine.

Graphite Furnace Atomic Absorption Analyser

This form of Atomic Absorption spectrometry analyses sample solutions by atomising them in a graphite induction furnace. The element concentration is measured by absorption of light passing through the furnace. The technique allows for more sensitive measurement than other atomic absorption techniques but is still not as good as the ICP-OES or ICP-MS. We use this instrument for samples and analytes that contain strong matrix interferences. Chromium in urine is a good example of a test we cannot perform by ICP.

Applications

Any sample that can be dissolved or digested into an aqueous solution can be analysed with either ICP technique. ELS can analyse environmental waters, sediments, potable waters, blood and urine, food and biota, metals in solution, and effluents. We can analyse samples from industry and contaminated sites.

We routinely analyse the heavy metal concentration in soil, coal, crayons and graphic materials, as well as fabric and ceramics.

Baseline environmental work offers the challenge of requiring meticulous care in three key facets: collecting a representative sample; preserving and transporting that sample without changing its composition; and analysing the sample. The combination of skilled staff, appropriate specialised protocols, and a full range of top class equipment mean that ELS can offer an elemental analysis service, of the highest quality.

The strengths of ICP techniques for elemental analysis are:

- simultaneous determination of most of the chemical elements
- high sensitivity
- large dynamic range (from the detection limit to the maximum working concentration represents about 8 orders of magnitude - compared with about 2 orders of magnitude in graphite furnace atomic absorption)
- short analysis time
- the ability to measure individual isotopes (ICP-MS)

The ELS ICP-MS has been used for many studies including:

- metals in aquatic ecosystems and shellfish
- contaminant impacts in Antarctica
- heavy metals effects when biosolids are applied to land
- inorganic contaminants in potable groundwaters
- ultra-trace metals in seawaters
- major and trace element composition of New Zealand foods

The ELS Periodic Table of the Elements

H Hydrogen								
Li Lithium	Be Beryllium							
Na Sodium	Mg Magnesium							
K Potassium	Ca Calcium	Sc Scandium	Ti Titanium	V Vanadium	Cr Chromium	Mn Manganese	Fe Iron	Co Cobalt
Rb Rubidium	Sr Strontium	Y Yttrium	Zr Zirconium	Nb Niobium	Mo Molybdenum	Tc Technetium	Ru Ruthenium	Rh Rhodium
Cs Cesium	Ba Barium		Hf Hafnium	Ta Tantalum	W Tungsten	Re Rhenium	Os Osmium	Ir Iridium
Fr Francium	Ra Radium		Rf Rutherfordium	Db Dubnium	Sg Seaborgium	Bh Bohrium	Hs Hassium	Mt Meitnerium

La Lanthanum	Ce Cerium	Pr Praseodymium	Nd Neodymium	Pm Promethium	Sm Samarium
Ac Actinium	Th Thorium	Pa Protactinium	U Uranium	Np Neptunium	Pu Plutonium

Liquids at room temperature

Gasses

39 elements that are routinely offered as IANZ accredited tests

								He Helium
Solids			B Boron	C Carbon	N Nitrogen	O Oxygen	F Fluorine	Ne Neon
Artificially Made			Al Aluminium	Si Silicon	P Phosphorus	S Sulphur	Cl Chlorine	Ar Argon
Ni Nickel	Cu Copper	Zn Zinc	Ga Gallium	Ge Germanium	As Arsenic	Se Selenium	Br Bromine	Kr Krypton
Pd Palladium	Ag Silver	Cd Cadmium	In Indium	Sn Tin	Sb Antimony	Te Tellurium	I Iodine	Xe Xenon
Pt Platinum	Au Gold	Hg Mercury	Tl Thallium	Pb Lead	Bi Bismuth	Po Polonium	At Astatine	Rn Radon
Uun Ununniium	Uuu Ununium	Uub Ununbium						

Eu Europium	Gd Gadolinium	Tb Terbium	Dy Dysprosium	Ho Holmium	Er Erbium	Tm Thulium	Yb Ytterbium	Lu Lutetium
Am Americium	Cm Curium	Bk Berkelium	Cf Californium	Es Einsteinium	Fm Fermium	Md Mendelevium	No Nobelium	Lr Lawrencium

30 elements that can be performed by consultation with ELS analysts

Sample Pre-treatment

Clean water samples can be analysed directly through all instruments, but in order to gain accurate results on other samples, a pre-treatment may need to be applied.

ELS performs a variety of sample pre-treatments which are dependent on the type of sample and the purpose for the testing.

Preservation with acid and no digestion

Recommended for drinking waters and trace metals in colourless samples (with no visible turbidity).

Acid extraction of aqueous samples (based on APHA method 3030c)

Analysis of water samples for metals where extractable metals may be lightly absorbed onto particulate matter. Samples are digested in a dilute hot acid solution to extract lightly absorbed particulate material present in the sample.

Hot acid digestion of aqueous samples (based on APHA method 3030e)

Samples are digested in a hot acid solution to extract total metals. The analysis of aqueous samples i.e. leachate, influents, effluents, dirty ground waters and trade waste where there may be interference from organic matter and to convert metals associated with particulate to a form that can be analysed by ICPMS.

Microwave Digestion

Samples are digested in Nitric acid and Hydrofluoric acid in a microwave. This digestion is not suitable for the analysis of B and Hg, for which we have alternative methods. We use as a more vigorous digestion for sample types such as air-monitoring filters, coal, rocks, and samples that would otherwise not fully digest.

Reverse Aqua Regia Digestion for Soils and Sludge

Samples are digested in a hot acid solution of Nitric acid and Hg free Hydrochloric acid to extract total metals. This digest must be used for soils.

Acid leach of ceramics

A leaching solution of acetic acid is placed into vessels such as coffee cups, and cooking bowls to extract metals. The extract is then measured by ICPMS following Schedule 1 of the Food (Safety) Regulations 2002, which came into force on 20 December 2002.

Specialist Sample Pre-treatment

Several leaching procedures are available to evaluate metals mobility. Two of the more frequently used procedures require that solid waste be mixed with the appropriate extraction fluid and tumbled for 18 hours in a rotary agitator. The liquid is filtered and then analysed for metals.

Toxicity Characteristic Leaching Procedure

The most commonly used EPA Method 1311, Toxicity Characteristic Leaching Procedure TCLP), evaluates metal mobility in a landfill. The extraction simulates a worst case scenario where the waste is co-disposed with municipal solid waste. The primary extraction fluid is a buffered organic acid solution at pH 4.98. If the waste is highly alkaline, a different extraction fluid at pH 2.88 is used. This combination of highly alkaline waste and a weak organic acid produces a buffered solution similar to the first fluid.

Synthetic Precipitation Leaching Procedure

EPA Method 1312, the Synthetic Precipitation Leaching Procedure (SPLP) is used to evaluate the potential for leaching metals into ground and surface waters. This method provides a more realistic assessment of metal mobility under actual field conditions, i.e. what happens when it rains (or snows). The extraction fluid is intended to simulate precipitation. East of the Mississippi River the fluid is slightly more acidic at pH 4.20 reflecting the air pollution impacts of heavy industrialisation and coal utilisation. A pH of 5.00 is used west of the Mississippi reflecting less industrialisation and smaller population densities. Here in New Zealand we apply the most appropriate technique!

The SPLP is a method of choice when evaluating fate and transport of metals in a properly engineered wasteland disposal facility from which municipal solid waste is excluded.

While both techniques tend to be time and resource intensive, leaching procedures are important analytical techniques.

Instruments and Selection of Sample Pre-treatment

ELS analysts work with our clients and with the samples to determine which pre-treatment is the most appropriate to use. Many different permutations can be used and almost all of them would arrive at a different result.

It is therefore very important that all appropriate information be discussed or provided prior to the analysis.

Having use of many instruments gives ELS the luxury of selecting the best instrument for each analysis.

We have determined that:

ICPOES provides the lower detection levels for lighter elements such as the alkali metals.

- Boron
- Calcium
- Iron
- Magnesium
- Potassium
- Sodium

ICP-MS provides the lower detection levels for the heavier elements such as

- Arsenic
- Cadmium
- Chromium
- Lead
- Mercury
- Zinc

When you send us a sample we will often perform individual metals analyses on both instruments in order to achieve the best result.

Most Relevant Metals Screen

ELS analysts have the skills necessary to identify the most relevant metals from within an unknown sample. For an additional charge we will scan the full set of instrument data and determine the metals with the most relevant levels for the sample under examination.

This may include the highest or lowest levels or even the most unusual levels.

ICP-OES	Al, As, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Li, Mn, Ni, P, Pb, Se, Sr, Ti, Tl, V, Zn.
ICP-MS	Ag, Al, As, Au, B, Ba, Be, Bi, Cd, Co, Cr, Cs, Cu, Fe, Li, Mn, Mo, Ni, Pb, Sb, Se, Sn, Sr, Ti, Tl, U, V, W, Zn, Zr.

Detection limits and Uncertainty

ELS follows principals of uncertainty measurement when setting the detection limits we report. While manufacturers state that an instrument can see a level of analyte, they may not include the level of uncertainty at which it is seen. There is no point reporting a result when the uncertainty associated with it is high. A result of 10 +/- 10 has no real value.

ELS has established via complex statistical spreadsheets, levels of detection that provide the smallest uncertainty possible. We would rather report a higher detection level but have greater confidence in the results we produce.

As a rule of thumb, any test we perform should have a detection limit of at least one fifth of the published guideline. For example lead in drinking water has a MAV of 0.01 g/m3. Any instrument used for this analyte should have a detection level of no greater than 0.002 g/m3, and should also have a small uncertainty associated with that level.

Fortunately, the ability of ICP technology allows for very low-level determination and uncertainty of many elements.

Pricing

Test Description	**Cost**
Mercury	$30
Up to 3 metals (Mercury not included in count)	$30
Each metal thereafter	$5
Total Hardness from Calcium and Magnesium results	$5
Calcium Hardness from Calcium	$5

Sample Pre-treatments	**Cost**
Dissolved/Soluble Metals	$5
Aqueous Metals Acid Extraction	$10
Aqueous Total Metal Digestion (water, leachate etc)	$10
Solids Total Metal Digestion (soil etc)	$20
Microwave Digestion	$40
Acid leach of Ceramics including metals analysis	$50 - $70
TCLP	$70
SPLP	$70

Other Pricing

Selection of the most relevant metals from within the full suite of results. This is an extra charge to those shown above.	$20

Bottles are supplied for all analyses, please ask for a copy of our “Assuring Sample Integrity” brochure.

Contact Details

Please feel free to contact ELS by any one of the methods shown below.

TELEPHONE

Main lines to Central Services

Main Telephone	(04) 576-5016
Facsimile	(04) 576-5017
Free Phone	(0800) 576-5016

Direct Lines

Joanne	Accounts	(04) 568-1205
Rob Deacon	General Manager	(04) 568-1203
Sue Meiklen	Occupation Health	(04) 568-1207
Sunita Raju	Microbiology	(04) 568-1206
Terry Manning	Managing Director	(04) 568-1204
Tracy Morrison	Instrumental Chemistry	(04) 568-1200
Jacinta Hira	General Chemistry	(04) 568-1209

Email can be directed to staff using "first initial last name"@els.co.nz

COURIER

85 Port Road, Seaview, Lower Hutt, New Zealand.

MAIL

P.O. Box 36-105, Moera, Lower Hutt, New Zealand.

EMAIL

General Information: solutions@els.co.nz

WEB

www.els.co.nz

NZFSA Laboratory Approval Scheme
Accreditation Number 905

IANZ Accreditation Numbers:
Biological 639, Drinking Water 787,
Chemistry 414, Dairy L1921