Handbook of Biological Monitoring for Health

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New Zealand

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Handbook of Biological Monitoring for Health

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1. Introduction

Canterbury Health Laboratories (CHL) is the leading medical diagnostic reference laboratory in New Zealand with laboratory links and collaborative partners throughout New Zealand and the World.

Operating from modern well equipped facilities opposite Christchurch Hospital, CHL provides laboratory services to general practice surgeries throughout the Canterbury District Health Board (CDHB), provides a level 6 tertiary care laboratory service for CDHB's hospitals and performs reference tests for all medical diagnostic laboratories within New Zealand.

CHL offers specialist clinical and medico-legal tests, and has significant experience in providing laboratory testing services to primary and secondary care, and occupational health settings.

Further to this, CHL runs an extensive routine automated laboratory service, with a long history of collaborative relationships over specialist testing. This includes involvement in contracts for the Newborn Metabolic Screening Program, Quality Improvements for Antenatal Downs Screening and Other Conditions, the National Cervical Screening Programme and acting as the WHO National Measles reference laboratory. Daily requests are received to perform specialist tests from laboratories and workplaces throughout New Zealand, using an established national courier network.

CHL has a highly skilled workforce of dedicated staff with close links to many clinical professionals in various speciality areas throughout New Zealand.

It is the combination of all of these provided services that ensure CHL has the biggest 'catchment' area of any medical laboratory in New Zealand.

CHL has been involved in biological monitoring since 1974 and has developed a comprehensive repertoire of tests.

The laboratory prides itself on rapid turnaround of results at competitive prices. Samples can be transported reliably overnight via pre-paid courier packs supplied on request (see Requesting Analyses for further details). Results can be faxed from the CHL Delphic Medical Computer System.

Please contact the Laboratory for further details of the service and for current prices:
Canterbury Health Laboratories
Corner Hagley Ave and Tuam Street
P O Box 151
Christchurch 8140
New Zealand

Phone: (+64 3) 364 0300
Fax: (+64 3) 364 0750
Within NZ phone: 0800 THE LAB (0800 843 522)

For general test enquiries and order of supplies please contact info@chl.co.nz

Website www.chl.co.nz & www.workplacedrugtest.co.nz

2. Scope of Laboratory Accreditation

The laboratory is accredited with International Accreditation New Zealand (IANZ) against the International standard ISO 15189:2207 "Medical Laboratories Particular Requirements for Quality and Competence ISO 15189:2007" and AS/NZS 4308:2008 "Procedures for Specimen Collection and the Detection and Quantitation of Drugs of Abuse in Urine".

The laboratory is registered under the Testing Laboratory Registration Act 1972 as an Accredited Laboratory in the field of Medical Testing.

3. Specimen Preparation Protocols

Sample collection & transport

Supplies of specimen collection containers and pre-paid courier packs can be obtained from the laboratory on request.

Blood samples

The use of evacuated collection tubes is recommended. Different tests require either anticoagulated blood or plasma (refer to the list of Analytes for Biological Monitoring). For tests requiring plasma, these must be separated from the red cells within the period specified.

Evacuated blood tubes

- Beckton Dickson Vacutainer - dark blue top (Royal Blue) K2EDTA Plus for all trace metal analysis.
- Beckton Dickson Vacutainer – green top lithium heparinised for solvents.

Urine samples

Sterile containers suitable for random urine collections are available from the laboratory. The urine sample should be collected with special care being taken to avoid contamination from hands and clothing. Ensure that the urine is not voided into a metal bed pan and then transferred to the collection bottle. The sample should be sealed, kept on ice and sent to the laboratory for analysis.

Do not use yellow top urine containers as they may be contaminated with cadmium sulphide (yellow pigment).

4. Analytes for Biological Monitoring

The following tests are available from Canterbury Health Laboratories.

In times of medical emergency all tests are available 24 hours per day, seven days per week.

Please contact the laboratory for further information.

Table of Analytes for Biological Monitoring
TAT = Turnaround time in working days

Agent of exposure	Analyte	Specimen	Sampling time
acetone	acetone, urine TAT 2 days	20 mL urine	end of shift
aluminium	aluminium, urine TAT 5 days	20 mL urine	end of shift
antimony	antimony, urine TAT 5 days	20 mL urine	end of shift
arsenic	inorganic arsenic TAT 5 days	20 mL urine	end of shift at end of working week
barium	barium, urine	20 mL urine	end of shift
bismuth	bismuth, urine bismuth, blood	20 mL urine 6 mL K2 EDTA blood	
cadmium	cadmium, blood TAT 5 days	6 mL K2 EDTA blood	not critical
	cadmium, urine TAT 5 days	20 mL urine	not critical
carbon monoxide	carboxyhaemo-globin TAT 1 day	5 mL heparinised blood	immediately following exposure
chromium	chromium, urine TAT 5 days	20 mL urine	end of shift at end of working week
cobalt	cobalt, urine TAT 5 days	20 mL urine	end of shift at end of working week
cyanide	cyanide TAT 2 days	5 mL heparinised blood, sent on ice	following exposure
fluoride	fluoride, urine TAT 5 days	20 mL urine	end of shift

.....Continued

Table of Analytes for Biological Monitoring .....

Agent of exposure	Analyte	Specimen	Sampling time
lead	lead, blood TAT 2 days	6 mL K2 EDTA blood	not critical
	zinc protoporphyrin, blood TAT 1 day	6 mL K2 EDTA blood	(protected from light)
	lead, urine TAT 5 days	20 mL urine	not critical
manganese	manganese, whole blood TAT 5 days	6 mL K2EDTA blood	
mercury	mercury, urine TAT 10 days	20 mL urine frozen immediately	not critical
methanol	methanol TAT 2 days	5 mL heparinised blood or 20 mL urine sent frozen	end of shift
methyl ethyl ketone	methyl ethyl ketone TAT 5 days	20 mL urine	end of shift
molybdenum	molybdenum, urine	20 mL urine	
methylbromide	bromide TAT 5 days	5 mL heparinised blood	end of shift
methylene chloride	methylene chloride TAT 5 days	5 mL heparinised blood	end of shift
nickel	nickel, urine TAT 5 days	20 mL urine	end of shift
organophosphate pesticides	cholinesterase TAT 5 days	5 mL EDTA blood	preseason & post exposure
pentachlorophenol	pentachlorophenol TAT 5 days	20 mL urine	end of shift
perchloroethylene	trichloroacetic acid TAT 5 days	20 mL urine	end of work week
selenium	selenium, urine TAT 5 days	20 mL urine	end of shift
silver	silver, plasma silver, urine	6 mL K2 EDTA 20 mL urine	

.....Continued

Table of Analytes for Biological Monitoring .....

Agent of exposure	Analyte	Specimen	Sampling time
styrene	mandelic acid TAT 5 days	20 mL urine	end of shift
toluene	hippuric acid TAT 5 days	20 mL urine	end of shift
thallium	thallium, urine TAT 5 days	20 mL urine	end of working week
tin	tin, urine	20 mL urine	pre and post shift
trichloroethylene	trichloroacetic acid TAT 5 days	20 mL urine	end of working week
vanadium	vanadium, urine TAT 5 days	20 mL urine	post shift
xylene	methylhippuric acid TAT 5 days	20 mL urine	end of shift
zinc	zinc, plasma TAT 2 days	6 mL K2 EDTA blood	plasma MUST be separated from red cells within 2 hours of collection

Sample collection period definitions[2]

Pre shift - Following a period of 16 hours with no exposure.

Post shift - The last two hours to immediately following the end of the working day.

End of work week - After at least 4 days of exposure.

5. Workplace Urine Drug Screens

Introduction

With the current strong emphasis on occupational safety and health issues, establishing and maintaining a safe working environment is now a mandatory industry responsibility. Non-medical use of drugs can affect the performance of staff leading to potentially unsafe work practices. Urine drug testing establishes those staff at risk and may also act as a useful tool in the selection of staff. A broad range of drug classes are able to be tested for using a number of different analytical techniques. An approved testing standard (AS-4308-2008) is adhered to in consultation with the requirements of the client.

Why Screen?

In these intensely competitive times, maintaining an experienced, responsible and reliable healthy workforce is a prime objective. Your people are one of your most valuable resources and assets. Their welfare – even whilst they are not at work – should be your concern.

With the recent strong emphasis on occupational safety and health issues, establishing and maintaining a safe working environment is now a mandatory industry responsibility.

Under the Health and Safety in Employment Act 1992, and its 2003 amendments, employers have an obligation to take "all practicable steps" to ensure the safety of employees while at work. Drugs and Alcohol are listed in the amendments as being a potential hazard. The introduction of workplace drug testing, particularly in safety sensitive areas, is one way in which employers can meet their obligations. Workplace Drug Testing must, however, take account of ALL APPLICABLE LAWS including the Privacy Act 1993, the New Zealand Bill of Rights Act 1990, and the Human Rights Act 1993.

There are many reasons for a company implementing a comprehensive Health and Safety Policy which incorporates occupational screening, biological monitoring or workplace drug testing. Some industries, particularly those which are deemed more safety sensitive have more stringent processes, but in today's fast paced working environments ALL employers should be investing in their staff and their ongoing well being. Not only can occupational screening help safe guard businesses against potential lawsuits, but can increase revenue through happier and healthier staff members.

Drug and Alcohol Abuse

Around 15 % of safety issues identified in the workplace are directly related to drug and alcohol abuse.

Drug and alcohol abuse can severely impair human judgement, resulting in a higher incidence of injuries and in some extreme cases, death. In fact, research has shown that the accident rate for substance abusers is 4 times that of their co-workers and is responsible for up to 50% of all workplace injuries and up to 40% of deaths. Absenteeism is also a significant problem, as is the drop in productivity of between 20-25%.

Problem drinkers and other drug users create a range of problems in the workplace, but not only to themselves. There is the potential to affect employers, employees, and members of the public, customers and visitors.

Work colleagues may face increased risk of injury, increased workload and levels of distress, the possibility of needing to work harder, repeat work, and cover for the impaired colleague.

The economic impact of drug and alcohol abuse to a business results in lost productivity, lower profits, potentially reduced company competitive strength and reputation, and increased ACC, legal and insurance costs not to mention an impact on staff morale and quality.

It is clear that alcohol and other drug use can affect productivity and profitability and that affected employees can be a danger to themselves and others.

Policy

One of the most effective ways in which you can combat the problem of substance abuse in the workplace is to introduce a formal drug testing programme.

It may sound a radical step, but one which may effectively allow you to meet all your responsibilities under the Health and Safety in Employment Act 1992… especially if your industry is considered a 'safety' sensitive one.

Despite many businesses having drug and alcohol policies in their standard employment contract, they do not easily have the means of ensuring this policy is upheld.

In addition to performing the actual drug and alcohol testing, CHL can provide a conduit to appropriate independent OSH consultancies who have a wealth of experience in helping to design and establish Employee Assistance Programmes and can offer support and advice on the training of counsellors and all those involved in ongoing drug and alcohol rehabilitation.

Very often this impartial viewpoint can prove invaluable when assisting companies unaccustomed to addressing such sensitive issues.

Sample requirements

Testing kits are available from the Toxicology Laboratory, Canterbury Health Laboratories along with instructions for sampling and handling of the urine samples. The kit includes pottles, tamperproof seals and security bags. A urine sample split into two 20 mL aliquots is required.

Interpretation

Consultation is provided depending on the class of drug being tested for and the standard of analysis required.

6. Requesting Analyses

Specimens should be accompanied by a request form showing:

- Patient's name, sex and date of birth
- Patient's firm or location
- Location for the report to be sent to
- Location for the invoice to be sent to
- Name of the person requesting the test
- Test(s) requested
- Clinical history and/or details of occupation and exposure
- Additional information may be required for the interpretation of particular analytes

Pre-paid courier packs

Pre-paid courier packs are available from the laboratory for transporting specimens. Samples will be couriered overnight and will arrive in the laboratory by 08:00 the following morning.
Contact info@chl.co.nz.

Request forms

Biological Monitoring for Health Request Form - for requests relating to occupational exposure. These forms are available by emailing: info@chl.co.nz.

7. External Quality Control

The laboratory actively participates in the following external quality control programmes.

- **RCPA QAP Trace Elements Programme**

  Six samples sent monthly from Australia
  - Two blood samples for lead, cadmium, manganese and mercury
  - Two urine sample for cadmium, copper, chromium, arsenic, lead, mercury, zinc, cobalt, nickel and selenium
  - Two serum samples for copper, zinc, aluminium and selenium

- **World-wide International Aluminium Quality Control Scheme**

  Three plasma and three water samples sent every 3 months from Poitiers (France) for aluminium analysis

- **RCPA-AACB Urine Chemistry Quality Assurance Scheme**

  Two urine samples from Australia analysed monthly for routine biochemical analytes

- **Proficiency Water Testing Program**

  A comprehensive range of samples including potable ground water, surface and river waters, and synthetic materials analysed at regular periods. A performance summary is produced each year

- **Austox Urine Drug Screen Programme**

  Three samples per month for 11 months of year

- **RCPAQAP Toxicology Programme**

  Yearly cycle of one sample per month

Summaries of the laboratory's performance in these programmes are available on request.

8. Acetone

Introduction

Acetone is frequently employed as a solvent for paints, plastics and adhesives and as a chemical intermediate

Acetone is considered relatively non-toxic.

Sample requirements

A 20 mL random urine sample should be collected into a sterile urine pottle at the end of the working shift. The sample should be sealed, kept on ice and sent to the laboratory for analysis.

Interpretation

Non exposed levels 2 mg/L

Workplace Exposure Standards (2011)[2]

- Biological Exposure Index 50 mg/L (end of shift)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

9. Aluminium in Urine

Introduction

Aluminium is used in a wide range of industrial processes such as the manufacture of alloys, window frames, engine parts, aircraft parts, roofs, electric wires etc.

Aluminium is mainly absorbed through the lungs by inhalation of fumes and fine dust particles. Some aluminium is absorbed through the gastrointestinal tract when large amounts of high aluminium containing compounds are ingested, such as antacids. It is largely excreted via the urine, although some is also excreted in the bile.

Measurement of urine aluminium is used to monitor workers occupationally exposed to fumes and dust. Welders have the highest excretion levels among exposed workers.

The half life of aluminium is 8 hours, a relatively short period, at first exposure. However, this increases with the length of exposure, and can reach 6 months after 10 years of exposure.

Sample requirements

Aluminium is widespread throughout the environment, so care must be taken when collecting the sample.

A 20 mL urine sample is collected into a sterile aluminium free container at the end of the shift.

Interpretation

Non exposed levels < 0.4 μmol/L (<10 μg/L) [3]

Workers should be removed from exposure to aluminium if urinary excretion is greater than 7.4 μmol/L (>200 μg/L)

Occupational exposure to aluminium fumes and dust has been associated with pulmonary fibrosis

10. Antimony in Urine

Introduction

Antimony is a brittle silver-white metalloid obtained from the sulphide ore stibnite. It is mainly used as a fire retardant for paint, plastics, textiles, paper, rubber and adhesives and in the glass production industry. Its use as an alloy with lead in storage batteries has greatly decreased. It is also used in the semiconductor industry.
It is frequently found together with arsenic and some of the toxic effects described in the past may have been due to arsenic. Organic antimony compounds are used in the treatment of Leishmaniasis which can lead to toxicity.
Antimony is ingested or inhaled and is rapidly excreted in the urine and faeces. Inorganic trivalent antimony compounds are conjugated with glutathione and mainly excreted in the bile and pentavalent compounds in the urine.
Stibine, antimony hydride (SbH_3) is a highly toxic colourless strongly smelling gas which is formed when an acid reacts with a metal alloy containing antimony. Exposure can happen when charging lead batteries. It is extremely toxic causing haemolytic anaemia and tubular necrosis.

Toxicity

Symptoms of exposure are similar to arsenic but much less toxic. Dermatitis and irritation of the mucous membranes used to be common along with a simple pneumoconiosis among process workers with chronic exposure, but as conditions have improved symptoms have become uncommon.
Acute exposure to Stibine gas causes headache nausea and vomiting.

Sample requirements

20mL fresh random urine collected into a sterile container. Ensure that hands are washed and clothes are free of contamination.

For occupational exposure samples are collected at the end of the shift at the end of the working week as Antimony is rapidly excreted.

Interpretation

Non-exposed <1µg/L

No Biological Exposure Index is available for Antimony however a level of 35µg/g creatinine has been proposed for workers exposed to pentavalent Antimony compounds.[7]

11. Arsenic in Urine

Introduction

The main exposure to arsenic in New Zealand occurs in the timber treatment industry. The preservation of timber (tanalising) is carried out using a mixture of salts of copper sulphate, potassium dichromate and arsenic pentoxide. The timber is pressure injected with the preservation liquid in large pressure cylinders, after which it is stacked in the yard while still wet with preservation chemicals. Arsenic may also be encountered in the plating industry and in foundries and glassworks, and is found in some fruit tree sprays. To ensure accurate assessment of exposure to arsenic, urine samples must be collected at the end of the working shift or at the end of the working week if the exposure is continuous. As the method used does not measure the organic arsenic compounds present in dietary fish, samples can be collected without dietary restrictions.

Sample requirements

A 20 mL random urine sample is taken into a sterile container at the end of the shift at the end of the working week. Ensure that hands are washed and clothes are free of contamination. The testing method used measures only inorganic arsenic levels in the urine, so it is not necessary to exclude seafood (organic arsenic) from the diet prior to urine collection. Urine chromium can also be measured in the same sample.

Frequency of biological monitoring

The concentration of arsenic in urine generally reflects very recent exposure. The frequency of biological monitoring is thus dependent on whether the work is seasonal. For example:

<u>Seasonal timber treatment</u>

Initial testing should be made in the first few weeks of timber treatment. If the results are normal and adequate precautions are being taken, the tests need not be repeated until a change occurs in work patterns or environment.

<u>Regular timber treatment</u>

Workers should be tested at least yearly. If the results are normal and adequate precautions are being taken, the tests need not be repeated until a change occurs in work patterns or environment.

Interpretation

Non exposed levels < 0.5 μmol/L

Workplace Exposure Standards (2011)[2]

- Biological Exposure Index — 1.3 µmol/L (100 µg/L) end of shift at end of working week

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

12. Barium in Urine

Introduction

Barium is an alkaline earth metal found in ores principally as sulphates and carbonates (barite and witherite respectively). The commercial use ranges from getters in electrical tubes, rodenticides, colourants in paint and as a contrast medium in medical imaging. It is also found in oil and gas drilling muds, stabilizers for plastics, case hardening steels, bricks, tiles and lubricating oils and jet fuel. Barium occurs naturally in food and drinking water. Most exposure occurs through oral ingestion or inhalation of barium containing dust. Foods such as Brazil nuts, seaweed, fish and certain plants may contain high levels of barium. The toxicity of barium is related to the solubility and hence availability of the salt. Barium sulphate (medical contrast) being very insoluble is non-toxic as very little is absorbed. Barium carbonate which dissolves in the stomach acids is readily absorbed, as are barium hydroxide and nitrate, and these compounds are more toxic. Barium has the potential to bio-concentrate. Occupational exposure is generally in the barium mining or processing industries.

Barium exerts its toxicity through its effects on potassium channels; it is a competitive potassium channel antagonist, blocking the passive efflux of potassium from the intracellular compartment, resulting in hypokalaemia. This in turn leads to ventricular tachycardia, unstable blood pressure, muscle weakness and paralysis. Local gastrointestinal effects include abdominal cramps, vomiting and diarrhoea. Nephropathy is considered the most sensitive measure of toxicity with a clear dose response curve in animal studies.

Approximately 90% of the body burden of barium is contained in the bones and teeth; the primary route for excretion is through the faeces.

There is no data correlating exposure levels with blood or urine barium levels.

Sample requirements

20 mL urine sample collected in a pottle shown to be free of barium contamination. Ensure that hands are washed and clothes are free of contamination.

Interpretation

Reference range < 5 µg/L
Urine levels > 7 µg/L are associated with toxicity[12].

No Biological Exposure Index is available for urine barium.

13. Bismuth

Bismuth is used in low melting point alloys and is used in malleable iron. It is added to aluminium and steel for better machinability. Bismuth compounds are used as catalysts and in semiconductors.
Bismuth compounds are used therapeutically for the treatment of gastric and duodenal ulcers. Bismuth subsalicylate appears to be effective in the suppression of Helicobactor pylori and is increasing used for the treatment of relapsing gastric ulcers.
Bismuth is rapidly excreted in the urine.

Toxicity

Severe side effects from taking bismuth compounds including gingivastomatitis, toxicity to the kidney, liver and central nervous system have been recorded. Abnormal MRI scans and encephalopathy may develop at high bismuth concentrations. This is usually reversible when treatment ceases.

Specimen requirements

Whole blood sample collected into a navy top 6 mL K2 EDTA trace element tube.

20 mL fresh random urine collected into a sterile container. Ensure that hands are washed and clothes are free of contamination.

Interpretation

Urine
Non-exposed levels <1.2 µg/L[3]

Blood
Non-exposed levels 0-1.0 µg/L[3]

The monitoring of bismuth levels in blood is recommended for patients undergoing oral therapy, normal levels during treatment should be below 50µg/L, close monitoring is required at levels between 50 and 100 µg/L and treatment should be suspended at levels above 100 µg/L.

14. Cadmium in Blood

Introduction

Cadmium metal is used as an anticorrosion coating for ferrous metals and in welding and brazing alloys. Cadmium compounds are used in nickel/cadmium batteries and as pigments in paints, plastics and glazes. The welding and gas cutting of cadmium coated steel carries a high risk due to the high volatility of cadmium metal. Cadmium occurs naturally with zinc and is a by-product in the smelting of zinc and some lead ores.

Cadmium has a long biological half life (10-33 years) and accumulates progressively in the body. Tobacco smoking may significantly increase exposure to cadmium, as cigarettes contain 1-2 μg of cadmium, about 10% of which is absorbed. Cadmium accumulates in the liver and kidneys, which account for 50% of the body burden, and is excreted in the urine.

Biological monitoring

- Blood cadmium reflects average intake over the previous few months.
- Urine cadmium is indicative of body burden when exposure is low to moderate.

Sample requirements

Whole blood sample collected into a navy top 6 mL K2 EDTA trace element tube. To minimise contamination of the sample with cadmium from tobacco, the sample should be collected in a smoke free environment. Sampling time is not critical.

Interpretation

Non exposed levels < 20 nmol/L (2.2 μg/L)

Workplace Exposure Standards (2011)[2]

- Biological Exposure Index 44 nmol/L (5 μg/L)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

Urine cadmium levels should be monitored for renal dysfunction in workers regularly exposed to low levels of cadmium.

Toxic effects

Acute exposure:

Ingestion from food in cadmium plated cans or ingestion of cadmium dust affects the gastrointestinal tract and causes increased salivation, choking, vomiting, abdominal pain, diarrhoea. Cadmium ingestion can also lead to shock, renal failure and death. Inhalation of dust or fumes is responsible for most fatal industrial accidents. It causes cough, headache, vomiting and chest pain, and may lead to pulmonary edema and death.

Chronic exposure:

Renal tubule damage appears to be the main effect of chronic exposure. The time at which renal damage can occur depends on the intensity of exposure and is usually greater than 10 years. The bone damage (osteomalacia) seen in chronic cadmium exposure is secondary to renal tubule damage causing alterations in calcium, phosphate and vitamin D metabolism. Cadmium and some cadmium compounds have been listed as carcinogenic.

15. Cadmium in Urine

Introduction

Cadmium metal is used as an anticorrosion coating for ferrous metals and in welding and brazing alloys. Cadmium compounds are used in nickel/cadmium batteries and as pigments in paints, plastics and glazes. The welding and gas cutting of cadmium coated steel carries a high risk due its high volatility. Cadmium occurs naturally with zinc and is a by-product in the smelting of zinc and some lead ores. Cadmium has a long biological half life (10-33 years) and accumulates progressively in the body. Tobacco smoking may significantly increase exposure to cadmium, as cigarettes contain 1-2 μg of cadmium about 10% of which is absorbed. Cadmium accumulates in the liver and kidneys, which account for 50% of the body burden, and is excreted in the urine.

Biological monitoring

- Blood cadmium reflects average intake over the previous few months.
- Urine cadmium is indicative of body burden when exposure is low to moderate.

Sample requirements

A 20 mL sample of random urine is collected into a sterile container shown to be free of cadmium contamination. Ensure that hands are washed and clothes are free of cadmium contamination. To minimise contamination of the sample with cadmium from tobacco, the sample should be collected in a smoke free environment. Sampling time is not critical.
Note: some yellow top specimen collection containers have been shown to be contaminated with cadmium.

Interpretation

Non exposed levels < 18 nmol/L (2.0 μg/L)
< 1 μmol/mol creatinine (1 μg/g)
Workplace Exposure Standards (2011)[2]
Biological Exposure Index 5 μmol/mol creatinine (5 μg/g)

- *Biological Exposure Index (BEI) - levels above which excessive exposure has occurred*.

16. Carbon Monoxide in Blood

Introduction

Carbon monoxide is a colourless, odourless, non-irritating gas which is slightly soluble in water and burns in air with a bright blue flame. Carbon monoxide is a chemical asphyxiant - it combines with haemoglobin to form carboxyhaemoglobin and hence reduces the oxygen-carrying capacity of the blood. Carbon monoxide is also a metabolite of Methylene Chloride (see Methylene Chloride).

Potentially dangerous sources of carbon monoxide in homes and workplaces are faulty heaters that produce excessive fumes or burn in a restricted air supply and motor vehicle exhaust gasses. Reducing ventilation in buildings to conserve heat may unwittingly raise carbon monoxide levels to hazardous levels.

Sample requirements

Send a full vacutainer tube of heparin anticoagulated blood on ice to the laboratory.

Interpretation

Since carbon monoxide is present in tobacco smoke the background level of carboxyhaemoglobin is higher in smokers.

<u>Carboxyhaemoglobin, blood</u>

Non exposed levels	<2.0% (Non smoker)
	< 9% (Smoker)
Workplace Exposure Standards (2011)[2]	
Biological Exposure Index	3.5 % (end of shift)

- *Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.*

17. Cholinesterase Activity in Blood

Introduction

Many organophosphate esters are potent insecticides. They are readily taken up by the body by different routes even the skin and conjunctiva of the eyes, which when unprotected may receive considerable exposure. The acute toxicity of the organophosphates is mainly due to inhibition of cholinesterase in synapses of the nervous system and its end organs. Cholinesterase inhibition by organophosphates is to a large extent irreversible and the recovery of the enzyme activity is slow and may require several weeks. The symptoms of organophosphate poisoning are nausea, giddiness, blurred vision, vomiting, diarrhoea, excessive salivation, impaired night vision and sometimes loss of consciousness.

Sample requirements

5 mL of EDTA anticoagulated blood (lithium heparinised blood is acceptable). Specimen should be stored refrigerated and sent to the laboratory on ice.)

Interpretation

Non exposed levels (baseline) > 8 kU/L
Workplace Exposure Standards (2011)[2]
Biological Exposure Index < 60% baseline "Suspension Level"
< 80% baseline "Action Level"
>75% baseline "Return to Work"

- *Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.*

"Suspension Level" - *Suspend from working with pesticides which inhibit cholinesterase activity.*
"Action Level" - *Repeat test to confirm result.*
"Return to Work" - *Permit a previously suspended worker to recommence normal duties.*

18. Chromium in Urine

Introduction

Chromium is an essential trace element necessary for the metabolism of carbohydrates and fats. In chromium deficiency a condition similar to diabetes is exhibited. Natural complexes that include chromium (e.g. brewers yeast) appear to be better absorbed from the GI tract than inorganic salts of chromium. Chromium enters the blood stream and is converted to chromium$^{(III)}$ and is rapidly taken up in the tissues. As the tissues and blood are not in equilibrium with regards to chromium, the blood level is not a good indicator of chromium stores. About 80% of absorbed chromium is eliminated in the urine, so that urinary chromium levels can be used as an indication of body burden.

Chromium can also be absorbed through the lungs from chromate fumes and dust. Chromium exists in two main valency states, trivalent and hexavalent. Chromium$^{(VI)}$ is better absorbed and more toxic than chromium$^{(III)}$, and has also been listed as a carcinogen implicated in lung cancer. If absorbed $Cr^{(VI)}$ is not converted to $Cr^{(III)}$ in the red blood cells, acute kidney damage can occur.

Occupational exposure to chromium occurs in wood tanalising, stainless steel welding, chrome plating, the leather tanning industry and the use of lead chromate or strontium chromate paints.

Sample requirements

A 20 mL random urine sample is taken into a sterile container at the end of the shift at the end of the working week. Ensure that hands are washed and clothes are free of contamination. Urine arsenic can also be measured in the same sample. Refer to **'Arsenic in Urine'** for the frequency of testing of timber treatment workers.

Interpretation

Non exposed levels < 20 nmol/L(<1µg/L)
Workplace Exposure Standards (2011)[2]
(Exposure to soluble hexavalent chromium salts CrVI)
Biological Exposure Index 600 nmol/L (30 µg/L)
end of shift at end of working week

- *Biological Exposure Index (BEI) - levels above which excessive exposure has occurred*.

To ensure accurate assessment of exposure to chromium, urine samples must be collected at the end of the working shift or at the end of the working week if the exposure is continuous.

Toxic effects

The toxic effects of chromium are largely caused by the highly corrosive nature and solubility of chromate compounds used in industry.

Skin:

Skin contact causes allergic reactions and sensitisation. 'Chrome Burn', where the skin is broken, may lead to increased absorption and possible kidney damage.

Inhalation:

Acute inhalation of chromium fumes causes coughing, wheezing and fever may lead to kidney damage. The chromium$^{(VI)}$ compounds of low solubility are recognized as carcinogens from exposure by inhalation leading to lung cancer. Perforation of the nasal septum and chronic bronchitis are also consequences of chromium inhalation.

Urine chromium is used in occupational monitoring. Because chromium is rapidly eliminated from the system, a sample is taken at the end of the working week to give a good indication of exposure.

19. Cobalt in Urine

Introduction

Cobalt is a naturally occurring element widely distributed in the environment, it is an essential trace element and is utilised as a component of B12. Cobalt is absorbed by inhalation and ingestion and the amount absorbed depends on the solubility, soluble compounds are easily absorbed and rapidly excreted in the urine. Due to the low level of cobalt in body fluids urine cobalt is used as a measure of occupational exposure.
Occupationally cobalt is used as an alloy in the production of hard metal (tungsten carbide), manufacture of high temperature alloys for jet engines, in magnets and as a catalyst in after burners. It is also used as an alloy in joint prostheses. Workers in the saw-doctor and knife-grinder industries are at risk from inhalation of cobalt from the dust created during grinding processes.

Sample requirements

20 mL fresh random urine collected into a sterile container. Ensure that hands are washed and clothes are free of contamination
For occupational exposure samples are collected at the end of the shift at the end of the working week as Cobalt is rapidly excreted.

Interpretation

Non exposed levels	< 20 nmol/L (1ug/L)
Workplace exposure standards (2011)[2]	
Biological Exposure Index	255 nmol/L (15 µg/L)

Biological Exposure Index (BEI) – levels above which excessive exposure has occurred.

Cobalt in urine has a short biological half life and reflects recent exposure therefore samples should be taken at the end of the working shift at the end of the week.

<u>Toxic effects</u>
Inhalation of cobalt compounds can cause cobalt sensitisation, occupational asthma and interstitial lung disease associated with high exposure, previously called 'hard metal' disease. Cobalt may also cause allergic dermatitis.

20. Cyanide

Introduction

Hydrocyanic acid and its sodium and potassium salts are used industrially as fumigants, insecticides, metal polishes and in electroplating solutions. Hydrogen cyanide may be produced in relatively high concentrations in fires that involve nitrogen-containing materials. Other potential sources of cyanide are acetonitrile, amygdalin, acrylonitrile and nitroprusside.

Cyanides can be absorbed from the respiratory tract following inhalation of cyanide-containing aerosols, from the gastrointestinal tract after ingestion, or through the skin after direct contact with cyanide solutions. Hydrogen cyanide is a gas and is easily absorbed by the respiratory tract.

Cyanide produces hypoxia by the inhibition of cytochrome oxidase. Chronic cyanide poisoning can produce dizziness, weakness and permanent motor and mental impairment.

Sample requirements

Acute Intoxication

In the acute exposure to cyanide send a full vacutainer tube of heparin anticoagulated blood on ice to the laboratory.

Biological Monitoring

Alternatively plasma and urine thiocyanate concentrations are useful in monitoring occupational exposure to cyanide, if pre-exposure levels are determined to identify smoking and dietary influences.

Interpretation

Since hydrogen cyanide is present in tobacco smoke the background level of cyanide and thiosulphate is higher in smokers.

Cyanide, blood

Non exposed levels	<0.15 mg/L (Non smoker)
	<0.41 mg/L (Smoker)
	Toxic 0.50 mg/L

Thiocyanate, plasma

Non exposed levels	1 - 4 mg/L (Non smoker)
	3 - 12 mg/L (Smoker)

Thiocyanate, urine

Non exposed levels	1 - 4 mg/L (Non smoker)
	3 - 17 mg/L (Smoker)

Lauwerys Guidelines for Biological Monitoring[7]

- Biological Exposure Index 6 mg/g creatinine (Non-smoker)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

21. Fluoride in Urine

Introduction

Industrial exposure to fluoride occurs in the manufacture of superphosphate, where phosphate rock (which contains small amounts of fluoride) is crushed and dried, releasing fine particles of fluoride dust. Fluoride is also released as an impurity in the production of aluminium. Workers are monitored to prevent osteofluorosis.

Sample requirements

A 20 mL random urine sample is taken into a sterile plastic container at the end of the shift after 4 or more consecutive days of exposure. Ensure that hands are washed and clothes are free of contamination.

Interpretation

An acute dose of fluoride is rapidly excreted in the urine with a half life of a few hours.

Non exposed levels 0 - 31 µmol/L

Workplace Exposure Standards (2011)[2]

- Pre shift Biological Exposure Index 160 µmol/L (3 mg/L)
- Post shift Biological Exposure Index 530 µmol/L (10 mg/L)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

If the post-shift level is exceeded, a pre-shift sample should be taken at the beginning of the shift 48 hours after previous exposure, and another post-shift sample taken at the end of the working week.

The pre-shift sample reflects the body (skeletal) burden of fluoride while post-shift samples reflect exposure.

If the pre-shift sample and repeat post-shift samples exceed the BEI level then dietary (tea and coffee) intake and work practices need to be evaluated.

22. Lead in Blood

Introduction

Lead is used in storage batteries, ammunition and type metal, cable sheaths, solder, previously used in anti-knock compounds in petrol and the plastics industry. It is also present in many metals such as brass (1-3.5%). Lead can also be a problem in the home, particularly from sanding old lead based paints and making diving and fishing weights, and in artists' studios and potteries. Indoor small bore rifle shooters are also at risk from lead poisoning.

Acute lead poisoning in adults is commonly characterized by abdominal pain, tiredness, aching limbs and joints, and irritability. Nerve palsy and wrist drop have also been mentioned but are very rare. In children and animals lead poisoning is accompanied by CNS signs such as convulsions, irritability, vomiting and anaemia. High lead intake can also be asymptomatic as in a lot of occupational exposure where increased lead intake is seen only by blood lead level measurement. Chronic cases present in neurological wards with polyneuritis and renal impairment.

Sample requirements

Note: Blood lead levels reported in µmol/L of whole blood (rather than red cell lead levels) are now used for assessment of blood lead status in line with OSH requirements.

Whole blood sample collected into a navy top 6 mL K_2 EDTA trace element tube. Collection tubes and needles can be supplied by the laboratory.

Interpretation

Population reference range (last updated 24 August 1995)

Age group	Red cell lead (µmol/L)	Whole blood lead (µmol/L)	PCV
adult			
male	0.0-1.10	0.0-0.50	0.40-0.55
female	0.0-0.90	0.0-0.35	0.38-0.45
child			
5-16 yrs	0.0-1.40	0.0-0.55	0.35-0.40
9 mths - 4 yrs	0.0-1.50	0.0-0.55	0.33-0.37
< 9 mths	0.0-1.30	0.0-0.50	0.30-0.35
dog	0.0-0.90	0.0-0.45	0.40-0.56
cat	0.0-1.10	0.0-0.45	0.32-0.44

Non occupational exposure

A whole blood lead of > 0.48 μmol/L (10 μg/ml) is a notifiable disease to the local Public Health Units.

Results greater than 0.48 μmol/L are abnormal; they are indicative of increased lead absorption and should initiate environmental measures to minimise the level of exposure. Between 1.0 and 1.9 μmol/L some children will require chelation therapy and a paediatric consultation is recommended. Above 1.9 μmol/L most children will require chelation and referral to a paediatrician is highly desirable. Levels above 3.0 μmol/L generally require URGENT medical treatment to reduce the risk of lead encephalopathy.

Occupational exposure

It is desirable for all lead workers to minimize their exposure to lead and maintain a whole blood lead level less than 1.5 μmol/L. It is the responsibility of the employer to ensure regular monitoring of blood lead levels and to report all blood lead levels equal to or above 2.4 μmol/L to the Occupational Safety And Health (OSH) Service of the Department of Labour.
Guidelines for The Medical Surveillance of Lead Workers (Dept of Labour 2011)
The suspension level is a single whole blood lead result equal to or greater than 2.4 μmol/L. The worker can return to work when the blood lead level has decreased to 1.93μmol/L.

Note: For further information please see next section.

23. Biological Monitoring of Lead Workers

The aim of blood lead monitoring of workers exposed to lead is to maintain a blood lead level below 1.5 μmol/L of whole blood. A pre employment screen is recommended to exclude sources of lead other than occupational exposure; these may include home renovations, small bore rifle shooting, casting lead sinkers, home mechanics etc.

New employees in 'at risk' occupations should be monitored monthly until the blood lead level is stabilised. After that monitoring at regular intervals is recommended;

< 1.5 μmol/L whole blood lead	repeat 12 monthly
1.5 - 1.9 μmol/L whole blood lead	repeat 6 monthly
2.0 - 2.3 μmol/L whole blood lead	repeat 3 monthly
≥ 2.4 μmol/L whole blood lead	repeat fortnightly until the level has decreased to 1.93 μmol/L or less

Blood lead results of 2.4 μmol/L whole blood or above should be notified to the OSH Service.

Female workers

It is considered unwise for females who could become pregnant to work with lead due to the harmful effects of lead on a foetus. However, if a female works in a job where excessive exposure is possible, a whole blood lead less than 1.5 μmol/L should be maintained. A lead level equal to or less than 0.48 μmol/L of whole blood is considered 'safe' for a developing foetus.

Occupations at risk of lead exposure

High risk:

Majority of workers with whole blood lead > 1.5 μmol/L

Radiator repair	Smelting
Muffler repair	Scrap metal
Foundry (general)	Container repair
Engine reconditioning	Small bore rifle shooting
Paint removal (with lead based paints)	Lead battery manufacture

Medium risk:

Majority of workers with whole blood lead > 0.9 < 1.5 μmol/L

Panel beating
Metal machining
Printing
Gas cutting/welding
Spray painting
Metal polishing
Metal extrusion
Garage mechanic
Pottery/ceramics
Lead casting
Plastic production

Low risk:

Majority of workers with whole blood lead < 0.9 μmol/L

Plumbing
Cable jointing
Car assembly
Electroplating
Boat building
Bright soldering
Petrol pump attendant
Exhaust fume exposure

Sources of lead for different occupational groups

Radiator repair:

Solder (60% lead, 40% tin) is used. After repair the excess solder is buffed off using a grinder type wheel, creating dust. In addition radiators were formerly painted with lead based paint but this practice has been discontinued.

Smelting:

High heat generated in the furnace leads to fumes. Lead (2-3%) is added to brass (copper/zinc alloy) and some bronzes (copper/tin alloy) e.g. gunmetal, as it gives the metal a lubrication quality and prevents machinery seizure. Phosphor bronze and aluminium bronze have minimal lead content.

Muffler repair:

Exhaust systems may have deposits of lead oxide from lead petrol. This creates fine dust and lead fumes during welding.

Scrap metal:

This includes burning off the covering of old cables, cutting lead enamelled baths, handling old lead batteries and smelting down lead using crude furnaces.

Metal moulding:

The high temperatures used produce fumes from lead and lead containing alloys.

Container repair:

Welding, brushing and sandblasting of lead paint in the confined spaces of containers produces dusts and fumes.

Engine reconditioning:

This involves engines and oils that may be contaminated with lead deposits from leaded petrol.

Panel beating:

Workers are exposed to lead dust and fumes from sanding and welding car bodies containing lead. Lead is still used by some panel beaters to repair surface defects.

Metal machining:

Dust is created by the cutting and spinning of metal alloys containing lead.

Metal polishing:

Fine dust is created when buffing lead based alloys.

Printing:

Old printing equipment used lead based letters for printing.

Welding/gas cutting:

This involves cutting metals coated with lead based paints or bath enamel.

Spray painting:

Exposure occurs during the preparation of surfaces previously coated with lead based paints.

Lead battery manufacture:

Used lead batteries are recycled by smelting down and making lead ingots. Manufacture of new lead batteries involves making the lead plates, pasting them with a lead oxide paste and assembling the battery.

Plumbing:

Plumbers sometimes use red lead putty as a sealant, as well as soldered joints and lead flashings.

Plastic production:

PVC contains tri basic lead sulphate as a scavenger of acids produced in the degradation of PVC and improves thermal stability. Workers are exposed in the debagging room, where the dampened powder is opened and mixed with high speed mixers and a free flowing

powder is formed which contains approximately 2% lead. A fine dust can escape from the mixers.

Leadlighting:

Soldering temperatures are generally not high enough for the fumes to be hazardous. However, lead dust is created when sanding and buffing the lead solder seams.

Metal extruding:

See metal moulding.

Garage mechanic:

See engine reconditioning.

Pottery/ceramics:

Lead based glazes are used.

Cable jointing:

Lead is used to mould around joins in cables, which is generally carried out in confined spaces. This practice is gradually being phased out in favour of plastics.

Electroplating:

Lead soldered seams are buffed up and polished prior to chrome plating.

Bright solder/electronics:

These use lead solder. Jewellers mostly use silver solder (bright solder).

Paint removal/painting and decorating:

Exposure occurs during removal of lead based paints, eg by sanding.

Exhaust exposure/petrol pump operation:

Leaded petrol exhaust fumes affect car park attendants and WOF workers.

Smallbore rifle shooting:

Lead fumes arise from both the bullet and the primer. There is additional lead in the dust when cleaning the shooting range.

24. Lead in Urine

Introduction

Lead is excreted via the kidneys and the faeces. Measurement of urine lead is used most commonly to follow lead excretion of patients on chelation therapy for lead poisoning.

Urine lead is also measured to indicate exposure to tetra-alkyl (organic) lead which was used up until October 1996 as an antiknock agent in petrol. Excessive exposure to petrol is unlikely to lead to high urine lead levels.
ref Guidelines for Monitoring Lead Workers

Sample requirements

20mL fresh random urine collected into a sterile container. Ensure that hands are washed and clothes are free of contamination.

For occupational exposure sample collection time is not critical.

Interpretation

Industrial

Workplace Exposure Standards (2011)[2]

- Biological Exposure Index 0.72 µmol/L (150 µg/L)(Inorganic)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred

25. Manganese in Whole Blood

Introduction

Manganese is an essential micronutrient found throughout the body, with the highest levels found in the liver. It accumulates in tissues high in mitochondria and is a cofactor in enzymes such as hexokinase, superoxide dismutase and xanthine oxidase. Manganese is associated with bone and tissue formation, carbohydrate metabolism, reproductive processes and lipid metabolism. Manganese is absorbed through the gastrointestinal tract with absorption being similar to iron absorption. Manganese is mainly excreted in bile with only a small amount excreted in urine. The human requirement for manganese is very low and even during prolonged TPN no clear evidence of deficiency has been documented. However because of the potential importance of manganese,
additives containing it have been included in TPN regimens.
The concentration of whole blood manganese is about 10 times higher than in serum therefore the manganese from contamination is proportionately less significant, eliminating some sampling precautions. Whole blood manganese may better reflect manganese stores in tissue therefore it is recommended to use whole blood samples for assessment of manganese status and long term
occupational exposure.

Manganese is used in iron, steel and battery production industries. Occupational exposure to manganese is through the lungs via inhalation during mining of manganese ores and welding of mild steel (used as a toughening agent). Permanganate compounds are used in glass and ceramics industries and are also used as powerful oxidising agents.

Sample requirements

Whole blood sample collected into a navy top 6 mL K_2 EDTA trace element tube. These collection tubes are free of manganese contamination. The whole blood sample is sent to the laboratory at ambient temperature.

Interpretation

Normal reference range 73 – 210 nmol/L

No BEI is available but levels > 360 nmol/L are potentially toxic.

Toxic effects

Exposure to high levels of manganese can cause non-specific symptoms and signs of neurological deterioration including irritability, apathy asthenia, headaches, lethargy and weakness in the extremities and in a few cases can lead to Parkinson's disease. These symptoms are believed to arise due to excess manganese deposition in the basal ganglia which can be seen as hyper-intense areas on MRI of the brain.

Manganese toxicity has also been documented in patients on long term TPN who are particularly at risk if there is liver dysfunction. Increased whole blood manganese has also been reported in liver disease, rheumatoid arthritis and iron deficiency anaemia. Neurological effects exhibit Parkinson like symptoms, including behavioral and emotional disturbances, if diagnosed in the early stages these effects can be reversed. Some haematological changes may also be observed, such as greatly reduced white cell count (leucopoenia) and lymphocytosis, or an increase in haemoglobin count. However in some cases there may be no changes at all.

26. Mercury in Urine

Introduction

Mercury, commonly called quicksilver, is a heavy, mobile liquid metal and is slightly volatile at room temperature. The vapour is readily absorbed through the lungs. Sources of mercury include metallic vapours, mercury salts and the more toxic organic mercury compounds. Metallic mercury (used in gold mining) is particularly dangerous due to mercury vapour being absorbed via the respiratory tract. This danger is increased further when the mercury is heated.

Mercury and its inorganic salts are used in a variety of ways. These include disinfectants, antiseptics and insecticides, and in scientific instruments and processes. Mercury is also used for extracting gold and silver from ores. Organic mercurials are found as antifungal preparations. A continuing source of exposure to mercury which has become a cause for concern is that of dental nurses who use amalgams for fillings in teeth. However, due to advances in dental surgery hygiene and the use of different types of fillings, this is not as significant a problem as it was 15 years ago. Methyl mercury, which is highly toxic, is found in fish and is a major cause for concern in badly polluted waters.

Mercury and its salts can enter the body by inhalation, oral ingestion or absorption. Mercury vapour cannot be absorbed through intact skin but many mercurial compounds can be. It is very toxic and cumulative. In the blood inorganic mercury is found equally in the plasma and red cells, while the alkyl compounds, such as methyl mercury, are concentrated ten to twenty fold in the red cells. The main target organs for mercury are the central nervous system and the kidney. Mercury is excreted in the urine (inorganic and metallic) and faeces (organic) and has a half life in the body of about 70 days. Increased exposure intensifies the symptoms.

Low grade continuous exposure can lead to:

- Inflammation of the mouth, soft gums, loose teeth, excessive salivation, metallic taste and foul breath.
- Tremor (hatter's shakes), particularly when the person is being observed or is in an unfamiliar environment or job.
- Mental and nervous symptoms including behavioural changes, stammering, anxiety, loss of sleep and loss of energy and drive.

Sample requirements

Screening test

A 20 mL random urine sample is taken into a sterile container and frozen immediately to prevent loss of mercury in the sample. Ensure that hands are washed and clothes are free of contamination. Sampling time is not critical

Interpretation

Non exposed levels	<50 nmol/L
Workplace Exposure Standards (2011)[2]	
Biological Exposure Index	250 nmol/L (50 µg/L)

- *Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.*

The reported manifestations of subacute mercury poisoning are primarily neurological, with tremors, vertigo, irritability, moodiness and depression. They are associated with salivation, stomatitis and diarrhoea.

27. Methanol

Synonyms

Methyl alcohol, Wood alcohol.

Introduction

Methanol is used as a solvent for natural and synthetic resins, denaturant for ethanol and intermediate for the manufacture of several chemicals.

Serious health effects resulting from excessive uptake of methanol involves temporary or permanent loss of vision. Headaches, giddiness and upset stomachs have been reported by workers exposed to lower concentrations of methanol.

Sample requirements

A 20 mL random urine sample should be collected into a sterile urine pottle at the end of the working shift. The sample should be sealed, kept on ice and sent to the laboratory for analysis.

Interpretation

Non exposed levels < 2.6 mg/L

Workplace Exposure Standards (2011)[2]

- Biological Exposure Index 15 mg/L (end of shift)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

28. Methyl Bromide

Introduction

Methyl bromide is a gaseous chemical used as a fumigant for large enclosed industrial and agricultural areas. It has also been used as a refrigerant and fire extinguishant.

Methyl bromide is known to be partially converted in man to inorganic bromide. The contribution of this metabolite to the toxicity of the parent compound is not clear, but since inorganic bromide blood concentrations after methyl bromide poisoning are generally much lower than during intoxication by bromide salts, it seems likely that the methyl bromide is the primary toxic agent. Toxicity may develop after a latent period of several hours and is manifested by confusion, abdominal pain, weakness nausea, convulsions, coma and occasionally pulmonary edema.

Sample requirements

A 5 mL heparinised blood sample is collected into an evacuated tube. The sample should be sent to the laboratory with minimal delay.

Interpretation

Non exposed levels (depending on diet) 1 - 20 mg/L
Toxic symptoms may occur at 30 mg/L with severe symptoms at levels of 120 mg/L
(Source: National Poisons Centre Dunedin NZ)

29. Methylene Chloride

Synonyms

Methylene dichloride; Dichloromethane.

Introduction

Methylene chloride is used as a degreasing solvent; paint stripper; local anaesthetic; blowing agent for foams; refrigerant; solvent in pharmaceutical production and plastics.

Methylene chloride exhibits narcotic effects and is a severe irritant to the eyes and skin if the exposure is prolonged. Another acute effect relates to the elevated carboxyhaemoglobin levels resulting from the metabolic conversion to carbon monoxide. Long term effects that have been considered when assigning the work place exposure standard are liver damage and carcinogenic effects.

Sample Requirements

In situations where there is no additional exposure to carbon monoxide, carboxyhaemoglobin in blood provides a good indication of recent exposure.
A full vacutainer tube of heparin anticoagulated blood should be sent on ice to the laboratory. Carboxyhaemoglobin and Methylene chloride assay may be carried out on the same blood sample.

Interpretation

<u>Methylene chloride, blood</u>

Non exposed levels <0.1 mg/L
Lauwerys Guidelines for Biological Monitoring[7]

- Biological Exposure Index 0.5 mg/L (end of shift)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

<u>Carboxyhaemoglobin, blood</u>

Non exposed levels <2.0% (non smoker)
Workplace Exposure Standards (2002)[2]

- Biological Exposure Index 3.5 % (end of shift)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

30. Methyl Ethyl Ketone

Synonyms

MEK; Ethyl methyl ketone; 2-Butanone.

Introduction

Methyl ethyl ketone is used as a solvent in surface coatings and adhesives.

Methyl ethyl ketone is a volatile solvent that is absorbed in the body by inhalation of the vapours and through the skin by contact with the fluid.

Sample requirements

MEK in urine is the only determinant that has been studied in sufficient detail to allow the establishment of an exposure index.

Urine samples (20 mL) should be collected into a sterile pottle at the end of the shift, sealed and sent on ice to the analytical laboratory as soon as possible.

Interpretation

Non exposed levels <0.1 mg/L

Workplace Exposure Standards (2011)[2]

- Biological Exposure Index 2 mg/L (end of shift)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

31. Molybdenum in Urine

Introduction

Molybdenum is an essential trace element used as a co factor for enzymes such as xanthine oxidase, which is involved in the degradation of purines to uric acid. The human requirement for molybdenum is extremely low and deficiency is rare.
In ruminant animals high molybdenum from grazing interferes with copper absorption, causing anaemia, stunted growth and bone deformities, sheep also show degeneration of the central nervous system.
Occupationally molybdenum is used in alloys as a hardener for steels and superalloys, used in turbine wheels and jet engines; they can contain as much as 30% molybdenum. It is also used in the production of some ceramics including joint prostheses, pigments and electrical wire. Its compounds are also used as catalysts and in lubricants. Small amounts are sometimes added to fertilizer as in some plants it is necessary for nitrogen fixation.
Molybdenum is absorbed through the gastrointestinal tract and is rapidly excreted in the urine.

Toxicity

Reports of toxicity are rare.
Exposure to molybdenum trioxide during production of compounds at high temperatures has been reported as causing irritation to the mucous membranes, headaches and aching joints. After high exposure uric acid and ceruloplasmin were slightly increased.
In Armenia where soil concentration is high an increase in gout-like symptoms have been reported.

Sample requirements

20 mL fresh random urine collected into a sterile container. Ensure that hands are washed and clothes are free of contamination

Interpretation

Non-exposed levels 11-80 µg/L[3]
Ref: SAS 2006
No Biological Exposure Index has been proposed.

32. Nickel in Urine

Introduction

Nickel is relatively non toxic essential trace element. It is important in the metabolism of cell membranes and is found in significant concentrations in RNA & DNA. Nickel is poorly absorbed from the diet and is mainly excreted in the faeces, with small amounts being excreted in the sweat and urine. However, when excess nickel is present in the system due to occupational exposure the amount excreted in the urine increases. Urinary concentration is therefore used as an index of exposure. Nickel has a half life of 17-39 hours.

Occupational exposure occurs in nickel plating, with different alloys being used in the manufacture of stainless steel, coins, nickel chrome resistance wire, magnets and silver cutlery. Nickel carbonyl is the gas formed in the nickel refining process when carbon monoxide reacts with nickel. It is the basis for the Mond process, in which objects are coated with nickel of very high purity. Nickel fumes are also given off during gas cutting or stainless steel welding.

Sample requirements

A 20 mL random urine sample is taken into a sterile container at the end of the shift. Ensure that hands are washed and clothes are free from contamination.

Interpretation[3]

Non exposed levels	< 0.4 µmol/L
Mild exposure	1.7 - 8.5 µmol/L
Severe exposure	> 8.5 µmol/L

Toxic effects

Nickel carbonyl gas is the most toxic form of the element, causing dizziness, headache, fever and acute breathing problems. Nickel has also been implicated in nasal and lung cancer.

Contact dermatitis, or 'nickel itch' is common in individuals dealing with nickel compounds, even in wearing of jewellery and domes on clothing.

33. Pentachlorophenol

Synonyms

PCP

Introduction

Pentachlorophenol and its sodium salt are frequently employed industrially and in the home as wood preservatives, contact herbicides, disinfectants and mildew retardants. There are concerns regarding its carcinogenic potential and its uses are severely reduced.

Pentachlorophenol is a highly toxic substance that can result in chloracne and disturbances in lipid metabolism with chronic exposure. Acute overdosage produces delirium, weakness, flushing, hyperpyrexia, tachycardia, tachypnea, coma and death within hours of the absorption.

Sampling requirements

20 mL of urine prior to the last shift of the work week or 5 mL of heparinised blood.

Interpretation

Non exposed levels <0.04 mg/L

Workplace Exposure Standards (2011)[2]

- Biological Exposure Index 1 mg/L (prior to last shift of week)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

34. Perchloroethylene

Synonym

Tetrachloroethylene

Introduction

Perchloroethylene is used as a dry cleaning fluid and for metal degreasing.

Central nervous system depression is the most common effect occurring at moderate perchloroethylene exposure. Complaints from workers include: loss of coordination, headaches, eye irritation and soporific effects. The work place exposure standards have been set to prevent anaesthetic effects, discomfort and subjective complaints as well as providing a wide margin of safety in preventing possible liver injury'.

Sample requirements

Trichloroacetic acid in urine is recommended in situations where exposure is limited to perchloroethylene and there is no co-exposure to other halogenated hydrocarbons. The urine samples should be taken just before the beginning of the last shift of the working week (i.e. approximately 16 hours after finishing work on the second last day of the week). Urine samples (20 mL) should be collected into a sterile pottle, sealed and sent on ice to the analytical laboratory as soon as possible.

Being more specific, a perchloroethylene in blood assay or, if available, a perchloroethylene in end-expired air, may be used in situations where there may be exposure to more than one halogenated hydrocarbon.

Environmental monitoring should be employed to determine the actual solvents present in the work place air.

Interpretation

Trichloroacetic acid, urine

Non exposed levels <0.1 mg/L

- Biological Exposure Index 3.5 mg/L (end of work week)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

Perchloroethylene, blood

Non exposed levels <0.1 mg/L

ACGIH Adopted 1997 Biological Exposure Indices[9]

- Biological Exposure Index 0.5 mg/L (prior to last shift of the week)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

35. Selenium in Urine

Introduction

Selenium is used to supplement livestock feed and in some fertilisers. It is also used in the electrical and electronics industry, semiconductors, glass production, and the paint industry. The cosmetic industry uses selenium in antidandruff shampoos.

Sample requirements

A 20 mL random urine sample is taken into a sterile collection container at the end of the shift. Ensure that hands are washed and clothes are free from selenium contamination.

Interpretation

Non exposed levels < 0.4 µmol/L (< 30 µg/L)

No Biological Exposure Index is given for urine selenium, however urine selenium levels may be used to confirm absorption but the relationship to exposure has not been established. For occupational monitoring a maximum level of 1.3 µmol/L (100 µg/L)[7] has been recommended.

To ensure adequate assessment of exposure to selenium, urine samples must be collected at the end of the working shift. Urinary concentrations rise dramatically with a sudden increase in ingestion of selenium and can be used to differentiate between acute and chronic exposure.

36. Silver

Introduction

Silver is a rare element occurring naturally as a pure metal and in ores. It is released into the air and soils through natural weathering and through the processing of ore, steel refining, combustion of fossil fuels and incineration of municipal waste. The main industrial use of silver has been in the photographic industry. The general population is exposed to silver through ingestion of drinking water and food. Foods with high silver content include seafood from areas near sewerage outflows and industrial sources and crops grown in areas with high ambient soil levels.

Occupational exposure occurs in the primary metal industries, air conditioning and refrigeration mechanics, plumbers, welders, and those involved in processing silver nitrate and oxide for use in the photography, smelting and refining industries. Absorption is either through inhalation or oral ingestion or dermal absorption. Bioaccumulation occurs in filter feeding seafood, but reliable data on food-chain bioaccumulation is not available. Little data is available on exposure levels in humans.

There are no known acute effects of exposure to silver metal; but some silver compounds, such as oxides and nitrates, are irritants. With chronic exposure silver binds to sulphhydryl groups on proteins and can lead to darkening of the skin, particularly sun exposed skin (argyria), and deposition in the cornea (argyrosis). Nephrotoxicity has been reported. Elimination is primarily through the faeces.

Plasma silver levels are an indicator of recent exposure irrespective of the route. Urine silver is a less reliable indicator of exposure, (in a study by DiVincenzo[13] – 100 % of exposed workers had faecal silver above the limit of detection, but only 6 % of urine samples had detectable silver). Intermediate and long-term exposure to silver may be determined by monitoring plasma silver levels or from skin biopsy.

Silver in Plasma

Sample requirements

Whole blood sample collected into a navy top 6 mL K_2 EDTA trace element tube. The plasma should be separated as soon as possible.

Interpretation

Upper limits for non-exposed < 1 ug/L[14]

No Biological Exposure Index is available for serum silver.

Silver in Urine

Sample requirements

20 mL urine in a pottle shown to be free of silver contamination

Interpretation

Upper limits for non-exposed < 2 ug/L[14]

No Biological Exposure Index is available for urine silver.

37. Styrene

Synonyms

Vinylbenzene; Phenylethylene; Cinnamene.

Introduction

Styrene is used in the manufacture of polystyrene plastics; solvent and copolymer in resins; production of styrenebutadiene rubber.

Absorption of styrene occurs through inhalation of vapours and through skin contact with the liquid. Styrene is a neurotoxin that may impair both the central and peripheral nervous systems. Other adverse health effects, such as hepatic toxicity have also been reported.

Sample Requirements

Mandelic acid in urine is the recommended biological test for monitoring exposure to styrene. Urine samples (20 mL) should be collected into a sterile pottle at the end of the shift but not the first day of the week, sealed and sent on ice to the analytical laboratory as soon as possible.

Interpretation

Non exposed levels <0.1 mg/L

Workplace Exposure Standards (2011)[2]

- Biological Exposure Index 1 g/L (end of shift)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

38. Thallium in Urine

Introduction

Thallium is a soft heavy metal found as a by product from smelting copper, lead or zinc. Thallium is used in small quantities in the manufacture of optical lenses, imitation jewellery, in dyes and pigments and thallium sulphate is used as a rodenticide.
Thallium is absorbed through inhalation, ingestion and through the skin. In the blood it is mainly bound to the red cells and is excreted by the kidneys.
Thallium compounds are highly toxic cumulative poisons. Large doses cause gastrointestinal symptoms such as vomiting and diarrhoea followed by hypotension and brachycardia initially then followed by hypertension and tachycardia. Severe cases lead to muscle paralysis and cardio respiratory failure.
Chronic poisoning causes peripheral neuropathy, gastroenteritis and characteristically, loss of hair.

Specimen requirements

20 mL fresh random urine collected into a sterile container. Ensure that hands are washed and clothes are free of contamination.

Interpretation

Non exposure levels 0 – 1 μg/L

Thallium is initially rapidly excreted in the urine and samples should be collected at the end of the working week.

39. Tin in Urine

Introduction

Tin is a soft, insoluble metal extensively used in the caning industry to line food, beverage and aerosol cans. It is present in brass, bronze, pewter and solder. Tin can be combined with other elements (chlorine, sulphur, oxygen) to form so called inorganic tin, these compounds are present in toothpastes, food additives, colourants, perfumes and soaps. Organotin compounds – alkyl and phenyl derivatives – are used in the manufacture of plastic pipes, food packaging, wood preservatives, antifouling paints and rodenticides.

Normal population exposure is primarily from food and drinking water. Tin in its various forms is present in normal soils and hence vegetables. Food preserved in tin lined cans is a significant source of tin in the diet; however more than 90 % of cans are lacquered to prevent contact of food with the tin, reducing the tin content of the food from 100 ppm in unlacquered cans to 25 ppm in lacquered cans. Light coloured fruit and fruit juices are an exception being packed in unlacquered cans; the tin helps preserve the colour of the fruit. Stannous fluoride is often added to toothpaste. Seafood and drinking water may also contain tin (butyltin) as leachates from antifouling paints and PVC pipes. Occupational exposure occurs in processing industries which work with tin containing compounds, exposure is generally through inhalation of dust. Workplace exposure limits are in place.

Only small amounts of inorganic tin and tin compounds are absorbed from the gastrointestinal tract and the urine is the main route for excretion. The majority of ingested tin is excreted within 24 hours but some can be retained in the bones and tissues for 2 – 3 months. Acute health effects from ingestion of large quantities of tin include abdominal pain, anaemia, hepatic and renal dysfunction. Tin absorption reduces the absorption of zinc.

Organic tin compounds (alkyl- and phenyltin derivatives) can cause a range of toxic effects after inhalation, ingestion or dermal exposure. These include skin, eye and respiratory irritation. Acute and chronic neurological problems have also been reported. Very large acute ingestions may be lethal.

Sample requirements

20 mL urine sample collected in a pottle shown to be free of tin contamination.

Non exposure levels 1 – 20 µg/L

Pre and post exposure samples are recommended.

Interpretation

Urinary tin levels are known to increase after acute exposure to tin and tin compounds and reflect the body load of tin and tin compounds. Levels can vary with dietary intake, hence pre and post exposure samples are recommended.

No Biological Exposure Index is available for urine tin.

40. Toluene

Synonyms

Toluol; Methylbenzene; Phenylmethane.

Introduction

Toluene is an aromatic solvent used in paints and adhesives; as a general solvent and cleaning fluid; as a raw material for the production of numerous chemicals and is present in petrol. As with the majority of organic solvents, toluene produces symptoms related to depression of the central nervous system - headaches, nausea and tiredness. When considering toluene and the aetiology of long term effects on the central and peripheral nervous systems co-exposure with other solvents, especially n-hexane, is a complicating factor.

Sample Requirements

Urine samples (20 mL) should be collected into a sterile pottle at the end of the shift, sealed and sent on ice to the analytical laboratory as soon as possible. Hippuric acid in urine is the most commonly used biological procedure for monitoring exposure to toluene. Hippuric acid levels in urine are not specific for exposure to toluene since fruit, canned food and other items in a diet result in excretion of hippuric acid in urine.

Interpretation

<u>Hippuric Acid</u>

Non exposed levels <1.5 g/g creatinine

Lauwerys Guidelines for Biological Monitoring[7]

- Biological Exposure Index 2.5 g/g creatinine

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

41. Trichloroethylene

Introduction

Trichloroethylene is used for metal degreasing and as an extraction solvent.

Short term exposure to trichloroethylene depression of the central nervous system, long term exposure effects the liver, kidney, lung, heart and skin.

Sample requirements

Trichloroacetic acid in urine is recommended in situations where exposure is limited to trichloroethylene and there is no co-exposure to other halogenated hydrocarbons.

Urine samples (20 mL) should be collected into a sterile pottle at the end of the shift, sealed and sent on ice to the analytical laboratory as soon as possible.

Interpretation

Non exposed levels 0.1 mg/L

Workplace Exposure Standards (2011)[2]

- Biological Exposure Index 100 mg/L (end of shift)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

42. Vanadium in Urine

Introduction

Vanadium is widely dispersed in the environment and is essential in the control of some enzyme systems in humans, eg vanadate inhibits Na^+/K^+ ATPase and Ca^{2+} ATPase and stimulates adenylate cyclase activity.

Occupational exposure to vanadium mainly occurs when fossil fuel oils rich in vanadium are burnt. The remaining ash contains vanadium, and workers who clean the boilers are at risk of exposure. Vanadium is also used in the manufacture of pigment paints and printing inks and is used in association with titanium in the manufacture of jet engines and air frames. Vanadium is excreted in the urine and levels correlate well with airborne vanadium.

Vanadium is relatively toxic at high levels, causing diarrhoea and vomiting. Dust particles cause irritation to the skin, eyes and lungs.

Sample requirements

A 20 mL urine sample is collected into a sterile plastic container (contamination is possible if the sample is collected or stored in a glass container). Daily exposure can be assessed from the difference between pre and post shift urine levels otherwise collect the sample at the end of the working week.

Interpretation

Non exposed levels	< 20 nmol/L (< 1 µg/L) < 2.0 µmol/mol creatinine
Workplace Exposure Standards[10] (for exposure to vanadium pentoxide)	
Biological Exposure Index	110 µmol/mol creatinine

- *Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.*

43. Xylene

Synonyms

Xylol; dimethylbenzene. Commercial xylene is a mixture of the three isomers, *ortho-, meta-*, and *para*-xylene.

Introduction

Xylene is used as a solvent in surface coatings and adhesives and as a starting material for the synthesis of organic chemicals.

Exposure to excessive levels of xylene vapour may result in intoxication with symptoms of dizziness, fatigue and face flushes. Flatulence may also be a less welcome consequence of excessive exposure.

Sample requirements

Urine methylhippuric acid is the recommended analyte for biological monitoring of exposure to xylene.

A 20 mL random urine sample should be collected into a sterile urine pottle at the end of the working shift. The sample should be sealed, kept on ice and sent to the laboratory for analysis.

Interpretation

Non exposed levels <0.1 mg/L

Workplace Exposure Standards (2011)[2]

- Biological Exposure Index 1.5 g/L (end of shift)

Biological Exposure Index (BEI) - levels above which excessive exposure has occurred.

44. Zinc in Plasma

Introduction

Industrial exposure

Zinc is used in galvanising iron and steel, and as an alloy of brass and bronze. Inhalation of zinc oxide fumes produced during welding can cause metal fume fever characterised by nausea, headaches, muscular and joint pain, shortness of breath, thirst and a cough. These symptoms develop 4-12 hours after exposure and last for 1-2 days. Zinc chloride fumes, which are highly corrosive to skin, eyes and mucous membranes, are produced from welding flux, wood preservatives and the manufacture of high quality paper, dyes and deodorants. It is also used in smoke screens.

Sample requirements

Whole blood sample collected into a navy top 6 mL K_2 EDTA trace element tube. Collection tubes and needles can be supplied by the laboratory. The plasma should be separated from the red cells within 2 hours of collection.

Interpretation

Normal reference range 10.0 - 17.0 μmol/L (plasma)

Haemolysed samples are unsuitable for plasma zinc estimation because the red cells contain 80% of circulating zinc. Zinc levels in serum are approximately 16% higher than those in plasma due to the release of zinc from platelets during the clotting process.

Plasma zinc levels are thought to follow a circadian pattern, with the highest values occurring in the morning at approximately 10.00 am.

45. Welding and Gas Cutting Metal Exposure

Types of welding

- MIG (metal inert gas welding) utilises continuous wire and is used for welding mild steel (manganese steel), aluminium and stainless steel.
- MMA (manual metal arc welding) utilises stick electrodes and is used for welding mild steel and stainless steel.

Metal Fumes

When metals are heated, such as in welding, fumes of the relevant metal oxides are given off.

Metal/type	Fume	Health hazard
aluminium	aluminium ozone	deposits in respiratory tract irritation to eyes, nose and throat
galvanised iron	zinc	fume fever
brass	copper, zinc, lead	fume fever
bronze	copper, tin	fume fever
cadmium coated steel	cadmium	kidney and liver damage
mild steel	manganese	nervous system disorders (Parkinsons type symptoms)
phosphate coated steel	phosphine gas	kidney damage, death
plastic coated metal	carbon monoxide	reduces oxygen carrying capacity of blood, can lead to death
silver solder	cadmium	kidney and liver damage
stainless steel	chromium, nickel	cancer, headache, nausea chest pain
steel alloys	vanadium	throat irritation, shortness of breath
lead/enameled steel	lead	lead poisoning and cholic
copper	copper	fume fever

Trace amounts of arsenic are also found when welding stainless steel and mild steel.

Metal Fume Fever

This acute illness is caused by inhalation of high concentrations of metal oxide fumes. Symptoms occur from 4 to 6 hours after exposure to particles, and last 24-48 hours. Flu like symptoms are seen, including chills, weakness, tiredness, high fever, a metallic taste and cough. Polyuria and diarrhoea are not uncommon. There is no specific treatment. Fume fever is not considered dangerous to health, although prolonged exposure may cause some lung damage. It is caused by fumes of copper, zinc, magnesium, aluminium, antimony, iron, nickel, cadmium and tin.

Long term chronic effects of welding fumes include damage to the nervous system, liver, kidneys, blood forming tissues and lungs.

Gases given off

- NO & NO_2 are given off during all types of welding at an approximate concentration 0.5 ppm. It is irritating to eyes, throat and mucous membranes of the lungs.
- Ozone is given off during MIG welding of aluminium and stainless steel. Ozone is produced by the UV radiation in the vicinity of arc welding and cutting operations. It is irritating to all mucous membranes and may result in pulmonary oedema.
- Phosgene gas is produced when the residues of chlorinated hydrocarbon solvents are left on the metal being welded or cut. It produces skin inflammation. Inhalation of high concentrations will cause pulmonary oedema.

46. Conversion Factors

In general this laboratory reports analytes in trace metal results in SI units (Le Systeme International d'Unites). These can be converted to mass units by multiplying the result reported by the atomic weight as given below. For example 1 μmol/L of arsenic (atomic weight = 75) is equivalent to 1 x 75 = 75μg/L. Conversely, mass units can be converted to SI units by division as follows: 10 μg/L of cadmium is equivalent to 10/112 = 0.089 μmol/L or 89 nmol/L. Other analytes are reported in mass per litre for urine e.g. mg/L, g/L or in mass per cubic metre for air e.g. mg/m^3, g/m^3.

Please contact the laboratory if you need any assistance with conversion of results and comparison with overseas literature.

Analyte	Symbol	Atomic wt
Aluminium	Al	27
Antimony	Sb	122
Arsenic	As	75
Barium	Ba	137
Bismuth	Bi	209
Cadmium	Cd	112
Calcium	Ca	40
Chlorine	Cl	35.5
Chromium	Cr	52
Cobalt	Co	59
Copper	Cu	63.5
Fluoride	F	19
Lead	Pb	207
Lithium	Li	7
Magnesium	Mg	24.3
Manganese	Mn	55
Mercury	Hg	201
Molybdenu	Mo	96
Nickel	Ni	59
Potassium	K	39

Analyte	Symbol	Atomic wt
Rubidium	Rb	85.5
Selenium	Se	79
Silver	Ag	018
Sodium	Na	23
Tin	Sn	119
Thallium	Tl	204
Vanadium	V	51
Zinc	Zn	65

Unit conversion examples	
1 g	= 1000 mg
1 mg	= 1000 μg
1 μg	= 1000 ng
1 mol	= 1000 mmol
1 μmol	= 1000 nmol
1 ppm	= 1 mg/L
1 ppb	= 1 μg/L
1 mg/100 mL	= 10 mg/L
1 mg/100 mL	= 1 mg/dL
1 mg/100 mL	= 1 mg%

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10 *Guidance on Laboratory Techniques in Occupational Medicine, Ninth Edition,* Health and Safety Laboratory, UK (2002).

11 *IUPAC SampleCollection Guidleines for Trace Elements in Blood and Urine (technical report). Pure and applied chem., vol67,1575-1608 1995*

12 *Centers for Disease Control and Prevention Case Definition (Barium) 2005, Atlanta, GA.*

13 DiVincenzo GD, Giordano CJ, Schriever LS. (1985) *Biologic monitoring of workers exposed to silver.* Int Arch Occup Environ Health; 56: 207–15.

14 K D Rosenman et al, *Potential nephrotoxic effects of exposure to silver*. British Journal of Industrial Medicine 1987;44:267-272.

48. Contacts

Supplies & General Testing Enquiries

Please use the blow contact details if you require testing supplies or general testing information, including specimen request forms and workplace drug testing supplies, and chain of custody forms.

Phone:	(+64 3) 3640 484
Within NZ phone:	0800 THE LAB (843 522) xtn 80484
E-mail	info@chl.co.nz

Specific Testing Information

For specific testing information we suggest you visit www.chl.co.nz and click on the Test Manager option.

This site is set up as an A to Z of all testing services available at Canterbury Health Laboratories.

Each individual test will also provide direct dial, and specific e-mail contact information for the Senior Scientist responsible for the test.

Results

Phone:	(+64 3) 3640 300 XTN 81166
Within NZ phone:	0800 THE LAB (843 522) xtn 81166

Workplace Drug Testing

For workplace drug testing results, please contact the Toxicology laboratory directly.

Phone:	0800 THE LAB (843 522) option 3
E-mail:	info@workplacedrugtest.co.nz
Web:	www.workplacedrugtest.co.nz