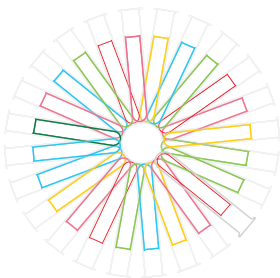
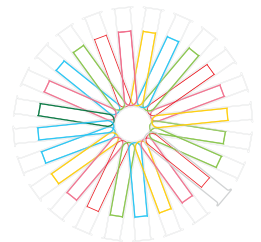
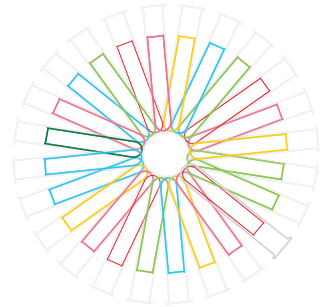
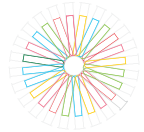
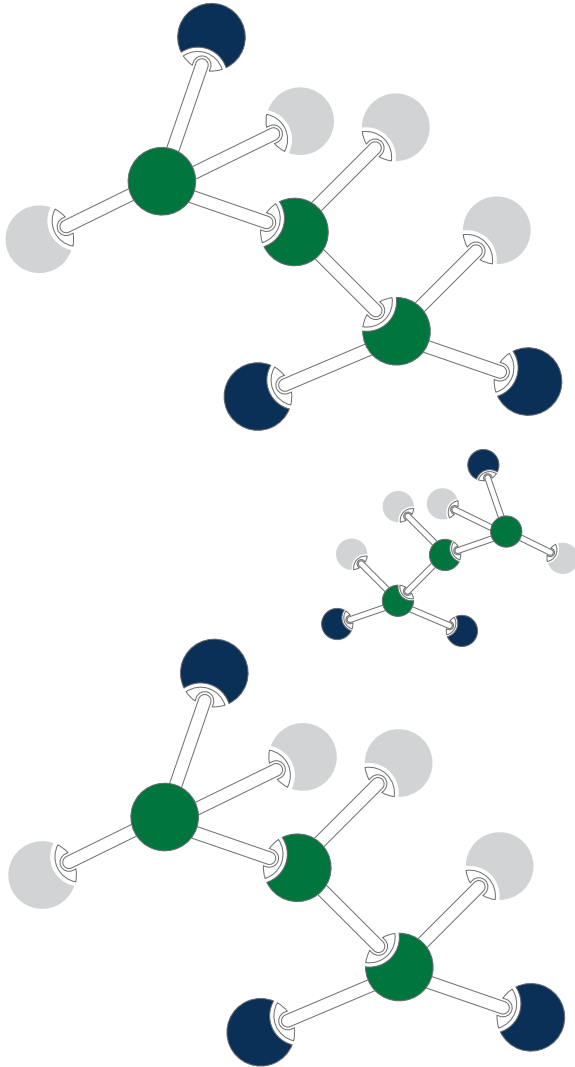


Biological Monitoring In The Workplace

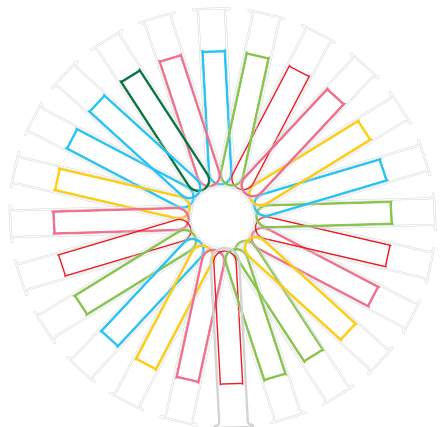
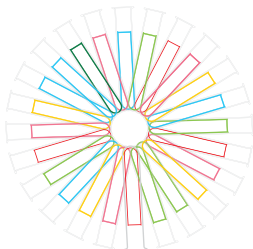
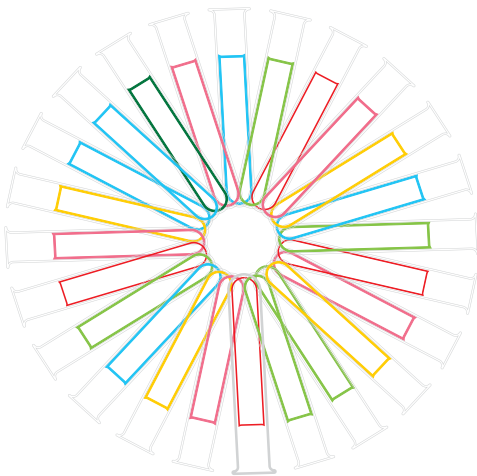


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Role of biological monitoring

The aim of biological monitoring is to prevent unacceptable health risks of chemical exposure and to provide information on the control of occupational exposure.

What is biological monitoring?

Biological monitoring is the measurement and assessment of hazardous chemicals or their metabolites (compounds the body converts the chemical into) in exposed workers. It differs from environmental monitoring where the ambient environment (breathing zone of employees, water, soil) is sampled. Thus, environmental monitoring leads to estimates of external exposure, whereas, biological monitoring measures the internal or absorbed dose.

What is biological effect monitoring?

Biological effect monitoring is the measurement and assessment of early biochemical or physiological changes caused by exposure to hazardous chemicals. These responses may arise from causes other than occupational exposure, therefore this monitoring should always be supervised by an occupational health physician.

Advantages of biological monitoring

Individual variation in the absorption of the airborne chemical, due to differences in the pulmonary ventilation and absorption across the air- blood barrier are accounted for. This implies, that if two workers are exposed to the same air concentration of a chemical, but one is doing heavy physical work while the other is sedentary, both would have the same exposure as measured by the traditional air sampling methods, but they could have very different absorbed doses. Biological monitoring can reveal this difference.

Biological monitoring can give an indication of absorption by all routes of exposure. Therefore, biological monitoring is very useful for chemicals easily absorbed through the skin, inhaled or taken in by ingestion.

The effectiveness of personal protective equipment can often be assessed.

Workers who are exposed to chemicals outside of the workplace may have higher biological levels of those chemicals or their metabolites, than their work colleagues. Therefore, biological monitoring can pick up hobbies or activities outside the workplace.

Biological monitoring can reveal idiosyncratic differences among the workers, in terms of absorption and distribution of chemicals in the body.

Disadvantages of biological monitoring

Many biological monitoring sampling procedures are invasive, including venepuncture blood and biopsy. Urine sampling is unpleasant or inconvenient for many. The results of biological monitoring can be used to discriminate against workers, especially if one worker has a higher absorbed dose than others with similar exposures. Biological exposure indices are available for only a very small number of hazardous chemicals.

BASIC CONSIDERATIONS IN BIOLOGICAL MONITORING

Type of Sample

Urine is the most favoured sample, since it is relatively easy to collect.

Blood samples generally gives a direct measure of the internal levels of the chemicals, however, the collection of sample is invasive and inconvenient.

Breath samples are easier than urine or blood, however, lower concentrations of the analyte are found in breath samples. Problems in the interpretation related to the variable dilution of alveolar gas may also be encountered.

Hair, nails, teeth and secretions, such as saliva, breast milk and semen can also be used. These are currently used in a very small number of workplaces, as the interpretation of the results can be difficult.

Sample collection

Sample collection, storage and transportation requires careful consideration and attention, as they could affect the integrity of the sample and hence the results. The correct blood or urine contamination free containers should be used. The employees have to change out of their work clothes and wash their hands before providing the sample. Time of sample collection is very important due to the variable half-lives of chemicals. The half-life of a substance or its metabolites is the time taken for its concentration to fall to 50% of its original value after the end of exposure and this can be minutes, hours or days. For half-lives of 2- 10 hours, samples should be taken at the end of the shift. Those chemicals that have half-lives >10 hours, the optimum time of taking samples is at the end of the shift at the end of the work week. With urine samples there is a problem of dilution and concentration effects. Measurement of the concentration of a chemical in either very dilute or concentrated urine specimens can give the wrong picture of absorption and excretion. In order to overcome this difficulty, urine samples are corrected for creatinine content.

Interpretation of the results

Biological monitoring results are compared to Biological Exposure Indices (BEIs), which are reference values intended as guidelines for the evaluation of potential health effects. BEIs are not an indicator of health effect from exposure to hazardous chemicals.

BEIs represent biological levels of workplace chemicals which are most likely to be found in blood or urine of employees who have been exposed.

The BEI results may be interpreted on a group basis. If all the observed values are significantly below the BEI, the working conditions may be assumed to be satisfactory. If all or the majority of the results are above the BEI, the cause of the high values must be investigated and proper action taken to reduce the exposure.

When a worker has high results which do not correspond to environmental and biological monitoring of his fellow employees, careful investigation should be followed. Action on unexpected values should not be based on single isolated measurements, particularly for spot urine samples, as these can vary considerably between the same person and contamination of the sample is always a possibility.

Immediate repeat samples are recommended, particularly after high urine sample results. Abnormally high results may indicate atypical exposure from maintenance or emergency repair operations. They may also indicate the failure to use personal protective equipment adequately, in which case better operator training and personal hygiene may be required.

When elevated results are obtained, the key to prudent practice is follow-up and investigation of the source of exposure and correction of the problem. This follow-up should be conducted by an experienced occupational health physician who has the knowledge to interpret the implications of an abnormal result.

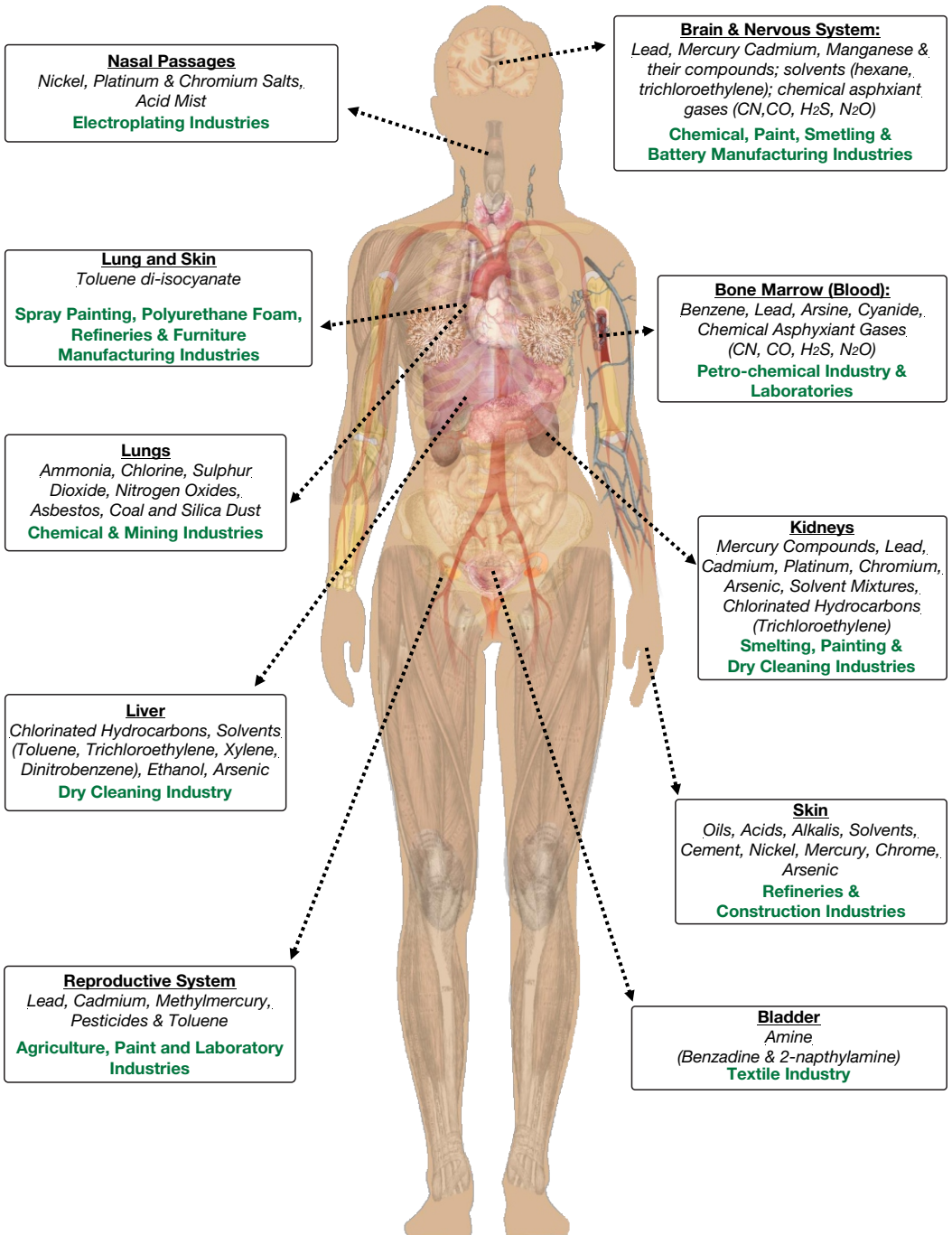
Confidentiality/Ethics

Biological monitoring measurements are carried out on individuals' body fluids, therefore confidentiality of the results is required. These results should be treated as measurements in clinical practice, and there must be appropriate safeguards for the interests of the individual. However, the results must be made available to people who will investigate and make improvements, where necessary.

An informed written consent of the employees should be obtained.

A biological monitoring programme must be well planned and part of a larger programme that includes environmental monitoring. Participating employees must understand its requirements and objectives, and be informed of how the results will be handled. Appropriate feedback is a necessity.

Organ Toxicity



Chemical Exposure	Metabolite / Chemical Measured	Assay Material	Time Of Collection	TAT (Days)
Acetone	Acetone	Urine 20ml on ice	ESEW	14
Aniline	p-Aminophenol	Urine 20ml on ice	ES	14
	Aniline	Urine 20ml on ice	ES	14
Acetylcholinesterase inhibiting pesticides	Cholinesterase activity	Blood 2xEDTA	ESEW	24 Hrs
Aluminium	Aluminium	Urine 20ml on ice	R	7
Arsenic	Arsenic	Urine Special Diet	ESEW	7
Benzene	t,t-Muconic Acid	Urine 20ml on ice	ES	14
	s-Phenylmercapturic acid	Urine 20ml on ice	ES	14
	Phenol*	Urine 20ml on ice	ES	14
Beryllium	Beryllium	Urine 20ml on ice	R	7
Bromine	Bromine	Urine 20ml on ice	ES	14
2-Butoxyethanol	Butoxyacetic acid	Urine 20ml on ice	ES	20
2-Butoxyethyl acetate	Butoxyacetic acid	Urine 20ml on ice	ES	20
n-Butyl alcohol	n-Butyl alcohol	Urine 20ml on ice	ESEW	14
p-tert-Butylphenol	p-tert-Butylphenol	Urine 20ml on ice	ESEW	20
Cadmium	Cadmium	Urine	R	7
	Cadmium	Blood 2xEDTA	R	7
Carbamate pesticides	Bendiocarb & Primidicarb	Urine 20ml on ice	ES	14
Carbon disulphide	2-Thiozolidine-4-carboxylic acid (TTCA)	Urine 20ml on ice	ES	14
Carbon monoxide	Carboxyhaemoglobin	Blood 2xEDTA	ES	24 Hrs
Carbon tetrachloride	Carbon tetrachloride	Blood 2xEDTA	ESEW	14
Chlorobenzene	4-Chlorocatechol	Urine 20ml on ice	ES	14
	p-Chlorophenol	Urine 20ml on ice	ES	14
Chromium	Chromium	Blood 2xEDTA	ES	7
	Chromium	Urine	ES	7
Cobalt	Cobalt	Urine	ESEW	7
	Cobalt	Blood 2xEDTA	ESEW	7

Abbreviations:

*Not Recommended | PS - Pre Shift | ES - End of Shift | R - Random | ESEW - End of Shift End of Workweek | PLSEW - Prior to last Shift of Workweek | Sample Stating "on ice" must be stored and transported on ice

Chemical Exposure	Metabolite / Chemical Measured	Assay Material	Time Of Collection	TAT (Days)
Colophony	Dehydroabiatic acid	Urine 20ml on ice	ES	14
Cyanide	Cyanide	Blood 2xEDTA	ESEW	14
	Thiocyanate	Urine 20ml on ice	ESEW	14
Cyclohexanone	Cyclohexanol	Urine 20ml on ice	ESEW	14
	1,2-Cyclohexanediol	Urine 20ml on ice	ESEW	14
Cresol	o-cresol	Urine 20ml on ice	ES	14
	m-cresol	Urine 20ml on ice	ES	14
	p-cresol	Urine 20ml on ice	ES	14
Cumene	2-Phenyl-2-propanol	Urine 20ml on ice	ES	14
	Cumene	Blood 2xEDTA	ES	14
Cyclohexane	1,2-Cyclohexanediol	Urine 20ml on ice	ESEW	14
Coal Tar Volatiles	1-Hydroxypyrene	Urine 20ml on ice	ES	10
Copper	Copper	Urine	R	7
	Copper	Clotted Blood Plastic Tube	R	7
Dichloromethane	Dichloromethane	Urine 20ml on ice	ES	14
Diesel exhaust	tt-muconic acid	Urine 20ml on ice	ES	14
	1-Nitropyrene	Urine 20ml on ice	ES	14
	1-hydroxypyrene	Urine 20ml on ice	ES	10
N,N-Dimethylacetamide	N,N-Dimethylacetamide	Urine 20ml on ice	ES	14
Dimethylformamide	N-methylformamide	Urine 20ml on ice	ES	14
1,2-Dichlorobenzene	1,2-Dichlorobenzene	Urine 20ml on ice	ES	14
Dry cleaning agent	Trichloroacetic acid	Urine	ES	14
	Carbon tetrachloride	Blood 2xEDTA	ESEW	14
2-Ethoxy ethanol	Ethoxyacetic acid	Urine 20ml on ice	ESEW	14
2-Ethoxy ethylacetate	Ethoxyacetic acid	Urine 20ml on ice	ESEW	14
Ethylbenzene	Mandelic acid	Urine 20ml on ice	ES	14
	Ethylbenzene	Blood 2xEDTA	ES	14

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Chemical Exposure	Metabolite / Chemical Measured	Assay Material	Time Of Collection	TAT (Days)
Ethylene glycol	Ethylene glycol	Urine 20ml on ice	ES	14
	Oxalic acid - poisoning	Urine 20ml on ice	ES	14
	Glycolic acid - poisoning	Urine 20ml on ice	ES	14
Ethylene glycol dinitrate	Ethylene glycol dinitrate	Blood 2xEDTA	ES	14
Ethylene glycol monobutyl ether	Butoxyacetic acid	Urine 20ml on ice	ESEW	14
Ethylene glycol monobutyl ether acetate	Butoxyacetic acid	Urine 20ml on ice	ESEW	14
Ethylene glycol monoethyl ether	Ethoxyacetic acid	Urine 20ml on ice	ESEW	14
Ethylene glycol monoethyl ether acetate	Ethoxyacetic acid	Urine 20ml on ice	ESEW	14
Ethylene glycol monomethyl ether	Methoxyacetic acid	Urine 20ml on ice	ES	14
Ethylene glycol monomethyl ether acetate	Methoxyacetic acid	Urine 20ml on ice	ES	14
Formaldehyde	Formic acid	Urine 20ml on ice	ES	14
Fluorides	Fluorides	Urine 20ml on ice	Prior to Shift	14
Fluorides	Fluorides	Urine 20ml on ice	ES	14
Furfural	Furoic acid	Urine 20ml on ice	ES	14
Glue sniffing	Hexanedione	Urine 20ml on ice	ES	14
	o-cresol	Urine 20ml on ice	ES	14
	methylhippuric acid	Urine 20ml on ice	ES	14
n-Hexane	2,5- Hexanedione	Urine 20ml on ice	ESEW	14
2-Hexanone	2,5- Hexanedione	Urine 20ml on ice	ESEW	14
Hydrogen fluoride	Fluorides	Urine 20ml on ice	Prior to Shift	14
	Fluorides	Urine 20ml on ice	ES	14
Isocyanates	Hexane diamine	Urine 20ml on ice	ESEW	14
	Toluene diamine	Urine 20ml on ice	ESEW	14
	4,4'-Diaminodiphenylmethane	Urine 20ml on ice	ESEW	14
Isopropyl alcohol	Acetone	Urine 20ml on ice	ES	14

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Chemical Exposure	Metabolite / Chemical Measured	Assay Material	Time Of Collection	TAT (Days)
Kerosene	Dimethylbenzoic acid	Urine 20ml on ice	ES	14
Lead	Lead	Urine	ESEW	7
	Lead	Blood 2xEDTA	R	7
Lindane	Lindane	Blood 2xEDTA	ES	14
Manganese	Manganese	Blood 2xEDTA	ES	7
	Manganese	Urine	ES	7
Mercury	Mercury	Urine	PS	7
	Mercury	Blood 2xEDTA	ESEW	7
Methanol	Methanol	Urine 20ml on ice	ES	14
Methemoglobin inducers	Methemoglobin	Blood Heparin	ES	24 Hrs
1-Methoxypropan-2-ol	1-Methoxypropan-2-ol	Urine 20ml on ice	ES	14
2-Methoxyethanol	Methoxyacetic acid	Urine 20ml on ice	PS	14
2-Methoxyethyl acetate	Methoxyacetic acid	Urine 20ml on ice	PS	ES
Methylene Chloride	Methylene Chloride	Urine 20ml on ice	ES	14
Methyl Bromide	Bromide	Blood 2xEDTA	R	14
methylhippuric acid	s-Methylcysteine	Urine 20ml on ice	ES	14
2-Methyl-4-chlorophenoxyacetic acid	2-Methyl-4-chlorophenoxyacetic acid	Urine 20ml on ice	ESEW	14
Methylene bis(2chloroaniline)	Methylene bis(2chloroaniline)	Urine 20ml on ice	ES	14
Methylene diphenyl Diisocyanate	Methylene dianiline	Urine 20ml on ice	ES	14
Methyl Chloroform	Methyl Chloroform	Blood 2xEDTA	ESEW	14
	Trichloroacetic acid	Urine 20ml on ice	ES	14
	Trichloroethanol	Urine 20ml on ice	ESEW	14
	Trichloroethanol	Blood 2xEDTA	ESEW	14
Methyl ethyl ketone	Methyl ethyl ketone	Urine 20ml on ice	ES	14
Methyl-n-butyl ketone	2.5 Hexanedione	Urine 20ml on ice	ESEW	14
Methyl isobutyl ketone	Methyl isobutyl ketone	Urine 20ml on ice	ES	14

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Chemical Exposure	Metabolite / Chemical Measured	Assay Material	Time Of Collection	TAT (Days)
1-Methyl-2-pyrrolidone	5-Hydroxy-1-methyl-2-pyrrolidone	Urine 20ml on ice	ES	14
Monochloromethane	s-Methylcysteine	Urine 20ml on ice	ES	14
Nickel	Nickel	Urine	ESEW	7
Nitriles	Thiocyanate	Urine 20ml on ice	ESEW	14
Nitobenzene	p-Nitrophenol	Urine 20ml on ice	ESEW	14
	Methaemoglobin	Blood Heparin	ES	24 Hrs
Organophosphorus Pesticides	Cholinesterase activity	Blood 2xEDTA	ES	24 Hrs
	Dialkylphosphate metabolites	Urine	ESEW	14
Parathion	p-Nitrophenol	Urine 20ml on ice	ESEW	14
	Cholinesterase activity	Blood 2xEDTA	ES	24 Hrs
Pentachlorophenol	Pentachlorophenol	Urine 20ml on ice	PLS EW	14
	Pentachlorophenol	Blood 2xEDTA	ES	14
Perchloroethylene	Perchloroethylene	Blood 2xEDTA	PLS EW	14
	Trichloroacetic acid*	Urine 20ml on ice	ESEW	14
Phenol	Phenol	Urine 20ml on ice	ES	14
Polychlorinated biphenyls PCB	Various	Blood 2xEDTA	R	14
Polycyclic aromatic hydrocarbons	1-hydroxypyrene	Urine 20ml on ice	ES	10
Perfluorooctanesulfonic acid	Perfluorooctanesulfonic acid	Urine 20ml on ice	R	14
Perfluorooctanoic acid	Perfluorooctanoic acid	Urine 20ml on ice	R	14
Propylene glycol 1-methyl ether	Propylene glycol 1-methyl ether	Urine 20ml on ice	ES	14
Propylene oxide	2-Hydroxypropylmercapturic acid	Urine 20ml on ice	ESEW	14
2-Propanol	Acetone	Urine 20ml on ice	ESEW	14
Pyrethroids (e.g allethrin, cyfluthrin, cypermethrin, deltamethrin, permethrin, resmethrin, phenothrin)	trans-Chrysanthemum-dicarboxylic acid	Urine 20ml on ice	ES	14
	4-Fluoro-3-phenoxy-benzoic acid	Urine 20ml on ice	ESEW	14
Toluene diamine	cis & trans-3-(2,2-dichlorovinyl)-2,2-dimethyl-cyclopropanecarboxylic acid	Urine 20ml on ice	ES	14
4,4'-Diaminodiphenylmethane	cis-3-(2,2-dibromovinyl) 2,2-dimethyl cyclopropanecarboxylic acid	Urine 20ml on ice	ES	14

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Chemical Exposure	Metabolite / Chemical Measured	Assay Material	Time Of Collection	TAT (Days)
Selenium	Selenium	Urine	ESEW	7
		Serum	R	
Styrene	Mandelic acid + Phenylglyoxylic acid	Urine 20ml on ice	ES	14
	Mandelic acid only	Urine 20ml on ice	ES	14
	Styrene	Blood 2xEDTA	ES	14
Tetrachloroethylene	Tetrachloroethylene	Blood 2xEDTA	PLS EW	14
	Trichloroacetic acid*	Urine 20ml on ice	ESEW	14
Thinners	Toluene (o-cresol)	Urine 20ml on ice	ES	14
	Xylene (Methylhippuric acid)	Urine 20ml on ice	ES	14
	Methanol	Urine 20ml on ice	ES	14
	Methyl ethyl ketone	Urine 20ml on ice	ES	14
	Acetone	Urine 20ml on ice	ESEW	14
Tetrahydrofuran	Tetrahydrofuran	Urine 20ml on ice	ES	14
Trichloroethylene	Trichloroacetic acid	Urine 20ml on ice	ESEW	14
	Trichloroethanol	Blood 2xEDTA	ESEW	14
Thallium	Thallium	Urine 20ml on ice	ESEW	10
Toluene	Toluene - Blood	Blood 2xEDTA	ESEW	14
	Toluene - Urine	Urine 20ml on ice	ES	14
	o-Cresol	Urine 20ml on ice	ES	14
	Hippuric acid*	Urine 20ml on ice	ES	14
o-Toluidine	o-Toluidine	Urine 20ml on ice	ES	14
Toluene-2,4-diamine	Toluene-2,4-diamine	Urine 20ml on ice	ESEW	14
Toluene-2,4-diisocyanate	Toluene-2,4-diamine	Urine 20ml on ice	ESEW	14
1,1,1-Trichloroethane	Methyl Chloroform	Blood 2xEDTA	ESEW	14
	Trichloroacetic acid	Urine 20ml on ice	ES	14
	Trichloroethanol	Urine 20ml on ice	ESEW	14
	Trichloroethanol	Blood 2xEDTA	ESEW	14

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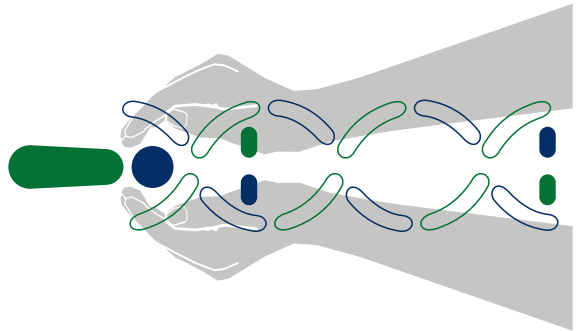
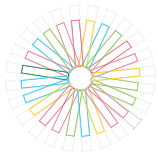
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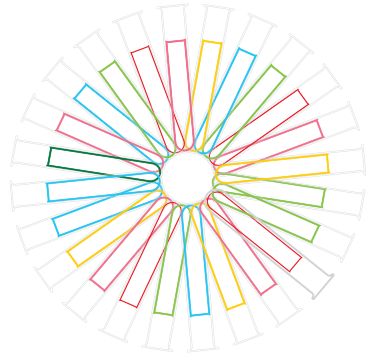
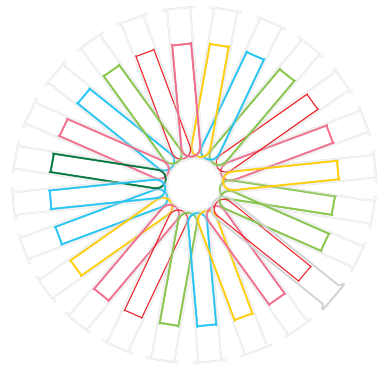
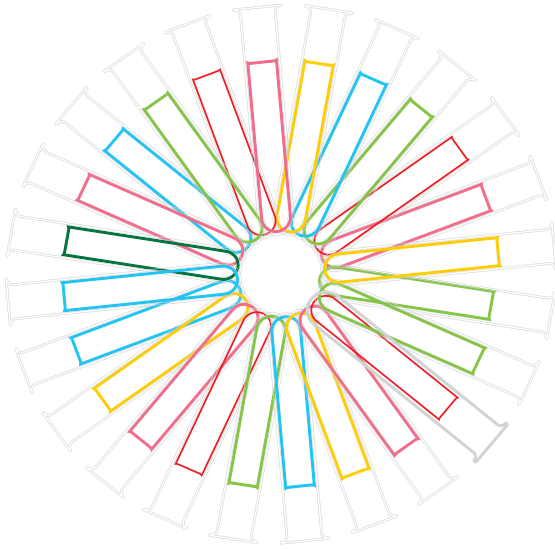
Chemical Exposure	Metabolite / Chemical Measured	Assay Material	Time Of Collection	TAT (Days)
Trimethylbenzene	Dimethylbenzoic acid	Urine 20ml on ice	ES	14
Uranium	Uranium	Urine	ES	7
Vanadium	Vanadium	Urine	ES	7
Vinyl Chloride	Thiodiacetic acid	Urine 20ml on ice	ES	14
Xylene	o,m,p-Methylhippuric acid	Urine	ES	14
	Xylene	Blood EDTA	ES	14
Zinc	Zinc	Urine	ES	7
Methoxyacetic acid	Zinc	Blood EDTA	ES	7

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