

# Reference data

## Biomonitoring

### Trace elements in human biological material



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Element	Median	Range	Reference	Note
<b>Ag, silver</b>				
whole blood	0.077 ng/ml	<0.045-0.272 ng/ml	1	
whole blood		0.045-0.28 ng/ml	7	
serum		0.062-0.24 ng/ml	7	
serum		0.11-0.17 ng/ml	10	1
urine	0.016 ng/ml	0.008-0.026 ng/ml	2	
urine		<0.01-0.02 ng/ml	7	
urine		0.003-0.007 ng/ml	10	1
hair	0.132 µg/g	0.025-1.96 µg/g	5	2, 3, 4
nails	0.108 µg/g	0.019-1.76 µg/g	5	2
<b>Al, aluminium</b>				
whole blood	15 ng/ml	<5-192 ng/ml	1	1
whole blood		4.9-14.9 ng/ml	7	1
serum		0.8-5.9 ng/ml	7	1, 2
urine	1.9 ng/ml	<1.2-4.1 ng/ml	2	
urine		0.6-5.1 ng/ml	7	
hair	6.4 µg/g	2.7-25.6 µg/g	5	3
nails	32 µg/g	12-137 µg/g	5	3
<b>As, arsenic</b>				
whole blood		<0.5-4.2 ng/ml	7	
serum		<0.5-3.6 ng/ml	7	
urine		5.3-11.7 ng/ml	7	
hair	0.067 µg/g	0.034-0.319 µg/g	5	
nails	0.223 µg/g	0.065-1.09 µg/g	5	
<b>Au, gold</b>				
whole blood	0.018 ng/ml	0.007-0.217 ng/ml	1	
whole blood		0.007-0.18 ng/ml	7	
serum		<0.0026-0.1 ng/ml	7	
serum		0.006-0.018 ng/ml	10	1
urine	0.0058 ng/ml	0.002-0.019 ng/ml	2	
urine		0.002-0.04 ng/ml	7	
urine		0.008-0.013 ng/ml	10	1
hair	0.017 µg/g	0.003-0.200 µg/g	5	2, 3
nails	0.047 µg/g	0.006-0.255 µg/g	5	2

#### Notes Ag

- Range for 3 pooled samples, each representing 30-35 subjects.
- Concentrations were correlated with Hg, which was attributed to dental amalgam fillings as a common source.
- Higher in female hair.
- This element is highly enriched in hair relative to blood.

#### Notes Al

- Warning: Due to aluminium contamination, determination may be impossible with some blood collection and serum separation tubes (Ref. 3).
- Possibly too high results. Normal levels <0.35 ng/ml.
- Higher in the age interval 2-7 y, which was attributed to soil-borne contamination.

#### Notes Au

- Range for 3 pooled samples, each representing 30-35 subjects.
- Concentrations were higher in females, and correlated with platinum. These relationships were attributed to use of jewellery.
- This element is highly enriched in hair relative to blood.

Element	Median	Range	Reference	Note
<b>B, boron</b>				
whole blood	7 ng/ml	6–33 ng/ml	1	1
whole blood		9–78 ng/ml	7	1
serum		7–19 ng/ml	7	1
urine	730 ng/ml	540–1700 ng/ml	2	
urine		380–3600 ng/ml	7	
hair	0.46 µg/g	0.13–3.30 µg/g	5	2
nails	0.36 µg/g	0.12–3.33 µg/g	5	
<b>Ba, barium</b>				
whole blood		<0.21–1.6 ng/ml	7	1
serum		0.4–1.7 ng/ml	7	1
urine	1.6 ng/ml	<0.2–3.3 ng/ml	2	
urine		0.22–2.7 ng/ml	7	
hair	0.46 µg/g	0.16–1.92 µg/g	5	2
nails	0.89 µg/g	0.28–3.99 µg/g	5	
<b>Be, beryllium</b>				
whole blood	0.083 ng/ml	<0.075–0.278 ng/ml	1	
whole blood		<0.015–0.033 ng/ml	7	
serum		<0.01–0.014 ng/ml	7	
urine		<0.031–0.041 ng/ml	2	
urine		<0.01–0.018 ng/ml	7	
hair	0.001 µg/g	0.0004–0.0042 µg/g	5	
nails	0.0013 µg/g	<0.0002–0.0066 µg/g	5	
<b>Bi, bismuth</b>				
whole blood	0.0073 ng/ml	<0.0045–0.029 ng/ml	1	
whole blood		<0.002–0.020 ng/ml	7	
serum		<0.001–0.009 ng/ml	7	
serum		0.0016–0.0029 ng/ml	10	1
urine	0.028 ng/ml	<0.008–0.062 ng/ml	2	
urine		0.004–0.04 ng/ml	7	
urine		0.0008–0.0026 ng/ml	10	1
hair	0.009 µg/g	0.002–0.255 µg/g	5	2, 3, 4
nails	0.021 µg/g	0.004–0.543 µg/g	5	2, 3, 5
<b>Br, bromine</b>				
whole blood	6600 ng/ml	3300–23400 ng/ml	1	1
whole blood		3400–8400 ng/ml	7	1
serum		1200–2800 ng/ml	7	1
urine		2200–3700 ng/ml	7	1
hair	26 µg/g	5.6–221 µg/g	5	1
nails	20 µg/g	6.5–49.9 µg/g	5	1, 2
<b>Ca, calcium</b>				
hair	590 µg/g	113–2890 µg/g	5	1, 2
nails	650 µg/g	345–1160 µg/g	5	
<b>Cd, cadmium</b>				
whole blood	0.109 ng/ml	<0.030–0.317 ng/ml	1	
whole blood		0.09–0.54 ng/ml	7	
serum		0.013–0.074 ng/ml	7	
urine	0.145 ng/ml	0.044–0.358 ng/ml	2	
urine		0.005–0.46 ng/ml	7	
hair	0.034 µg/g	0.010–0.356 µg/g	5	1, 3
nails	0.061 µg/g	0.013–0.438 µg/g	5	2, 3
<b>Ce, cerium</b>				
whole blood		0.014–0.19 ng/ml	7	1
serum		0.013–0.062 ng/ml	7	
urine		<0.058–0.211 ng/ml	2	
urine		0.005–0.03 ng/ml	7	
hair	0.019 µg/g	0.007–0.164 µg/g	5	2
nails	0.077 µg/g	0.024–0.771 µg/g	5	2

#### Notes B

- Warning: disposable polyethylene pipettes may cause substantial contamination with boron (Ref. 3).
- Males showed significantly higher values than females.

#### Notes Ba

- Warning: Due to barium contamination, determination may be impossible with some blood collection and serum separation tubes (Ref. 3).
- Females showed significantly higher values than males.

#### Notes Bi

- Range for 3 pooled samples, each representing 30–35 subjects.
- Hair and nail concentrations are highly correlated.
- Females showed significantly higher values than males.
- This element is highly enriched in hair relative to blood.
- No significant difference between outer and inner layers (Ref. 4).

#### Notes Br

- Results for this element should be treated with caution.
- No significant difference between outer and inner layers (Ref. 4).

#### Notes Ca

- Concentration was age-dependent, with a maximum between 30 and 50 y.
- Females showed significantly higher values than males.

#### Notes Cd

- Smokers showed, on the average, five times higher concentrations.
- Smokers showed, on the average, ten times higher concentrations.
- Hair and nail concentrations were highly correlated.

#### Notes Ce

- Warning: Cerium is used as a glass-polishing agent. Avoid glass tubes.
- Some smokers showed elevated concentrations, probably due to flint in disposable lighters, containing this element.

Element	Median	Range	Reference	Note
<b>Cl, chlorine</b>				
hair	7300 µg/g	1350-27000 µg/g	5	1, 2
nails	7500 µg/g	2020-22600 µg/g	5	3
<b>Co, cobalt</b>				
whole blood	0.092 ng/ml	<0.022-0.255 ng/ml	1	
whole blood		0.04-0.20 ng/ml	7	
serum		0.03-0.18 ng/ml	7	
urine	0.17 ng/ml	0.06-0.51 ng/ml	2	
urine		0.04-0.81 ng/ml	7	
hair	0.01 µg/g	0.002-0.063 µg/g	5	1
nails	0.025 µg/g	0.006-0.120 µg/g	5	
<b>Cr, chromium</b>				
whole blood	0.51 ng/ml	<0.4-1.2 ng/ml	1	
whole blood		<0.19-0.47 ng/ml	7	
serum		0.05-0.48 ng/ml	7	
urine	0.18 ng/ml	0.06-0.26 ng/ml	2	
urine		<0.04-0.30 ng/ml	7	
hair	0.131 µg/g	0.046-0.527 µg/g	5	1
nails	0.76 µg/g	0.224-3.20 µg/g	5	
<b>Cs, cesium</b>				
whole blood	3.8 ng/ml	2.5-7.5 ng/ml	1	
whole blood		2.6-7.5 ng/ml	7	
serum		0.45-0.82 ng/ml	7	
urine	12.2 ng/ml	3.8-17.4 ng/ml	2	
urine		3.4-19 ng/ml	7	
hair	0.00051 µg/g	0.00017-0.0019 µg/g	5	1
nails	0.0027 µg/g	0.0008-0.013 µg/g		
<b>Cu, copper</b>				
whole blood	830 ng/ml	590-1470 ng/ml	1	
whole blood		780-1760 ng/ml	7	
serum		740-1300 ng/ml	7	
urine	8.3 ng/ml	1.9-15.9 ng/ml	2	
hair	18 µg/g	8.5-96 µg/g	5	
nails	7.6 µg/g	4.2-17 µg/g	5	1
<b>Dy, dysprosium</b>				
whole blood		0.0009-0.0035 ng/ml	7	
serum		0.0007-0.0025 ng/ml	7	
urine		<0.0005-0.0007 ng/ml	7	
<b>Er, erbium</b>				
whole blood		0.0007-0.0020 ng/ml	7	
serum		0.0004-0.0024 ng/ml	7	
urine		<0.0002-0.0009 ng/ml	7	
<b>Eu, europium</b>				
whole blood		<0.0005-0.002 ng/ml	7	
serum		<0.0005-0.0023 ng/ml	7	
urine		<0.0005 ng/ml	7	
<b>Fe, iron</b>				
whole blood	476000 ng/ml	236000-614000 ng/ml	1	
whole blood		390000-550000 ng/ml	7	
serum		550-1200 ng/ml	7	
urine	4.9 ng/ml	<2.1-16.4 ng/ml	2	
urine		1.2-16 ng/ml	7	
hair	8.4 µg/g	4.9-23 µg/g	5	1
nails	37 µg/g	12-189 µg/g	5	
<b>Ga, gallium</b>				
whole blood		<0.030-0.086 ng/ml	1	
whole blood		0.015-0.043 ng/ml	7	
serum		<0.002-0.029 ng/ml	7	
urine		<0.002-0.018 ng/ml	7	
hair	0.0021 µg/g	0.0008-0.0067 µg/g	5	
nails	0.009 µg/g	0.003-0.053 µg/g	5	

#### Notes Cl

1. Males showed significantly higher values than females.
2. This element shows no enrichment in hair relative to blood.
3. No significant difference between outer and inner layers.

#### Note Co

1. Females showed significantly higher values than males.

#### Note Cr

1. Possibly too low (Low recovery for the reference material GBW07601 human hair).

#### Note Cs

1. This element shows no enrichment in hair relative to blood.

#### Note Cu

1. No significant difference between outer and inner layers.



#### Note Fe

1. This element shows no enrichment in hair relative to blood.

Element	Median	Range	Reference	Note
<b>Gd, gadolinium</b>				
whole blood		0.0013–0.0102 ng/ml	7	
serum		<0.0006–0.0049 ng/ml	7	
urine		<0.0006–0.0010 ng/ml	7	
<b>Ge, germanium</b>				
whole blood		<0.10 ng/ml	7	
serum		<0.07 ng/ml	7	
urine		<0.07 ng/ml	7	
hair	0.0032 µg/g	<0.0022–0.015 µg/g	5	
nails	0.0045 µg/g	<0.0022–0.024 µg/g	5	
<b>Hf, hafnium</b>				
whole blood	0.48 ng/ml	<0.1–6.5 ng/ml	1	
whole blood		<0.002–0.010 ng/ml	7	
serum		<0.001–0.008 ng/ml	7	
serum		0.003–0.004 ng/ml	10	1
urine		<0.0017–0.0066 ng/ml	2	
urine		0.001–0.01 ng/ml	7	
urine		0.0014–0.0025 ng/ml	10	1
hair	0.0017 µg/g	0.0004–0.037 µg/g	5	2
nails	0.009 µg/g	0.002–0.192 µg/g	5	2
<b>Hg, mercury</b>				
whole blood	1.7 ng/ml	0.44–6.47 ng/ml	1	
whole blood		0.46–7.5 ng/ml	7	
serum		0.21–1.3 ng/ml	7	
urine	0.72 ng/ml	0.22–2.00 ng/ml	2	
urine		0.14–4.2 ng/ml	7	
hair	0.249 µg/g	0.053–0.927 µg/g	5	1, 2
nails	0.098 µg/g	0.028–0.311 µg/g	5	1, 2, 3
<b>Ho, holmium</b>				
whole blood		0.0003–0.0009 ng/ml	7	
serum		0.0004–0.0008 ng/ml	7	
urine		0.0003–0.0013 ng/ml	7	
<b>I, iodine</b>				
whole blood	65 ng/ml	35–118 ng/ml	1	1
whole blood		116–134 ng/ml	7	1
serum		65–104 ng/ml	7	1
urine		170–630 ng/ml	7	1
hair		0.13–3.31 µg/g	5	1, 2
nails		0.077–0.810 µg/g	5	1, 3
<b>Ir, iridium</b>				
whole blood	0.0006 ng/ml	<0.0012–0.0029 ng/ml	1	
whole blood		<0.0003–0.0005 ng/ml	7	
serum		<0.0002–0.0009 ng/ml	7	
serum		0.00016–0.00024 ng/ml	10	1
urine		<0.0009–0.0021 ng/ml	2	2
urine		<0.0002–0.0006 ng/ml	7	
urine		0.00004–0.00005 ng/ml	10	1
hair	0.00001 µg/g	<0.00001–0.000045 ng/ml	5	
nails	0.00001 µg/g	<0.00001–0.00026 ng/ml	5	
<b>K, potassium</b>				
hair	52 µg/g	7.4–420 µg/g	5	1
nails	110 µg/g	17–1080 µg/g	5	2
<b>La, lanthanum</b>				
whole blood		0.008–0.046 ng/ml	7	1
serum		<0.002–0.006 ng/ml	7	
urine	0.009 ng/ml	<0.006–0.020 ng/ml	2	
urine		<0.002–0.004 ng/ml	7	
hair	0.018 µg/g	0.0046–0.106 µg/g	5	2
nails	0.043 µg/g	0.015–0.425 µg/g	5	2

#### Notes Hf

1. Range for 3 pooled samples, each representing 30–35 subjects.
2. Hair and nail concentrations are highly correlated.

#### Notes Hg

1. Correlated with silver, possibly with dental amalgam fillings as common source.
2. Hair and nail concentrations are highly correlated.
3. No significant difference between outer and inner layers.

#### Notes I

1. Results for this element should be treated with caution.
2. Females showed significantly higher values than males.
3. No significant difference between outer and inner layers.

#### Notes Ir

1. Range for 3 pooled samples, each representing 30–35 subjects.
2. Results were generally below the lower limit of quantification.

#### Notes K

1. This element shows no enrichment in hair relative to blood.
2. Males showed significantly higher values than females.

#### Notes La

1. Warning: Lanthanum may follow cerium, which is used as a glass-polishing agent. Avoid glass tubes.
2. Some smokers showed elevated concentrations, probably due to flint in disposable lighters, containing this element.

Element	Median	Range	Reference	Note
<b>Li, lithium</b>				
whole blood	2.3 ng/ml	1.2–3.4 ng/ml	1	
whole blood		1.1–6.4 ng/ml	7	
serum		0.24–1.27 ng/ml	7	
urine	13.4 ng/ml	5.3–27.6 ng/ml	2	
urine		5.2–23 ng/ml	7	
hair	0.012 µg/g	0.005–0.046 µg/g	5	
nails	0.053 µg/g	0.013–0.255 µg/g	5	1
<b>Lu, lutetium</b>				
whole blood		<0.0002–0.0005 ng/ml	7	
serum		0.0009–0.0013 ng/ml	7	
urine		0.0006–0.0009 ng/ml	7	
<b>Mg, magnesium</b>				
hair	32 µg/g	8.5–141 µg/g	5	1
nails	93 µg/g	55–191 µg/g	5	2
<b>Mn, manganese</b>				
whole blood	12 ng/ml	7–18 ng/ml	1	1
whole blood		3.3–8.4 ng/ml	7	
serum		0.3–1.04 ng/ml	7	
urine	0.53 ng/ml	<0.27–2.50 ng/ml	2	
urine		<0.05–0.24 ng/ml	7	
hair	0.35 µg/g	0.080–2.41 µg/g	5	
nails	0.65 µg/g	0.19–3.30 µg/g	5	
<b>Mo, molybdenum</b>				
whole blood	0.9 ng/ml	0.21–5.41 ng/ml	1	
whole blood		0.3–1.5 ng/ml	7	
serum		0.27–0.85 ng/ml	7	
urine	41 ng/ml	11–81 ng/ml	2	
urine		12–108 ng/ml	7	
hair	0.037 µg/g	0.021–0.165 µg/g	5	
nails	0.044 µg/g	0.015–0.160 µg/g	5	
<b>Na, sodium</b>				
hair	94 µg/g	17–670 µg/g	5	1, 2
nails	150 µg/g	37–960 µg/g	5	1, 3
<b>Nb, niobium</b>				
whole blood	0.038 ng/ml	<0.008–0.179 ng/ml	1	
whole blood		0.006–0.034 ng/ml	7	
serum		0.005–0.032 ng/ml	7	
serum		0.040–0.13 ng/ml	10	1
urine	0.034 ng/ml	<0.031–0.089 ng/ml	2	
urine		0.01–0.098 ng/ml	7	
urine		0.003–0.004 ng/ml	10	1
hair	0.0017 µg/g	0.0005–0.0058 µg/g	5	
nails	0.007 µg/g	0.003–0.067 µg/g	5	2
<b>Nd, neodymium</b>				
whole blood		0.004–0.023 ng/ml	7	
serum		0.006–0.014 ng/ml	7	
urine		0.0016–0.0042 ng/ml	7	
hair		—	5	1
nails		—	5	1
<b>Ni, nickel</b>				
whole blood		<0.3–0.77 ng/ml	7	1
serum		0.13–0.55 ng/ml	7	
urine	1.7 ng/ml	0.27–3.68 ng/ml	2	
urine		0.24–2.7 ng/ml	7	
hair	0.29 µg/g	0.11–1.60 µg/g	5	
nails	0.84 µg/g	0.14–6.95 µg/g	5	
<b>Os, osmium</b>				
serum		0.0004–0.0008 ng/ml	10	1
urine		<0.00003–0.00013 ng/ml	10	1

#### Note Li

1. No significant difference between outer and inner layers.

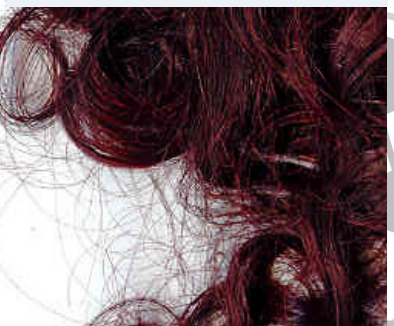


#### Notes Mg

1. Females showed significantly higher values than males.
2. Males showed significantly higher values than females.

#### Note Mn

1. Values are higher than recently reported, and may reflect contamination in sampling.



#### Notes Na

1. Males showed significantly higher values than females.
2. This element shows no enrichment in hair relative to blood.
3. No significant difference between outer and inner layers.

#### Notes Nb

1. Range for 3 pooled samples, each representing 30–35 subjects.
2. No significant difference between outer and inner layers.

#### Note Nd

1. Some smokers showed elevated concentrations, probably due to flint in disposable lighters, containing this element.

#### Note Ni

1. Needles may contribute Ni, but also pipettes, vials and tubes (Ref. 3).

#### Note Os

1. Range for 3 pooled samples, each representing 30–35 subjects.

Element	Median	Range	Reference	Note
<b>P, phosphorus</b>				
whole blood	375000 ng/ml	325000-455000 ng/ml	1	
hair	134 µg/g	102-169 µg/g	5	1
nails	319 µg/g	199-625 µg/g	5	2
<b>Pb, lead</b>				
whole blood	15 ng/ml	4-43 ng/ml	1	
whole blood		4-47 ng/ml	7	
serum		0.12-0.51 ng/ml	7	
urine	1.1 ng/ml	0.3-2.0 ng/ml	2	
urine		0.12-2.9 ng/ml	7	
hair	0.66 µg/g	0.22-7.26 µg/g	5	1
nails	1.06 µg/g	0.27-4.75 µg/g	5	1
<b>Pd, palladium</b>				
whole blood	0.035 ng/ml	0.009-0.125 ng/ml	1	
whole blood		<0.050 ng/ml	7	
serum		<0.030 ng/ml	7	
serum		0.006-0.020 ng/ml	10	1, 2
urine		<0.040 ng/ml	7	
urine		0.012-0.035 ng/ml	10	1, 2
hair	0.00006 µg/g	<0.00006-0.0021 µg/g	5	
nails	0.0006 µg/g	<0.00006-0.0098 µg/g	5	3
<b>Pr, praseodymium</b>				
whole blood		0.0019-0.02 ng/ml	7	
serum		0.0022-0.004 ng/ml	7	
urine		<0.0004-0.002 ng/ml	7	
hair		—	5	1
nails		—	5	1
<b>Pt, platinum</b>				
whole blood	0.0006 ng/ml	<0.0012-0.098 ng/ml	1	
whole blood		<0.001-0.0013 ng/ml	7	
serum		<0.0005-0.005 ng/ml	7	
serum		0.0017-0.016 ng/ml	10	1
urine		<0.0016 ng/ml	2	
urine		<0.0005-0.0012 ng/ml	7	
urine		0.0006-0.0011 ng/ml	10	1
hair	0.00008 µg/g	0.00002-0.00061 µg/g	5	2, 3
nails	0.00014 µg/g	0.00002-0.0011 µg/g	5	2
<b>Rb, rubidium</b>				
whole blood	2500 ng/ml	1900-3200 ng/ml	1	
whole blood		1900-3500 ng/ml	7	
serum		98-215 ng/ml	7	
urine	3400 ng/ml	1000-4400 ng/ml	2	
urine		500-5500 ng/ml	7	
hair	0.06 µg/g	0.012-0.482 µg/g	5	1
nails	0.201 µg/g	0.042-1.30 µg/g	5	
<b>Re, rhenium</b>				
whole blood	0.0014 ng/ml	<0.0006-0.0052 ng/ml	1	
whole blood		0.001-0.0061 ng/ml	7	
serum		0.0005-0.0057 ng/ml	7	
serum		0.0025-0.0032 ng/ml	10	1
urine	0.023 ng/ml	0.004-0.054 ng/ml	2	
urine		0.006-0.037 ng/ml	7	
urine		0.006-0.014 ng/ml	10	1
hair	0.000026 µg/g	<0.000005-0.00016 µg/g	5	
nails	0.000029 µg/g	<0.000005-0.00014 µg/g	5	
<b>Rh, rhodium</b>				
whole blood		<0.009 ng/ml	1	
whole blood		<0.020 ng/ml	7	
serum		<0.010 ng/ml	7	
serum		<0.0007-0.0010 ng/ml	10	1
urine		<0.010 ng/ml	7	
urine		<0.0007-0.0009 ng/ml	10	1
hair	0.00001 µg/g	<0.00001-0.00004 µg/g	5	
nails	0.00001 µg/g	<0.00001-0.000089 µg/g	5	

#### Notes P

1. This element shows no enrichment in hair relative to blood.
2. No significant difference between outer and inner layers.

#### Note Pb

1. Hair and nail concentrations are highly correlated.

#### Notes Pd

1. Total range for measurements on four Pd isotopes.
2. Range for 3 pooled samples, each representing 30-35 subjects.
3. No significant difference between outer and inner layers.

#### Note Pr

1. Some smokers showed elevated concentrations, probably due to flint in disposable lighters, containing this element.

#### Notes Pt

1. Range for 3 pooled samples, each representing 30-35 subjects.
2. Correlated with gold, which was attributed to jewellery as a common source.
3. Females showed significantly higher values than males.

#### Note Rb

1. This element shows no enrichment in hair relative to blood.

#### Note Re

1. Range for 3 pooled samples, each representing 30-35 subjects.

#### Note Rh

1. Range for 3 pooled samples, each representing 30-35 subjects.

Element	Median	Range	Reference	Note
<b>Ru, ruthenium</b>				
whole blood	0.054 ng/ml	<0.024-0.102 ng/ml	1	
whole blood		<0.025 ng/ml	7	
serum		<0.008 ng/ml	7	
serum		<0.002-0.010 ng/ml	10	1, 2
urine		<0.006 ng/ml	7	
urine		<0.002-0.004 ng/ml	10	1, 2
hair	0.00002 µg/g	<0.00002-0.000039 µg/g	5	
nails	0.00002 µg/g	<0.00002-0.000054 µg/g	5	
<b>S, sulfur</b>				
hair	48100 µg/g	40700-55000 µg/g	5	
nails	32600 µg/g	23400-43500 µg/g	5	
<b>Sb, antimony</b>				
whole blood	0.212 ng/ml	0.077-0.842 ng/ml	1	
whole blood		0.024-0.091 ng/ml	7	
serum		0.027-0.063 ng/ml	7	
serum		0.070-0.11 ng/ml	10	1
urine	0.116 ng/ml	0.012-0.223 ng/ml	2	
urine		0.022-0.104 ng/ml	7	
urine		0.070-0.12 ng/ml	10	1
hair	0.017 µg/g	0.007-0.122 µg/g	5	2
nails	0.037 µg/g	0.014-0.128 µg/g	5	2
<b>Sc, scandium</b>				
whole blood		<0.005-0.020 ng/ml	7	
serum		<0.003-0.016 ng/ml	7	
urine	0.01 ng/ml	<0.004-0.025 ng/ml	2	
urine		<0.003-0.044 ng/ml	7	
hair	0.0011 µg/g	0.0004-0.0045 µg/g	5	
nails	0.0042 µg/g	0.0013-0.040 µg/g	5	
<b>Se, selenium</b>				
whole blood	167 ng/ml	138-277 ng/ml	1	
whole blood		75-125 ng/ml	7	
serum		74-90 ng/ml	7	
urine			7	
hair	0.79 µg/g	0.48-1.84 µg/g	5	
nails	0.93 µg/g	0.62-1.53 µg/g	5	1
<b>Si, silicon</b>				
whole blood	2300 ng/ml	1000-8000 ng/ml	1	
whole blood		230-1600 ng/ml	7	
serum		170-550 ng/ml	7	
urine	3900 ng/ml	1900-17000 ng/ml	2	
urine		1700-20000 ng/ml	7	
hair	25 µg/g	<4.6-132 µg/g	5	1
nails	46 µg/g	13-326 µg/g	5	1
<b>Sm, samarium</b>				
whole blood		<0.001-0.015 ng/ml	7	
serum		<0.0005-0.0023 ng/ml	7	
urine		<0.0005-0.0016 ng/ml	7	
<b>Sn, tin</b>				
whole blood	0.53 ng/ml	<0.4-1.2 ng/ml	1	
whole blood		0.35-4.3 ng/ml	7	
serum		0.3-2.6 ng/ml	7	
urine	1.1 ng/ml	<0.3-5.5 ng/ml	2	
urine		0.46-4.7 ng/ml	7	
hair	0.195 µg/g	0.06-1.41 µg/g	5	1
nails	0.48 µg/g	0.11-2.56 µg/g	5	
<b>Sr, strontium</b>				
whole blood	12 ng/ml	7-25 ng/ml	1	
whole blood		7-25 ng/ml	7	
serum			7	
urine	115 ng/ml	27-220 ng/ml	2	
urine		18-260 ng/ml	7	
hair	0.97 µg/g	0.14-5.54 µg/g	5	1, 2
nails	0.39 µg/g	0.17-1.39 µg/g	5	

#### Notes Ru

1. Total range for measurements on the isotopes Ru-101 and Ru-102.
2. Range for 3 pooled samples, each representing 30-35 subjects.

#### Notes Sb

1. Range for 3 pooled samples, each representing 30-35 subject.
2. Hair and nail concentrations were highly correlated.

#### Note Se

1. No significant difference between outer and inner layers.

#### Note Si

1. Females showed significantly higher values than males.

#### Note Sn

1. Females showed significantly higher values than males.

#### Notes Sr

1. Markedly increased concentrations were attributed to exposure to aerosols of brackish water.
2. Females showed significantly higher values than males.

Element	Median	Range	Reference	Note
<b>Ta, tantalum</b>				
whole blood	0.0034 ng/ml	<0.0025-0.0076 ng/ml	1	
whole blood		<0.0005-0.015 ng/ml	7	
serum		<0.0005-0.010 ng/ml	7	
serum		0.008-0.010 ng/ml	10	1
urine		<0.0061-0.0192 ng/ml	2	
urine		0.001-0.021 ng/ml	7	
urine		0.006-0.011 ng/ml	10	1
hair	0.0031 µg/g	<0.002-0.020 µg/g	5	
nails	0.0053 µg/g	<0.002-0.068 µg/g	5	
<b>Ta, tantalum</b>				
whole blood		<0.0002-0.0018 ng/ml	7	
serum		<0.0001-0.0015 ng/ml	7	
urine		<0.0001-0.0003 ng/ml	7	
<b>Te, tellurium</b>				
whole blood	0.226 ng/ml	<0.050-0.572 ng/ml	1	
whole blood		<0.02-0.03 ng/ml	7	
serum		<0.013 ng/ml	7	
serum		0.035-0.038 ng/ml	10	1
urine		<0.013-0.26 ng/ml	7	
urine		0.045-0.078 ng/ml	10	1
hair	0.00024 µg/g	<0.00007-0.001 µg/g	5	
nails	0.00038 µg/g	<0.00007-0.0019 µg/g	5	
<b>Th, thorium</b>				
whole blood	0.067 ng/ml	0.008-0.200 ng/ml	1	1
whole blood		<0.001-0.04 ng/ml	7	1
serum		<0.0005-0.020 ng/ml	7	1
urine	0.012 ng/ml	0.007-0.034 ng/ml	2	
urine		0.0005-0.005 ng/ml	7	
hair	0.001 µg/g	0.0003-0.0044 µg/g	5	2, 3
nails	0.006 µg/g	0.002-0.063 µg/g	5	2
<b>Ti, titanium</b>				
whole blood	0.8 ng/ml	<0.17-2.95 ng/ml	1	
whole blood		<0.3-0.89 ng/ml	7	
serum		<0.1-0.28 ng/ml	7	
urine		<0.23-0.62 ng/ml	2	
urine		<0.1-0.18 ng/ml	7	
hair	0.58 µg/g	0.12-2.71 µg/g	5	1
nails	2.71 µg/g	0.94-16.1 µg/g	5	1
<b>Tl, thallium</b>				
whole blood	0.033 ng/ml	0.021-0.062 ng/ml	1	
whole blood		0.006-0.032 ng/ml	7	
serum		<0.002-0.020 ng/ml	7	
serum		0.018-0.021 ng/ml	10	1
urine	0.16 ng/ml	0.03-0.62 ng/ml	2	
urine		0.05-0.54 ng/ml	7	
urine		0.049-0.13 ng/ml	10	1
hair	0.00053 µg/g	0.0002-0.0016 µg/g	5	
nails	0.0012 µg/g	0.0003-0.0058 µg/g	5	
<b>Tm, thulium</b>				
whole blood		<0.0002-0.0005 ng/ml	7	
serum		<0.0002-0.0004 ng/ml	7	
urine		<0.0002 ng/ml	7	
<b>U, uranium</b>				
whole blood	0.013 ng/ml	0.008-0.035 ng/ml	1	
whole blood		0.0011-0.032 ng/ml	7	
serum		0.0005-0.019 ng/ml	7	
serum		0.014-0.015 ng/ml	10	1
urine		<0.0014-0.0174 ng/ml	2	
urine		0.0007-0.019 ng/ml	7	
urine		0.012-0.016 ng/ml	10	1
hair	0.036 µg/g	0.006-0.436 µg/g	5	2, 3
nails	0.008 µg/g	0.002-0.047 µg/g	5	

#### Note Ta

1. Range for 3 pooled samples, each representing 30-35 subjects.



#### Note Te

1. Range for 3 pooled samples, each representing 30-35 subjects.

#### Notes Th

1. Warning: Due to thorium contamination, determination may be impossible with some blood collection and serum separation tubes (Ref. 3).
2. Higher in the age interval 2-7y, which was attributed to soil-borne contamination.
3. Females showed significantly higher values than males.

#### Note Ti

1. Higher in the age interval 2-7y, which was attributed to soil-borne contamination.

#### Note Tl

1. Range for 3 pooled samples, each representing 30-35 subjects.

#### Notes U

1. Range for 3 pooled samples, each representing 30-35 subjects.
2. Females showed significantly higher values than males.
3. This element is highly enriched in hair relative to blood.



Element	Median	Range	Reference	Note
<b>V, vanadium</b>				
whole blood	0.029 ng/ml	<0.012-0.228 ng/ml	1	
whole blood		0.026-0.28 ng/ml	7	
serum		0.015-0.106 ng/ml	7	
urine	0.048 ng/ml	0.011-0.089 ng/ml	2	
urine		0.008-0.12 ng/ml	7	
hair	0.018 µg/g	0.005-0.134 µg/g	5	
nails	0.069 µg/g	0.018-0.476 µg/g	5	
<b>W, tungsten</b>				
whole blood	0.025 ng/ml	<0.020-0.184 ng/ml	1	
whole blood		<0.01-0.051 ng/ml	7	
serum		<0.004-0.019 ng/ml	7	
serum		0.027-0.065 ng/ml	10	1
urine	0.085 ng/ml	<0.037-0.178 ng/ml	2	
urine		0.12-0.68 ng/ml	7	
urine		0.030-0.095 ng/ml	10	1
hair	0.0035 µg/g	0.001-0.021 µg/g	5	
nails	0.015 µg/g	0.003-0.053 µg/g	5	
<b>Y, yttrium</b>				
whole blood	0.129 ng/ml	0.042-0.308 ng/ml	1	
whole blood		0.013-0.025 ng/ml	7	
serum		0.008-0.022 ng/ml	7	
serum		0.016-0.018 ng/ml	10	1
urine	0.0081 ng/ml	<0.004-0.013 ng/ml	2	
urine		0.0022-0.0058 ng/ml	7	
urine		0.003-0.070 ng/ml	10	1
hair	0.014 µg/g	0.003-0.104 µg/g	5	2
nails	0.017 µg/g	0.007-0.094 µg/g	5	
<b>Yb, ytterbium</b>				
whole blood		<0.0008-0.0025 ng/ml	7	
serum		<0.0006-0.0009 ng/ml	7	
urine		<0.0006 ng/ml	7	
hair		—	5	1
nails		—	5	1
<b>Zn, zinc</b>				
whole blood	5800 ng/ml	3500-9100 ng/ml	1	
whole blood		3900-5700 ng/ml	7	
serum		420-710 ng/ml	7	
urine	430 ng/ml	170-780 ng/ml	2	
urine		40-430 ng/ml	7	
hair	144 µg/g	68-198 µg/g	5	
nails	116 µg/g	80-191 µg/g	5	
<b>Zr, zirconium</b>				
whole blood	3.9 ng/ml	0.2-9.7 ng/ml	1	
whole blood		0.07-0.44 ng/ml	7	
serum		0.028-0.22 ng/ml	7	
serum		0.090-0.16 ng/ml	10	1
urine	0.058 ng/ml	0.024-0.071 ng/ml	2	
urine		0.020-0.045 ng/ml	7	
urine		0.020-0.038 ng/ml	10	1
hair	0.052 µg/g	0.011-1.21 µg/g	5	2
nails	0.26 µg/g	0.054-7.89 µg/g	5	2

#### Note W

1. Range for 3 pooled samples, each representing 30-35 subjects.

#### Notes Y

1. Range for 3 pooled samples, each representing 30-35 subjects.
2. Females showed significantly higher values than males.

#### Note Yb

1. Abnormally high concentrations in three subjects were attributed to dental porcelain bridges.

#### Notes Zr

1. Range for 3 pooled samples, each representing 30-35 subjects.
2. Hair and nail concentrations are highly correlated.

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