# Metals & Elements
TOXIC + ESSENTIAL

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|---|---|---|---|
| REQUISITION # | 260060158 | COLLECTION TIME | 01:29 PM |
| PATIENT NAME | Report Sample | COLLECTION DATE | Oct 12, 2026 |
| DATE OF BIRTH | Apr 15, 1998 | SAMPLE TYPE | Hair |
| GENDER | M | REPORT DATE | Oct 23, 2026 |
| PRACTITIONER | NO PHYSICIAN | | |

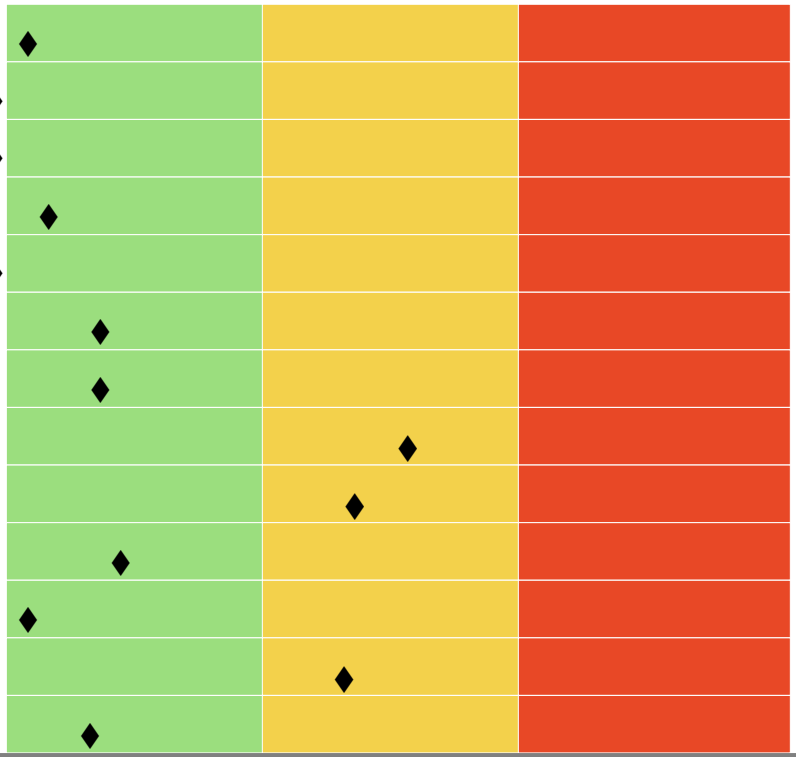
## Metals & Elements - Toxic + Essential (Hair)

Color Key — LOW — MODERATE — HIGH

### Toxic Heavy Metals

DL - Detectable Limit | ULOQ - Upper Limit of Quantification

| Analyte | Results (µg/g) | Reference Range |
|---|---|---|
| Aluminum (Al) | 4.00 | <23.1 |
| Antimony (Sb) | <DL | <0.0659 |
| Arsenic (As) | <DL | <0.0275 |
| Barium (Ba) | 1.00 | <3.08 |
| Bismuth (Bi) | <DL | <0.0478 |
| Cadmium (Cd) | 0.0180 | <0.0220 |
| Lead (Pb) | 0.200 | <0.322 |
| Mercury (Hg) | 0.500 | <0.180 |
| Nickel (Ni) | 0.770 | <0.372 |
| Silver (Ag) | 0.120 | <0.173 |
| Tin (Sn) | 0.0800 | <0.283 |
| Titanium (Ti) | 7.20 | <2.960 |
| Uranium (U) | 0.0200 | <0.0344 |




### Rare/Low-Frequency Toxic Heavy Metals

| Analyte | Results (µg/g) | Reference Range | Analyte | Results (µg/g) | Reference Range |
|---|---|---|---|---|---|
| Gold (Au) | <DL | <0.500 | Platinum (Pt) | 0.50 | <0.00500 |
| Beryllium (Be) | <DL | <0.0250 | Thorium (Th) | <DL | <0.00250 |
| Palladium (Pd) | <DL | <0.0250 | Thallium (Tl) | <DL | <0.00250 |

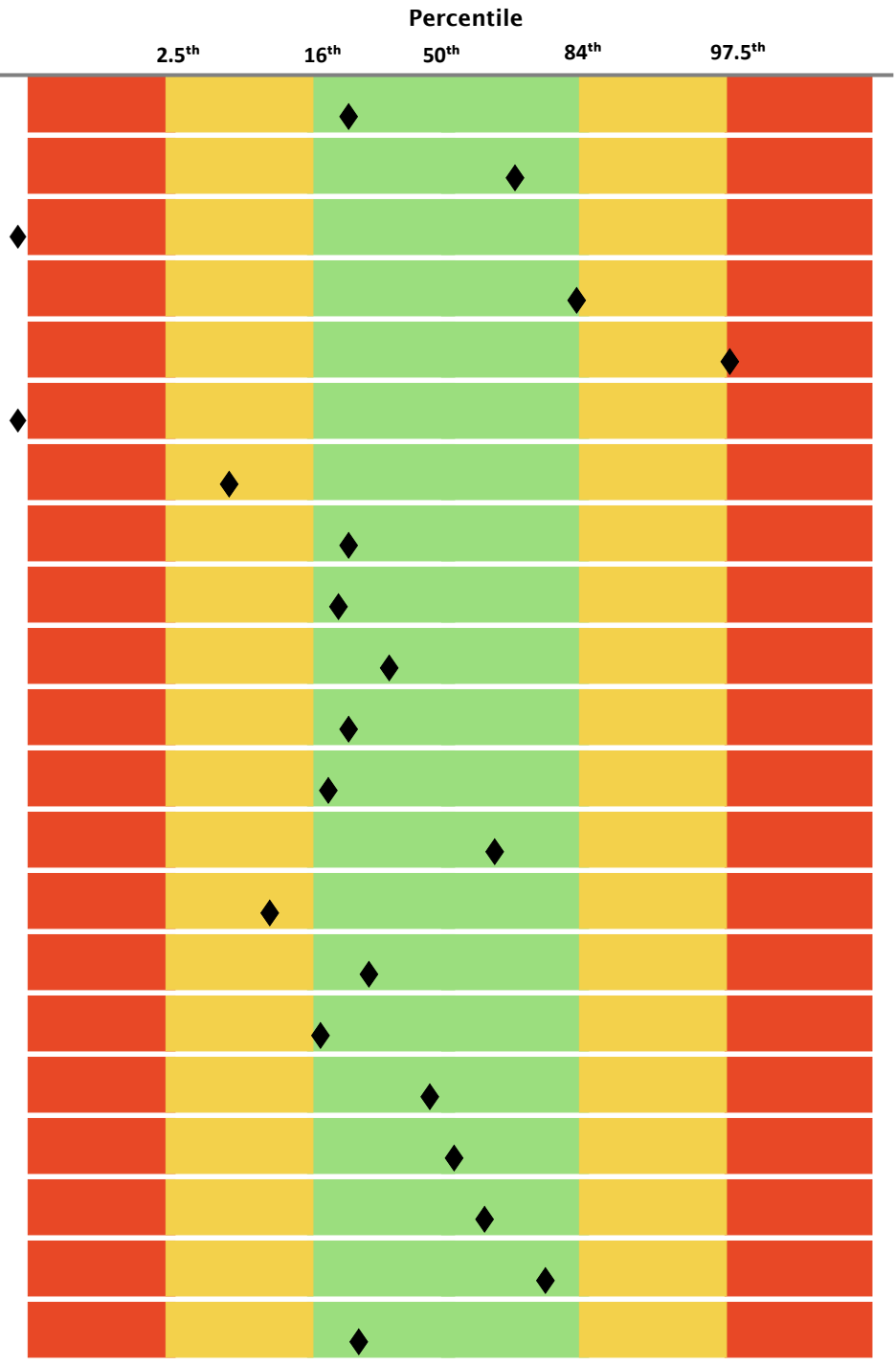
Elevated Toxin Indicator

Metals & Elements
TOXIC + ESSENTIAL

The Profile results offer a comprehensive breakdown of elements, grouped by Toxic, Essential, and Other. Ratios of certain elements will also be reported.

## Essential and Other Elements

| Analyte | Results (µg/g) | Reference Range |
|---|---|---|
| Boron (B) | 0.800 | 0.607 - 4.90 |
| Calcium (Ca) | 2000 | 405 - 2992 |
| Chromium (Cr) | <DL | 0.500 - 0.728 |
| Cobalt (Co) | 0.0800 | 0.0250 - 0.0733 |
| Copper (Cu) | 100 | 8.63 - 27.8 |
| Germanium (Ge) | <DL | 0.0250 - 0.0281 |
| Iron (Fe) | 5.50 | 6.08 - 19.2 |
| Lithium (Li) | 0.0200 | 0.0146 - 0.0698 |
| Magnesium (Mg) | 50.0 | 41.3 - 316 |
| Manganese (Mn) | 0.200 | 0.0857 - 0.830 |
| Molybdenum (Mo) | 0.0300 | 0.0260 - 0.0713 |
| Phosphorus (P) | 118 | 117 - 173 |
| Potassium (K) | 125 | 22.8 - 251 |
| Rubidium (Rb) | 0.0180 | 0.0213 - 0.217 |
| Selenium (Se) | 0.600 | 0.545 - 0.885 |
| Sodium (Na) | 90.0 | 91.5 - 579 |
| Strontium (Sr) | 3.46 | 1.26 - 10.7 |
| Sulfur (S) | 45850 | 42189 - 49987 |
| Vanadium (V) | 0.0600 | 0.0125 - 0.114 |
| Zinc (Zn) | 200 | 128 - 215 |
| Zirconium (Zr) | 0.250 | 0.0985 - 3.08 |



## Ratio - Essential and Other Elements

| Ratio | Reference Range | Results (µg/g) |
|---|---|---|
| Calcium/Magnesium | 6.13 - 19.0 | 40.00 |
| Calcium/Phosphorous | 2.98 - 22.0 | 16.90 |
| Calcium/Potassium | 2.73 - 76.5 | 16.00 |
| Sodium/Magnesium | 0.493 - 8.16 | 1.80 |
| Sodium/Potassium | 1.28 - 5.60 | 0.72 |
| Zinc/Cadmium | 4208 - 63219 | 11,111.11 |
| Zinc/Copper | 5.67 - 20.5 | 2.00 |

# Interpretations

The information provided in this report, including the results and commentary, is intended solely for educational purposes and should not be construed as treatment recommendations. It is recommended that you consult with your healthcare provider for any necessary treatment. References related to this report and interpretations can be found at MosaicDX.com/test/heavy-metals-test.

## Toxic Heavy Metals

Color Key — LOW | MODERATE | HIGH

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Mercury (Hg)** | | **0.500** | **Nickel (Ni)** | | **0.770** | **Titanium (Ti)** | | **7.20** |
| Normal Range | <0.180 | µg/g | Normal Range | <0.372 | µg/g | Normal Range | <2.960 | µg/g |

## MERCURY

Mercury (Hg) is a toxic, non-essential heavy metal with no known physiological role. It is encountered through seafood, dental amalgams, occupational and industrial exposures, and environmental contamination, and exists in elemental, inorganic, and organic forms that differ in their absorption and distribution within the body. Mercury primarily affects the nervous system and kidneys by disrupting antioxidant defenses, mitochondrial function, and cellular signaling through high-affinity binding to sulfur- and selenium-containing proteins.
**Specimen Type:** The Center of Disease Control, through NHANES and the Agency for Toxic Substances and Disease Registry (ATSDR) utilizes blood to evaluate methylmercury and total mercury and urine for elemental or inorganic mercury. The Environmental Protection Agency (EPA) utilizes blood for methylmercury exposures. The World Health Organization (WHO), Joint FAO/WHO Expert Committee on Food Additives (JECFA) and the European Food Safety Authority (EFSA) recognize hair as a biomarker for methylmercury exposures.

## NICKEL

Nickel (Ni) is a non-essential ubiquitous transition metal classified as a Group 1 human carcinogen that is found in food, water, and consumer products. It is the leading cause of allergic contact dermatitis worldwide, while chronic occupational inhalation increases the risk of lung and nasal cancer. Nickel exists as soluble and insoluble compounds; soluble forms are more readily absorbed and acutely toxic, whereas insoluble forms are more strongly associated with respiratory carcinogenicity following inhalation.
**Specimen Type:** The National Health and Nutrition Examination Survey (NHANES) utilizes urine to evaluate nickel exposures. Environmental, occupational, and population biomonitoring studies have shown hair to be an additional indicator of nickel exposure however, correlations with blood and urine can be inconsistent. For suspected nickel allergy, patch testing remains the diagnostic gold standard.

## TITANIUM

Titanium (Ti) is a naturally occurring transition metal with no known physiological role in humans that is chemically similar to iron. It is widely used in medical and dental implants, food additives, cosmetics, pigments, and industrial applications because of its strength, corrosion resistance, and biocompatibility. Although gastrointestinal absorption is minimal and titanium is generally considered to have low systemic toxicity, certain forms, particularly nanoparticles, are more biologically active and have been associated with oxidative stress, inflammation, and tissue injury following chronic or high-level exposure. Titanium dioxide ($TiO_2$ also known as E171) has been classified as a possible human carcinogen (Group 2B), and its use as a food additive has been banned in the European Union.
**Specimen Type:** Pharmacokinetic modeling, health-based risk assessment, analytical validation, occupational, and implant-related studies support whole blood as a biomonitoring matrix for titanium. Occupational and implant-related studies have shown urinary titanium to increase with exposures. Occupational and implant-related studies have demonstrated that hair titanium can distinguish exposed from unexposed populations.

## ELEVATED TOXIN INDICATOR

Potentially toxic elements vary in relative toxicity, and multiple elevated elements can compound risk even when no single result is extreme. Co-exposure to multiple metals has been shown to produce greater organ damage than any single metal alone, even when each individual level is only moderately elevated, and cumulative multi-metal exposure is independently associated with adverse health outcomes beyond what any one metal's level would predict.
The Elevated Toxin Indicator flags this risk with a simple green/yellow/red status based on how many elements are elevated and how severe those elevations are - rather than combining results into a single composite score. A single high-toxicity element at an extreme level can trigger the highest alert on its own; a cluster of moderate elevations can do the same.Both the Toxic Heavy Metals and the Rare/Low-Frequency Toxic Heavy Metals are included in the Elevated Toxin Indicator status.

# Interpretations Continued

## Essential and Other Elements

**Chromium (Cr)** <DL

Normal Range 0.500 - 0.728 µg/g

**Cobalt (Co)** 0.0800

Normal Range 0.0250 - 0.0733 µg/g

**Copper (Cu)** 100

Normal Range 8.63 - 27.8 µg/g

**Germanium (Ge)** <DL

Normal Range 0.0250 - 0.0281 µg/g

**Iron (Fe)** 5.50

Normal Range 6.08 - 19.2 µg/g

**Rubidium (Rb)** 0.0180

Normal Range 0.0213 - 0.217 µg/g

**Sodium (Na)** 90.0

Normal Range 91.5 - 579 µg/g

## CHROMIUM

Chromium (Cr) is a transition metal that exists primarily as trivalent chromium (Cr III), found in foods such as meats, whole grains, brewer's yeast, and dietary supplements, and hexavalent chromium (Cr VI), an established human carcinogen encountered primarily through occupational exposures including welding, electroplating, painting, and chromate production. Although Cr(III) has historically been proposed to support insulin action and glucose and lipid metabolism, current evidence does not clearly establish chromium as an essential nutrient for humans. Chromium deficiency has been documented primarily in patients receiving long-term chromium-free parenteral nutrition and is associated with impaired glucose tolerance and insulin resistance, whereas excessive Cr(VI) exposure is associated with oxidative stress, respiratory disease, dermatitis, hepatic and renal injury, and an increased risk of lung cancer.
**Specimen Type:** The National Health and Nutrition Examination Survey (NHANES) utilizes urine and blood to monitor chromium. European biomonitoring initiative research indicates that RBC/Erythrocyte chromium can be a biomarker of Cr(VI) exposure. A cross-sectional observational biomonitoring study found chromium to be measurable in hair, but is limited.

## COBALT

Cobalt (Co) is a transition metal whose established biological role in humans is as the central metal component of vitamin $B_{12}$ (cobalamin), which is obtained from animal-derived food sources and supports DNA synthesis, red blood cell production, and neurologic function. Additional cobalt exposure may occur through occupational settings involving hard-metal manufacturing, cobalt alloys, cement production, and metal processing, as well as from cobalt-containing orthopedic implants. Inorganic cobalt deficiency has not been described in humans, whereas vitamin $B_{12}$ deficiency results in megaloblastic anemia, peripheral neuropathy, and cognitive impairment. Excess cobalt exposure may cause allergic dermatitis, asthma, hard-metal lung disease, cardiomyopathy, hypothyroidism, polycythemia, and neurologic or sensory impairment, depending on the route and duration of exposure.
**Specimen Type:** The National Health and Nutrition Examination Survey (NHANES) utilizes both urine and blood to monitor cobalt. Occupational studies have found cobalt measurable in hair, but correlations with internal levels can be inconsistent.

## COPPER

Copper (Cu) is an essential trace element obtained primarily from shellfish, organ meats, nuts, seeds, whole grains, and chocolate. Copper serves as a cofactor for numerous enzymes involved in energy production, iron metabolism, antioxidant defense, connective tissue formation, neurotransmitter synthesis, and immune function. Copper deficiency, most commonly associated with malabsorption, bariatric surgery, prolonged parenteral nutrition, or excess zinc intake, may result in anemia, neutropenia, osteoporosis, and potentially irreversible neurologic dysfunction, whereas excess copper can cause oxidative tissue injury and, in disorders such as Wilson disease, progressive hepatic and neurologic toxicity.
**Specimen Type:** The National Health and Nutrition Examination Survey (NHANES) utilizes serum to evaluate copper. The American Association for the Study of Liver Diseases (AASLD) recommends 24-hour urinary copper for insights into circulating free copper. A human biomonitoring study and an observational study both found copper measurable in hair, however, correlations with blood or serum can be inconsistent.

## GERMANIUM

Germanium (Ge) is a non-essential metalloid that can be found in trace amounts in foods, while substantially greater exposures have primarily resulted from germanium-containing dietary supplements. The antioxidant, immunomodulatory, antiviral, and anticancer effects of organogermanium compounds remains limited to in vitro and animal studies, and no deficiency state has been demonstrated in humans or animals, at this time. Excess germanium is the primary clinical concern, with prolonged supplement use associated with progressive and sometimes

irreversible renal injury, particularly with inorganic germanium. Chronic toxicity may also cause muscle weakness and mitochondrial myopathy, peripheral neuropathy, anemia, and, in severe cases, multisystem organ dysfunction and death.
**Specimen Type:** Comparative, epidemiological, and matrix validation studies have found both urine and hair to be supportive for measuring germanium.

## IRON

Iron (Fe) is an essential trace element obtained from heme sources such as red meat, poultry, and seafood, and non-heme sources including legumes, leafy greens, and fortified grains. Iron is required for oxygen transport, mitochondrial energy production, DNA synthesis, and neurotransmitter synthesis, with absorption and storage tightly regulated to maintain normal iron homeostasis. Iron deficiency is most commonly caused by blood loss, impaired absorption, inadequate intake, or increased physiological demand, and can cause fatigue, impaired cognitive and physical performance, restless legs syndrome, and microcytic anemia. Iron overload, from either hereditary hemochromatosis or repeated blood transfusion, chronic liver disease or excessive intake, can lead to progressive accumulation in the liver, heart, pancreas, and other tissues, resulting in cirrhosis, cardiomyopathy, diabetes, and other organ dysfunction.
**Specimen Type:** The American Academy of Family Physicians (AAFP) and the American Academy of Pediatrics (AAP) both recommend serum ferritin, in conjunction with a Complete Blood Count (CBC), for assessing iron status. Urine is not generally used for evaluating iron status because iron lacks a regulated renal excretory pathway. A biomonitoring study found iron is measurable in hair and may provide insights into long term trends, but correlations with serum were inconsistent.

## RUBIDIUM

Rubidium (Rb) is a naturally occurring, nonessential, ultra-trace alkali metal that is widely distributed in soil, water, plants, and foods, with additional exposure from industrial sources and medical use of radioactive rubidium-82 for cardiac PET imaging. Rubidium closely mimics potassium and is transported by the $Na^+/K^+$-ATPase and potassium channels, which allows it to enter cells and serves as the basis for its use as a potassium tracer and cardiac perfusion imaging agent. Deficiency has not been demonstrated in humans, although experimental studies have investigated potential influences on nitric oxide and NMDA pathways, however it remains unproven clinically.Excessive rubidium may interfere with potassium homeostasis because of its competition with it for cellular uptake and renal handling and may contribute to electrolyte disturbances, including hypokalemia.
**Specimen Type:** Population-based biomonitoring studies, national reference surveys, and analytical validation studies support urine as a biomonitoring matrix for rubidium. Analytical validation and occupational biomonitoring studies show hair rubidium is reliably measurable and varies with rubidium status, however concentrations appear to be influenced by potassium physiology rather than exposure alone, and standardization is limited.

## SODIUM

Sodium (Na) is an essential electrolyte and the principal extracellular cation, obtained primarily from processed, packaged, and restaurant foods (mainly in the U.S.), as well as naturally occurring sources such as vegetables, dairy products, and meat. Sodium maintains extracellular fluid volume, osmotic balance, nerve transmission, muscle contraction, and blood pressure regulation. Unlike most essential elements, serum sodium reflects water balance and extracellular tonicity rather than total body sodium stores due to tight regulation by renal sodium handling and vasopressin-mediated water balance. Sodium deficiency (hyponatremia) most commonly results from impaired water regulation, fluid losses, medications, or hormonal disturbances and may cause weakness, headache, cognitive changes, seizures, and severe neurologic complications. Excess sodium intake is common at the population level and is associated with increased blood pressure and risk of cardiovascular, cerebrovascular, and renal disease.
**Specimen Type:** Clinical guidelines from the American Academy of Family Physicians (AFP) support the use of spot

urine sodium combined with urine osmolality and creatinine for evaluating hyponatremia. Dietary sodium biomonitoring studies and expert consensus statements identify repeated 24-hour urine collections as the preferred method for estimating dietary sodium intake. Physiological and clinical studies demonstrate that serum or plasma sodium primarily reflects fluid balance and extracellular tonicity rather than total body sodium stores. Cross-sectional and laboratory assessment studies have found that hair sodium does not correlate with blood or dietary sodium.

**Disclaimer:** The preferred biomonitoring specimen varies by element; however, blood, serum and urine remain the most extensively validated matrices for assessing exposure to many metals and metalloids, while hair analysis serves as a complementary tool for selected elements and longer-term exposure assessment. Metal results should always be interpreted in the context of clinical history, exposure assessment, and other laboratory findings, and confirmed with validated blood, serum, or urine testing when clinically indicated.

# Metals & Elements
TOXIC + ESSENTIAL

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**Methodology: ICPMS**

This test was developed and its performance characteristics determined by Mosaic Diagnostics Laboratory. It has not been cleared or approved by the US Food and Drug Administration, however, does comply with CLIA regulations for clinical use.

MOSAIC DIAGNOSTICS