

Trace element species and its impact on human health

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Trace element species can influence toxicokinetics and toxicodynamics of elements with resultant human health effects. Speciation of trace elements is influenced by:

1. Carriers (elements of concern: e.g., As, Cr, Mn, Pb) - Examples: Cr(III) is unable to enter cells in contrast to Cr(VI). An anion-exchange carrier takes up Se(IV) into erythrocytes.
2. Valence state and isotope (elements of concern: e.g., As, Cr, Mn, Hg) - Examples: Cr(VI) is better absorbed via oral and dermal route than Cr(III). Sn(II) is better absorbed orally than Sn(IV). U(VI) is better absorbed inhalatively than U(IV). Inhaled Hg(0) is almost completely absorbed pulmonarily, inorganic Hg(I) and Hg(II) are incompletely gastrointestinally absorbed. As(III) is more toxic for the central nervous system (CNS) than As(V).
3. Particle size (elements of concern: e.g., Mn, Ni, Pb, Ti) - Example: Ultrafine particles of Ti dioxide produced greater inflammatory responses in rat lungs than did larger particles.
4. Element ligands (elements of concern: e.g., Al, As, Cr, Ga, Pb, Mn) - Examples: Astrocyte toxicity correlates with Mn-associated ligands in the order $\text{MnCl}_2 > \text{MnSO}_4 > \text{MnPO}_4$. Zn oxide and Zn chloride have potential health risks in workers. Complex halogenated salts of Pt are potent allergens in contrast to tetraammine Pt dichloride alone. The application of Gd-DTPA as contrast substance for magnetic resonance tomography (MRT) induces acute phase reaction in hemodialysis patients. Se compounds, which can generate monomethylated Se, seem to be more efficacious in cancer prevention than other Se compounds.
5. Organic versus inorganic element species (elements of concern: e.g., As, Pb, Hg) - Examples: Organic Hg is almost completely absorbed gastrointestinally in contrast to inorganic Hg(I) and Hg(II). Methyl Hg and Hg(0) enter the brain via blood-brain barrier than do inorganic Hg(I) and Hg(II). As(V) organic metabolites are less toxic than the inorganic forms.
6. Biotransformation (elements of concern: e.g., Al, As, Cr, Pb, Mn, Hg) - Examples: Hg(0) and organic Hg can be converted to inorganic Hg(II) in nearly all organs resulting in a slow redistribution of inorganic Hg(II) out of these organs. Ag precipitates and is then transformed into complexes or elemental metal that accumulates in the skin and produces a blue-gray discoloration.

Human-Biomonitoring ignores often the impact of species on bioavailability and toxicity and is then insufficiently specific for the evaluation of potential hazard and harm of environmental and/or occupational exposures. Because speciation can influence toxicokinetics and toxicodynamics, different exposure standards must be established for different element species. Further research in trace element speciation is needed to improve the measurement of potentially toxic substances and/or their metabolites and/or their human health effects. This can only be performed in cooperation between researchers in metallurgy, pharmacology, physics, toxicology, occupational health, hygiene, environmental medicine, medicine, biology, biochemistry and analytical chemistry. The outcome will clearly improve the evaluation of environmental and/or occupational exposures and the assessment of human health risks.