

Environmental Metallomics : between essential & toxic metals within biological systems

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Abstract

Environmental metallomics explores the complex interactions between essential and toxic metals within biological systems, focusing on their influence on living organisms and ecosystems. It links metal pollution to its effects on public health and the environment by examining metal concentrations, speciation, distribution, and toxicity. However, understanding the transport mechanisms of dissolved metals is crucial for predicting their accumulation and toxicity in living organisms. This knowledge makes it possible to anticipate risks associated with metal contamination and implement effective protection strategies for ecosystems and human health. To this end, this study focuses on the importance of understanding metal transport mechanisms, which will be studied by considering several points: accumulation prediction, environmental contamination management, toxicity assessment, and human health protection. These points will be essential for developing contamination management and public health protection strategies. On the other hand, in the context of monitoring, analyses relating to the detection and quantification of trace metal elements are generally carried out by measuring the "total" element. However, in environmental toxicology, the presence of a metal in "total" form does not reflect its real bioavailability or toxicity, because the latter depends on its oxidation state, its charge and its complexes with other substances. The study of speciation therefore makes it possible to evaluate the assimilation and the real dangers of an element for living beings, rather than its simple presence. In order to understand toxicity, the different forms (species) that a chemical element can take in a system (speciation) must be studied since the chemical form of an element strongly influences its bioavailability, its transport, and its fate in the environment, as well as its effects on health. To further understand the mechanisms of metal transport, the importance of speciation in toxicology will be studied to reveal the chemical form in which a metal exists in a given environment (e.g., soil, water) and which determines its transport, absorption and interaction with living organisms.

Keywords: Environmental metallomics, Speciation in toxicology, biological systems, metal transport mechanisms.

Graphical abstract

Key Aspects of Environmental Metallomics:

Essential vs. Toxic Metals:	Metal Speciation & Distribution:	Bioavailability & Toxicity:	Analytical Techniques:	Metabolic Pathways:	Environmental Applications:	Human Health:
Metallomics distinguishes between metals that are vital for biological functions (like iron or zinc) and those that can be harmful at high concentrations (like lead or mercury).	It investigates the different chemical forms of metals (speciation) and their distribution within cells, tissues, & the environment.	Metallomics helps understand how environmental factors influence the availability of metals for uptake by organisms and how this impacts their toxicity.	It utilizes advanced techniques like mass spectrometry (ICP-MS), chromatography, & spectroscopy to analyze the metal content and speciation in biological samples.	Metallomics also investigates how metals influence metabolic pathways & how these changes can be used as indicators of metal exposure and toxicity.	It has applications in bioleaching, phytoremediation, and understanding the effects of metal pollution on ecosystems.	Metallomics research is also crucial for understanding the role of metals in human health, including their involvement in disease development and potential as biomarkers.
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