# Chapter 2
# Tolerance of Microorganisms to Heavy Metals

**Joan Mwihaki Nyika**
https://orcid.org/0000-0001-8300-6990
*Technical University of Kenya, Kenya*

## ABSTRACT

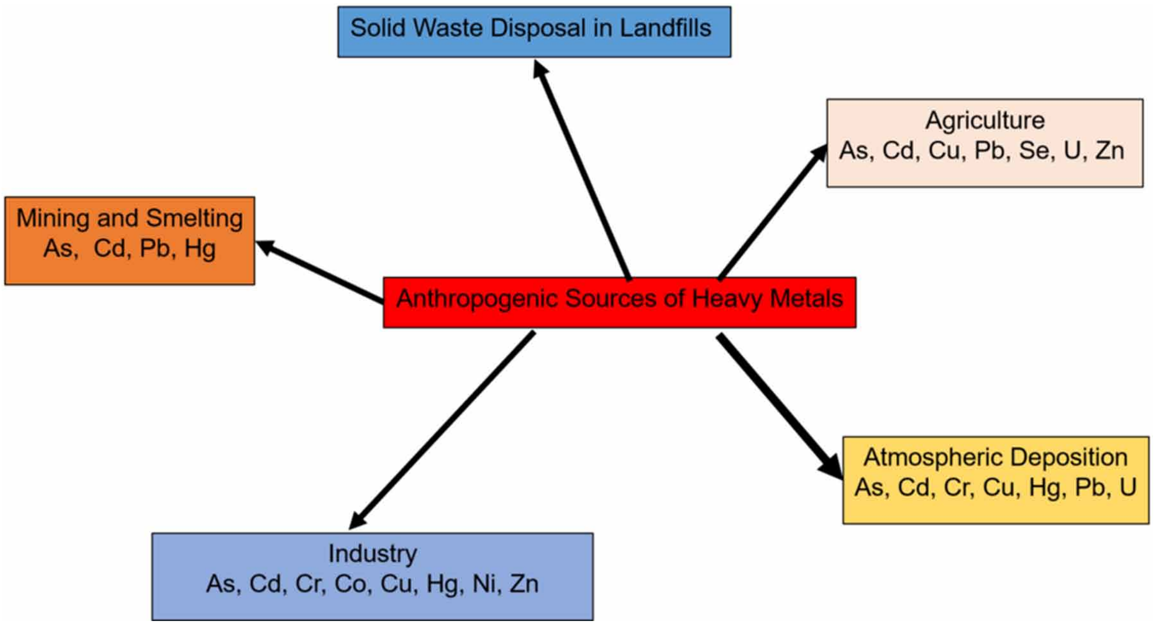
*Heavy metal pollution is a growing environmental concern due to the increase in anthropogenic-based sources. Microorganisms have high adsorptive capacities and surface-area-to-volume ratio that enable the uptake of these contaminants and their conversion to innocuous complexes in the process of bioremediation. This chapter explores the mechanisms and specific microorganisms that are resistant to metal toxicity. A wide range of bacterial, algae, and fungal species used as biosorbents are highlighted. Mechanisms such as reduction of metal cations, their sequestration, and binding on cell barriers are discussed. To optimise the efficacy of microorganisms in bioremediation processes, adoption of genetic and nano-technologies is recommended.*

## INTRODUCTION

Heavy metals are a variety of elements whose distribution in the environment is ubiquitous. Their distinguishing characteristics are a high atomic weight, density and assorted applications in different areas. Many heavy metals occur naturally in the earth's crust and have essential functions in living organisms. For instance, copper (Cu) is a cofactor in many metabolic reactions and proteins containing this metal enhance iron transport, free radical protection and respiration in living organisms (Singh, Parihar, Singh, Singh & Prasad, 2015). Other metals such as sodium (Na), nickel (Ni), zinc (Zn), manganese (Mn), magnesium (Mg), iron (Fe) and potassium (K) are essential minerals required for growth and functioning of plants and animals. These heavy metals are only required in trace concentrations. Other heavy metals such as cadmium (Cd) and mercury (Hg) do not have biological roles and are harmful even in minute concentrations. The heavy metals however can occur in excess levels in the environment because of anthropogenic activities as illustrated in Figure 1. In such a case, they induce harmful effects to plants, animals, humans and the ecosystems. Heavy metal pollution of the environment through human activi-

DOI: 10.4018/978-1-7998-4888-2.ch002

*Figure 1. Anthropogenic sources of named heavy metals*




ties is an ecological concern worldwide because metals persist and bio-accumulate in the environment causing disruptions in food chains and ecosystems (De Silva et al. 2012). Additionally, heavy metals do not decompose and cannot be degraded. Once in food chains, they enter in human and animal tissues, which increases the vulnerability of these organisms to diseases and gene transformations/mutations, which are carcinogenic in the long term.

The focus of this book chapter is heavy metal toxicity on microorganisms and approached to bioremediation. Some of the toxic effects of heavy metals on microorganisms documented in literature are summarised in Table 1. To alleviate this pollution problem, a number of biotechnological advances including geno-remediation, cyano-remediation, myco-remediation, rhizo-remediation, bio-stimulation, hyper-accumulation, phyto-stabilization, bio-sorption and bio-mineralization among others have been applied to remove heavy metals from the environment (Samantaray et al., 2014). The toxicity and ubiquitous nature of heavy metals has forced organisms to adapt to their presence. This is a natural process where microbes develop recycling and degradation potential to accumulated heavy metal contaminant resulting to the decrease of their toxicity. Singh et al. (2015) for instance, reported that plants are developing tolerance to heavy metals. Yang, Agouri, Tyrrell and Walsh (2018) associated *enterobacteriaceae* species to heavy metal resistance genes in humans. These bioremediation measures are growing to be effective and economic strategies to detoxify and accumulate metals in microorganisms so that they are no longer harmful to the environment. Apart from intrinsic bioremediation, some chemicals can be added to stimulate microbial bioavailability in the process of bio-stimulation.

Consequently, these microorganisms have developed mechanisms to immobilize and sequester these contaminants. Bacterial that can survive in high levels of heavy metals have been assayed in different sources including tannery effluents, coal mining areas, coastal waters, silver mines, pristine freshwater and sewage (De Silva et al. 2012). This tolerance of microorganisms to heavy metals depends on the availability and concentration of these elements and is influenced by many processes and factors in-

## Related Content

A Brief History of Prosthetics and Orthotics of the Lower Body and Their Types
Dheeman Bhuyanand Kaushik Kumar (2019). *Design, Development, and Optimization of Bio-Mechatronic Engineering Products (pp. 36-56).*
www.irma-international.org/chapter/a-brief-history-of-prosthetics-and-orthotics-of-the-lower-body-and-their-types/223405

Neuroprostheses as an Element of an Eclectic Approach to Intervention in Neurorehabilitation
Emilia Mikoajewska (2014). *Emerging Theory and Practice in Neuroprosthetics (pp. 101-115).*
www.irma-international.org/chapter/neuroprostheses-as-an-element-of-an-eclectic-approach-to-intervention-in-neurorehabilitation/109885

Biosynthesis of Silver Nanoparticles for Study of Their Antimicrobial Effect on Plasma-Treated Textiles: Silver Coating of Plasma-Treated Cotton Fabric
Shazia Shukrullah, Muhammad Anwar, Muhammad Yasin Nazand Inzamam Ul Haq (2022). *Emerging Developments and Applications of Low Temperature Plasma (pp. 149-166).*
www.irma-international.org/chapter/biosynthesis-of-silver-nanoparticles-for-study-of-their-antimicrobial-effect-on-plasma-treated-textiles/294715

Environmental Fluoride: Impact on Humans, Animals and Its Remediation Strategies
Junaid Ahmad Malik (2021). *Recent Advancements in Bioremediation of Metal Contaminants (pp. 165-188).*
www.irma-international.org/chapter/environmental-fluoride/259571

Open Access Journal in Bioinformatics: A Study
Rekha Pareekand Sudhir Kumar (2019). *Biotechnology: Concepts, Methodologies, Tools, and Applications (pp. 1531-1540).*
www.irma-international.org/chapter/open-access-journal-in-bioinformatics/228682