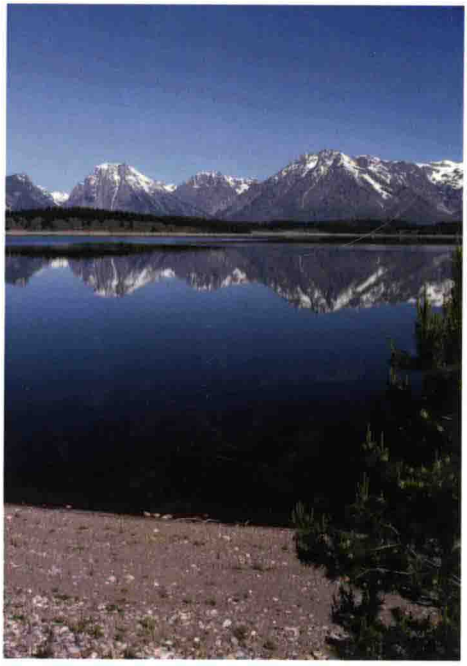
HEAVY METAL CONTAMINATION OF WATER AND SOIL

Analysis, Assessment, and Remediation Strategies



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Elham Asrari, PhD

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HEAVY METAL CONTAMINATION OF WATER AND SOIL

Analysis, Assessment, and Remediation Strategies

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Dr. Elham Asrari is an assistant professor in the Civil Engineering Department at Payame Noor University, Iran. She is a researcher and author, having published numerous peer-reviewed articles in the fields of air pollution, water and wastewater pollution. She received her MSc in Civil and Environmental Engineering from Mazandran University, Iran, and her PhD in Environmental Sciences from Pune University, India.

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The chapters in this book were previously published in various places and in various formats. By bringing them together here in one place, we offer the reader a comprehensive perspective on recent investigations into heavy metal contamination of water and soil. Each chapter is added to and enriched by being placed within the context of the larger investigative landscape. Specifically:

- Chapter 1 explains how remediation of heavy metal contaminated soils is necessary to make the land resource available for agricultural production, enhance food security, and scale down land tenure problems arising from changes in the land use pattern.
- Chapter 2 considers the leaching behavior and transformation of heavy metals when influenced by acid rain.
- Chapter 3 studies the relationship between landscape influence and trace metal concentrations in animals and in soils
- Chapter 4 provides basic information on the accumulation and transportation of studied pollutants to environmental conservation.
- Chapter 5 discusses the importance of human health risk assessment as a tool for estimating the nature and probability of adverse health effects in humans: one that can be used towards sustainability development
- Chapter 6 focuses on one of the most important subjects discussed in this book: the presence of metal pollution in coastal sediment. Heavy metal contaminations in sediment could affect the water quality; quantifying and explaining the spatial distribution of heavy metal contaminants can help control sediment chemistry and identify the potential ecological risks of heavy metals.
- Chapter 7 discusses the use of metallothionein (MT), a low molecular mass protein, as a tool for the assessment of heavy metal environmental pollution.
- Chapter 8 details several studies that monitor heavy metals in groundwater, studies that are important for their implications on public health.
- Chapter 9 argues for the adoption of an effective effluent management strategy, one that moves towards control over enhanced metal levels with recycling of effluents for toxic metal separation and soil remediation and reclamation.
- Chapter 10 considers phytoremediation as a cost effective and environmentally friendly technology for the remediation of heavy metals.

- Chapter 11 also focuses on phytoremediation: the study establishes an optimal time frame for harvesting Sesbaniaexaltata after chelate amendment, thereby limiting the likelihood of exposure of heavy metals to grazing animals.
- Chapter 12 investigates the biosorption of heavy metals, which is considered a practical method of wastewater bioremediation.
- Chapter 13 summarizes the use of bioremediation to remove mercury from polluted areas.

We wish to thank the authors who made their research available for this book, whether by granting permission individually or by releasing their research as open source articles. When citing information contained within this book, please do the authors the courtesy of attributing them by name, referring back to their original articles, using the credits provided at the beginning of each chapter.

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INTRODUCTION

Heavy metals have been used by humans for thousands of years. Although adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues and is even increasing in some areas. The adequate protection and restoration of soil and water ecosystems contaminated by heavy metals require their characterization and remediation. Remediating heavy metal contaminated soils and water is necessary to reduce the associated health and ecological risks, make the land resource available for agricultural production, enhance food security and scale down land tenure problems. The chapters in this book discuss both the causes and the environmental impact of heavy metal contamination; the articles highlighted also discuss many exciting new methods of analysis and decontamination currently studied and applied in the field today.

Chapter 1 provides an overall introduction to the scholarship on heacy metals; Wuana and Okieimen compile the scattered literature to critically review the possible sources, chemistry, potential biohazards and best available remedial strategies for a number of heavy metals (lead, chromium, arsenic, zinc, cadmium, copper, mercury and nickel) commonly found in contaminated soils. The principles, advantages and disadvantages of immobilization, soil washing and phytoremediation techniques which are frequently listed among the best demonstrated available technologies for cleaning up heavy metal contaminated sites are presented. Remediation of heavy metal contaminated soils is necessary to reduce the associated risks, make the land resource available for agricultural production, enhance food security and scale down land tenure problems arising from changes in the land use pattern.

Chapter 2 focuses on the heavy metals that leach from contaminated soils under acid rain. In this study by Zheng and colleagues, simulated acid rain (SAR) was pumped through columns of artificially contaminated purple soil. Column leaching tests and sequential extraction were conducted for the heavy metals Cu, Pb, Cd, and Zn to determine the extent of their

leaching as well as to examine the transformation of their speciation in the artificially contaminated soil columns. Results showed that the maximum leachate concentrations of Cu, Pb, Cd, and Zn were less than those specified in the Chinese Quality Standards for Groundwater (Grade IV), thereby suggesting that the heavy metals that leached from the polluted purple soil receiving acid rain may not pose as risks to water quality. Most of the Pb and Cd leachate concentrations were below their detection limits. By contrast, higher Cu and Zn leachate concentrations were found because they were released by the soil in larger amounts as compared with those of Pb and Cd. The differences in the Cu and Zn leachate concentrations between the controls (SAR at pH 5.6) and the treatments (SAR at pH 3.0 and 4.5) were significant. Similar trends were observed in the total leached amounts of Cu and Zn. The proportions of Cu, Pb, Cd, and Zn in the EXC and OX fractions were generally increased after the leaching experiment at three pH levels, whereas those of the RES, OM, and CAR fractions were slightly decreased. Acid rain favors the leaching of heavy metals from the contaminated purple soil and makes the heavy metal fractions become more labile. Moreover, a pH decrease from 5.6 to 3.0 significantly enhanced such effects.

Fritsch and colleagues discuss the field of "landscape ecotoxicology" in chapter 3. Concepts and developments for a new field in ecotoxicology, referred to as “landscape ecotoxicology,” were proposed in the 1990s; however, to date, few studies have been developed in this emergent field. In fact, there is a strong interest in developing this area, both for renewing the concepts and tools used in ecotoxicology as well as for responding to practical issues, such as risk assessment. The aim of this study was to investigate the spatial heterogeneity of metal bioaccumulation in animals in order to identify the role of spatially explicit factors, such as landscape as well as total and extractable metal concentrations in soils. Over a smelter-impacted area, the authors studied the accumulation of trace metals (TMs: Cd, Pb and Zn) in invertebrates (the grove snail *Cepaea sp* and the glass snail *Oxychilus draparnaudi)* and vertebrates (the bank vole *Myodes glareolus* and the greater white-toothed shrew *Crocidura russula*). Total and $CaCl_2$-extractable concentrations of TMs were measured in soils from woody patches where the animals were captured. TM concentrations in animals exhibited a high spatial heterogeneity. They increased with soil