Radionuclides and Heavy Metals in the Environment

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Lead in Plants and the Environment

Springer

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Preface

Lead (Pb) is a metal utilized by humans for many thousands of years. Metallic Pb globules manufactured in 6400 BC were discovered at Çatalhöyük (presently in Republic of Turkey). Pb is a bluish-white lustrous metal, which is very soft, highly malleable, and ductile, and is a relatively poor electric conductor. Metal is resistant to corrosion but tarnishes upon exposure to air. In nature, it is typically found as minerals, in combination with other elements.

A total of 49 isotopes of Pb were recorded till date with four stable isotopes (^{204,206,207,208}Pb). Among the stable isotopes, only ^{204}Pb is a primordial nuclide, and not a radiogenic one. The three other stable isotopes, ^{206,207,208}Pb, are the endpoints of three decay chains, i.e., uranium, actinium, and thorium series, respectively. ^{205}Pb and ^{202}Pb are the longest-lived radioisotopes with a half-life of approximately 15.3 million years and 53,000 years, respectively. The radiologically most relevant radioactive nuclide ^{210}Pb is part of the ^{238}U series and has a half-life of 22.3 years. ^{210}Pb is suitable for studying the chronology of sedimentation on time scales shorter than 100 years. Anthropogenic activities, like combustion of coal, are one of the major sources of ^{210}Pb in the atmosphere, but ^{210}Pb also occurs naturally since it is a progeny of the radioactive noble gas radon (^{222}Rn) emanating from soil air due to the omnipresent uranium.

Pb is a microelement with no known physiological function but found in trace amounts in all biotic resources, e.g., in soil, water, plants, and animals. Pb is a toxic element, pollution of which may come from various sources. In the environment, nearly 98% of stable Pb originates from paints, petrochemicals, pipes and supply systems, etc. Routes of Pb poisoning may be through consumption of contaminated food and water, breathing contaminated air from cigars and automobile exhausts, and using uncleaned adulterated hands/face where individual health and hygiene issues are compromised. However, usually, Pb is not absorbed through skin.

Recent extensive work on ^{210}Pb radioisotope for examining plant uptake, where, mostly, artificial spiking of the metal in the soil and observing its consequent absorption in plant and soils. Usually, Pb forms complexes with soil particles, and a very small amount or fractions are easily available for plants. Despite its lack of essential function in plants, Pb is taken up mostly through the roots from soil solutions at rhizosphere level, which may cause the entry of Pb into the food chain. It is also reported that uptake of Pb by roots occurs mainly through apoplastic pathway or via Ca^{2+} absorbent channels. Pb in soil and its uptake by plants depends on several factors, like soil pH, soil particle size, soil moisture, cation-exchange capacity, presence of other (in)organic substances (including humus), root structure and rhizosphere, root exudates, and root mycorrhizal properties. Once Pb enters into the plants through root, initially, it is getting deposited at root cells. However, reports also suggest that negatively charged root cell walls adsorb Pb. Accumulation of Pb in plants renders phytotoxic symptoms, disturbing morphological, physiological, and biochemical functions, like inhibition of ATP production, lipid peroxidation, and DNA damage by overproduction of reactive oxygen species (ROS). However, monitoring Pb remobilization and related secondary pollution and effective, environment-friendly remediation measures to reduce Pb pollution is the need of the hour.

The main features of this volume are interrelated to how Pb enters into the environment and its translocation from soil to plants and into the food chain. Chapters 1 and 2 deal with the analytical methods for determining Pb both in environmental and in biological samples and also the effect of radioisotopic lead behavior in plants and environment and distribution of radioactive Pb and its distribution in environment through modelling application. Chapters 3 and 4 focus on Pb exposure to humans via agroecosystem and its consequences. Chapters 5 and 6 focus on how Pb behaves in soil plant system and how it uptakes in plants. Chapters 7 and 8 emphasize on how Pb reacts on physiological and biochemical changes in plants with reference to different plant enzymes and photosynthetic apparatus. Last but not least, Chaps. 9 and 10 present the biological strategies of lichens symbionts, under Pb toxicity, and how Pb pollution is going to remediate via phytoremediation. The material composed in this volume will bring in-depth holistic information on Pb (both stable and radioactive) uptake and translocation and its toxicity in plants and effect on human health and phytoremediation strategies.

Drs. Dharmendra K. Gupta, Soumya Chatterjee, and Prof. Clemens Walther individually acknowledge all authors for contributing their valuable time, information, and interest to bring this book into its current form.

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