Chapter 15

SOURCES OF HEAVY METAL CONTAMINATION IN SOIL

Dr. Deepa K

Assistant Professor, PG Department of Chemistry, KAHM Unity Women's College, Manjeri, Kerala-676122, India
E-mail: deepakarat08@gmail.com

INTRODUCTION

Soils are the major sink for heavy metals released into the environment due to anthropogenic activities and unlike organic contaminants which are oxidized to carbon (IV) oxide by microbial action, most metals will not undergo microbial or chemical degradation. Heavy metals constitute a group of inorganic chemical hazards, and those most commonly found at contaminated sites are lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni), and they persist in soil for a long time [1]. Biodegradation of organic contaminants in soil will be severely inhibited by the presence of toxic metals [2]. Heavy metal contamination of soil cancause risks and hazards to humans and the ecosystem by: direct ingestion or contact with contaminated soil, the food chain (soil-plant-human or soil-plant-animalhuman), drinking of contaminated ground water, reduction in food qualityvia phytotoxicity, reduction in land usability for agricultural production causing food insecurity, and land tenure problems.Soils may become contaminated by the accumulation of heavy metals and metalloids from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and air borne particulate matter.

Heavy metals occur naturally in the soil from the processes of weathering of parent materials at levels that are regarded as trace. Because of the disturbance and acceleration of nature's slowly occurring geochemical cycle of metals by man, most soils of rural and urban environments have been accumulated by one or more of the heavy metals in concentrations high enough to cause risks to human health, plants, animals, ecosystems, or other media [3]. A wide variety of anthropogenic sources of Metal-bearing solids in contaminated soils have been discussed hereunder.

FERTILIZERS

Agriculture was the first major human influence on the soil. To grow and complete the lifecycle, plants require not only macronutrients (N, P, K, S, Ca, and Mg), but also essential micronutrients. In some soils there will be deficiency in the heavy metals (such as Co, Cu, Fe, Mn, Mo, Ni, and Zn) that are essential for healthy plant growth [4], and crops have been supplied with these as an addition to the soil or as a foliar spray.to provide adequate N, P, and K for crop growthlarge quantities of fertilizers are regularly added to soils in intensive farming systems. The compounds used to supply these contain trace amounts of heavy metals (e.g., Cd and Pb) as impurities, which, on continued fertilizer application can significantly increase their content in the soil. Cd and other potentially toxic elements including F, Hg, and Pb add to soil by application of certain phosphatic fertilizers.

ISBN 978-93-5457-774-1

PESTICIDES

Substantial concentrations of metals were found to be present inseveral common pesticides that are used fairly extensively in agriculture and horticulture in the past.Pesticides such as Bordeaux mixture (copper sulphate) and copper oxychloride are examples. Lead arsenate has been used in fruit orchards for many years to control some parasitic insects. Such contamination has the potential to cause problems, particularly when the sites are redeveloped for other agricultural or nonagricultural purposes. Compared with fertilizers, the use of pestisides has been more localized, being restricted to particular sites or crops [4].

BIOSOLIDS AND MANURES

The use of numerous biosolids (e.g., livestock manures, composts, and municipal sewage sludge) to land inadvertently leads to the accumulation of heavy metals such as As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Mo, Zn, Tl, Sb etc. in the soil [5]. Although most manure are seen as valuable fertilizers, in the pig and poultry industry, the Cu and Zn added to diets as growth promoters and As contained in poultry health products also have the potential to cause metal contamination of the soil. When repeatedly applied to restricted areas of land, the manures produced from animals on such diets contain high concentrations of As, Cu, and Zn can cause considerable buildup of these metals in the soil. Biosolids (sewage sludge) are primarily organic solid products, produced by wastewater treatment plants that can be beneficially recycled [6]. Land application of biosolids materials is a common practice in many countries that allow the reuse of biosolids produced by urban populations. There is considerable interest in the use of composting biosolids with other organic materials such as sawdust, straw, or garden waste. If this continues, there will be implications for metal contamination of soils. The potential of biosolids incausing heavy metal contamination of soil has great concern about their application in agricultural practices. Common heavy metals found in biosolids are Pb, Ni, Cd, Cr, Cu, and Zn, and the metal concentrations are governed by the nature and the intensity of the industrial activity, as well as the type of process employed during the biosolids treatment.

WASTE WATER

The metal concentrations in wastewater effluents are usually relatively low but long-term irrigation of land with such can eventually result in heavy metal accumulation in the soil.The application of municipal and industrial wastewater and related effluents to agriculture land dates back 400 years and now is a common practice in many parts of the world [7]. Farmers were not bothered about environmental benefits or hazards and are primarily interested in maximizing their yields and profits.

METAL MINING, MILLING PROCESSES AND INDUSTRIAL WASTES

Mining and milling of metal ores coupled with industries in many countries responsible for the legacy of wide distribution of metal contaminants in soil. During mining, tailings (heavier and larger particles settled at the bottom of the flotation cell during mining) are directly discharged into natural depressions, including onsite wetlands resulting in higher concentrations of heavy metals [8]. Extensive Pb and zinc Zn ore mining and smelting have been resulted in contamination of soil that poses risk to human and ecological health. Soil heavy metal environmental risk to humans is generally related to bioavailability. Assimilation of heavy metal pathways include the ingestion of plant material grown in (food chain), or the direct ingestion (oral bioavailability) of, contaminated soil. Heavy metals are generated by a variety of industries such as textile, tanning, petrochemicals from accidental oil spills or

ISBN 978-93-5457-774-1

utilization of petroleum-based products, pesticides, and pharmaceutical facilities and are highly variable in composition.

AIR-BORNE SOURCES

The airborne sources of metals include stack or duct emissions of air, gas, or vapor streams, and fugitive emissions such as dust from storage areas or waste piles. Metals such as As, Cd, and Pb can also volatilize during high-temperature processing. These metals will be converted to oxides and condense as fine particulates unless a reducing atmosphere is maintained [9]. All solid particles in smoke from fires and in other emissions from factory chimneys are eventually deposited on land or sea and most forms of fossil fuels contain some heavy metals.This is, therefore, a form of contamination which has been continuing on a large scale since the industrial revolution began.

SOLID WASTE

Environmental contamination of soil by heavy metals due to solid waste mismanagement is a global issue. Open dumping and open burning are the main implemented waste treatment and final disposal systems, mainly adopted in low-income countries. Uncontrolled disposal will lead to serious heavy metals pollution occurring in the water, soil, and plants [10]. As a result of poor solid waste management, most of developing countries were becoming a dumping ground for electronic and other hazardous wastes containing lead, cadmium, mercury, cobalt, arsenic etc.

TRAFFIC

Recent years witnessed intensification of road traffic and, with it, the quantity of substances emitted by vehicles. Such emissions need to be monitored for public health purposes. The contribution of cars and road transports to the global emission of atmospheric pollutants is highly increasing. The vehicle's fuel considered as the main source of heavy metals pollution [11]. These metals are found in vehicle's fuel, catalytic converters, fuel tanks, tires and brake pads, engines and other vehicle components, as well as in road surface materials. Heavy metals are released in the form of air particulates in urban atmosphere as liquid or solid particles. The emitted particulates in urban are rich in potentially toxic heavy metals such as lead, cadmium, nickel, chromium and zinc which can be a genuine health hazard. Pollution with heavy metal have a fallout. Soil considers the primary recipient of these pollutants as they enter the plants and then the food chain large impact on the environment as road transports contaminate the atmosphere, water and soil near the highways.

CONCLUSION

Soil pollution with heavy metals draws a serious concern because of their detrimental effects on the living biota. The persistent and non-biodegradable nature of heavy metals eases their accumulation in the environment. Due to the increasing awareness among the public and the detrimental effects of these contaminants on human health, scientific communities are focusing on development of some new technologies for removal of these metals from contaminated soils.

REFERENCES

1. T. A. Kirpichtchikova, A. Manceau, L. Spadini, F. Panfili, M. A. Marcus, and T. Jacquet, **2006**. “Speciation and solubility of heavy metals in contaminated soil using X-ray microfluorescence, EXAFS spectroscopy, chemical extraction, and thermodynamic modeling*,” Geochimica et Cosmochimica* Acta, 70(9), 2163–2190.

ISBN 978-93-5457-774-1

2. S. Khan, Q. Cao, Y. M. Zheng, Y. Z. Huang, and Y. G. Zhu, **2008**, "Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China," *Environmental Pollution*, 152(3), 686–692.
3. J. D'Amore, S. R. Al-Abed, K. G. Scheckel, and J. A. Ryan, **2005**, "Methods for speciation of metals in soils: a review*," Journal of Environmental Quality*, 34, (5), 1707–1745.
4. M.M. Lasat, **2000**, "Phytoextraction of metals from contaminated soil: a review of plant/soil/metal interaction and assessment of pertinent agronomic issues," *Journal of Hazardous Substances Research*, 2, 1–25.
5. N. T. Basta, J. A. Ryan, and R. L. Chaney, **2005**, "Trace element chemistry in residual-treated soil: key concepts and metal bioavailability," *Journal of Environmental Quality*, 34(1), 49–63.
6. USEPA, "A plain english guide to the EPA part 503 biosolids rule," USEPA Rep. 832/R-93/003, USEPA, Washington, DC, USA, **1994**.
7. S. C. Reed, R. W. Crites, and E. J. Middlebrooks, *Natural Systems for Waste Management and Treatment*, McGraw-Hill, New York, NY, USA, 2nd edition, **1995**.
8. P. S. DeVolder, S. L. Brown, D. Hesterberg, and K. Pandya, **2003**,"Metal bioavailability and speciation in a wetland tailings repository amended with biosolids compost, wood ash, and sulfate," *Journal of Environmental Quality*, 32(3), 851–864.
9. L. A. Smith, J. L. Means, A. Chen et al., *Remedial Options for Metals-Contaminated Sites*, Lewis Publishers, Boca Raton, Fla, USA, **1995**.
10. Vongdala, N.; Tran, H.D.; Xuan, T.D.; Teschke, R.; Khanh, T.D. **2019**, Heavy metal accumulation in water, soil, and plants of municipal solid waste landfill in Vientiane, Laos. *Int. J. Environ. Res. Public Health*, 16, 22.
11. A. Athanasopoulou and G. Kollaros, **2016**, "Heavy Metal Contamination of Soil Due to Road Traffic" *American Journal of Engineering Research*, 5(12), 354-363.

ISBN 978-93-5457-774-1