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Assessment of Heavy Metal Contamination in Soil: A Review

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Abstract: Metal contamination in soil is a major problem growing rapidly now-a-days due to industrialization and human activities such as mining, smelting and electroplating. Metals above their permissible limit are dangerous due to high toxicity as they affect human and animal health. The high amount of these metals in soil is unacceptable for the cultivation of crops due to the risk of bioaccumulation and biomagnifications in the food chain. Thus, indirectly affect human health. Furthermore, decreased soil microorganism activity is also due to the presence of high amount of metal in soil as a result soil quality decreased. Thus, presence of high amount of metal in soil is one of the major environmental factors which influences many aspects of human life. Therefore, in light of above this study is an attempt to assessing the heavy metaleffects in soiland its consequences.

Keywords: Contamination, Metal toxicity, Soil quality, Human health risk etc.

INTRODUCTION

Metal contamination in soil is of great concernsince it is the key factor for the sustainable agricultural productivity and alsoaffect the human and animal health (Bisht et al., 2022). Soil contamination is growing rapidly now-a-days. Contamination may be natural and manmade.

Natural contaminants are added into soil by volcanic activity or eruption, decay of parent soilmaterial (Dias and Edwards, 2003) and forest fire emissions (Andreae and Merlet, 2001; Karl et al., 2007). On the other hand, rapid industrialization and human activities like mining, smelting and electroplating resulted in the contamination of soil with toxic metals. Cadmium (Cd), lead (Pb),arsenic (As), chromium (Cr), zinc (Zn), copper (Cu) and mercury (Hg) are among the most occurring metals in the contaminated soils and are also responsible for the reduction in crop yield and risk of bioaccumulation and biomagnifications in the food chain. Thus, for understanding the bioavailability and remedial options of these metals, we should know very well the health risk associated by these metals. In the light of above this review,focused the sourcesof heavy metals and its consequences on soil,plant and human health.

Sources of heavy metalsin soil

(a) Fertilizer: Fertilization is one of theimportant sources for increasing nutrients availability and maintained the quality of agricultural fields (Savci, 2012). Excessive amounts of fertilizers in the agricultural fields are harmful since most of the fertilizers contain metals and high concentration of radio nuclides which have adverse impact on the environment and human health (Sonmezet al., 2006; Savci, 2012).Besides this,excessive use of fertilizers results in nutrients loss, soil acidification and basification and reduction in useful microbial population (Chen, 2006).

(b) Pesticides: Pesticides are the chemicals that are used in agricultural fields or protecting humans from many diseases. Due to the excessive use of pesticides in the agricultural fields, many useful microorganisms killed. Keeping this in mind, in U.S.A and England, DDT and many other organic chlorinated compounds which are used as a pesticide are banned (Apitz**,** 2008; Provoostet al., 2006).

(c) Bio-solids and manure: Bio-solids also known as sewage sludge, or nutrients rich organic matters (Kumar et al.,2017) and when applied to the agricultural lands, improves productivity and reduces the use of inorganic fertilizers(Kumar et al., 2013). Besides this, bio-solids, also contain toxic metals and thus, can enhance metals content in the soil which directly or indirectly affects the human health (Ghazy et al., 2009).

(d) Waste water: Waste water irrigation is the key source of the toxic metals in the agricultural fields (Mapandaet al., 2005). As metals accumulated in the soil and food crops, indirectly affect human health (Haroon et al., 2019).

(e) Metal mining and industrial waste products: Mining and industrial waste products affect our environment specially soil system (Razo et al., 2004; Weissenstein and Sinkala, 2011).Hence affect the living organism.

Impact of heavy metals on soil health

Excessive amount of metal in soil decreases organic matter decomposition, soil nutrients and enzymatic activity (Schaller and Diez, 1991).Metals when present in excess amount in the soil interferes the metabolism process of microorganism. As a result, it creates the abiotic stress in soil microorganism (Quan et al., 2010).Soil microbes participate in soil biochemical process which is very important for maintaining good soil quality and structure, soil organic matter and decomposition of harmful substances. Thus, excessive amount of metal affects the soil microbial activity which in turn is responsible for soil quality (Chu, 2018).

Impact of heavy metals onplants

Zinc within permissible limit is an important metal required for the functioning of a large number of enzymes involved in the growth and reproduction of both plants and animals. It also participatesfor the synthesis and functioning of chlorophyll, involved in the plant hormone system and as a catalyst for the plant growth regulator, auxin.Zinc toxicity in plants inhibits the growth of roots and shoots (Choi et al.,1996; Fontes and Cox, 1998) and also causes the chlorosis in younger leaves (Ebbs and Kochian,1997).Similarly, copper is a very important for the growth of the plants as it activates some enzymes in plants which are involved in lignin synthesis and is involved in several enzyme systems required in photosynthesis. It is also required in the process of plant respiration and assists carbohydrates and proteins in plant metabolism. Copper also serves to intensify flavour and colour in vegetables and colour in flowers.Excess amount of copper causes injury in plants and reduces the growth and leaf chlorosis (Lewis et al., 2001). It also induces oxidative stress in plants which causes disturbance in metabolic pathways and damages the macromolecules (Hedeguset al., 2001).Manganese is an essential for the growth of both plants and

animals. It is necessary for photosynthesis, including the building of chloroplast. In plants, it enhances root growth, disease resistance, the development of fruits and assimilation of nitrate. It is involved in the activation of many enzymes involved in photosynthesis and respiration. In animals, manganese is essential for growth, reproduction, skeletal growth and carbohydrate metabolism.Manganese toxicity creates chlorosis in plants and leave distortion. It also slows the growth rate of the plants(Blamey et al., 2015). Chromium toxicity effect growth and biomass of the plant. It also effects the seed germination process, oxidative imbalance and metabolic process (Kumar et al., 2016. Similarly, lipid peroxidation,inhibition of ATPproduction, and DNA damage by over production of ROS affect by lead toxicity(Pourrut et al., 2011). Carbon fixation and decrease photosynthetic activity in plants was observed by cadmium toxicity (Haider et al., 2021).

Impact of toxic metals on human health

Copper is an essential for many metabolic processes (Scheiberet al.,2013). It also participates in many enzymatic activity and copper dependent enzymes play an important role in bone and skin health (Eaton-Evans et al., 1996). Copper participates in cellular respiration, free radical defense, neurotransmitter and tissue biosynthesis process. It is also needed for proper development of antibodies, white blood cell and antioxidant enzyme production (Sharmaet al., 2005). In human, copper deficiency causes anemia, neuropenia, cholesterol metabolism, bone disorder, abnormal growth of hair and heart failure (Soetanet al., 2010). Copper toxicity affects the liver and brain of the human and it is the main cause of Wilson disease (Nazir et al.,2015).

Zinc is one of the biologically important micronutrients and is essential for cell growth, development, tissue growth, cell division and DNA synthesis (Chasapiset al., 2011). It regulates enzyme activity and stability of the protein as an activator or inhibitor ion and also plays a significant role in protecting from oxidative damage (Mocchhegiani et al., 2000; Tapiero andTew, 2003).Zinc deficiency causes reduced immune function, weight loss and growth retardation (Prasad, 2002). In human, zinc toxicity causes liver damage, nausea, vomiting and diarrhea, disturbance of copper mechanism, reduced iron function and cardiac function (Poreaet al., 2000).Cd is one of the toxic elements and considered as a by-product of zinc, it directly affects the kidney and bones. Further it affects the lung function and responsible for lung cancer.Bernard

(2008). Lead toxicity create rise in blood pressure, kidney and brain damage (Tewari et al., 2013).Mercury toxicity affect the human nervous system and kidney (Verma et al., 2018)

Remediation of heavy metal contamination in soil

Phytoremediation is one of the most suitable approaches for clean-up the metal contaminated soil. It makes by twowordsphyto + remediation, phyto means plants and remediation means clean up the evil. Thus, this method uses plants for clean-up the contamination to improve the quality of the environment (USEPA, 2010).This plant based green approach conducted by the following steps.

(a) Phytostabilisation process: Root plants diffused to stabilize, demobilize and bind the contaminants in the soil matrix; hence, reducing the bioavailability. In this process, the contaminant remains in soil. In this process, plant species are used to immobilize the contaminants in the soil and ground water through absorption (Erakhrumen and Agbontalor,2007).

(b) Phytodegradation Process: In this process, the contaminants are taken up by the roots and converted into less toxic substance within the rhizosphere through biodegradation by microbial activity (Ensley, 2000). By adding the microbes in the contaminated soil, we can enhance phytodegradation process.

(c) Phytoextraction process: This process is used for metal, metalloids, non-metals, radio-nuclides and organic contaminants in the soil and sludge medium. In phytoextraction process, the plant roots are the mediators for the uptake and translocation of the contaminants from root to shoot. Some plants are termed as hyper-accumulators having shoot to root ratio greater than one while in contrast, the other are termed as non-accumulators having shoot to ratio less than one (Ibeanusi, 2004; Erdeiet al., 2005).

(d) Phyto-voltization process: This process is used for metal contaminated groundwater sediments, soil and sludge medium. It is the measurement of plants ability to absorb the contaminants and convert them into gaseous state inside the plants and transform into volatile forms in the environment (Prasad and Freitas, 2003).

Conclusion

This review highlighted the toxic effect of heavy metals on the ecosystem components.Remediation of contaminated soil by heavy metal is mandatory so that the risk in terms of human health can be reduce and the agricultural land can be used for enhanced food security and other purposes.

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Declaration

The authors declare that it is the original work and this review research paper has not been previously published and not is currently under consideration by another journal.

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