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HEAVY METALS IN VARIOUS COMPONENTS OF THE ENVIRONMENT – A REVIEW

MANPREET KAUR CHAHAL[1], SAHIL MITTAN[1], AMANDEEP KAUR DHALIWAL[2], AMANPREET SINGH SRAN[1], DIVYA MITTAL[1], AMRITA KUMARI[3], ONKAR SINGH SIDHU[4] AND V.S. PAHIL[1]

[1]Department of Agriculture, Maharishi Markandeshwar University, Mullana 133 203, Ambala (Haryana), India
[2]Department of Zoology, D.A.V. College Bathinda, 151001(Punjab), India
[3]Department of Zoology and Environmental Sciences, Punjabi University, Patiala, 147 001(Punjab), India
[4]Department of Civil Engineering, Punjabi University, Patiala 147 001 (Punjab), India

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ABSTRACT

Heavy metals are naturally occurring elements having high atomic weight and density greater than five times that of water. Owing to their numerous industrial, residential, agricultural, medical and technical applications, they are widely distributed in the environment, raising worries about their possible effects on the environment and human health. The chemical species, their dose and method of exposure, as well as the age, gender, genetics and nutritional status of those exposed, all influence their toxicity. Arsenic, cadmium, chromium, lead and mercury are among the priority metals that are of public health concern due to their high toxicity. These metallic elements are known to cause numerous organ damage, even at very low doses and are considered systemic toxicants. Due to the above reasons, study of different heavy metals in various environmental matrices is more important and this review paper shows the heavy metal distribution, effects and permissible limits of these toxic substances in the ecosystem.

KEY WORDS : Heavy metals, Human exposure, Toxicity, Carcinogenicity, Total Hazard Quotient and Health Risk

INTRODUCTION

Across the world, heavy metal contamination in agricultural soils, crops, water and other components of the ecosystems has become a serious environmental issue from the last few years (Kalavrouziotis *et al*., 2012). These are group of elements having density greater than 4 g/cm^3, or five times higher than that of water (Hawkes, 1997). These elements are toxic to all living beings in concentration above the safe limits recommended by various agencies, as these metals cannot be easily removed from the bodies of the living beings (Lodenius, 2013). Accumulation of heavy metals may not only depend on the natural sources but anthropogenic activities like atmospheric deposition, overuse of fertilizers and pesticides, etc.are continuously adding toxic metals in various ecosystems of the environment (Khan *et al*., 2008). Heavy metals cause detrimental effects on soil microorganisms that play an important role in the recycling of plant nutrients, maintenance of soil structure, control of plant pests and removal of toxic chemicals (Wang-da *et al*., 2006).

Toxic metals accumulate in plants through soil-crop transfer system, which is a major pathway to human exposure (Rattan *et al*., 2005). These elements accumulate in human body either through inhalation or ingestion but the most important pathway is ingestion (Tripathi *et al*., 1997). Several factors that influence the accumulation of heavy metals in plants are local climatic conditions, metal species, physicochemical characteristics of the soil, *i.e.*, pH, cation exchange capacity and organic matter

and maturity level of the plants (Voutsa *et al*., 1996). Heavy metals, *viz*. iron, copper, manganese, molybdenum and zinc are important for biochemical and physiological processes in plants and animals as these are vital components of several enzymes (Wintz *et al*., 2002). Due to the consumption of food contaminated with heavy metals, the vital nutrients from the human body are reduced, which further cause retardation in intrauterine growth and decreased immunological defenses (Iyengar *et al*., 2000). The permissible limits of heavy metals in various components of the environment recommended by various agencies are given below in Table 1.

Overview of groundwater quality in various regions around the Globe

From the last few decades, there has been a remarkable increase in the demand of fresh water due to rapid increase in the population and industrialization in the country (Ramakrishnaiah *et al*., 2009). In both urban and rural areas, groundwater is used for drinking, agricultural and industrial purpose since groundwater is usually considered a safe source of fresh drinking water (Haloi *et al*., 2011). Several land- and water-based activities due to over exploitation are causing contamination of aquifers, leading to unsafe groundwater (Frostner *et al*., 1981). The analysis of physicochemical parameters of water used for drinking and irrigational purpose is important in terms of health risk determination and therefore, a safe limit has been set by the WHO (2011) and other regulatory bodies.

The content of heavy metal in groundwater is also a serious problem related to the areas of intensive industries but roadways and the automobiles exhaust now a day has become the largest source of heavy metals (Abdullah and Rootle, 1972). The content of most of the heavy metals is generally very low in unaffected environments as they are mostly derived from the mineralogy and weathering processes (Karbassi *et al*., 2007). In pre-monsoon season, the content of heavy metals in groundwater is generally higher as compared to monsoon and post-monsoon season (Giri *et al*., 2012; Tiwari *et al*., 2015).

Health risk related to Heavy metals

The assessment of health risk is a method to estimate the prospect of adverse health effects in humans who might be exposed to chemicals in contaminated environmental media (EPA, 2009). Drinking of water contaminated with heavy metals can cause risk to human health as it is a major route of exposure (Tripathi *et al.,* 1997). In developing countries like India, where most of the population is vegetarian, food grains and vegetables are vital constituents of human diet both in terms of nutritional value and quantity consumed by the individual (FAO, 2003). Therefore, concerning food safety issues, various international and national agencies like World Health Organization, Food and Agriculture Organization, European Commission, *etc*. has suggested maximum acceptable limits for toxic metals in different food articles in order to increase awareness against health risk (McLaughlin *et al*., 2000).

Various irrigation practices enhance thecontent of heavy metals in agricultural soil (Chopra *et al*., 2009). From soil, the bioavailable part of these heavy metals is transferred to food crops, which cause risk to human health, and 90% human exposure to heavy metals is through dietary intake as compared to inhalation and dermal routes (Fries, 1995). Several authoritarian agencies including World Health Organization and Food and Agriculture Organization (FAO/WHO, 2001) European Commission (EC, 2002), etc. have defined acceptable limits for the content of heavy metals in the foodstuffs. The content of heavy metals in food diet might possibly cause carcinogenic and non-

Table 1. Permissible limit of heavy metals in environmental components

Heavy metals	Soil (mg/kg) (WHO/FAO, 2001)	Rice grains (mg/kg)	Wheat grains (WHO/FAO)
Cadmium (Cd)	3	0.3 (WHO, 1993)	0.2
Chromium (Cr)	-	0.1 (USDA,2006)	-
Copper (Cu)	100	150 (FAA, 1954)	73.3
Iron (Fe)	-	10-60 (Kaplan *et al*., 1993)	425.5
Nickel (Ni)	50	-	-
Lead (Pb)	50	10 (PFA, 1954)	99.4
Zinc (Zn)	300	-	-

carcinogenic health problems (Duruibe *et al*., 2007). The most important non-carcinogenic health effects caused by heavy metals are hepatic, renal, neurological, gastrointestinal, respiratory, cardiovascular, reproductive and immunological disorders, *etc*. The non-carcinogenic health risk of heavy metals *via* oral route of exposure was assessed using different indices *viz*. chronic daily intake and total hazard quotient. These indices were calculated by means of standards equations for non-carcinogenic total hazard quotient (THQ) methodology developed by United States Environmental Protection Agency (USEPA) and Agency for Toxic Substances and Disease Registry (ATSDR). The non-carcinogenic quotient is less than one, showing that there was no health risk to the population of the study area.

CONCLUSION

According to several published evidences, the heavy metals like cadmium, chromium, lead and mercury are found naturally. Anthropogenic activities, on the other hand, have a substantial role in environmental contamination. Ingestion, inhalation and skin contact are the main routes of exposure for these metals, which are known to cause detrimental health effects in people. The severity of negative health impacts varies with the type of heavy metal used and its chemical form, as well as time and dose. These effects were discovered to be mediated by dose and exposure length. Chronic low dose exposure to several elements is a major public health hazard in many locations of metal contamination.

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