

A Study on Heavy Metal Sources and Pollution: Challenge to Biological and Ecosystem

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Received on 17.03.2023

Revised on 29.04.2023

Approved on 23.05.2023

Accepted on 31.05.2023

Published on 18.06.2023

Keywords:

Heavy metals,
Pollution,
Microbial populations,
Toxic,
Molecular Mechanisms.

Abstract

The heavy metals pollution is a major environmental problem the modern world is facing today. These are major inorganic contaminants in the environment. Though a number of heavy metals are essential micronutrients for both plants and animals, but these are toxic at higher concentrations. The heavy metal ions of Al, Cr, Mn, Ca, Fe, Ni, Cu, Zn, Cd, Hg and Pb are major inorganic contaminants in the environment. These also affect soil microbial populations and their metabolic activities. These adversely affect the molecular mechanisms of life. The weathering of bedrock, volcanoes, forest fires and dust are natural sources of heavy metals to soils and ecosystems. The man made activities such as mining, smelting, printing, battery-manufacturing, electroplating, tanning etc. are resulting in high concentrations of these metals in the environments. This study described the different sources of heavy metals and their health hazards.

How to cite this article: Arora V., Bithel N., and Singh R. (2023). A Study on Heavy Metal Sources and Pollution: Challenge to Biological and Ecosystem. *Bulletin of Pure and Applied Sciences-Botany*, 42B(1), 44-49.

INTRODUCTION

The term heavy metals, though not strictly defined, is commonly used for those metals which have atomic densities higher than 6g/cm³ (Akpore and Muchie, 2010) and which are able to form sulphides (Adriano, 1986). The metals with atomic number 23 onwards (except

Rb, Sr, Y, Cs, Ba, Fr) are generally referred to as heavy metals. There are about 40 elements which fall to this category. Though a number of heavy metals are essential micronutrients for both plants and animals (Eichenberger, 1986; Wintz et al., 2002), these are potentially toxic at

elevated concentrations (Gadd and White, 1989). Al, Cr, Mn, Ca, Fe, Ni, Cu, Zn, Cd, Hg and Pb have been announced as the metals of immediate concerns to the mankind especially with respect to pollution caused by the most specifically due to their discharge into the aquatic environment (Son et al., 2004). Once released into the soil matrix, heavy metals also find their way into the food web through ground water aquifers (Athar and Ahmad, 2002).

Environmental pollution, including that of water by heavy metals is a major environmental problem the modern world is facing today (Dushenkon et al., 1995; Crusberg et al., 2004; Nawachukwu et al., 2010). Due to their mobility in natural water ecosystems as well as their toxicity to higher life forms, heavy metal ions in surface water and ground water supplies are emerging as major inorganic contaminants in the environment (Atkinson et al., 1998). Even if these are present in dilute undetectable quantities, their recalcitrance and consequent persistence might ultimately, through biomagnification, increase their concentrations to such an extent that these begin exhibiting toxic characteristics Smith et al., 1996; Herawati et al., 2000).

SOURCES OF HEAVY METALS

In a natural undisturbed ecosystem, the primary source of most heavy metals are the (i) underlying bedrock (Adriano, 1986), or (ii) surface materials transported *via* atmosphere from one location to other (Davidson et al., 1985). During weathering of bedrock, heavy metals from the parent material get incorporated into nearby forming soil. Emissions of heavy metal as particulates and gases from volcanoes, forest fires and dust have also been a natural

input to soils and ecosystems (Salmons and Forstner, 1981). However, during the last 5000 years, human-related emissions of heavy metals have become increasingly important (Settle and Patterson, 1980). Modern agricultural ecosystems have been dependent upon a substantial input of a variety of agrochemicals most of which contain heavy metals, indiscriminate application of fertilizers has added appreciable quantities of Cd, Cr, Ni and Zn to the soil (Jones et al., 1988).

Mining, smelting, printing, battery-manufacturing, electroplating, tanning etc. are some of the other examples of anthropogenic activities resulting in high concentrations of these metals in the environments. In fact, any industrial activity involving metals is likely to lead to deposition of metals in the environment which, in the long run, may cause serious threat to the environment (Britto and Geetha, 1997; Lata et al., 2005). Many agricultural and industrial activities have resulted in the contamination of large areas across the world (Smith et al., 1996; Shallari et al., 1998; Herawati et al., 2000). Activities like mining and smelting operations as well as agriculture have led to the contamination of extensive areas all over the world. These include (a) Japan, Indonesia, China contaminated mostly by Cd, Cu and Zn (Herawati et al., 2000); (b) North Greece and Albania by Cu, Cd and Pb (Shallari et al., 1998; Zantopoulos et al., 1999); (c) Australia by Cr, Pb, Cu, Ni, Zn and Cd (Smith et al., 1996).

The chief sources of heavy metal contamination in the environment are presented in the table 1. Heavy metal pollutants are present mainly in the effluent from breweries, tanneries, dyeing textiles, paper and pulp mills, steel, glass, petroleum, fertilizers and pesticide industries.

Table 1: Sources of heavy metal contamination in the environment

(Modified from Verkleji, 1993; Singh, 2001)

Sources of heavy metals	Cd	Cu	Pb	Zn	Ni	Mn	Fe	Hg	Se	As	Cr
(A) Industries											
Alloy Steel, Cast iron											+
Ore outcrops	+	+	+	+	+						
Metal smelters	+	+	+	+	+			+		+	
Metal plating, Electroplating										+	+
Blast furnaces				+		+	+				
Electrical goods		+			+			+			
Batteries			+		+						
Lead processing			+								
Tin processing											+
Welding	+										
Refining	+			+							
Galvanising				+							
Polythene			+								
Paint and Textile			+						+		
(B) Traffic density											
Leaded gasoline			+								
Metal mission from types				+	+						
(C) Household Sources											
Wastes	+	+	+	+	+						
Sewage sludge	+	+	+	+	+						
(D) Energy supply											
Coal burning	+								+		
Petroleum combustion					+						
High tension line		+		+							
(E) Agricultural sources											
Food additives		+		+							
Phosphate fertilizers	+										
Pesticides	+	+	+								
(F) Chemicals											
					+			+			

EFFECTS OF HEAVY METALS

Once these reach the soil matrix, these also affect soil microbial populations, which are important for biogeochemical cycles and plant growth. Almost all aspects of microbial metabolism and activity (including primary productivity, methanogenesis, N₂-fixation, respiration, motility, mineralization, decomposition and enzyme synthesis) are affected (Gadd, 1992; Rani et al., 2008).

The adverse effects of metal ions can be grouped into five categories depending upon the

molecular mechanisms of their toxicity (Ochai, 1987). These include: (i) displacement of essential metal ions from biomolecules and other biologically functional units, (ii) blockage of essential functional groups of biomolecules, including enzymes and polynucleotides; (iii) modification of active conformation of biomolecules, especially enzymes of polynucleotides; (iv) disruption of the integrity of biomolecules; (v) modification of some other biologically active agents.

The ability to accumulate micronutrients in high parts per million (ppm) ranges is common

fungus attribute (Standberg et al., 1981; Gadd, 1986). By virtue of their aggressive growth, greater biomass production and extensive hyphal reach in the environment, and high surface: cell ratios of the filaments are likely to perform better than bacteria. The various aspects of the toxicity of heavy metals as also trapping and biosorption of heavy metals by the fungi have been studied and reviewed by a number of workers including Bumpus and Brock (1988), Aust (1990), Gupta (1992), McGrath et al. (1995), Nriagu (1996), Eisler (2003), Lacina et al. (2003), Gaur and Adholeya (2004), Ramteke (2003), Sharma (2005), Fomina et al. (2004, 2005), Swami and Buddhi (2006), Chander and Arora (2007), Duruibe et al. (2007), Zapotoazny et al. (2007), Das et al. (2008), Wang and Chen (2009), Lesmano et al. (2009), Ehrlich and Newman (2009), Sutherland and Venkobachar (2010), Javaid et al. (2010), Pan (R.) et al. (2010), Ramasamy et al. (2011), Marandi (2011) and Hemambika et al. (2011).

CONCLUSION

These studies provide an insight of heavy metals sources and their possible health hazards. The plant animals as well as microbial populations equally affected with these metals. Though a number of heavy metals are essential micronutrients for growth and development of life in lesser concentrations, but these adversely affects the biologically active agents in higher amounts.

Acknowledgment

Authors are grateful to the Prof. M.U. Charaya, Department of Botany, Chaudhary Charan Singh University, Meerut for their continuous guidance and providing the necessary facilities.

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