

Heavy Metals Contamination in Soil and Its Implications on Human Well Being

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ABSTRACT

Heavy metals are common pollutants in the soil environment distributed naturally by both geologic and biologic cycles, poses a threat to environment and food security due to the fast growth of industry and agriculture, and the disruption of natural ecosystems by anthropogenic activities linked to the growth of human populations. Extensive use and combustion of fossil fuels, mining and processing wastes are the other sources responsible for extreme emission of these elements into the soil environment. Heavy metals soil contamination persist long-term in soil and causes hazardous health effects in living organisms including humans if enter into food chain. In this paper, contamination of soil by heavy metals and their toxic effect on human well being has been discussed.

Keywords: Environment, Heavy metals, Soil contamination, Ecosystem, Toxicity, Health disorders.

INTRODUCTION

Heavy metals are group of elements with metallic properties that include transition metals, metallics, lanthanides and actinides (Singh *et al.*, 2011). Some of them are essential constituents for different enzymes e.g. Cobalt, Copper, Magnesium, Molybdenum and Zinc etc., while others e.g. Arsenic, Cadmium, Lead, Mercury and Vanadium etc., are non-essential. Soil may become contaminated by the accumulation of these metals through emissions from the rapidly expanding industrial areas, sewage irrigation, mining activities, use of fertilizers, pesticides, fossil fuel combustion etc. Soils act as the major sink for pollutants. These heavy metals in the soil do not affect by microbial disintegration and persist in soil for long time (Adriano DC, 2003) pose risks and hazards to human health by direction ingestion and through ecosystem by entering into food chain (Ling *et al.*, 2007). Heavy metals play a very important role in living organisms by serving as bio-stimulants, catalysts, co-factors etc. and form an important component of a number of bio-molecules. Definite amount and proportion of these elements is needed for healthier growth of living system. However, if their concentration is raised a little, it may become harmful for living organism. There is rather a thin line demarcating the sufficient and the condition of excess supply.

SOURCES OF HEAVY METALS IN CONTAMINATED SOILS

Heavy metals occur naturally in the soil environment from the pedogenesis, weathering of parent materials at levels that are regarded as traces (<1000 mg/kg) and rarely toxic (Kabata-Pendias and Pendias, 2001; Bolan *et al.*, 2008). The concentrated deposits of these elements generally occur in insoluble state in rock, deposits and sediments, which are usually not available to the living systems. The natural rate of weathering, decomposition and dissolution is normally pretty slow and as such there is hardly any threat of trace element pollution. It is mainly human activity which has added enormous quantities of these elements in various compartments of the environment. (D'A more *et al.*, 2005). Many

studies have been done in this area, reporting that the primary sources of heavy metals are agriculture, mining, agrochemicals and industries. In other words, the soil surface is a fertile place for storing heavy metals, and the transferring them to the plants by absorption along with water through roots, followed by the vascular system.

Another, important source of heavy metals in the environment is combustion of fossil fuels and organic matter. In coal, petroleum crude and dead organic matter, most of these elements occur in small amount whereas ash/fly -ash or unburned scum left after the combustion is rich in a number of toxic elements which are usually added to the environmental burden of pollutants. As a consequence of consumption of large quantities of fossil fuels urban localities around the world possess a higher concentration of heavy metals and trace elements in their soil, atmosphere as well as the plants, animals including man.

Agriculture was the first major human activity on the soil since historic period (Scragg, 2006). These days, to increase the productivity and fertility of soil, several fertilizers are used either of bio or chemical origin. Large quantities of fertilizers are regularly added to soil in intensive farming systems to provide adequate N, P and K for crop growth. The compounds used to supply these elements contain trace amounts of heavy metals (eg Cd & Pb) as impurities. Continuous use of fertilizers leads to increase in content of heavy metals in the soil (Raven *et al.*, 1998).

The pesticides used in agriculture are washed away in the environment. These toxicants are transferred to different organisms in food chain, and at any trophic level, a given toxicant may accumulate in higher amount. Several common pesticides used fairly extensively in agriculture in the past contained appropriate concentrations of metals. Common spray pesticide Bordeaux mixture contains Copper. Lead arsenate commonly used in fruit orchards as insecticide contains Lead. Arsenic containing compounds are also used extensively to control cattle ticks and pests. Such contamination has the potential to cause problems to soil health as well as living systems.

A number of toxic heavy metals traces are introduced into the environment as a consequence of industrial activity. Industrial effluents may contain some radioactive substances, solvents, oils, grease, plastics, plasticizers and suspended solids etc. Effluents from plastic chloralkali units, electrical and electronic industries contribute mercury contamination to the soil. Similarly, chromium present in soil arises from leather tanning, explosive, photography, ceramics, pigment and paints producing units.

Mining of minerals and their processing to obtain the required metal have created enormous ecological disaster areas at many places around the globe. During mining, tailings are directly discharged into natural depressions, including onsite wetlands resulting in elevated concentrations (De Volder *et al.*, 2003). Excessive Lead and other heavy metals ore mining and smelting have resulted in contamination of soil that poses risk to human and ecological health. Assimilation pathways include the ingestion of plant material grown in (food chain), or the direct ingestion orally of contaminated soil (Basta and Grandwohl, 1998).

IMPLICATION OF HEAVY METALS ON HUMAN WELL BEING

During the last five or six decades an increasing amount of heavy metals has been discharged into the soil as discussed earlier. The most common six heavy metals found contaminated sites are As, Pb, Cr, Cd, Hg, Ni etc. (US EPA, 1996).

- 1) **Arsenic (AS)** - Arsenic is ubiquitous in distribution found extremely in limestones and siliceous deposits. Common source of arsenic is weathering and degradation of rocks naturally and its sulphide ores. Smelting of lead, Copper, gold and iron ores yields volatile oxides of arsenic, which gets deposited in flues from where they are collected and refined. Arsenic compounds absorb strongly to soils and are therefore transported only over short distances in ground water and surface water. Arsenic is associated with skin damage, increased risk of cancer, and problems with circulatory system.
- 2) **Lead (Pb)** – It is the ubiquitous toxic metal and can be detected in practically all components of the environment as well as of the biosphere. In humans, inhalation and ingestion are the two routes of exposure, and the effects from both are the same. Lead accumulates in the body organs (i.e. brain) which may lead to poisoning or even death. More than 90% of the Lead absorbed by the blood, associated with haemoglobin (Barltop and Smith, 1971). Later it is distributed to liver, kidney and bones including teeth. It is finally deposited in bones leads osteolysis. Ingestion of large quantity of Lead causes burning pain in mouth, throat and stomach, followed by abdominal pain accompanied by constipation or diarrhoea and often bleeding in severe causes. Finally, there may be failure of blood circulation and termination of liver and kidney function. In growing child, degeneration of intellect and mental retardation may occur due to lead toxicity (NSC, 2009).
- 3) **Chromium (Cr)** – Chromium metal and its salts are used in production of stainless steel, ferrochromium and other alloys, chrome pigments, in tanning of leather, mordant dyeing, wood preservation and as an anti-corrosive agent in cooling systems & boilers, oil drilling muds etc. Important sources are ferrochrome production units, refining of ores, industrial activities and combustion of fossil fuels. Only trivalent and hexavalent forms of chromium are of biological significance. Trivalent form of chromium is almost always occurs in living system. Small quantities of this form are essential to carbohydrate metabolism in mammals while it is also a co-factor for action of insulin. Acute chromium toxicity causes serious renal tubular necrosis. Exposure to hexavalent chromium causes dermatitis, allergic skin reactions, chronic ulceration, injury to nasal septum, gastrointestinal ulcers etc. At present, both forms are considered equally potent carcinogenic agent (Norseth T, 1981).
- 4) **Cadmium (Cd)**- Cadmium belongs to the same family of elements as Zinc and mercury. The metal is obtained as a by-product of mining and smelting of zinc and lead. Cadmium gains entry into the soil from mining and metallurgical operations, electroplating units, paints, pigments and dyes industries and combustion of fossil fuels etc. The most significant use of cadmium is in nickel / cadmium batteries, coating with cadmium to vessels provide good corrosion resistance. Cadmium is also present as an impurity in several products, including phosphate fertilizers, detergents and petroleum products. The deposition of these contaminants increases the total concentration of cadmium in soils. Cadmium is a potent enzyme inhibitor. It interacts with protein part of several enzyme systems, form metal protein complex that is resulting proteinurea. Food intake and tobacco smoking are the main routes by which cadmium enters the body (Manahan SE, 2003).
- 5) **Mercury (Hg)** - Mercury belongs to the same group in periodic table with zinc and cadmium main source of mercury is Cinnabar. It is the only liquid heavy metals, released from coal combustion, is a major source of mercury contamination. Inhalation of mercury vapours produces acute corrosive

bronchitis, intestinal pneumonitis, impaired vision, muscular convulsions, madness and Paralysis. Mercury is also associated with kidney failure. (Scragg A, 2006).

- 6) **Nickel (Ni)** - Nickel is a known carcinogen of respiratory tract. The major sources of nickel contamination in the soil are metal plating industries, combustion of fossil fuels, nickel mining and electroplating (Khodadoust *et al.*, 2004). The larger part of nickel compounds in environment will adsorb to sediments or soil particles and become immobile as a result. It mixes with ground water by the process of leaching. Common toxic effects produced by nickel exposures in large amounts include dermatitis and respiratory disorders. Most severe cases precede pneumonia respiratory failure and eventually edema and death.

CONCLUSION

Due to enormous economic development and rapid growth in many fields, such as agriculture and industries, the environment is becoming more polluted. Certain environmental processes, such as synthetic industries, coal conservation and waste burning results in hazardous problems for abiotic elements and biotic communities. Usually environmental toxicants include heavy metals and pesticides, threatened the entire ecosystem, seriously damaging its function and structure.

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