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Review Article

A REVIEW ON SOURCES OF HEAVY METAL POLLUTION IND ITS IMPACTS ON ENVIRONMENT

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A B S T R A C T

Human activities such as industrial production, mining, agriculture and transportation, release high amounts of heavy metals into surface and ground water, soils and ultimately to the biosphere. Some of heavy metals at very low concentration are essential for plants and animals but at higher concentration all heavy metals are toxic to the environment. This paper briefly explains about the impacts of heavy metals on environment. It is evident from the several research reports that judicious use and presence of heavy metals have toxic effects on plants, animals and other living organisms and affects the same after certain limits. Therefore, it is well needed to intensify the research programmes for better understanding of heavy metal toxicity on environment and its remediation.

INTRODUCTION

Pollution of the environment with toxic metals has increased dramatically since the onset of the industrial revolution (Voegelan *et. al*., 2003). There are 35 metals that concern us because of occupational and residential exposure; 23 of these are the heavy elements or "heavy metals". Heavy metal can include elements lighter than carbon and can exclude some of the heaviest metals (Duffus, 2002). The term ''heavy metals'' refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration. ''Heavy metals'' in a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm^3, or 5 times or more, greater than water (Hawkes, 1997). Heavy metals are metals with specific gravity greater than 5 g/cm^3 (Nies, 1999). Metals such as aluminium, arsenic, cadmium, cobalt, chromium, copper, lead, manganese, mercury, nickel, selenium and zinc have been considered as the major environmental pollutants and their phytotoxicity has already been established (Ross, 1994; Cseh, 2002; Fodor, 2002).

Some of heavy metals (Fe, Cu and Zn) are essential for plants and animals (Wintz *et. al*., 2002). The availability of heavy metals in medium varies, and metals such as Cu, Zn, Fe, Mn, Mo, Ni and Co are essential micronutrients (Reeves and Baker, 2000), whose uptake in excess to the plant requirements result in toxic effects (Monni *et. al*., 2000; Blaylock and Huang, 2000).

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They are also called as trace elements due to their presence in trace (10 mg/kg, or mg/l) or in ultra trace quantities in the environmental matrices.

Sources of heavy metal pollution

There are various sources of heavy metals; some originates from anthropogenic activities Conversely, metals also occur in small amounts naturally. The primary sources of metal pollution are the burning of fossil fuels, mining and smelting of metalliferous ores, municipal wastes, sewage, pesticides, and fertilizers.

Natural sources of heavy metals pollution

The most important natural source of heavy metals is geologic parent material or rock outcroppings. The composition and concentration of heavy metals depend on the rock type and environmental conditions, activating the weathering process. The geologic plant materials generally have high concentrations of Cr, Mn, Co, Ni, Cu, Zn, Cd, Sn, Hg and Pb. However, class-wise the heavy metal concentrations vary within the rocks. Soil formation takes place mostly from sedimentary rock, but is only a small source of heavy metals, since it is not generally or easily weathered. However, many igneous rocks such as olivine and hornblende contribute considerable amounts of Mn, Co, Ni, Cu and Zn to the soils. Within the class of sedimentary rocks, shale has highest concentrations of Cr, Mn, Co, Ni, Cu, Zn, Cd, Sn, Hg and Pb followed by limestone and sand stone. Volcanoes have been reported to emit high levels of Al, Zn, Mn, Pb, Ni, Cu and Hg along with toxic and harmful gases.

Anthropogenic sources of heavy metal pollution

The major causes of emission are the anthropogenic sources specifically mining operations (Nriagu, 1988). In some cases, even long after the mining activities have ceased, the emitted metals continue to persist in the environment. Heavy metals are emitted both in elemental and in compound (organic and inorganic) forms. Anthropogenic sources of emission are the various industrial point sources including former and present mining sites, foundries and smelters, combustion by-products and traffics (UNEP/GPA, 2004).

Impacts of heavy metals on lithosphere

Heavy metal accumulation in soils is of concern in agricultural production due to the adverse effects on food safety and marketability, crop growth due to phytotoxicity, and environmental health of soil organisms. The influence of plants and their metabolic activities affects the geological and biological redistribution of heavy metals through pollution of the air, water and soil. Soil pollution by heavy metals such as cadmium, lead, chromium, copper and zinc is a problem of concern. Although heavy metals are naturally present in soil and comes from local sources that is mostly from industries like non-ferrous industries, iron, steel and chemical industries and also from power plants (Rashad and Shalaby, 2007) pollutes agricultural land through irrigation with polluted waters, sewage sludge and fertilizer, especially phosphates, contaminated manure and pesticide and containing heavy metals. It also causes waste incineration, combustion of fossil fuels and road traffic, long - range transport of atmospheric pollutants adds to the metals in the natural environment. In recent years, it has been shown that lead levels in soil and vegetation have increased considerably due to traffic pollution, especially from usage of leaded petrol and exhaust combustion (Ano *et. al*., 2007; Onde *et. al*., 2007; Osakwe, 2009). Sutterland (2000) stated that the problem worsens as daily traffic increases. Cement dust has been shown to adversely affect the soil and exhibit elevated pH levels. Cement industry also plays a vital role in the imbalances of the environment and produces air pollution hazards. It was well documented that work done on the composition of soil around cement factories has shown that there were very high levels of chromium, silica, iron and calcium with contamination levels decreasing dramatically with distance from the factories (Asubojo, *et. al*.,1991; Mandre *et. al*., 1998). Nigerian soil has being bio-accumulated by most heavy metals resulting to serious disease infection to crops, animals and human beings. Contamination of agricultural soil by heavy metals has become a critical environmental concern due to their potential adverse ecological effects. Such toxic elements are considered as soil pollutants due to their widespread occurrence and their acute and chronic toxic effect on plants grown of such soils.

Impacts of Heavy metals on hydrosphere

Pollution of heavy metals in aquatic environment is a growing problem worldwide and currently it has reached an alarming rate. Heavy metals occur in the soil in soluble form and in combined state. However, only soluble, exchangeable and chelated metal species in soils are mobile and hence more available in water. As heavy metals cannot be degraded, they are continuously being deposited and incorporated in water, thus causing heavy metal pollution in water bodies. The presence of heavy metals in the water may have a profound effect on the microalgae which constitute the main food source for bivalve molluscs in all their growth stages, zooplankton (rotifers, copepods, and brine shrimps) and for larval stages of some crustacean and fish species. Moreover, bioconcentration and magnification could lead to high toxicity of these metals in organisms, even when the exposure level is low. Under such conditions, the toxicity of a moderately toxic metal could be enhanced by synergism and fish population may decline. Apart from destabilizing the ecosystem, the accumulation of these toxic metals in aquatic food web is a threat to public health and thus their potential long term impact on ecosystem integrity cannot be ignored (Ogoyi *et. al*., 2011). Pollution of fresh water bodies, especially the rivers is no longer within safe limits for human consumption as well as aquatic fauna.

The heavy metal load from domestic wastewater and sewage alone (Nriagu and Pacyna, 1988) ensures that this will be a continuing problem for science and humankind. The rate of input of metals into the world's waterways is still very high (McCormac, 1991; Nriagu and Pacyna, 1988) and the dumping of metal-containing sludge into the ocean is still disturbing the aquatic ecosystems (Purves, 1990). Water in rivers and lakes can become heavily polluted, depending on the volume flow and its proximity to point sources. The influences of human civilizations are reflected by elevated contents of Cd, Cr, Pb, Hg, and Zn, of which Cr is usually only of local significance An inventory for Lake Erie, United States, (Nriagu *et. al*.,1979). Revealed that atmospheric inputs accounted for 20%, 35%, and 50%, respectively, of the Cu, Zn, and Pb discharges originating from the lake's catchments, while contributions from sewage effluents were 45%, 30%, and 50%, respectively. The biomethylation of Hg, As, Sb, and Sn have been shown to occur in aquatic ecosystems (McCormac, 1991). Methylmercury comprises 2% of the total Hg in Swedish freshwaters, but may increase to 10% of total Hg in sediments of heavily polluted rivers in Germany (Wilken and Hintelmann, 1991).

Heavily contaminated aquatic sites are completely denuded in flora and fauna, thus the contamination adversely affects aquatic biodiversity. Toxic metal contamination of aqueous water streams and ground water poses a major environmental and health problem that is still in need of an effective and affordable technological solution. Major sources of heavy metals in aquatic ecosystems are of the anthropogenic type and this contamination can be remediated using a variety of technologies, whether chemical, physical, or biological. Methods such as precipitation (Rebhun and Galil, 1990), reduction (Brewster and Passmore, 1994), artificial membranes (Geckeler and Volchek, 1996), and ion exchange (Markus and Kertes, 1969) are used to remove toxic metals from industrial effluents. Methods using living wetland plants to remove metals from water appear to be an alternative. Plants that have a high metal-bioaccumulation capacity and a good tolerance to high metal concentrations over long periods of time are necessary. However, before mentioning the role of wetland plants in heavy metal phytoremediation, a concise view of salient features of the wetland ecosystem is a prerequisite.

Impacts of heavy metal pollution on atmosphere

Motor vehicle emissions are a major source of air borne contaminants including arsenic, cadmium, cobalt, nickel, lead, antimony, vanadium, zinc, platinum, palladium and rhodium. Heavy metals enter plant, animal and human tissues via air inhalation. The large input of mercury (Hg) into the arable

lands has resulted in the wide spread occurrence of mercury contamination in the entire food chain. High temperature processing of metals such as smelting and castings emit metals in particulate and vapour forms. Vapour form of heavy metals such as As, Cd, Cu, Pb, Sn and Zn combine with water in the atmosphere to form aerosols. These may be either dispersed by wind (dry deposition) or precipitated in rainfall (wet deposition) causing contamination of whole environment. Cement dust has been shown to adversely affect the soil and exhibit elevated pH levels. Cement industry also plays a vital role in the imbalances of the environment and produces air pollution hazards (Asubojo, *et. al*.,1991; Mandre *et. al*., 1998).
The contribution to ecosystem of elements from sea sprays and mists often transported many kilometers in land is widely recognized. Cu and Mn (Vermette and Bingham, 1986) from such marine sources have been detected in rain water input to terrestrial environments. The natural process of 'bubble bursting' is a source of air-borne Cd, Cu, Ni, Pb and Zn via sea salt particles (Pacyna, 1986). Air-borne emissions of heavy metals originate from forest and prairie fires (Ross, 1994). Volatile heavy metals such as Hg and Se are part of carbonaceous matter produced during the fire. Natural vegetation emits heavy metals into the soil and atmosphere through leaching from leaves and stems, decomposition and volatilization.

Effects of heavy metals on biosphere

Contamination of agricultural soil by heavy metals has become a critical environmental concern due to their potential adverse ecological effects. Such toxic elements are considered as soil pollutants due to their widespread occurrence and their acute and chronic toxic effect on plants grown on such soils which are ultimately transfer to animals through food chain.

Effects of heavy metals on plants

Some of heavy metals at very low concentration are essential for plants but at higher concentration all heavy metals are toxic. Zinc (Zn) is an essential micronutrient that affects several metabolic processes of plants (Cakmak and Marshner., 1993) and has a long biological half-life. The phytotoxicity of Zn and Cd is indicated by decrease in growth and development, metabolism and an induction of oxidative damage in various plant species such as *Phaseolus vulgaris* (Cakmak and Marshner., 1993) and *Brassica juncea* (Prasad *et. al*., 1999). Copper (Cu) is considered as a micronutrient for plants (Thomas *et. al*., 1998) and plays important role in CO2 assimilation and ATP synthesis. Cu is also an essential component of various proteins like plastocyanin of photosynthetic system and cytochrome oxidase of respiratory electron transport chain (Demirevska-kepova *et. al*., 2004). Excess of Cu in soil plays a cytotoxic role, induces stress and causes injury to plants. This leads to plant growth retardation and leaf chlorosis (Lewis *et. al*., 2001). Exposure of plants to excess Cu generates oxidative stress and (Stadtman and Oliver 1991). Oxidative stress causes disturbance of metabolic pathways and damage to macromolecules (Hegedus *et. al*. 2001). The regulatory limit of cadmium (Cd) in agricultural soil is 100 mg/kg soil (Salt *et. al*., 1995). In general, Cd has been shown to interfere with the uptake, transport and use of several elements (Ca, Mg, P and K) and water by plants (Das *et. al*., 1997). Cd also reduced the absorption of nitrate and its transport from roots to shoots, by inhibiting the nitrate reductase activity in the shoots (Hernandez *et. al*., 1996).
Early seedling growth was also inhibited by lead in Soyabean (Huang *et. al*., 1974). Lead also induces proliferation effects on the repair process of vascular plants (Kaji *et. al*., 1995). It is also known to affect photosynthesis by inhibiting activity of carboxylating enzymes (Stiborova *et. al*., 1987). Excess of Ni^{2+} in soil causes various physiological alterations and diverse toxicity symptoms such as chlorosis and necrosis in rice (Das *et. al*., 1997). Accumulation of excessive manganese (Mn) in leaves causes a reduction of photosynthetic rate, necrotic brown spotting on leaves, petioles and stems is a common symptom of Mn toxicity (Wu, 1994).

Impacts of heavy metal on animals

Exposure of the population to heavy metals may cause neurobehavioural disorders such as fatigue, insomnia, decreased concentration, depression, irritability, gastric symptoms, sensory symptoms, and motor symptoms. Exposure to heavy metals has been linked with developmental retardation, various cancers, kidney damage, autoimmunity, and even death in some instances of exposure to very high concentrations (Glover-Kerkvilet, 1995). Methyl mercury intake through fish and aquatic foods has a considerable effect on human health. At higher levels, mercury can damage vital organs such as lungs and kidneys. Methyl mercury can cross placental barriers and cause fatal brain damage. An accumulation of cadmium in human bodies can cause renal dysfunction and bone disease such as Itai-Itai (Nordberg, 1996). Due to major public health concerns about cadmium exposure in a general population, its accumulation and possible renal damage through contamination in the food chain has attracted much attention worldwide. Elevated concentrations of cadmium have been reported in sewage, irrigation water, and vegetables grown in the Gangetic plane of Eastern Uttar Pradesh and the Western Bihar region of India (Shukla *et. al*., 1998).

Another reason that toxic heavy metals are causing potential concern is that the metals may be transferred and accumulated in the bodies of animals or human beings through the food chain, which potentially causes DNA damage and carcinogenic effects caused by their mutagenic ability (Knasmuller *et. al*., 1998). Examples include Cd, Cr, and Cu, which have been associated with health effects ranging from dermatitis to various types of cancer (Das et.al., 1997; McLaughlin *et. al*., 1999). In addition, some metals occur in the environment as radioactive isotopes (*e.g.*, U^{238}, Cs^{137}, Pt^{239}, and Sr^{90}), which can greatly increase the health risk (Pilon-Smits and Pilon, 2002).

CONCLUSION

Heavy metals can be removed by physical, chemical, and various biological processes. Although heavy metals are deposited continuously to the environment due to various natural as well as anthropogenic activities which have toxic effects on plants, animals and other living organisms. So it is well needed to intensify the research programmes for better understanding of heavy metal toxicity on plants, animals and environments and its proper remediation.

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