IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 11, Issue 2 Ver. I (Feb. 2017), PP 113-116
www.iosrjournals.org

Heavy Metals Toxicity and the Environment Protection

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Abstract: *Pollution of environment is one of the most horrible ecological crisis to which we are subjected today. One of the main sources of pollution in the environments is metallic compounds. Metals and metalloids have long been mined and used in numerous applications. This has led to a significant increase of metal pollutions. Metals can accumulate in all environmental matrices at either high or trace levels of concentration. Heavy metals are naturally occurring elements that have a high atomic weight and a density. Therefore amount of various kinds of metals are present in soil, plants, air, lakes, animals, oceanic regions, even in foodstuffs and human beings. Their widespread distribution, especially heavy metals, became serious problems because of their toxicities for animals, human health and the environment. Their toxicity of heavy metals depends on several factors including the dose, route of exposure, and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals. Because of their high degree of toxicity, lead, cadmium, chromium, zinc, nickel, arsenic, and mercury rank among the priority metals that are of public health significance. Metals generally enter in the ecosystem in a relatively non-toxic form and generally become intrinsic components of the environment in such a way that it is difficult to remove them from the environment. Some of them are converted into toxic forms through the environmental reactions involving various micro-organisms and non-biological pathways. For example, methylated compounds like dimethyl mercury,* $(CH_3)_2Hg$, *are more toxic than their inorganic forms. In the present investigation more attention has been given to heavy metals like lead, cadmium, nickel and zinc. Although, the term "heavy metals" refer to any metallic element that has a relatively high density and is toxic or poisonous at low concentrations. Examples of heavy metals include Pb, Cd, Hg, As, Cr, and Ti etc. This review provides an analysis of their environmental occurrence, production and use, potential for human exposure, and molecular mechanisms of toxicity, genotoxicity, and carcinogenicity.*
Keywords: *heavy metals, huma health, Environmental, toxicity, carcinogenicity*

I. Environmental Occurrence, Industrial Production and Use

Heavy metals are defined as metallic elements that have a relatively high density compared to water According to United Nation Development Programme (UNDP), human development report there was about 185.4 million people during 1988-93, who were not having access of safe drinking water. According to a survey published in "The Hindu" (Nov. 23, 2002), at present about 15,000 habitations in the country have no potable drinking water, while two lakhs are partially covered and 2-17 lakh villages are identified with problem with quality of water. Lakes like Dal and Nagin in Kashmir, Loktak in Manipur and Hussain Sagar in Hyderabad have seriously chocked by aquatic weeds due to eutrophication. Sukh-tal and Saria tal represent high pollution level in Kumaun region. In urban sector also, the drinking piped water is not safe. Many experiments found industrial pollutants[1-5], e.g., lead, mercury, chemical wastes and other toxic substance in piped water. Arsenic species are determined in water, soil and plants[6]. Mercury pollution was found in the Tapajos River basin Amazon[7]. Aluminium, Pb, Cd have been determined in water samples[8-11]. The heavy metals like lead, mercury, synthetic chemicals and some hazardous wastes dissolve in water in a manner that it is quite difficult to detect and separate them in the purification process. Thus problem of deteriorating water quality and thus aquatic ecosystem is worst where rivers pass through large cities or areas having industrial establishment which discharge effluents, solid wastes, particles and other hazardous wastes, which account for one–third of the total water pollution. In rural and semi-urban sectors having less number of industrial establishments, water pollution is mostly due to human wastes and agricultural run off. Utilization of contaminated water causes many water borne diseases. The tendency of heavy metals to concentrate in the sediments may result in a persistent source of the contamination to various tropic levels in the aquatic environment[12].

LEAD

Lead is a relatively abundant metal in nature, occurring in lead minerals. In the atmosphere, it is relatively more abundant than other heavy metals. The major source of air borne Pb is the combustion of leaded petrol/gasoline. Pb is added in the form of tetra alkyl lead, primarily $Pb(CH_3)_4$ and $Pb(C_2H_5)_4$, together with 1,2-

Dibromoethane. The major biochemical effect of Pb is its interference with Heme synthesis, which leads to hematological damage. Pb inhibits several of the key enzymes involved in the overall process of Heme synthesis whereby the metabolic intermediates accumulate. One such intermediate is delta-amino levulinic acid. An important phase of heme synthesis is the conversion of delta-aminolevulinic acid to porphoblinogen. The Pb inhibits the porphoblinogen synthase enzyme so that it cannot proceed further to form porphoblinogen. The overall effect is the disruption of the synthesis of hemoglobin as well as other respiratory pigments, such as cytochromes; which require heme. Pb doesn't permit utilization of O_2 and glucose for life sustaining energy production. At higher levels of Pb in the blood (more than 0.8 ppm) there will be symptoms of anemia due to deficiency of hemoglobin. Elevated Pb levels (more than 0.5-0.8 ppm) in the blood cause kidney dysfunction and brain damage, CNS- syndrome that may result to coma and death. Lead poisoning also causes constipation, abdominal pain and abnormalities in fertility and pregnancy.

The study of effect of lead intoxication on peripheral blood and hematopoietic bone marrow has been done which shows that the percent of reticulocyte in the peripheral blood was 10 times more elevated than the controls. It delays the maturation of erythrocyte[13]. Lead poisoning can be cured by treatment with chelating agents which strongly bind Pb^{2+}. Thus calcium chelate in solution is fed to the victim of lead poisoning; Pb^{2+} displaces Ca^{2+} from the chelate and the resulting Pb^{2+} chelate is rapidly excreted in the urine. Long term exposure to lead has been shown to produce behavioral disturbances in human and animal models which are associated with the alternations in cholinergic and dopaminergic nero-transmission in the central nervous system[14]. Lead poisoning is also observed in wild waterfowl in Japan[15] and wood peckers in Sweden[16].

CADMIUM

Cadmium occurs in low concentration in all natural materials. It is a by product of zinc and lead smelting. Cd mainly finds use in cathode material of alkaline batteries, electroplating and galvanizing stabilizer PVC plastics, silver solders and as colour pigment in paint. Some of the important sources of exposure of Cd are air pollution, cigarette smoke, fruits, grains and vegetables grown in Cd- laden soil, meat (kidney, liver, and poultry), fresh water fish, fungicides, incinerators, mining, Ni-Cd batteries, oxide dust, paint, phosphate fertilizers, power plants, sea foods, smelting plants, tobacco etc[17]. Cereals and vegetables accounts for about 50% of the Cd intake, which is normally about 2-25 µg/day in children and 10-50 µg/day in adults. Sea food like mollusks and crustaceans also contribute to daily Cd intake. Hyper accumulation of cadmium by hairy roots of Thalspi caerulescens[18] and its content in herbal raw material is determined[19]. It is also determined in Chinese ceramic by using Oscillopolarography[20]. Long term exposure to Cd from industrial or other sources may cause chronic poisoning and thus result in disorders of various systems, e.g. renal diseases, bone diseases, pulmonary damage, anemia, hypertension, yellow discoloration of the front teeth near gum line and possibly cancer (prostate, renal and lung). Even low levels of environmental cadmium exposure may cause bone demineralization leading to increased bone fragility and increased risk of fractures[21].

NICKEL

Nickel is an essential trace metal for animal nutrition. The nutritional essentiality of Ni was established it when was found that rats fed on diet deficient in nickel had retarded body growth associated with reduction of blood hemoglobin concentration, hematocyte and erythrocytes count. However, the ingestion of Ni above the tolerable limits over long period of time causes harmful health effects. The various sources of exposure of Ni are: - Ceramics, cocoa, hair dye, cooking utensils, cosmetics, coins, dental materials, food (chocolates, hydrogenated oils, nuts, food grown near industrial areas), hair spray, industrial waste, jewellery, medicinal plants, metal refineries, metal tools, nickel-cadmium batteries, shampoo, soil waste incinerators, stainless steel kitchen utensils, tap water, tobacco, water pipes[22] etc. Copper and nickel has been determined in the crude oil simultaneously with single sweep polarography[23].

The dietary intake of nickel is highly variable and depends on the Ni content of foodstuffs from various regions. In general food of animal origin has lower Ni content compared to that of plant origin. Bread, cereals, beverages contribute to half of the daily intake of Ni. Based on certain human experiments where skin reaction to Hg was observed after oral dose of 600 µg[24] nickel (as nickel sulphate), it appears that the safe threshold level for Ni Toxicity may be much lower than 600 µg. Ecotoxicity of nickel to Epsenia fetida, Enchytraceus, Folsomia candida is observed[25-26].

ZINC

The total content of zinc in an adult body is about 2.0g. Prostate gland is very rich in Zn (100 µg/g). Zinc is mainly an intracellular element.

Biochemical Functions

- Zn is an essential component of several enzymes e.g. carbonic anhydrase, alcoholic dehdrogenase, alkaline phosphatase, carboxypeptidase, superoxide dismutase.
- The storage and secretion of insulin from the beta-cells of pancreas requires Zn.
- Zn is necessary to maintain the normal levels of vitamin A in serum.
- It is required for wound healing.
- Gusten, a zinc containing protein of the saliva, is important for taste sensation.

Besides all above heavy metals, arsenic is posing harmful effects on human health in present time[27]. A review of As exposure through the ages shows that metals has poisoned and killed more people than any other toxin known to human kind[28]. Humans may come into contact with and may be exposed to chemicals in soils via. a number of pathways, including inhalation, dermal absorption, and ingestion. In most cases, the significant pathway in regard to exposure to metal-contaminated soils is ingestion. Incidental soil ingestion by children is an important pathway in assessing public health risks associated with exposure to arsenic contaminated soils. Hair arsenic levels are the useful indicators of chronic arsenic poisoning[29]. Similarly excessive intake of selenium can cause selenosis which includes weight loss, emotional disturbance, diarrhoea, and hair loss and garlic odour in breath. In recent years Rajasthan has taken big strides in agricultural production. This has become possible mainly because of irrigation facilities and use of pesticides and fertilizers.

Large number of analytical techniques such as X- ray fluorescence[39], Atomic absorption spectrophotometery[40-47], Flame photometery[48-49], Chronopotentiometry[50-52], Neutron activation analysis[53-56], are available today for trace analysis purposes but factors such as high cost of instrumentation, much time consumption, lower sensitivity and lesser reproducibility reduce the efficacy of these techniques in trace analysis. Voltammetric methods have proved to be one of the most sensitive and reproducible methods available today for carrying out trace analysis in diverse matrices like food[57-62], drugs[63-74], plants[75-78], soil[79-85] water[86-92], etc. In the last three decades, classical d.c. Polarography which was the best analytical technique has been modified to give birth to a number of highly sensitive and reproducible techniques like Normal pulse Polarography, Differential pulse Polarography, Linear sweep voltammetry, Square wave Polarography, Stripping voltammetry, Cyclic voltammetry etc. These techniques are among the best analytical techniques available today for any type of analysis at microgram to nanogram levels. The techniques are so versatile that 80% elements of the periodic table can be analyzed using them. Moreover, instrumentation for these techniques is very simple.

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