HEAVY METALS AND THEIR EFFECT ON HUMAN HEALTH

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Abstract

The main threats to human health are associated with the exposure to heavy metals like lead, cadmium, chromium, mercury and arsenic. Even though adverse health effect due to heavy metals is known, still exposure continues the same in most of the developing countries. Cadmium found in low concentration in rocks, coal, and petroleum, enters the groundwater and surface water through industrial discharge, metal painting by which it replaces the zinc biochemically in the body and causes high blood pressure, liver and kidney damage and anemia. Cadmium emission is increasing dramatically as it is not recycled and often dumped along with the household waste. The general population is exposed to mercury through food; fish is the major source of methyl mercury exposure and dental amalgam. Lead enters environment from industry, mining and as a water additive; Affects red blood cell chemistry, delays normal physical and mental development in babies and young children, increase in blood pressure in some adults. In ground water used as drinking water, arsenic concentrations ranged from 0.1–1340 µg L− 1. Exposure to the arsenic is mainly through food and drinking water which has the high risk of cancer of lung, skin, bladder and kidney, skin lesions such as hyperkeratosis and pigmentation changes.

Keywords: *heavy metals, health effects, metal toxicity*

Introduction

Heavy metals constitute a very heterogeneous group of elements widely varied in their chemical properties and biological functions. Heavy metals are kept under environmental pollutant category due to their toxic effects on plants, animals and human being. Anthropogenic activities such as mining, smelting operation and agriculture have locally increased the levels of heavy metals such as Cd, Co, Cr, Pb, As and Ni in soil up to dangerous levels. Heavy metals have largest availability in soil and aquatic ecosystems and to a relatively smaller proportion in atmosphere as particulate or vapors. Several heavy metals are considered toxic metals due to adverse human health effects, when taken in excess.

Heavy metal toxicity in plants vary with plant species, specific metal, concentration, chemical form, and soil composition and pH, as many heavy metals are considered to be essential for plant growth few metals like Cu and Zn serve as the co-factor and activators for the enzyme reactions. Some of heavy metal such as Cd, Hg and As etc. are strongly poisonous to metal sensitive enzymes, resulting in growth inhibition and death of organisms. Heavy metals which are categorized as class B metals that come under non-essential trace elements, which are highly toxic elements such as Hg, Ag, Pb, Ni. These heavy metals are persistent, bio accumulative and do not readily breakdown in the environment or not easily metabolized. Such metals accumulate in ecological food chain through uptake at primary producer level and then through consumption at consumer levels. Heavy metals such as Cd, Ni, As and Cr pose a number of hazards to humans.

Heavy metals are also potent carcinogens. Mercury intake leads to mina Mata disease and Arsenic causes poisoning due to drinking water contamination. The essential heavy metals (Cu, In, Fe, Mn and Mo) play biochemical and physiological functions in plants and animals. Two major functions of essential heavy metals are: (a) Participation in redox reaction, and (b) Direct participation, being an integral part of several enzymes. Vapor form of heavy metals such as As, Cd, Cu, Pb, and Sn combine with water in the atmosphere to form aerosols. Heavy metal toxicity is reported to increase the activity of enzymes such as, glucose-6- phosphate dehydrogenates and peroxides in the leaf of plants grown in polluted soil.[2] Mercury, Cu and Zn ions have changed the hydrolytic activity of chlorophylls in rice leaves, with Hg increasing the activity maximally out of the three metals. In drinking water presence of Zn is 5.0 mg/l where as Cd is 0.001mg/l.

Lead

Lead in Water

Drinking water can also have dangerously high levels of lead. Lead rarely found in water at its source. The water becomes contaminated as it moves through the water distribution system. The lead can come from lead pipes or connectors; lead solder used to connect pipes and fumes; brass fixtures; and lead lined tanks in water coolers. The most serious problems come when the water is acidic. The acidic water will greatly increase the amount of lead that will leech from lead plumbing. In 1986, the federal government has made it illegal to use lead solder (greater than 2% lead in solder) or nine (9) waterlines.[11] Newer pipes may pose more of a hazard than older pipes. In older pipes, a mineral scale develops on the interior of the pipe, preventing the lead from leaching into the water. Newer pipes do not have this scale.

Components causing lead contamination include lead pipes, lead-based copper piping solders and brass fixtures. **Lead pipes** for conveying drinking water has been used for centuries because of its flexibility, durability and long life. Lead pipes are used in the United States, however, lead concentrations exceeding the regulation levels owing to lead pipe were reported in a number of cities. **Lead Solder** have been identified as a significance source of lead contamination. **Brass Faucet** fixtures have been identified as a major lead source in tap water. Levels of lead contamination found in natural raw waters, treatment plants or in distribution mains are typically low and rarely exceed drinking water regulations. However, high lead levels are usually found at consumers taps. Tap water can be contaminated by lead pipes, copper pipes with lead solder or bronze and brass faucets contaminating lead.

Contamination of lead in groundwater origin from the dissolution of lead from soil and earth crust. Lead particulate from the combustion of leaded gasoline, fossil and ore smelting can contaminate local surface water by surface runoff. . Lead itself has minor content in the earth crust. A widely distribution in of lead sedimentary rock and soils are reported an average lead content of 10 mg in 1 kg (10ppm) soil usually found in upper ground soil and lead in a range of 7 to 12.5 ppm is found in sedimentary rock.(U.S..EPA, 1987).[12]

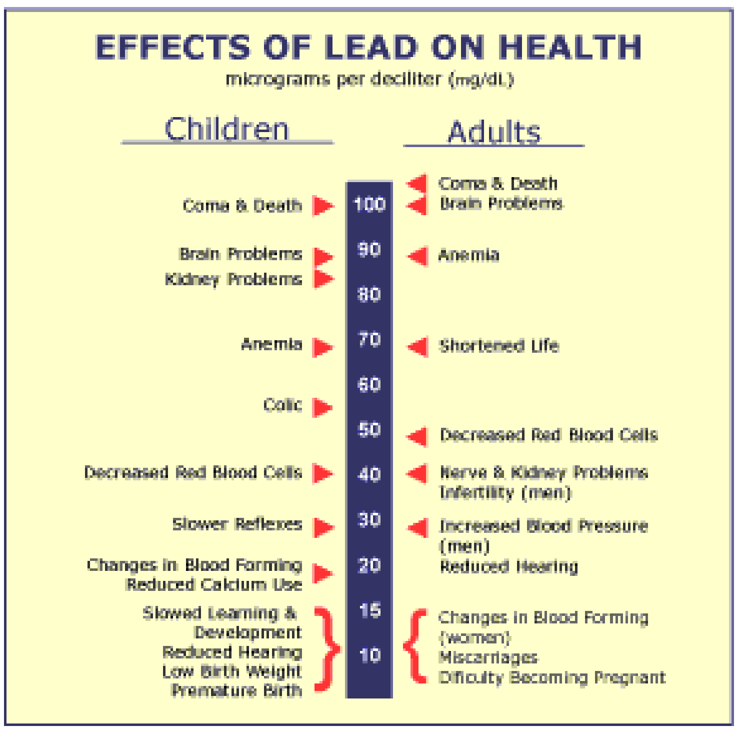
This means that lead generally present in a form of carbonates and hydroxide complex in soil. The solubility of lead control the lead dissolution into surrounding water. Strongly absorption by soil and complexion by humus can further limit the lead concentrations in surface waters and groundwater.

Children are more affected by the same amount of lead from these and other sources than adults. Foods such as baby formula may pose a significant lead poisoning hazard if lead contaminated water is used in its preparation. As many as 5% of children have high enough lead intake through water and foods to cause health risks.[13]

Higher levels or chronic exposure results in more severe symptoms such as kidney and nervous system damage. Lead accumulate primarily in the bones and other organs.

The general population is exposed to Pb from air and food. There is currently no lead level believed to be safe for infants and young children.

Children are particularly more susceptible to Pb exposure due to high gastrointestinal uptake, and the permeable blood brain barrier leading to neurotoxin effects even at low level of exposure.[1] The toxicity of Pb is caused by its direct interference with activity of different enzymes or displacing essential metal ions from metalloenzymes. The major exposure pathway of inorganic Pb is via ingestion and adsorption through the gastrointestinal tract, respiratory tract and inhalation. Kidney and liver are considered potential targets of Pb toxicity before storage in bones. Depending on the level of exposure, Pb has potential to cause a variety of biological effects such as decreased hemoglobin synthesis, impairment of neurobehavioral and psychological functions, peripheral neuropathy, indirect effect on heart, renal tubular damage and reproductive problems.[2.3] Plumbism is the main disease caused by exposure to the pollutants of lead. Reticulocyte percentage, stipple cell counts, and polychromatophylia estimations tended to be higher in lead affected men. All three sets of values increased with increasing lead concentration. Albuminuria was twice as frequent among the lead affected group. Sever microcytic hypo chromic anemia with low plasma iron and percent iron saturation can be seen in affected children and adults.The total iron binding capacity was lower in the lead poisoning individual.The most noted finding was a great increase in the free erythrocyte protoporphyrin.[4] Reduced glomerular filtration rate can be seen by the urinary excretion of more than 1,000 µg of lead per day .renal biopsies and kidney damage is confirmed by lead nephropathy.[5]



Arsenic

Until 2002, arsenic compounds were used to treat wood to prevent rot. The arsenic leaches out into soil and rubs off the wood on to people or animals. Arsenic is also in the soil from smelters and some pesticides. Arsenic compounds are still used to make special glass, semi-conductors (gallium arsenide), some paints, dyes, metals, soaps, and drugs. Seafood can contain arsenic (although in a less-toxic form), as does drinking water in some locations

Arsenic and arsenic containing compounds are human carcinogens. Exposure to arsenic is mainly through intake of food and drinking water, food being the most important source in most populations. Long-term exposure to arsenic in drinking-water is mainly related to increased risks of skin cancer, hyperkeratosis and pigmentation changes. Occupational exposure is by inhalation which causes lung cancer.[6] Intake of 70 to 80 mg of trivalent arsenic (III) oxide has been reported to be fatal for man (WHO, 1987).Inorganic arsenic produces acute, sub acute and chronic toxic effects, which may be either local or system. Acute toxic effects include abdominal cramping, hyperesthesia in extremities in abdominal patellar reflexes and abdominal electrocardiograms.[7] Such effects generally occur at the levels of exposure equal to 50 ~ glkg weight/day. However, chronic poisoning of As includes anemia, liver - and kidney damage, hyper pigmentation and keratosis Le. Skin damage. Other effects of arsenic include peripheral vascular disturbances resulting in gangrene and a disease termed Black foots disease .In groundwater used as drinking water, arsenic concentrations ranged from 0.1–1340 μg L^{-1}, with 37% of the studied wells exceeding the WHO guidelines of 10 μg L^{-1} arsenic. Chronic arsenic poisoning is the most serious health risk for the ~ 2 million people drinking this groundwater without treatment, followed by malfunction in children's development through excessive manganese uptake. Government agencies, water specialists and scientists must get aware of the serious situation. Mitigation measures are urgently needed to protect the unaware people from such health problems. [8]

Mercury

Human are exposed to all forms of mercury through accidents, environmental pollution, food contamination, dental care, preventive medical practice, industrial and agricultural operations, and occupational. Mercury is in many consumer products, including: fluorescent light bulbs, electrical fixtures, auto switches, thermostats, medical equipment, and dental amalgam fillings. Mercury is also used in thermometers, although this use in many areas is being phased out in favor of non-mercury digital thermometers. The major sources of chronic, low level mercury exposures are dental amalgams and fish consumption. When we eat fish that contain mercury, it tags along and settles in our bodies. Mercury enters water as a natural of off gassing from earth‘s crust and also through industrial pollution. When mercury gets into water, bacteria convert it to toxic methylmercury, which builds up in fish. Generally population are not much effected by the methyl mercury, in certain cases high consumption of fish with high mercury concentration may attain blood levels associated with a low risk of neurological damage to adults. The safe daily intake of mercury as suggested by WHO is 43 ~ g. Since there is the high risk in fetus, pregnant women should avoid high intake of certain fishes like shark, swordfish, tuna fish taken from polluted fresh water.[9] The effect of Hg poisoning depends on its different forms. Maximum toxicity results due to methyl mercury or mercury vapor. Mercury toxicity includes neurological and renal disturbances. Mercury intake led to minimata disease, where liver accumulated substantial amounts of Hg. Fishes's contain more than 0.4 ppm Hg are unfit for human consumption. The critical urinary concentration of Hg has been suggested as 1 to 2 ~ g/ml. Minimata disease is characterized by symptoms of fatigue, loss of memory and concentration, tremours constrictionof visual field, cortical blindness, etc. Mercury passes through placental barrier and may cause intra-uterine death, fetal resorption and stillbirth. The alkyl derivatives are particularly phototoxic.[10]

Cadmium

Cadmium (Cd) has been in industrial use for a long period of time. Its serious toxicity moved into scientific focus during the middle of the last century. Food and cigarette smoking are the most important sources of Cd apart from water. Daily dietary intake of Cd ranges from 40 to 50 ~gl day. Cd accumulates within the kidney and liver over long time. Long-term low-level exposure leads to cardiovascular disease and cancer. It is known to primarily affect renal tubular function of reabsorbing protein, sugar and amino acids. Cadmium exposure in conjunction with Ca, Fe, Zn, protein, fat and vitamin D deficiencies, led to ostomalacia and bone fractures in postmenopausal women in polluted Jintsu valley, Japan commonly referred to as Itai-Itai disease. Cadmium can affect calcium, phosphorus and bone metabolisms in both industrial workers and people exposed to Cd in general Environment. [11]

Chromium

Average daily intake of chromium ranges between 100 and 300 ~g/day (). The harmful effects of Cr to human are mostly associated with its hexavalent form. Chromium toxicity includes liver necrosis, membrane ulcers and cause dermatitis by skin contact. Differentiation between the biological effects caused by Cr+6 and Cr+3 is difficult because after penetration through membrane the Cr+6 gets reduced into Cr+3 form. A similar has potent carcinogenic effects on human beings and other animals. [12]

Conclusion

Anthropogenic activities greatly influence the availability of heavy metals in the environment. Since heavy metals are not naturally degraded, they are progressively accumulated in plants and soil. Copper, Fe, Mn and Zn cause growth reductions at high concentrations, whereas Cd, Ni, Pb and Cr cause growth reductions at lower levels of accumulation. Heavy metals interfere with physiological processes such as gaseous exchange, CO2 fixation, respiration, and nutrient absorption and photosynthetic translocation. Heavy metal uptake is not linear in response to the increasing concentrations. Wide species variations are recorded for the accumulative efficiency for different heavy metals. The difference in metal accumulation is not correlated with tolerance to the heavy metal. Heavy metals pose a number of hazards to human health. Therefore their concentration in the environment and their effects on human health must be regularly monitored. More researches are required to understand the mechanisms Metal induced defense response at molecular level need to be worked out for understanding the cascade of chemical mechanisms of heavy metal tolerance.

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