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Review Paper

Lead Effects on Health

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Abstract

Lead is a highly poisonous metal affecting almost every organ and system in the body and introduced by transportation and other developmental activities. It is one of the oldest established poisons. Knowledge of its general toxic effects stretches back three millennia. Depending upon the exposure levels, lead is said to have both mild and adverse effects on the central and peripheral nervous systems, growth and development, cognitive development, behavior, hearing, sight, movement and muscular activities and digestive, excretory and cardiovascular systems. At the extreme, lead poisoning can even cause death of the individuals affected by it. An attempt has been made through this article to throw light on various sources of lead toxicity and its effects on human health based on the past work done in this area.

Keywords: Lead, human health, sources, toxicity.

Introduction

Our environment is filled up with a large number of toxicants in different forms. They contaminate our water, soil and atmosphere where we live. Most of the toxicants enter the human body either through a number of routs likes through drinks, breath, and food or by exposures which are responsible for ill effects on human health. Lead is one of those toxicants found in the earth's crust which is most commonly used in modern industries. Lead is a member of group IVB in the periodic table and has a melting point of 327^{o} C. Being purely toxic in nature, the lead has been extensively studied by various research workers. It is one out of four metals that have the most damaging effects on human health[1]. Lead is a relatively corrosion resistant, dense and malleable metal that has been used by humans for at least 5000 years. During this time, lead pollution has increased from an estimated 10 tons per year to 1,000,000 tons per year, accompanying population and economic growth[2]. Increase amount of lead creates major environmental health problem across the world. Lead is an important environmental contaminant because of its known toxicity to humans and other living organisms.

Lead is a well-known non-biodegradable toxic metal in the environment and has occupied a place in global health issues[3, 4]. Lead poisoning occurs when people are exposed to lead and chemicals that contain lead as breathing air, taking drinks such as water and milk, eating foods such as fruits, vegetables, meats, grains and seafood or touching dust or dirt that contains lead. In this paper, an attempt has been made to throw light on some of the aspects of lead effects on living organisms.

Sources of Lead

Lead is found in a variety of products of general use in day-to-day life. Thus, there are many sources of lead in our environment. Lead in paint and gasoline together accounts for most of the lead in the human environment. Another common source of lead is contaminated soil. Soil gets contaminated due to leaded gasoline and industrial operations like smelters. Some jewelry is made of lead and can pose a danger to children if they put the jewelry in their mouths. Adults working in the industries like battery manufacturing, pipe fitting, firing ranges, demolition, glass production, smelting operations etc. are more prone to be affected by lead. Drinking water may have lead in it, if permitted levels in municipal sources are not regulated carefully. The largest source of lead in drinking water occurs through leaching from lead –containing pipes, faucets and solder, which can be found in plumbing of older buildings. There is evidence that some soft vinyl lunch boxes may contain lead in the lining. The center for environmental health claims that there is a real risk to children. Combustion processes such as production of heat and electricity, primary and secondary production of lead, zinc, copper and nickel constitute as the major sources of lead in air. Household processes such as wood, oil and coal combustion are the medium sources of lead in air.

Lead levels are typically low in ground and surface water, but may increase once the water enters the water distribution system. The major sources of lead are discharged to water during primary and secondary zinc production, extraction and distribution of fossil fuels and geothermal energy and wastewater treatment. Inhalation and ingestion are potential routes of lead exposure in mining. Grinding and sintering operations generate high levels of lead dust and fumes[5]. Workers engaged in the reclamation of lead from secondary sources have potential exposure to lead as well as other metal contaminants. Exposure is a constant hazard in the manufacture of lead batteries. People engaged in paint and pigment production are exposed to lead, especially during fine spray-painting operations.

Lead and Human Health

Lead poisoning is an age old incidence. Lead is said to have both mild and adverse effects on the central as well as peripheral nervous system. It also affects growth and physical development, cognitive development, behavior, hearing, sight, movement and muscular activities together with digestive, excretory and cardiovascular systems. The severe lead poisoning can also lead to death.

Lead may be absorbed by the body through inhalation or ingestion. It can be transferred to the fetus through the placenta[5]. Inhalation and dermal contact are routes of exposure more typical of occupational settings, whereas the primary route of exposure for the general population is ingestion from minor amounts in food and hand to mouth activity, particularly in children. Adults absorb approximately 5-15 percent of ingested lead into the circulation; of this amount, less than five percent is retained in the body [6]. Young children can absorb considerably more (30-40%) of ingested lead; this explains their enhanced susceptibility to the potential effects of lead[6].

Lead has since long been one of the most intensely studied and researched toxicants, with thousands of studies conducted on its effects in both animals and humans. Not surprisingly, there are numerous effects that have been reported in the literature, including neurotoxicity, carcinogenicity, reproductive toxicity, and neurobehavioral/ developmental effects. While much of our knowledge on the effects of lead comes from experience involving excessive industrial or occupational exposure, the present challenge is to discern what effects occur, if any, at low, environmentally relevant levels. Neurotoxicity resulting from the overexposure of lead appears to be the most documented effect, particularly in occupational exposures. Manifestations of lead toxicity in adults consist of ataxia, memory loss, and at the highest levels, coma and death. Nerve conduction is reversibly slowed in peripheral nerves at blood lead level of approximately 40µg/dL[6].

Travish et al.[7] reported that lead poisoning is one of the most significant environmental health threats children face. The US Centre for Disease Control and Prevention has reported an elevated blood lead level in children as ≥10 µg/dl, on the basis of neurologic toxicity. The US Environmental Protection Agency suggests a threshold lead level of 20-40 µg/dl for risk of childhood anemia, but there is little information relating to lead levels < 40 µg/dl to anemia. Therefore, the authors have tried to examine the association between lead levels as low as 10 µg/dl and anemia in Indian children less than 3 years of age[8]. More than fifteen million children in developing countries are suffering permanent neurological damage due to lead poisoning[9]. The concentration, total amount consumed and duration of lead exposure influence the severity of health effects. Because the lead accumulates in the body, it's all sources should be controlled or eliminated to prevent childhood lead poisoning. Most of the lead entering the body is excreted in the urine, feces, sweat and as sloughing of dead cells of skin. Lead may also be found in breast milk. The lead that remains in the body tends to accumulate in bone where it can be stored for decades. Lead in bones can be released back into the blood long after the original exposure. It disrupts the function of enzyme systems that use other metals such as calcium, zinc and iron. The combustion in vehicles of petrol containing ant knocking additive lead has become a major source of atmospheric lead[10]. Mahaffey et al.[11] reported blood lead concentration of 13.9 and 16.5 µg/g/dl in the children residing in the rural and urban areas, respectively.

According to Chisolm[12], in the young children of urban slums lead poisoning is a major source of brain damage, mental deficiency and serious behavior problems. The condition is difficult to diagnose, often unrecognized and until recently it was largely ignored by physicians and public health officials. Now public attention is finally being focused on childhood lead poisoning, although the difficult task of its eradication has just begun. Symptomatic lead poisoning is the result of very high levels of lead in the tissues. Among the natural substances that man concentrates in his immediate environment, lead is one of the most ubiquitous.

Environment pollution is a wide-reaching problem and its likelihood of influencing the health of human populations is great[13]. Far reaching effects of environment pollution in perspective of air, water and land waste pollution on human by diseases and problems, animals and trees have greatly been emphasized. According to author[13], still time is left in the hands of global institutions, governments and local bodies to use the advance resources to balance the environment for living and initiates the breathed intellectuals to live friendly with environment. The polluted environment is global issue and world community would bear its worst results if no attempts are taken to make the environment free from pollution of various kinds. An effective response to pollution is largely based on human appraisal of the problem and voluntary participation of people towards its control. Education, research and advocacy are lacking in the region as preventive strategy for pollution in Asia. At present, the adoption of auditing in any economic sector is voluntary but future legislation could well make it mandatory and still time is available to use technology and information for environmental health decision. Policymakers in developing countries like India still need to carefully adopt available knowledge from other settings, keeping in mind the differences in pollutant mixtures, concentration levels, exposure patterns and various underlying population characteristics.

Willoughby and Wilkins[14] opined that the lead content of the blood under normal and pathological conditions is of particular interest in relation to its absorption and excretion. The analysis of blood specimens from 189 individuals, who gave no history of previous undue lead exposure and who exhibited no positive clinical symptoms of lead poisoning, revealed the amount of lead to range from 0.00 to 0.09 mg of per 100 g of blood with a most probable value of 0.025 ± 0.002 mg of lead. Although the most probable blood lead concentration in their cases was considerably less than 0.09 mg of lead per 100 g of blood, it was concluded in agreement with the general consensus that values of this magnitude, as well as 0.10 mg, may occasionally occur without indisputable clinical evidences of plumbism.

Selander and Cramer[15] determined the lead in blood by atomic absorption spectrophotometry, using a ashing procedure and a procedure in which the proteins were precipitated with trichloroacetic acid. Spectral analysis is considered to be the most exact of all existing methods for the determinations of lead. The present comparison demonstrated that the much simpler and less expensive equipment for atomic absorption spectrophotometry can give almost identical results. The two AAS methods gave identical results, so that determination of lead in blood does not require ashing of the samples, in contrast to the determination of lead in urine.

Dinius et al.[16] studied the effect of subclinical lead intake on calves. Grazing of pastures near lead industries and along heavily travelled roadways resulted in elevated rates of lead ingestion. Sixteen bull calves were fed a 70% concentrate diet containing no added lead, 10 ppm lead from newsprint, or 10 and 100 ppm lead from lead chromate. At the end of the 100-day feeding trial, the calves were sacrificed and samples of skeletal muscle, cerebral cortex, liver and kidney were collected for lead analysis. Supplemental lead did not affect feed consumption or weight gain; however, newsprint depressed both intake and gain. Neither EKG patterns, heart rate nor respiration rate were affected by dietary treatment. The percentage of ingested lead excreted in feces and urine was not significantly different among treatments. There were no significant tissue accumulations of lead from feeding newsprint or 10 ppm lead chromate; however, feeding 100 ppm lead chromate resulted in accumulations of the element in liver and kidney. Microscopic examination of cortex did not reveal any change in the cellular ultrastructure neither in control nor in treated animals.

Clausen and Rastogi[17] investigated lead contents among autoworkers in Ireland of Denmark and reported an increased blood lead level in these workers. About 59 % workers have 80 µg/dL blood lead level. It was also reported that raised lead values were maximum among diesel engine workers who are exposed to high pressure resistance lubricants containing lead naphthenate.

Howard and Sledzinski[18] studied the geochemical behavior of lead in an Alfisol and Ultisol at high levels of contamination. The behavior of lead in the A and B horizons of an Alfisol from Michigan and an Ultisol from Virginia was studied to determine the effects of shock loading. Combined sequential extraction-sorption isotherm analysis (CSSA), a relatively new and little tested method, was used in the study. After spiking to stimulate severe contamination (3000-60,000 mg/kg), CSSA revealed unexpectedly high levels of exchangeable lead in the A horizon of the Alfisol and in both horizons of the Ultisol, and showed that the sorption capacities of the phases commonly responsible for fixation of Pb at low to moderate levels of contamination exceeded. Carbonate sorbed the bulk of the lead in the Alfisol B horizon and has a high sorption capacity in both soils, despite the presence of other phases with a strong affinity for lead. Thus, when shock loading occurs (e.g.at a shooting range or dump sites), the highly contaminated A horizons of both soils are expected to pose a serious toxic hazard to humans, and groundwater contamination is possible in association with the Ultisol. CSSA proved useful for determining the sorption capacities of the individual phases while together in natural soil system and therefore is a valuable method for predicting the attenuation capabilities of soils.

Hernandez et al.[19] found a strong relationship between whole blood lead and plasma lead levels in environmentally exposed adults. In addition, they found a strong relationship between bone lead and plasma lead concentrations and patella bone lead retained an independent influence on plasma lead as well as on the plasma–whole–blood ratio after adjusting for whole blood lead levels. This independence of the bone lead – plasma lead association from whole – blood lead levels was consistent with the potential role of the skeleton as important endogenous sources of labile lead that may not be adequately discerned by examining whole - blood lead levels. It also indicated that skeletal sources of lead accumulated from past exposures should be considered along with sources of current exposures when exposure pathways are being evaluated. Finally, the findings of this study may have great importance in terms of public health. Given the lack of an agreed-upon threshold for lead's neurotoxic effect, a fetotoxic effect may in fact be operative even among women with relatively low blood lead levels but a high bone lead burden. Thus, current regulations governing occupational exposure to lead may not adequately protect women who may become pregnant.

Jaradat and Momani[20] carried out the comparative study for contamination of roadside soil, plants and air with heavy metals in Jordan. Copper, lead, cadmium and zinc levels were analyzed by atomic absorption spectrophotometry in surface soil, plants and air samples taken from both sides of the major highway connecting Amman with the southern parts of Jordan. Elevated levels of the studied elements were found in both soil and plants on the east side and on the west side of the road compared with the background values. The higher levels of heavy metals east of the road were due to the westerly prevailing wind at the sampling sites. The contamination decreased exponentially with distance from the edge of the road and dropped to the background level at about 60 m. In soil samples, the average concentrations 1.5 m east of the highway were 29.7, 0.75, 188.8 and 121.7 µg/g for copper, cadmium, lead and zinc, respectively. The levels of these elements in plants 3 m east of the highway were 31.3, 7.3 and 98.7 µg/g for copper, lead and zinc, respectively; whereas for air they were 0.40, 0.94 and 0.26 $\mu g/m^3$. The values of the heavy metals suggest that automobiles are a major source of these metals in the roadside environment and also these values were compared with results found by other investigators in various countries worldwide. Finally, the roadside soil and plants had significantly high contents of heavy metals and their levels increased with increasing traffic densities and, furthermore, they reached elevated levels in urban areas.

Conclusion

Although lead is useful in the society, yet it can cause several unwanted effects such as a rise in blood pressure, kidney damage, brain damage, declined fertility of men through sperm damage, diminishing learning ability of children and behavioral disruption of children, etc. Since increased human activities enhance the amount of lead into the environment, it is recommended to know the lead amount in various important cities so that proper preventive measure can be taken up to reduce the adverse effect of lead on environment and human being. Government should come forward to implement risk management principles to minimize lead exposure in the home, community and work place. Better management of known sources of pollution in cities will decrease the average blood lead levels. The degree to which the whole blood lead level reflects liable toxic fraction of lead in the circulation is not well known, though it has been suggested that plasma lead provides a more kinetically responsive and toxicologically relevant marker of lead than whole-blood lead[21,22]. Lead will continue to be an important public health concern and hence people should be aware about the lead poisoning and there should be check in the lead source.

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