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Toxicity of Lead in Drinking Water

Aqsa Nazaqat* **and Nadia Noureen**

Department of Environmental Science, University of Punjab, Punjab, Pakistan

***Corresponding author:** Aqsa Nazaqat, Department of Environmental Science, University of Punjab, Punjab, Pakistan, Tel: 3033810638; Email: aqsarao120@gmail.com

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Abstract

Lead (Pb) particles that detach from the plumbing and contaminate drinking water can pose a significant health threat, which is often underestimated. Because lead is a persistent metal, it is still present in the environment in water, brass plumbing fittings, soil, dust, and imported products manufactured with lead. Diagnosis of lead toxicity has traditionally been based on significantly elevated blood lead levels. Data now implicates low-level exposures and blood lead levels previously considered normal as causative factors in cognitive dysfunction, neuro behavioral disorders, neurological damage, hypertension, and renal impairment. Issues surrounding the assessment of body lead burden and the consequences of low-level environmental exposure are critical in the treatment of chronic disease related to lead toxicity.

Keywords: Toxicity; Lead; Environmental exposure

Introduction

Toxic heavy metals

Heavy metals become toxic when they are not metabolized by body and accumulate in the soft tissues [1,2]. Heavy metals by enter the human body through food, water, air or absorption through skin when they come in contact with humans in agriculture and in manufacturing, pharmaceutical, industrial [3]. Ingestion is the most common route of exposure children [4]. The common heavy toxic metals are arsenic, lead, mercury, cadmium, iron and aluminum [5-9]. All these metals are highly toxic, but in this review we discuss more about lead and its toxicity in drinking water [10].

Characteristic nature of lead

Lead is common heavy metal. It accounts for that 13 mg/kg of earth's crust [11]. Physically it is soft metal [12]. Its melting point is 327°C. Several stable isotopes of lead exist in nature, including in order of abundance, 208 Pb, 206 Pb, 207 Pb, and 204 Pb [13]. Lead is a pervasive environmental contaminant [14]. Lead is relatively corrosion resistant, dense, and ductile, mellable metal that has been used by humans for at least 5,000 years [15]. During this time, lead production has increased from an estimated 10 tons per year to 1,000,000 tons per year, accompanying population and economic growth [16].

Literature Review

Major uses of lead

Lead is used in the production of lead acid batteries, solder, alloys, cable sheathing, pigments, rust inhibitors, glazes, and plastic stabilizers [17]. Pigments, rust inhibitors, ammunition, glazes and plastic stabilizers [18]. Tetraethyl and tetramethyl lead are use as antiknock compounds in petrol in North America and Western Europe [19]. From a drinking-water perspective, the almost universal use of Lead compounds in plumbing fittings and as solder in water distribution systems is important [20].

Concentration of lead in environmental levels

Air: Concentration of lead in air depend upon a number of factors, including proximity to roads and point sources [21]. Annual geometric mean concentrations measured at more than 100 stations across [22].

Canada declined steadily from 0.74 µg/m in 1973 to 0.10 µg/m in 1989, reflecting the decrease in the use of lead additives in petrol [23]. If an average concentration in air of 0.2 µg/m^3 is assumed, the intake of lead from air can be calculated to range from 0.5 µg/day for an infant to 4 µg/day for an adult [24].

Food: Prepared food contains small but significant amounts of lead [25]. Lead content is increased when the water used for cooking or the cooking utensils contain lead 0r the food, especially if acidic, has been stored in lead-ceramic pottery ware or lead soldered cans [26]. A number of estimates based on figures for per capita consumption have been made of the daily dietary lead intake, for example, 27 µg/day in Sweden [27]. Intake of lead, cadmium and certain other metals *via* a typical Swedish weekly diet [28]. In some countries, dietary intake as high as 500 µg/day have been reported [29]. The regular consumption of wine can also result in a significant increase in lead intake; an average level of 73 µg/l has been reported [30].

Water: With the decline in atmospheric emissions of lead since the introduction of legislation stop its use in fuels, water has assumed new importance as the largest controllable source of lead exposure In the USA [31]. Lead is present in tap water to some extent as a result of its dissolution from natural sources, but primarily from household plumbing systems in which the pipes, solder, fittings or service connections to homes contain lead. Polyvinyl Chloride (PVC) pipes also contain lead compounds that can be leached from them and result in high lead concentrations in drinking-water. The amount of lead dissolved from the plumbing system depends on several factors, including the presence of chloride and dissolved oxygen, pH, temperature, water softness and standing time of the water, soft, acidic water being the most plumb solvent. Although lead can be leached from lead piping indefinitely, it appears that the leaching of lead from soldered joints and brass taps decreases with time. In 1988, it was estimated that a lead level of 5 µg/l was exceeded in only 1.1% of public water distribution systems in the USA (US Environmental Protection Agency, Federal register, 1988. A more recent review of lead levels in drinking-water in the USA found the geometric mean to be 2.8 µg/l. A recent study in Ontario (Canada) found that the average concentration of lead in water actually consumed over a 1-week sampling period was in the range l-1 µg/l-30.7 µg/l, with main median level of 4.8 µg/l. If a concentration and dust. At 5 µg/l, the average daily intake of lead from water forms a relatively small proportion of the total daily intake for children and adults, but a significant one for bottle-fed infants.

Other sources of lead

For children, soil and household dust are significant source of lead, but the levels are highly variable, ranging from 5 µg⁄g to tens of milligrams per gram in contaminated areas. The highest lead concentration usually occurs in soil surface at depth of 1 cm-5 cm.

The level of lead remains unchangeable in soil unless action is taken to decontaminate. In a 2-year study in England during 1984 and 1985, the geometric mean concentrations of lead in road dust collected in the vicinity of two London schools and in a rural area were 1552-1881 and 83 µg/g-144 µg/g, respectively. Household dust concentrations were 332 µg/g in an Edinburgh study and 424 µg/g in one in Birmingham. The amount of soil ingested by children aged 1-3 years is about 40 mg/day-55 mg/day. Studies in inner-city areas in the USA have shown that peeling paint or dust originating from leaded paint during removal may contribute significantly to children's exposure to lead.

Absorption of lead in human body

Adults absorb approximately 10% of the lead contained in food, but young children absorb 4-5 times as much (the gastrointestinal absorption of lead from ingested soil and dust by children has been estimated to be close to 30%. When dietary intake of iron, calcium and phosphorus are low, the absorption of lead is increased. Through red blood cells, lead is transferred from intestine to various tissues. In red blood cells, lead is primarily bound to hemoglobin and has special affinity for the beta, delta and in particular, fetal gamma chains The half-life of lead in blood and soft tissue is about 36-40 days for adults. In humans, lead is transferring through placenta to fetus as early as 12 weeks of gestation and fetus uptake it continuous through its development.

Effects on Human

Lead is a cumulative general poison, with infants, children up to 6 years of age, the fetus and pregnant women being the most vulnerable to adverse health effects. Its effects on the central nervous system can be particularly serious.

Acute and long term exposure

The signs of acute intoxication are dullness, restlessness, irritability, poor attention, headache, abdominal cramps, kidney damage, loss of memory and occur at blood lead levels of 100 µg/dl-120 µg/dl in adults and 80 µg/dl-100 µg/dl in children. Signs of chronic lead toxicity include tiredness, sleeplessness, joint pain and gastrointestinal symptoms may appear in adults at blood lead levels of 50 µg/dl-80 µg/dl. Due to lead poisoning, renal diseases occur in human. The concentration of lead complex protein in blood in the proximal tubular epithelial cells 40 µg/dl-80 µg/dl, and it damage kidney include acute proximal tubular dysfunction.

Reproductive effect

Gonadal dysfunction in men, including depressed sperm counts, has been associated with blood lead levels of 40 µg/dl-50 µg/dl. Reproductive dysfunction may also occur in female occupationally exposed to lead. Epidemiological studies have shown that exposure of pregnant women to lead increases the risk of preterm delivery, at blood lead levels above 14 µg/dl.

Mutagenicity

Cytogenetic studies in humans exposed to lead (blood lead levels >40 µg/dl) have given conflicting results; chromatid and chromosomal aberrations, breaks and gaps (International Agency for Research on Cancer, 1980).

Neurological effects in infants and children

A number of cross-sectional and longitudinal epidemiological studies show the possible detrimental effects of lead in young children on their intellectual abilities and behavior.

Toxic effect of lead on renal system

Lead nephropathy has been well documented in occupationally exposed workers. It reveals as proximal tubular damage, glomerular sclerosis, and interstitial fibrosis. Signs include proteinuria, impaired transport of glucose and organic anions, and lowered Glomerular Filtration Rate (GFR) Classically, renal insufficiency is found in acute lead toxicity and is accompanied by abdominal pain (lead colic), cognitive defects, peripheral neuropathy, arthralgia's, anemia with basophilic stippling, a "lead line" at the junction of the teeth and gums, and high PbBs>80 µg/dL. However, there is significant evidence that renal damage occurs at much lower expo-sure levels in the general population and occur a strong relationship between blood lead levels and a decline in renal function associated with age in study populations not occupationally exposed In a prospective trial, EDTA-mobilization tests demonstrated that chronic low-level lead exposure is related to chronic renal insufficiency. The trial revealed a significant relationship between blood lead levels, body burden as diagnosed by EDTA mobilization, and GFR. An elevated body lead burden was defined as 600 µg urine lead in a 72-hour collection after infusion of 1 g calcium disodium EDTA.

Analytical Method

The methods that was frequently used for determining levels of lead in environmental and biological materials are atomic absorption spectrometry and stripping voltammetries. Detection limits of less than 1 µg/l can be achieved by means of atomic absorption of spectrometry. Because corrosion of plumbing a systems is an important source of excessive lead in drinking water, lead levels in water should be measured at the tap, rather than at the drinking-water source, when estimating human exposure.

Prevention and Control

Lead is remarkable in that most lead in drinking-water arises from plumbing in buildings, and the remedy comprises principally of removing plumbing and fittings containing it, which requires both time and money. In the interim, all practical measures to reduce total exposure to lead, including corrosion control should be implemented. It is extremely difficult to achieve a concentration below 10 µg/l by a central conditioning such as phosphate dosing.

Conclusion

Lead is associated with a wide range of effects, including various neurodevelopmental effects, mortalities (mainly due to cardiovascular diseases), impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes. It needs to be recognized that lead is exceptional, in that most lead in drinking-water arises from plumbing in buildings, and the remedy consists principally of removing plumbing and fitting containing lead, which requires much time and money. It is therefore emphasized that all other practical measures to reduce total exposure to lead, including corrosion control should be implemented. A specific procedure must be used collect samples and a certified laboratory should be used for testing the presence of lead in drinking water and its possible source. A water test is the only way to determine the lead concentration. If drinking water exceeds the EPA lead standard of 15 ppb, steps can taken voluntarily to reduce the risk. Options include removing the lead source, managing the water supply used for drinking and cooking by flushing with high concentration from the water system, using water treatment equipment or using an alternative water source.

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