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Research Paper

Study of Lead Levels in Soil, Mother's Milk And Children Blood Near the Site of Proposed Beneficiation Plant, Rajasthan, India

Healthcare

KEYWORDS : Biological monitoring, lead, soil, mother's milk.

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ABSTRACT

Study of lead levels in soil, mother's milk and children blood was carried out in the vicinity of proposed beneficiation plant site and nearby villages. The beneficiation plant is to be set up for beneficiation of ore to produce separate copper, zinc and lead concentrates, from which the copper, lead & zinc metals will be extracted at smelter. Since lead is an important metal, the study was focused on lead estimation only. Mean blood lead levels were found to be 1.69 ± 0.37μg/dL. Mean lead in mother's milk and soil were found to be 24.68 ± 4.82 ppb and 59.60±18.89 ppm respectively. Lead levels in blood, mother's milk and soil were found to be within the safe levels reported in the literature.

INTRODUCTION

Lead is a naturally occurring element that has been found in earths crust and all compartments of the biosphere. Although both natural and anthropogenic processes are responsible for the distribution of the lead throughout the environment, anthropogenic release of lead is predominant. Due to ban on lead in gasoline which was earlier primary source of anthropogenic atmosphere for release of lead, industrial releases to soil from non-ferrous smelters and other lead based sources are now major contributors to total lead exposure[1]

The general population is exposed to lead in ambient air, in many foods, in drinking water, in soil, and in dust [1].

The main target for lead toxicity is the nervous system, both in adults and children. It may also cause weakness in fingers, wrists, or ankles. Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people and can cause anemia. Exposure to high lead levels can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. High-level exposure in men can damage the organs responsible for sperm production.

Small children are exposed by eating lead based paint chips, chewing and sucking lead painted or used toys, swallowing house dust, soil that contains lead. Children are more vulnerable to lead poisoning than adults. A child who swallows large amounts of lead may develop blood anemia, severe stomachache, muscle weakness, and brain damage. If a child swallows smaller amounts of lead, much less severe effects on blood and brain function may occur. Even at much lower levels of exposure, lead can affect a child's mental and physical growth. Exposure to lead is more dangerous for young and unborn children. Unborn children can be exposed to lead through their mothers. Harmful effects include premature births, smaller babies, and decreased mental ability in the infant, learning difficulties, and reduced growth in young children. These effects are more common if the mother or baby was exposed to high levels of lead. Some of these effects may persist beyond childhood [1].

Lead exposure occurs mainly through the respiratory and gastrointestinal (GI) tracts. Approximately 30-40 percent of inhaled lead is absorbed into the bloodstream [2].We are all exposed to small amounts of lead from before birth (from our mother's blood through the placenta) and every day of our lives after birth from pollution in the air, water, soil, and home environment. If we also are exposed to lead on the job, the risk of health damage increases. We should have regular lead tests and be able to interpret these tests if we work with lead. Owing to its unique nutritional and immunological characteristics, human milk is the most important food source for infants. Breast milk can, however, also be a pathway of maternal excretion of toxic elements such as lead [3].

Apart from contributions from maternal sources during pregnancy such as from the skeleton [3, 4], other potential lead sources for the infant are mainly dietary, that is, from breast milk, infant formulae and baby foods. Recently, it has been shown [3] that there was an increased and sustained mobilization of maternal skeletal lead during lactation compared with during pregnancy, from which arises the question: *Are the infants at more risk from breast feeding than from formula feeding?*

In 2004, the National Toxicology Program's Report on Carcinogens1 listed "Lead and Lead Compounds as "R" (reasonably anticipated to be human carcinogens). Two lead compounds, lead phosphate and lead acetate have been listed as "R" since the early 1980s. Now there is enough data from human and animal studies on many lead compounds to list them all [5].

Importance of studying lead levels in soil, blood and mothers milk

Normal behavior in young children makes them more likely to find and swallow lead if their surroundings are contaminated, particularly with lead dust or lead contaminated soil. The contamination of this soil may produce the pollution and hazards. Hence assessment of lead concentration in soil gives lead levels of exposure. Measurement of lead in blood gives the current exposure and is most widely used biomarker of lead exposure . Pregnant and breast – feeding women can pass lead on to their babies. Care must be taken to avoid or reduce exposure to lead during pregnancy and breast – feeding. As women's bodies change during pregnancy, previously stored lead can be released from the bones and affect the health of the developing fetus. There is evidence that lead can increase the risk of pre-term delivery, low birth weight, miscarriage and stillbirth. Hence it is necessary to measure lead levels in breast milk of the women [6].

Lead- Zinc mines which are considered as stationary emission sources have the potential of lead exposure to the people staying in the vicinity of mines. People residing in the vicinity of mines, specially, children, old people and pregnant women have highest risk of health effects from lead exposure. Hence, it is essential to carry out environmental assessment for collecting base line data related to environmental and biological monitoring of the residents before the starting mines and/or their beneficiation plants.

Mineral Beneficiation

The ore production from three mines will be transported by road to common beneficiation plant for treating the ore. The plant will be set up for beneficiation of ore to produce separate

copper, zinc and lead concentrates, from which the copper, lead & zinc metals will be extracted at smelter. The capacity of beneficiation plant will be to treat 2000 tons per day (TPD) ore.

METHODS AND MATERIALS

Scientists of the institute visited village where beneficiation plant is to be set up and discussed the project with the management to explore the possibility of collecting biological samples from village where beneficiation plant is proposed and nearby villages to assess possible health risk due to lead exposure. They met Locals, School teachers, Primary Health Centers, and other concerned officers for the co-operation in this project. They explained the objectives of the study to all participants and received their written consent and willingness for giving blood and breast milk samples. Soil samples were randomly collected.

24 mother's milk samples, 22 children blood samples and 9 soil samples were collected and were transported to NIOH, Ahmedabad.

4 ml venous blood was collected taking due precautions in heparinised vacuette for lead estimation. Mother's milk samples (5 ml. each) were collected with the help of Nurses of Primary Health Centre (Govt. of Rajasthan) using breast pump.2ml of whole blood was digested in wet digestion system (Ethos 1600, advanced Microwave lab station made of Italy) using a mixture of 2ml of nitric acid (Ultra Pure) and 0.2ml hydrogen peroxide. Final volume was made to 4ml using triple distilled water and centrifuged [7]. Mother's milk samples were digested in the same way. The clear solutions of blood and milk digested samples were analyzed by graphite furnace Atomic Absorption Spectrophotometer (GF-AAS, Model 800 Perkin-Elmer make), to estimate the lead levels in samples.

Soil samples were collected in the polythene bags as per standard method. Soil samples were sieved and 2.0±0.02grams of soil samples were wet digested using 4 ml of concentrated nitric acid (HNO_3) and 5.0 ml of distilled water on a hot plate at the temp of 60C and sample was evaporated to dryness. Then the sample volume was made to 10ml using triple distilled water. Aliquots were analyzed by GF-AAS after the calibration of the instrument. Instrument, Atomic absorption spectrophotometer with graphite furnace (GF-AAS) was calibrated using lead standards of different concentrations using NIST certified standard reference materials (SRM).

RESULTS AND DISCUSSION

Table-1 shows that mean blood lead level (BLL) of children (between the age of 7 years to 12 years) is 1.69 ± 0.37 with the range of 0.40-6.19 µg/dL. As such there are no safe levels of lead in blood but in US normal blood lead levels in adults are less than 20 µg/dL as reported by U.S. National library of Medicine and National Institute of Health-Medline Plus. [8]. Joel et al (1999)[9] also considered blood lead level greater than 20 µg/dL as elevated which indicates that Blood lead level of less than 20 is in the normal range. Further, EPA considers blood lead level of 25 as elevated [10]. Ranjana et al [11] reported that blood lead levels (BLL) in exposed children residing near a mine were 7.7µg/dL for boys and 8.56 µg/dL for girls while in the comparative group the mean BLLs in boys were 6.12 µg/dL and 4.63 µg/dL in girls. Mean BLLs for the exposed group of children were less than10 µg/dL, which was considered as a normal value for children as per the CDC [12], USA. Bhagia et al reported BLL of 9.25µg/dL in children residing near a proposed mine [13].

Pre-industrial blood lead levels of Native Americans living in the United States 700-1,000 years ago are estimated to have been 0.016 µg/dL [14, 15].These levels are 50-200 times lower than those currently reported in individuals living in remote regions of the Himalayas with no known lead exposure (0.78-3.2 µg/dL).On the other hand, children with lead dust or soil dust exposure can have blood lead levels as high as 90 µg/dL [14, 15].

Measuring blood lead is the most commonly accepted and verifiable biomarker for lead exposure. Lead is unique as a toxicant in that there is agreement among the CDC, the Agency for Toxic Substances and Disease Registry, and the Environmental Protection Agency that there is no toxic threshold for lead. This means there is no measurable level of lead in the body below which no harm occurs. Current excessive exposure guidelines developed by the CDC and the American Pediatric Association (APA) consider blood levels ≥10 µg/dL to be excessive for infants, children, and women of childbearing age [15, 16].

Mean blood lead levels in the United States have dropped significantly since federal regulations decreased production of leaded gasoline and lead containing paints. Between 1976 and 1980, children ages 1-5 years had a median blood lead level of 15.0µg/dL [15, 17]; by 1999 the median blood lead level had dropped to 1.9 µg/dL. There are still 454,000 children in the United States with blood lead levels greater than 10µg/dL [15, 18].

Lead causes devastating effects on children including retardation, hearing loss, and kidney damage depending on the amounts the child takes in. The effects that occur at the lowest doses are subtle effects on mental acuity. Studies have shown a measurable reduction in IQ in children whose blood lead levels are at10 µg/dL. For years, experts thought that reduction of mental acuity probably occurs at even lower lead levels. Now this has been shown to be true [5].The values of lead in children blood in our study are in the safe range as per CDC [12].

Table 1 about here

Table-1 also shows mean lead levels in mother's (between the age of 20-40 years of age) milk is 24.68±4.82 ppb. There are no national and international standards for lead in mothers' milk. Therefore, the values were compared with the values reported in literature. As reported by Somogyi et al (1993) [19],lead levels in mothers' milk of various countries are in the range of 0.0-41.1 ppb.

More studies on lead concentrations in breast milk in rural areas of different countries are presented in Table-2.

Table 2 about here

It can be seen that mean lead concentrations in breast milk varies from 2.8-84 ppb. Results of the mother's milk samples collected from plant site and nearby villages are comparable with the values reported around the world (Table-2).

Table 3 about here

Table–3 depicts the lead levels in soil samples collected from plant site and nearby villages. The lead concentration in soil samples varies from 7.12 to 152.00 ppm with a mean of 59.60±18.89 ppm. However, lead concentration in samples collected from the proposed site is 126.88±13.00 ppm whereas the lead concentration in samples collected from nearby villages is 25.96±6.97 ppm. Bhagia et al reported 83.74 ppm lead in soil in nearby villages of a proposed mine in Rajasthan[13]. Berlin [28] digital environmental atlas reports the lead levels in various use categories like garden, house yard, agriculture, horticulture, sewage firm, forests, green spaces, playgrounds and other uses varied from 32-228 ppm. A study of correlation between lead in soil and lead in blood serum showed that when the soil content of lead exceeded about 500 ppm, it could affect children's blood lead levels. Much of this effect came from young children (below age 5) getting soil in their mouths while playing. In several countries, lead standards have been adopted for residential land use. Generally, a maximum soil concentration of 500 ppm has been adopted. In Canada, a lower level of 375 ppm was adopted for sandy soils only [29, 30]. If a very small child were exposed to soil having a lead concentration of 140 ppm for 24 hours a day, 365 days a year there would be no effect on blood lead levels. The United States Environmental Protection Agency (USEPA) considers soil lead levels up to 400 ppm as 'requiring no action'. Soil lead levels between 400-1200 ppm are considered a 'level of concern' [31]. An acceptable level of 600 ppm of lead in soil suggested as a "safe" level would contribute no more

than 5 micrograms/dl to total blood lead of children under12 years of age [32]. Lead in soil samples collected from plant site and nearby villages (Table-3) is lower than the values reported in literature.

CONCLUSIONS AND RECOMMENDATIONS

This preliminary study describes the analysis of lead levels in soil, mother's milk and blood samples collected from village where the beneficiation plant is to be set up and nearby villages. The objective of the study was to collect baseline data of these parameters before the commissioning of beneficiation plant. The results suggest that the levels of lead in blood and mother's milk in rural areas are in the safe range and comparable with the values reported around the world for rural areas. Lead in soil from plant site and nearby villages is also comparable with the values reported in literature and is in the safe range. It is recommended that regular monitoring of all the parameters studied should be carried out after the plant starts operating.

Table-1 Lead in children blood and mother's milk samples.

	BLOOD (µg/dL)	MOTHER'S MILK (ppb)
MEAN ± SE	1.69 ± 0.37	24.68 ± 4.82
SAMPLE SIZE (N)	22	24
RANGE	0.40-6.19	2.39-81.54

Table-2 Reported Lead concentrations (ppb) in breast milk of rural areas.

COUNTRY	LEAD (ppb)	COMMENTS
Italy	45.6	Rural[21]
--	20.0	Rural areas[22]
--	16.0	Rural areas
Germany	12.5	Rural, colostrum[23]
	8.0	Rural, Mature
Greece	84	Rural[24]
Guatemala	2.8	Rural[25]
Nigeria	4.1	Rural[25]
Philippines	17	Rural[25]
Zaire	6.0	Rural[25]
Australia	0.73	Gulson et. al. (1998)[26]
Malaysia	21.1	Rural[27]

Source: José G. Dorea [20]

Table-3 Lead in soil samples (ppm).

Site (N)	MEAN ± SE (Range)
PLANT SITE (3)	126.88±13.00 (108.63-152.00)
Nearby villages (6)	25.96±6.97 (7.12-56.91)
Combined (9)	59.60±18.89 (7.12- 152.00)

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