Risk analysis of a populated area near tailings wastes

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Abstract

In the last years, there has been a large population growth in the contaminated area adjacent to the old Avalos Foundry in the city of Chihuahua, located in the State of Chihuahua, Mexico. This represents a public health risk, which is why the concentrations of Pb in the soil were analyzed, and the risk for the infant population was estimated using the IUEBK model (US EPA). Three exposure scenarios were considered based on Pb concentration in the soil: maximum (A), medium (B), and minimum (C). Ninety percent of the soil samples are over the admissible level of Pb for residential use and eighty-five percent is above the level for the industrial use. The Pb concentration in blood in scenario A was 79.9µg/dL, in scenario B 16.68µg/dL, and in scenario C 9.2µg/dL. These represent a high public health risk and that is why it is necessary to reduce the levels of Pb in the soil to minimize the risk and take preventive measures and control of the exposure of the inhabitants of the area.

Introduction

The most common potentially toxic elements derived from mining processes in Mexico are, Pb, Cd, Zn, As, Se, and Hg (Gutierrez and Moreno, 1997). Pb and Cd are the contaminants found more frequently in the mining areas in Mexico (Velasco et al., 2004). As a consequence of its extended use, today Pb can be found in our bodies at higher levels than in the past, these levels can cause adverse effects in the health of adults and especially in children. As neurological damages caused by Pb have been detected at levels of exposure that were considered harmless before (<10µg/dL) (ATSDR, 2007); a minimum threshold for Pb that indicates the beginning of adverse neurological effects in children may be difficult to establish.

The Avalos Mineral and Foundry processing plant was established in the southeast area of Chihuahua City in Mexico, beginning activities in 1908. In the 1950s this company was considered as one of the most important in Latin America and then at an international level. The company closed in 1993 and in the last years of operation it produced around 250 tons daily of Pb (Ornelas et al., 2007).

In the past 5 years the population growth has incremented in the area adjacent to tailings wastes of the company, representing a public health risk. This is why the objective of this study was to perform a risk analysis for the infant population in this area, using the program IUEBK (Integrated Exposure Uptake Biokinetic Model for Lead in Children Version 1.1.) (EPA, 2010).

Materials and Methods

Sampling and soil characterization. The sampling was performed according to the criteria of the Norma Técnica Mexicana 132 (Mexican Technical Norm 132) in the area adjacent to the tailings dams of the company. 39 samples were collected from an area of approximately 60 ha. These samples were extracted at a depth of less than 10 cm and were taken to the laboratory for analysis (Image 1).

Determination of Pb concentration in the soil. To obtain the total Pb the procedures of the Norma Official Mexicana 147 (Mexican Official Norm 147) were performed.

Figure . Location of sampling points of the area according to NMX 132**.**

Risk Analysis. The risk analysis was developed according to the model IUEBK (EPA, 2010) which allows estimation of the Pb concentration in blood of infants. For this study 3 scenarios were considered (maximum (A), medium (B) and minimum (C)) derived from the actual Pb concentration of the soil in the corresponding area recently populated (15 ha Triangle in Figure 1). Data of soil quantities ingested by children in Latin American countries, suggested by Diaz-Barriga as ideal for Mexico were considered (350 mg/day) (Diaz-Barriga, 2000). Results of lead concentration in air obtained recently from a study of air quality in the Avalos area were considered (0.03µg/m^3) (Campos et al., 2009).

Results

Total Pb Concentration in the soil. The area of the populated zone shows Pb concentrations in the range 103 to 18,201 mg/kg. 90 % of the samples are above the admissible level of the NOM 147 for residential use (400 mg/kg) and 85 % is above the level for industrial use (750 mg/kg) (Figure 2).

Risk Analysis. In scenario A the concentrations of Pb in blood were estimated at 72.7µg/dL for children from 6 to 7 years old up to 98.6µg/dL for children under 1 year of age, geometric mean 79.94µg/dL (Table 1). With these levels of Pb in blood the children could show: Bad muscular development, lack of coordination, early onset anemia, lowered hemoglobin, tiredness and sleepiness (40µg/dL); pain and stomach contractions, anemia, destruction of red blood cells and brain damage (50 µg/dL); difficulty in cellular growth, in bone and teeth development (>62µg/dL) and encephalopathy (70-80µg/dL). These children are at risk of presenting brain inflammation, convulsions, coma, and death if they are not treated (≥100µg/dL) (ATSDR, 2007).

Figure . Curve of isoconcentration of total Pb (mg/kg) according to sampling in the site.

In this scenario B the concentrations of Pb in blood were calculated to be 14.6µg/dL for children from 6 to 7 years old up to 20.8µg/dL for children under 1 year of age, the geometric mean was 16.58µg/dL (Table 1). At these concentrations children could manifest a decrease of IQ, hyperactivity, short attention span, learning disabilities, speech and language disabilities, slower reflexes (10 to 50µg/dL); in addition hearing and developmental problems (10 to 30µg/dL) (EPA, 2010).

In scenario C the estimate concentration of Pb in blood was of 7.7µg/dL for children from 6 to 7 years old up to 12.3µg/dL for children under a year of age, the geometric mean was 9.25µg/dL (Table 1). In this case for indicators greater than 10µg/dL, the children show the same symptoms that in scenario B, and for indicators under 10µg/dL show cavities, motor, visual, and behavioral problems (ATSDR, 2010).

Table . Geometric mean of Pb in blood according to the Pb concentration in soil.

Discussion

Previous studies of another populated zone close to the same foundry reports that the exposure doses of Pb in blood found were consistent with those predicted after applying the IEUBK (Ornelas et al., 2007). Other studies done in Chihuahua with the IEUBK showed a good prediction of lead concentration in blood, calculating it from lead concentration in soil (Bustillos, et al., 2007). Therefore we assume that the values obtained in the present study through this model are very close to the real ones.

It can be seen in the three scenarios that there is a relationship of increased concentration of Pb in blood according to the increment of the concentration of Pb in the soil. In previous studies it was shown that the soil contributes 98 % of the total doses of the Pb intake (Ornelas et al., 2007). A reduction of exposure to the environmental Pb source results in a substantial reduction of the levels of Pb in blood.

The results show that there is a risk of intoxication with Pb for the children near the contaminated area, showing diverse physical, neurological and behavioral problems. This could turn out to be not only a public health problem but a social problem as well. A relationship of delinquent behavior in adulthood when exposed to Pb in childhood has been demonstrated (Bustillos, et al., 2007).

Conclusions

This analysis has emphasized the fact that this area has been contaminated with an elevated amount of Pb, showing a high risk for public health. The adverse effects can be severe, ranging from behavioral to neurological disorders and cancer. Therefore it is urgent to reduce the Pb levels in the soil to minimize the risk and take the measures of prevention and control of exposure for the inhabitants of the area.

References

ATSDR. 2007. La toxicidad del Plomo. Agencia para Sustancias Tóxicas y el Registro de Enfermedades.

ATSDR. 2010. Lead health effects. ToxFAQs™. US: Agency for Toxic Substance and Disease Registry.

Bustillos, S., Ruiz, M., Alarcón, T., and Sanin, L. 2007. Evaluación de riesgo de intoxicación por plomo en niños de 1 a 7 años de edad en Ávalos, chihuahua utilizando el modelo IEUBK. Veracruz, México: XXIX Congreso Internacional de Metalurgia y Materiales.

Campos, A., Herrera, E., Carrillo, J., and Gómez, R. 2009. Source Category Identification of Trace Elements in PM10 from Chihuahua City (Northern Mexico). Chihuahua: 10th ICOBTE.

Díaz-Barriga, F. 2000. Evaluación del riesgo por la exposición a Plomo. CEPIS . México.

EPA. 2010. Addressing Lead at Superfund Sites. Software and Users' Manuals (IEUBK) . EPA Home.

Gutiérrez, M., and Moreno, M. 1997. Los residuos en la minería mexicana. México: INE.

Órnelas, M., Sanin, L., and Díaz, F. 2007. Evaluación de riesgo de intoxicación por plomo en la zona urbana aledaña a una fundidora en Chihuahua, México. 1 (1), 26-35. Chihuahua: Tecnociencia.

Velasco, A., de la Rosa, A., Solórzano, G., and Volke, T. 2004. Evaluación de tecnologías de remediación para suelos contaminados con metales. México: SEMARNAT.