Lead and Arsenic Contamination by a Smelter Plant Located in the Mexico-USA Boundary Area

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Summary
The ASARCO smelter, located in El Paso del Norte border region between Chihuahua (Mexico) and Texas and New Mexico (United States of America), was working for approximately 100 years, mainly in the casting of metals. The direct impacts to soil and water due to the emissions coming out from the smelter are considered in this study. It is assumed that during the period of its operation, the plant continuously released lead, cadmium and arsenic to the atmosphere. This research is limited to an area enclosed in 5 km-perimeter circle, Ciudad Juarez included. A geospatial analysis, using a digital-thematic cartography, is presented. The types of soil in the area of interest included variables such as: geology, topography, surface hydrology and regional climate. Taking the main chimney of the smelter as a center, the study area is enclosed into concentric circles with radii that range from 500 m up to 5000 m. Within this area, 160 soil samples of 0.60 m depth and 160 soil samples of 0.05 m were collected. The lab analysis of the samples showed that after the closing of the plant, 10 years ago, the pollution of soil by arsenic and lead still remains in some points near the main Chimney. Appropriate measures must be considered for the remediation of the contaminated area, and limit the exposure of the population.

Introduction

Pollution of the soil could be either the beginning or the end of the cycle of pollutants. A contaminated soil may cause negative impacts on the quality of life of living beings and the environment. El Paso del Norte region embraces an area near the border between United States of America and Mexico, which includes the cities of El Paso, Texas (USA), Sunland Park, New Mexico (USA), and Ciudad Juarez, Chihuahua (Mexico). These three cities share a common atmospheric basin. For this reason, it is important to take into account the interaction between the three cities, since air pollutants, powered by the dominant winds, travel freely across the border (Management Program for the Quality of the Air of Ciudad Juarez, 1988). Located on this region is the American Smelting and Refining Company (ASARCO), a lead and copper smelter, currently closed. In 1887, the El Paso Lead Smelter was established in El Paso, Texas, on the banks of the Rio Grande/Rio Bravo, which runs through the Border States of Chihuahua (Mexico), Texas and New Mexico (USA). In 1899, the plant was bought by ASARCO. It is assumed that for more than a century this plant expelled out hundreds of tons of lead, arsenic, cadmium and zinc to the urban area of Ciudad Juarez (including Northwest neighborhoods of Anapra, Ladrillera and Felipe Angeles), as well as to surrounding areas of El Paso, Texas, and Sunland Park, New Mexico (García et al., 2003).Between 1969 and 1971, the smelter expelled out 1100 tons of lead, 560 tons of zinc, 12 tons of cadmium and 1.2 tons of arsenic to the air (García et al., 2003). Ndame (1993) analyzed 78 soil samples from the facilities of the University of Texas in El Paso (UTEP) and from parks and public schools within a radius of 2 km away from the campus of UTEP nearest to the smelter. Arsenic concentrations were above 92 mg/kg in soil samples taken within the campus; the maximum lead concentration was 1500 mg/kg and was located to the East of the smelter. While ASARCO was operating, its emissions caused contamination of soil, groundwater and the American Dam, with arsenic and lead (Meza, 2010). In a 2007 agreement, ASARCO paid $19 million dollars to the USA side. This money was invested to clean up the American Dam and the Canal. A total of $1.79 billion dollars were paid to fund environmental cleanup and restoration of contaminated sites (Meza, 2010). On the other hand, on the Mexico side it is uncertain to know whether there is, or there is not, contamination of soil due to the operation of the smelter. The main objective of this study is to present the analysis of the geospatial distribution and to show the results from the lab analysis of 320 soils samples in order to identify a possible dispersion of lead and arsenic, as well as the presence of other potentially toxic elements in Ciudad Juarez and its surroundings.

Materials and Methods

For the development of this work, the sampling zone boundaries were set applying geographic information systems (GIS) and satellite imagery. The overall analysis of the evaluated territories was considered in order to set strategies for the planning and the selection of sampling points within the area of interest. Similarly, based on a geostatistics analysis, the area of influence of the emissions of the main chimney of ASARCO was enclosed. Using the ARCGIS software, a series of circles with radii of

500 m, 1000 m, 1500… 5000 m were traced. These circles had a common centre: the main chimney of the ASARCO plant. To these boundaries, a digital thematic cartography in geographic format (*.shape), suitable for GIS, was added. A simple visualization was chosen to manage the major issues related to the natural resources theme, such as: Geology, Edaphology, Surface Hydrology and Climate (scale 1:250000), and Topography with contour lines every 20 m (scale 1:50000).Within the circles, 160 points were distributed in order to take soil samples. Each point was located within the urban area, discarding paved streets, houses and sidewalks. Using ARC-GIS and the satellite images, the geographic coordinates of all the sampling points were registered and a location map or these points was drawn. Using this map, 160 soil samples of 0.60 m depth and 160 soil samples of 0.05 m were collected. The fluorescence analyzer Thermo Scientific Nitón XL3t was used to carry out the analysis of the soil samples. The concentration of the following 10 elements was obtained: lead, selenium, arsenic, mercury, nickel, chromium, vanadium, barium, cadmium and silver. These elements are considered potentially toxic according to the Mexican Regulation NOM-147, 2004.

Results

According to the weather records, during the period between November and February, the wind intensity is classified as very strong with high speeds and gusts; the rest of the year the wind has an average speed of 20 km/h. The strong intensity of the wind generates a dispersion of contaminants and soil erosion. Different types of soil in the area of study were identified using the charts of Geology and Edaphology. The dominant soils were: Litosols, Regosols, and Solonchaks. According to chart of Edaphology the soils located near the Sierra Juarez are identified as Regosols, while the Solonchaks are located within an area 200 m away from the Rio Grande. For the sampling and testing of soils, two Mexican Regulations were followed: NMX-AA-132-SCFI-2006, and the NOM-147, 2004). For the 320 samples tested, the results from the laboratory indicated that, 3 out of 10 elements exceeded the levels of reference: arsenic (As), lead (Pb) and vanadium (V). Therefore, the analysis focused primarily on Pb and As.

Results and discussion

The strong intensity of the winds blowing from November to February originate the dispersion of the superficial dust contaminating the Rio Grande/Rio Bravo, residential areas, schools, parks and gardens. The rainfall during the months of June to September drags the contaminants to the sewage system and streams of Ciudad Juarez, and these will lead such contaminants to the Rio Grande. The lead concentrations of 1500 mg/kg, found in previous studies, have decreased to the levels found in this study: 968 mg/kg. Similarly, the arsenic concentrations decreased from 92 mg/kg to 66 mg/kg. However, in some sampling points the concentrations of both lead and arsenic were higher in the samples of 0.60 m depth, compared to the surface samples.. This fact may be attributable to the action of water streams, the wind and the type of soil, which is mostly sandy. In the latter, the water runs through the void spaces and drags down the pollutants from the surface soil to the subsoil. Regarding previous studies of El Paso area, the As and Pb concentrations have decreased 35% and 28% respectively. This is due probably to the natural attenuation, i. e., erosion caused mainly by water and wind, and to the fact that the smelter has been out of service for more than 10 years. However, pollution from both elements, As and Pb, still persists, thus requiring study in greater detail to determine the extent of contamination and required remediation.

Conclusions

Despite that the ASARCO smelter plant has been closed for 10 years, there is evidence that the surrounding soil remains contaminated by As and Pb. Appropriate measures must be taken for the remediation of the contaminated area, and limit the exposure of the population.

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