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Environmental Contamination and Toxicology

Environmental Sampling of Lead Near a Battery Reprocessing Factory

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Lead contamination in the environment presents an important health hazard. Reported cases of lead poisoning, especially among young children, are still quite prevalent. Children had been known to ingest peeling paint chips containing lead and develop symptoms of lead poisoning ranging from subtle behavioral changes to kidney damage to convulsions or death (Goyer 1986). Today, however, it is estimated that 40 to 45% of reported lead poisonings in the United States are not directly related to ingestion of lead paint chips but are a result of other contamination sources in the environment (Mielke et al. 1983). These sources may include contaminated plant, soil, water, roadside dustfall, and indoor dust.

Schmidt (1979) reported that lead in surface soil and dust accounts for most of the lead exposure in young children. Brunekreef et al. (1981) showed that there was a statistically significant correlation between the blood lead levels of children between the ages of one to three living in the vicinity of a secondary lead smelter plant and the lead levels found in garden soil and indoor and outdoor dustfall around the children's homes. In a study of children living in a Minneapolis urban area, 50% of the lead poisoning victims had soil lead levels around their homes ranging from 500 to 999 µg/g, with 40% having soil lead levels in excess of 1000 µg/g. Reported guidelines from the U.S.D.A. and E.P.A state that lead levels in garden soils ranging from 500 to 1000 µg/g can be a potential health hazard for children that may ingest the soil (Mielke et al. 1984). Although lead contamination in soil may not be at a level high enough to be an immediate health hazard, ingested soil containing lead could contribute to the body's burden for lead, as it accumulates in the body over time and is rapidly incorporated into bone material.

Reported cases of lead poisoning due to ingestion are greater in children than in adults for two main reasons. First, young

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children have a tendency to place objects in their mouth (pica). Any contaminated material that they come into contact with can thus serve as a primary route of exposure. Second, the oral absorption rate of lead is greater in children than in adults, about 40% vs. 8% (Goyer 1986).

Adult cases of lead poisoning do exist. Exposed workers in lead smelting plants and lead storage battery factories have reported illnesses related to inhalation of lead oxide fumes (Neri et al. 1983; Jones and Gamble 1984; Richter et al. 1979).

The residential community of La Gloria, a town of about 15,000 people located approximately 13 km southwest of Tijuana, Baja California, Mexico was an area where residents were concerned about possible health effects and environmental contamination from lead due to the proximity of a battery factory that used lead oxide in the battery grid separation procedure. This study was undertaken to investigate the lead levels in the soil, plant and water collected in various areas around this battery reprocessing plant.

MATERIALS AND METHODS

Soil samples were taken using a standard stainless steel soil borer which took a topsoil core sample approximately 2.5 cm in diameter and 15 cm in length. The samples were dried initially in an oven at 110° C for 24 hours, cooled, then crushed and pulverized by hand using a mortar and pestle. The soil was sifted through a stainless steel screen (U.S.G.S. #10, 100 mesh), and dried again for an additional 24 hours at 110° C.

Two samples from each site, weighing one gram each, were digested on a hotplate at 90° C in 50 ml beakers according to Katz and Jenniss (1983) with slight modifications. Each sample was treated with 25 ml of concentrated nitric acid and 1 ml 70% perchloric acid. Three blanks were also used. After each sample had evaporated to dryness on a hotplate, 2 ml of concentrated hydrochloric acid were added. The samples were heated for 5 minutes on the hotplate, allowed to cool, and filtered through filter paper (Whatman® No. 1) inside a stainless steel funnel supplied with slow and continuous suction. The filtrate was collected and diluted to a final volume of 25 ml with deionized distilled water. Samples were stored in 30 ml acid washed plastic containers.

Plant samples were collected in the same location as soil. Grass samples were taken, and, if not possible in certain areas, other types of vegetation (not identified) were substituted.

The plant material was dried for 48 hours in a 70° C oven. After drying, the plants were ground in a Wiley mill with a 40 mesh delivery. Each sample was homogenized for uniformity and a representative sample taken. These samples were again dried at 70° C for 24 hours.

Two 0.5 g samples of plant material from each site, along with three blanks, were digested on a hotplate at 90° C in 50 ml Erlenmeyer flasks. The samples were treated with 5 ml of a mixture of concentrated nitric and 70% perchloric acids (2:1 v/v). Reflux action was accomplished by placing a glass marble atop each flask held slightly askew by Parafilm® to avoid pressure build up. When the samples neared dryness, another 5 ml of the acid mixture was added. The samples were heated to near dryness, allowed to cool to room temperature, and then filtered and diluted to 25 ml in the same manner as described for soil.

Two 50 ml portions of unfiltered water from each site, along with three blanks of deionized distilled water, were allowed to evaporate in 50 ml beakers on a medium-heat hotplate (90° C) for approximately 30 minutes. After the addition of 5 ml of concentrated nitric acid, the samples were evaporated to near dryness. This procedure was repeated. When the samples had almost evaporated, 5 ml of concentrated hydrochloric acid : deionized distilled water (2:1 v/v) were added. The samples were heated for 10 minutes, allowed to cool to room temperature, then filtered and diluted to 25 ml in the same manner as described for soil (Van Loon 1980).

Recoveries for the above methods for soil, plant and water samples were determined as follows. A sample was chosen from each site with a previously determined concentration of lead present, with the exception of water samples where deionized distilled water was substituted. Four sets of samples in duplicates, along with a blank, were set up as follows:

Set I: Sample (soil, plant or water) with known amount of lead present

Set II: Sample with an addition of 1 ml of 250 ppm lead standard (making the final concentration of the lead standard 10 ppm).

Set III: Sample with 1 ml of 250 ppm lead standard added after digestion, before filtering and final dilution.

Set IV: One ml of 250 ppm lead standard only.

The percent recoveries were determined by the lead levels found in Set III divided by the levels found in Set II (hypothetically equivalent to the levels present in Set I added to Set IV). Values were averaged between the duplicates. Losses of lead which might have occurred due to technique or procedure would be noted in the difference between Sets II and III. In addition, a 25 ml portion of dilute nitric acid (0.5%) was used to wash the filter paper; the filtrate was analyzed to determine if any soluble lead was left on the filter paper.

Duplicate samples were analyzed using a Jarrell-Ash model 810 atomic absorption spectrophotometer, which was operated under standard operating procedures with an air-acetylene flame. The wavelength used was 217.0 nm. The absorbances of the samples were compared with those of known lead standards ($Pb(NO_3)_2$ dissolved in 0.5% nitric acid) and concentrations noted. Lead standards used ranged from 0.0 to 25.0 ppm. Any unknown sample with absorbance falling out of the linear working range for lead (greater than 25 ppm for this model) was diluted and rerun accordingly. In addition, identical duplicate samples of soil, plant, and water were analyzed by another independent team using the dithizone method (Allen 1974).

All glassware, sample vials and other equipment used throughout the analysis for lead were acid washed with 33% nitric acid solution and rinsed in deionized distilled water.

RESULTS AND DISCUSSION

Figure 1 is a representation of the northeast section of La Gloria where sampling took place. Sampling was conducted during a two-week period in March 1985. The battery factory was located in block 2, and the remaining areas were largely residential. Samples were taken in areas away from vehicular traffic. Sampling of soil and plants took place in six areas in La Gloria, and three additional samples were taken north of block 8 at a non-lead producing smelter plant. One site at the smelting plant had a dried oily flow on the soil which was sampled to see if any lead was present. Water samples were taken in three lots in the area; in addition, one was taken north of block 8 from a garden hose, and two were taken from La Gloria hospital, located south of block 12. One of the hospital samples was taken from a tap inside the hospital and one was taken from an outdoor pond. A water sample taken from a tap of a university at Tijuana served as reference.

Table 1 shows the concentrations of lead in soil and plants. Total recovery was 93% for soil and 95% for plants. For soil, the highest lead levels were in block 3. The smelting plant north of block 8 had markedly different lead levels in the soil between the right and left sides of the road. A low lead level was found in the "oily" soil. Lead levels in plants were much lower than in soil, and in some cases not detectable. The highest lead level in plants was again found in block 3. Total recovery for the water samples was 98% and the lead levels in the water samples are shown in Table 2. No detectable levels of lead were found in the water collected in residential blocks. There were low lead levels found in the garden hose north of block 8 and in the two hospital samples.

The highest lead levels in plants and soil were found in block 3 which was closest to the battery factory. The further away from

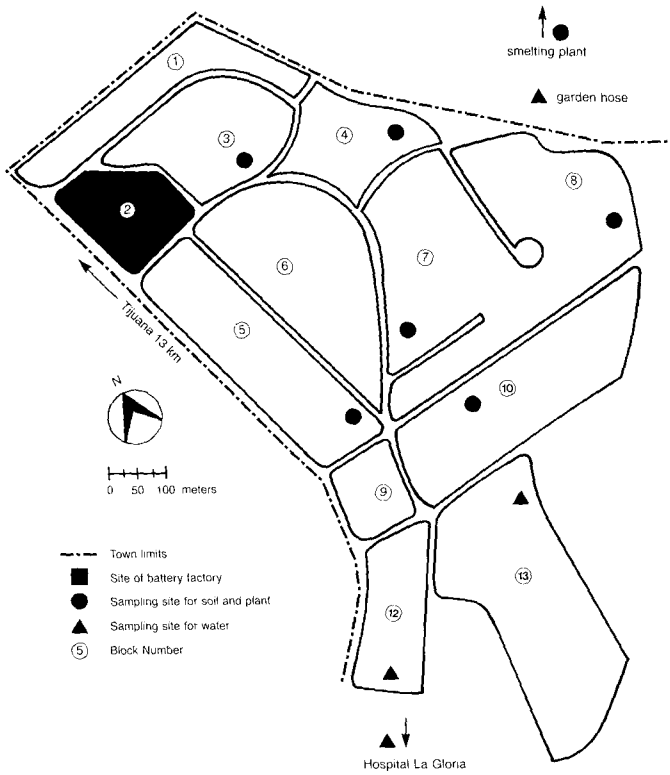

Figure 1. Map of northeastern section of La Gloria showing the sampling locations.

the factory, the lower the lead levels. This suggests that any lead oxide fumes from the factory tended to settle quite closely to the factory. The topography of the land and wind patterns probably played an important role in determining where the fallout might settle. The highest levels of lead found (about 40 µg/g soil) was below those (500-1000 µg/g soil) considered by the EPA as posing potential health hazard (Mielke 1984).

Soil and plant samples taken at the smelting plant entrance were relatively low compared to samples taken from the battery factory. The differences in lead levels on both sides of the

Table 1. Lead concentrations in soil and plants.

Block	Distance from Factory (km)	Concentration (µg/g dry wt.) Soil		Plants	
3	.17	32.24[a]	42.00[b]	0.39[a]	0.51[b]
4	.45	0.74	0.54	0.38	ND
5	.50	0.59	0.83	ND	0.23
7	.45	0.51	0.45	ND	0.09
8	.80	0.07	0.10	ND	ND
10	.61	0.12	0.28	0.10	0.15
Rt. side road†	---	3.17	---	0.13	---
Left side road†	---	0.44	---	0.13	---
"Oily" soil†	---	0.32	---	0.10	---

† These samples came from the entrance of a non-lead producing smelting plant located north of block 8.
[a] Lead concentrations in these columns were determined by atomic absorption spectrophotometry.
[b] Lead concentrations in these columns were determined by the dithizone method.
ND = Not detectable.

Table 2. Lead concentrations in water samples.

Block	Distance from Factory (km)	Concentration (µg/ml)	
12	0.87	ND[a]	---[b]
13	0.78	ND	---
8*	0.77	0.010	0.017
Hospital tap	---	0.012	0.020
Hospital pond†	---	0.022	---
University tap	---	ND	ND

* This sample came from a garden hose located in the area north of block 8.
† This sample contained a large amount of algae which was digested and analyzed.
[a] Lead concentrations in this column were determined by atomic absorption spectrometry.
[b] Lead concentrations in this column were determined by the dithizone method.
ND = Not detectable.

road might be due to the pattern of fallout from vehicle exhaust. Water samples showed low levels of lead, which were not remarkably different from those occurring in finished waters in the U.S. (mean lead concentration = 0.034 μg/ml) (Neely and Blau 1985). The recommended maximum contaminant level in drinking water established by the EPA for lead is 0.02 μg/ml. So it would appear that the groundwater or rainwater catch basins were not contaminated by the lead fallout.

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