Soil Contamination from Lead in Paint Chips

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The ubiquity of lead as an environmental contaminant is well established. In addition to the usually cited sources of environmental lead-paint chips and air -- excessive lead contamination has also been found in a number of other substances, including printed matter (JOSELOW and BOGDEN 1974), and even toothpaste (BERMAN and McKIEL 1972). Childhood lead poisoning as a result of the ingestion of lead-containing paint chips from old, dilapidated inner-city housing is widely recognized. However, there may be an additional hazard from lead containing paint chips, specifically the contamination of soil and plants as a result of the removal of leaded paint from older houses prior to repainting.

METHODS

Sampling

During August of 1973, the house of one of the authors was repainted. Prior to the application of the top-coat of paint, it was necessary to remove several layers of old paint by sanding and scraping. The procedure resulted in the distribution of flakes of paint behind the house, especially at the base of the house. Since the house was built 40 years ago, lead contamination of soil around the house might result because of the generally high lead content of exterior paints. Until very recently, regulations to limit the lead content of paints were directed only toward interior paints (COHEN et al. 1973).

In August of 1973, just after the house was repainted, two topsoil samples were obtained; one from 15 meters away, and a second 30 meters from the house.

Samples from approximately the same locations were again obtained one year later in August of 1974. Soil samples were also obtained from the lots of five other neighborhood houses which had not been recently repainted. The houses are all on a street with little automobile traffic.

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Samples from a cylindrical area 10 cm in diameter were collected directly into plastic containers to a depth of 8 cm. Care was exercised to avoid any sample contamination. The plastic containers were rinsed with dilute nitric acid and distilled water and dried prior to soil collection. Paint chips from the surface of the house were also collected.

Analysis

The soil samples were dried at 50° C for 24 hours. Any clumps of soil present were pulverized using a porcelain mortar and pestle. The samples were then passed through a 10-mesh wire screen to remove any stones and other unpulverized material. Ten milliliters of 50% nitric acid (J.T. Baker, low lead) was added to 0.50 gm of soil and heated at the boiling point for 30 minutes to dissolve the lead present and evaporate most of the nitric acid. The entire sample was then quantitatively transferred to a centrifuge tube and diluted to 10 ml. After centrifugation, 1.0 ml of the supernatant liquid was further diluted with distilled water to 10.0 ml. This provided a final dilution of the lead from 0.50 gm of soil into 100 ml. The lead content of the soil samples was then determined by atomic absorption spectrophotometry using a Perkin-Elmer Model 403 atomic absorption spectrophotometer with the monochromater set at 2833A. Aqueous lead standards of 0, 5, 10, and 20 ppm were used to calibrate the instrument. No detectable amounts of additional lead could be extracted from the insoluble solid material at the bottom of a centrifuge tube. Soil samples were analyzed in duplicate and the results averaged. Duplicate analyses agreed within 15% in all cases. This method of analysis is similar to that employed by other analysts (BARLTROP et al. 1973, TER HAAR and ARONOW 1974, FAIREY and GRAY 1970). The paint chips collected from the house were also analyzed for their lead content by a reported technique (SEARLE et al. 1969).

RESULTS AND DISCUSSION

Table 1 contains the lead concentrations determined for the nine soil samples analyzed.

TABLE 1

LEAD CONTENT OF SOIL SAMPLES

Sample	Date of Collection	Sampling Site	Lead Content ppm dry weight
1	8/73	15 meters from house	185
2	8/73	30 meters from house	165
3	8/74	15 meters from house	440
4	8/74	30 meters from house	490
5-9	8/74	5 neighboring houses, not painted, on same street	130-220

The house was painted in August, 1973 and the lead contents found at this time are not abnormally high, 165-185 ppm (1 and 2 of Table 1).

However, soil samples from approximately the same locations had substantially higher lead contents, 440 and 490 ppm (3 and 4 of Table 1), one year after the painting of the house. It appears that over the course of the one year period, natural forces such as rain and wind washed or blew the paint chips away from the house and distributed the lead compounds in them throughout the soil in the area behind it. The process could be aided by the fact that the land behind the house slopes downward away from the house. The paint chips from the house had a mean lead content of 17%.

To ascertain that the high lead levels found were not a characteristic of the area, soil samples were obtained from behind five neighboring houses. These had substantially lower lead contents, 130-220 ppm (5-9 of Table 1). Since all of these houses were located on the same suburban street with minimal auto traffic, lead from auto exhaust does not appear to be important in explaining the relatively high lead contents of the soil behind the painted house. The range of total lead content in uncontaminated agricultural soils has been estimated to be 2-200 ppm, with a mean of 50 ppm (MOTTO et al. 1970).

The lead contents of the soil samples collected from behind the house one year after the scraping of old paint from the house were 440 and 490 ppm of lead (3 and 4 of Table 1). These values are similar to those found in a separate study for soil samples collected only 3 meters from heavily traveled major highways in 1970, 313-700 ppm, with a mean of 468 ppm of lead (GISH and CHRISTENSEN 1973).

The mean lead content of the two soil samples collected from behind the house in 1974, 465 ppm, is significantly higher ($t=10.8$, $p<0.01$) than the mean value, 175 ppm, for the two soil samples collected from the same locations one year earlier just after repainting and is also significantly higher ($t=10.2$, $p<0.01$) than the mean value, 182 ppm, for the soil samples from the neighboring houses. There is no significant difference ($t=0.28$) at the 95% confidence level between the mean value for the two soil samples collected from behind the house in 1973, 175 ppm, and the mean value for the 5 neighboring houses, 182 ppm.

There are several possible health hazards to man and other wildlife from soils with such relatively high lead contents. Highly significant ($r=0.92$, $p<0.01$) correlations have been found between the lead content of soils and earthworms residing in these soils (GISH and CHRISTENSEN 1973). Earthworms are, of course, food items for many species of birds. Vegetables grown in soils with high lead contents may accumulate excessive quantities of lead with a corresponding hazard to the amateur vegetable gardener and his family (JOHN and VANLAERHOVEN). The lead content of such vegetables, of course, will depend upon several factors, for example soil pH and organic matter, the chemical form in which the lead is present, air lead levels, seasonal and climatic factors, and the physiology of the specific plant species (JOHN and VANLAERHOVEN 1972).

The same problem could occur in urban locations in which the area surrounding a dwelling is not completely paved. Soil lead contamination could be especially hazardous for urban children with the habit of pica, as has been suggested by other researchers (SAYRE et al. 1974). The child with pica who swallows 1.0 gm of soil with a lead content of 500 ppm would be ingesting 500 micrograms of lead, a quantity substantially in excess of the recommended maximum daily intake for children of 300 micrograms (KING 1971). Barltrop (1966) has reported that 23% of a population of Boston children investigated in an interview study and 44% investigated in a mail study were found to have pica for soil and dirt.

It is, of course, possible that contamination of soil from paint chips could result in even higher soil lead contents than the 490 ppm found in this study and represent a greater hazard for children. For example, Ter Haar and Aronow (1974) have reported that the average lead content of soil samples collected within 2 feet of older houses is approximately 2000 ppm. They attribute nearly all of the lead in the soil around the houses they studied to paint from the houses. Another investigation in South Carolina revealed that soil lead contents of 1000 ppm or greater were found in the yards of almost all houses in which pediatric lead poisoning has occurred (FAIREY and GRAY 1970). However, it has also been suggested that high soil lead concentrations may not be a significant source of lead for children (BARLTROP et al. 1974).

Many houses in the United States are more than 30 years old and probably have lower layers of paint with relatively high lead contents. This is true not only in urban areas, but also in the more affluent suburban communities, and may help explain the fact that 9% of the rural children studied in a recent investigation had blood lead levels of 40 ug/100 ml or greater, since exterior paint was the only lead hazard found in half of the rural homes (COHEN et al. 1973).

The deterioration of the outer layer of paint to the extent that the scraping and sanding of lower layers is required may present problems of excessive soil contamination. There is also, of course, a risk of excess inhalation of lead to the homeowner or professional painter during the removal of lead-based paint (WILLIAMS and SOBELESKY 1974). However, as demonstrated in this study, the hazard may persist long after the initial paint removal because of the resulting lead contamination of the soil in the vicinity of the house. The passage of time may result in the redistribution of lead from the base of a house to points 30 meters or more from the house. We intend to continue to monitor the soil locations in this study to determine the persistence of the elevated soil lead concentrations found.

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