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Lead in Albuquerque Street Dirt and the Effect of Curb Paint

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Many studies have demonstrated the existence of lead contamination of the roadside environment (SMITH 1976), and several have dealt specifically with urban street dirt and dust (ARCHER and BARRATT 1976; CAREY et al. 1980; DAY et al. 1975; DUGGAN and WILLIAMS 1977; FARMER and LYON 1977; HO 1979; KHAN et al. 1973; SOLOMON and HARTFORD 1976). In the case of isolated roadways, elevated soil lead concentrations were correlated directly with traffic volume and inversely with distance from the highway or depth in the soil profile (SMITH 1976). In the more complicated urban situations, reported concentrations in street dirt were usually in the range of 1000-5000 µg Pb g^{-1}. However, correlations with urban traffic density were necessarily less exact, and in two cases, lead contamination was so prevalent that no correlation was found (DAY et al. 1975; HO 1979). In all studies, the suggested source of the lead was automotive combustion of leaded gasoline.

As part of a monitoring program for lead in a semi-arid urban environment, we report here results for lead in the street dirts of Albuquerque, New Mexico, as well as data concerning the effects of sample-sieving techniques and the observation that the erosion of curb paint can be a significant, non-vehicular source of lead in street dirts.

MATERIALS AND METHODS

Loose surface material was collected by means of a plastic scoop and brush, transferred to polyethylene bags, air dried, sieved through a 2 mm plastic sieve (10 mesh), and thoroughly mixed in covered plastic containers. For a size distribution study, additional sieving of the dry material was made through a bank of U.S. Standard sieves (W. S. Tyler Co.). Triplicate samples (1 to 5 g) were digested at 90°C for 2 h with 20 mL of 2N nitric acid (ACS reagent grade, ascertained lead-free by carbon rod atomic absorption), filtered (Whatman 541), washed, and diluted to 100 mL with 0.5% nitric acid. Lead was analyzed by flame atomic absorption spectrophotometry (Varian 1250) with simultaneous background correction at 217 nm. Lead standards (1-25 µg Pb/mL) were made by dilution of a commercial standard (Alfa Products) with 1% nitric acid. The absence of analytical interferences was confirmed by the method of standard additions. High purity water, double-distilled from quartz, was used throughout.

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All glassware was subjected to a strict washing protocol which included a final rinse in 10% nitric acid.

Recovery studies with spiked soil samples showed a range of 95% to 105% recovery, with an average of 99.7%. Analysis of an NBS Standard Reference Material [SRM 3 1645, River Sediment, 714 ± 28 (S.D.) μg Pb g^{-1}] gave a value of 697 ± 4.5 (S.D.) μg Pb g^{-1}, for a recovery of 97.6%. Analysis of the same SRM by means of a Parr bomb nitric acid digestion (2 h at 100°C) yielded a value of 715 ± 22 (S.D.) μg Pb g^{-1}.

Tests of statistical significance were made according to Student's t-test at a confidence level of 95% ($P<0.05$).

RESULTS AND DISCUSSION

Urban Soil and Dirt

Although this study was not exhaustive for the city of Albuquerque, the findings (Table 1) are similar to results from other urban areas. The highest lead concentrations were found in dirt on and adjacent to busy streets, while near-background levels were found in soils from residential streets and schoolyards. More exact correlations with traffic volume were not possible. At any given street collection site, lead levels were lowest in the soil on the residence side of the sidewalk, higher in the dirt from curb and gutter, and highest in the soil from a median strip. Median strips were approximately 20 cm high and 10 m to 20 m wide, surrounded by concrete curbing, and filled with gravel and sandy soils.

TABLE 1

Concentration of Lead in Albuquerque Urban Soils and Dirts

Type of Sample Site	Lead, μg g^{-1}, Range
Residential and school yards[a] (16)[b]	3-110
City streets, residence side of walks (7)[c]	270-1640
City streets, curbs and gutters (13)[c]	950-3540
City streets, central medians (7)[c]	980-5280

a) >30 m from street
b) Number of samples in parentheses
c) Traffic volume >14,000 vehicles/day

Effects of Particle Size

Because researchers have used a variety of sample-sieving techniques when analyzing street dirts, we undertook a study of particle size in relation to lead content for dirt samples taken from a busy street median. From the results (Table 2), the weight percent of each particle-size fraction was multiplied by its respective lead content and the products summed to calculate the percent lead contribution of each fraction. Similarly, a weighted average of 4910 μg Pb g^{-1} was calculated for the composite sample. This was in close agreement with the bulk analysis (before fractionation) of 5180 ± 420 (S.D.) μg Pb g^{-1}.

TABLE 2

Particle Size and Lead Content of a Median Strip Soil[a]

Particle Size			Lead Concentration			
Mesh[b]	Diam. μm	Weight %	μg g^{-1}	± SD	(± RSD)[c]	% of Total[d,e]
10-20	2000-841	13.4	1517	880	(58%)	4.1
20-30	841-600	8.1	2184	1066	(49%)	3.6
30-40	600-420	9.4	3400	974	(29%)	6.4
40-60	420-250	18.1	7123	1167	(16%)	25.9
60-80	250-180	8.7	7366	1027	(14%)	12.9
80-100	180-150	8.3	6075	383	(6%)	10.1
100	150	34.0	5410	281	(5%)	37.0

a) Average daily traffic volume - 24,400
b) ASTM Specification E-11
c) Standard deviation (SD) and percent relative standard deviation (RSD %), based on triplicate analyses
d) Total lead: 4910 μg Pb g^{-1}, calculated as a fraction-weighted average
e) Total lead: 5180 ± 420 μg Pb g^{-1} (8% RSD), based on six analyses of bulk material

Most of the lead (86%) was associated with particles which were smaller than 420μm (40 mesh). Possible ingestion of the finer material has been suggested as a potential health hazard, especially for children (DAY et al. 1979; DUGGAN and WILLIAMS 1977; SCHMITT 1979). However, our results for Albuquerque indicate that high lead content material remains confined to busy street corridors, where children are unlikely to play. For example, all soil samples (13) taken from school playgrounds were below 40 μg Pb g^{-1}.

The choice of mesh size for sample-sieving can markedly affect results. For example, had a 40-mesh sieve been used in the initial sieving, a value of 6200 μg Pb g^{-1} would have been obtained for the bulk analysis of the sample in Table 2. This is considerably higher than the value of 5180 μg Pb g^{-1} obtained using a 10-mesh sieve. The use of finer meshes for initial screening will also improve analytical precision, as can be seen in Table 2 where the relative standard deviation for analysis of each size fraction decreases as the particle size decreases. Comparison of results obtained by different laboratories must be made with these effects in mind.

Effects of Roadway Curb Paint

At each median strip sampling site, we noted a wide variation in lead concentrations within the same general area, as well as large analytical variances for each sample. Inspection revealed that these soils contained small yellow flecks which were traced to a breakdown of paint used to highlight the median curbing. The manufacturer of the Yellow Alkyd Traffic Enamel used by the city of Albuquerque states that the paint is formulated to contain 7.5% Pb by weight in the dried film (WELLBORN 1981). Ten paint chip samples taken from different curbs were analyzed with an average of 8.0 ± 0.7 (S.D.) %Pb by weight.

Yellow Alkyd Traffic Enamel is used throughout Albuquerque to highlight median and sidewalk curbs, and no-parking zones. The paint has been observed to chip off from curbs in large pieces, with thicknesses up to 3 mm. It can also chip off or gradually break down to small particles which become widely scattered beyond the point of original application. Paint flecks were observed in median strip soils 40 m from the nearest painted curb. Because the paint is applied by sprayer, overspray may also distribute the material to neighboring soils. Consequently, virtually all soil and dirt samples collected along streets with painted curbs may contain paint particles.

To gauge the extent of any effect which paint particles may have on soil lead contents, soil samples were collected from different locations on median strips of three different streets (Table 3). In each case, the lead content of a sample collected from an area in close proximity to a painted curb was significantly higher ($P<0.05$) than that of a "control" sample collected from the same median, but at a distance greater than 30 m from any painted surface. Similar results have been reported for lawn soils adjacent to houses painted with leaded paint (TER HAAR and ARONOW 1974).

TABLE 3

Lead Content of Median Strip Soil
Relative to Proximity of Painted Curbing

Site	Traffic Volume Vehicles/Day[a]	Lead Content $\mu g\ Pb\ g^{-1} \pm SD$ Close[b]	Distant[c]	Difference % of Total
A	30,000	1770[d] ± 240	1120 ± 190	37
B	23,200	3720[d] ± 820	2600 ± 180	30
C	24,400	4860[d] ± 430	3660 ± 220	25

a) 1979 Traffic Flow Data, City of Albuquerque Traffic Division
b) Sampling site <2 m from painted curb
c) Sampling site >30 m from painted curb
d) Significantly higher than "distant" site on same median ($P<0.05$)

The erosion of leaded roadway paint constitutes a hitherto unrecognized contribution to high lead levels in urban street dirt in Albuquerque, and possible in other cities. Traditionally, automotive exhausts were assumed to be the only significant source of lead in such samples. However, with curbing paint averaging 8.0 %Pb, a soil need contain only 1% by weight of paint particles to have its lead content elevated by 800 $\mu g\ Pb\ g^{-1}$, a very significant contribution to the typical values of 1000-5000 $\mu g\ Pb\ g^{-1}$ for street dirt and dust. By comparing the data in Table 3, it can be seen that leaded paint particles may contribute as much as 25% to 37% of the total lead content of such samples.

A comparison of curb paint with auto emissions as sources of lead can also be made by the following mass-balance calculations. For the years 1977-1980, Albuquerque consumed an average of 2×10^8 gal yr^{-1} of gasoline (STATE OF NEW MEXICO 1981). A survey of local bulk distributors reveals that roughly 60% of this gasoline was leaded at about 1.0 g Pb gal^{-1}, the remainder at 0.03 g Pb gal^{-1}. HUNTZICKER (1975) has estimated for the city of Los Angeles that 40% of auto-combusted lead settles within the urban area. Applying this 40% factor to Albuquerque, we calculate an urban lead loading from auto emissions of 4.9×10^4 kg Pb yr^{-1}.

An estimate for the amount of lead contributed by the erosion of curb paint is 2.4×10^3 kg yr^{-1}, a value which is only 5% of that due to auto emissions. This estimate is based on the assumption that the annual rate of paint application represents a steady-state replacement for paint which degrades into loose soil and dirt. The city of Albuquerque uses about 7500 gal yr^{-1} of Yellow Traffic Enamel which weighs 11.7 lb gal^{-1}, is 76% total solids (WELLBORN 1981), and chips off, forming particles which average 8.0% Pb.

Thus, for the entire Albuquerque urban area, automotive emissions constitute the most significant source of lead. No significant industrial point source is present. However, it has also been estimated (HUNTZICKER et al. 1975) that only 8% of auto-combusted lead is deposited directly on city streets. For Albuquerque, this would represent 9.8×10^3 kg yr^{-1}. When compared to this figure, the lead contributed by erosion of curb paint (2.4×10^3 kg yr^{-1}) in the immediate streetside locale can be 20% of the total (12.2×10^3 kg yr^{-1}), and probably much higher in some samples. This estimate agrees well with the findings in Table 3.

The presence of leaded paint particles in street dirts may obviate any correlations between lead levels and traffic volume. Researchers who are monitoring urban lead levels or modeling lead transport mechanisms should be cognizant of the potentially significant source of lead from the erosion of roadway paint.

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