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# Comparative Analysis of Lead in Maine Urban Soils

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Lead contaminated soil has been identified as a contributing environmental source of childhood lead poisoning. A recent public health service study indicates low levels of blood lead, previously considered acceptable, may present significant health risks for many sectors of the population, especially children (CDC 1982; Klein 1977).

In large cities, previous studies have repeatedly linked both subclinical and overt pediatric lead poisoning to the ingestion of leaded paint and other media contaminated with leaded paint (Mielke,Anderson et al 1983). Soil and dust which have been contaminated by leaded paint chips are a major source of lead which may be inhaled or ingested by children. The Centers for Disease Control has stated that lead in soil appears to be responsible for blood lead levels in children increasing above the background levels when the concentration of lead in the soil exceeds 500-1000 ppm (CDC 1985).

Soil lead may be an important source of ingested lead for children between two and six years, especially those children with a history of pica. Adults absorb about 10 percent of lead into the bloodstream through ingestion whereas children absorb 35 to 50 percent. Children also inhale more air relative to their body weight compared to adults. This suggests that a multifactorial approach to the prevention of excessive lead absorption by children is required (Walter et al. 1980). Prior to the mid 1950's, there was no regulation of the use of lead in house paint in the U.S. The widespread prevalence of lead-bearing soil and house dust contaminated by the deterioration of lead based paint suggests that there may be many asymtomatic children with increased absorption of lead in the United States (Com on Env Haz 1987).

The State of Maine has little scientific data concerning lead absorption from contaminated lead soil

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Send reprint requests to John Krueger at the above address surrounding its many older dwellings. As new residency patterns in older urban and rural areas have been established and increased knowledge of health problems associated with lead have continued to emerge, a need exists to survey soil lead concentrations in Maine.

To study this problem in Maine, an interagency, multistate pilot project was initiated to document lead contamination in rural Maine's largest urban area, Portland (population approximately 120,000). Specific benefits of this study would include: (1.) documentation of a simple sampling protocol for high risk and low risk areas and (2.) a comparison of two different analytical methodologies for determining the concentration lead in soil.

## MATERIALS AND METHODS

A model protocol for choosing sites in Portland, Maine was developed. A total of 100 composite samples were collected, 75 from high risk areas and 25 from low risk areas. A high risk area was identified as any area with exposed soil one to two feet from a foundation of a painted frame building at least 30 years old. Low risk area included everything else such as playgrounds and parks. Samples were collected from public and private locations, in a pattern designed to represent a cross sample of the population.

The following collection procedure was utilized. A plot plan of each dwelling or area was drawn on grid paper at each location. Two tablespoons of the top 1/2" of soil were collected from four random locations along a parallel line drawn one to two feet from the foundation of the dwelling. Random samples were collected similarly at parks and playgrounds, in the common play areas. Soil was placed in plastic ziplock bags, mixed thoroughly and labeled by sample number and date. The city of Portland's zoning maps were used for coding to insure confidentiality. The procedure was repeated on four different subsamples in order to include four sides of a dwelling. The tablespoon was cleaned after each collection to avoid contamination.

From these four subsamples, a composite was made by mixing two tablespoons of soil from each bag. The composite was further divided into two ziplock bags, marked with the same code, for duplicate analyses by two analytical procedures at two different locations.

The two analytical procedures employed were: (1.) X-ray fluorescence analysis by EPA's Region I Laboratory, under the Direction of Dr. Thomas Spittler and (2.) Atomic Absorption analysis by Maine's Public Health Laboratory. All results from both methods were converted to lead concentration in soil as mg/kg (ppm). The procedures are briefly summarized below.

The X-Ray Fluorescence (XRF) procedure was as follows: Approximately 20 grams of soil were dried at $103^{o}$ C overnight. The dried samples were sieved, using a U.S. Standard Sieves Series #60 - 250 microns mechanism. A one gram aliquot was taken from the sieved fraction and analyzed on a Kevex 0700 X-ray Fluorescence Spectrophotometer equipped with a ZR target and operated at 25 Kev and 1.0 ma. Each sample was evaluated for 60 sec and the resultant spectra analyzed by comparing the peak heights and locations against a standard to quantitate and identify the lead in the sample. Lead was identified by locating the $L_a$ and the $L_b$ lines at 10.5 Kev and 12.6 Kev. The ratio of the heights and location confirmed the presence of lead.

The Atomic Absorption (AAS) procedure was as follows: Sample Preparation: 1.00 gram portions of the samples were placed in 100 ml beakers and digested with 1+1 nitric acid on a hot plate for 2 hours at $80^{o}$C. After cooling, the digestates were filtered into 25 ml volumetric flasks and brought to volume with deionized water. A spiked sample was prepared the same way by adding a known amount of lead to a gram of one of the samples. The lead concentrations of these solutions were determined on a Perkin-Elmer 1100 flame atomic absorption spectrophotometer using a 5.0 mg/l aqueous standard.

The two analytical procedures differed in the instrumental technique and in the sample procedure prior to analyses. Initial testing demonstrated that the analytical preparation was responsible for different results on certain high concentration samples. Consequently, a second round of analyses was performed on just one of the sample bags using a common preanalysis preparation of the sample.

## RESULTS AND DISCUSSION

The X-Ray Fluorescence procedure was advantageous in being able to analyze a large number of samples in a short period of time; with minimal chemical hazards, and was quite automated. One hundred (100) samples were analyzed by this method. Forty-one (41) of these samples were also analyzed by the Atomic Absorption procedure. The comparative results of these analyses are summarized in Tables 1-7.

Clear discrepancies were observed between the AAS method and the XRF method on high lead concentration soil samples. Experience with duplicate analyses suggests that a certain amount of analytical variation can be expected from non-homogeneous samples. The large scale differences were explained after microscopic analysis of soil particles revealed that many of the soil samples that gave higher lead concentrations by AAS than by XRF contained leaded paint chips. Initially, only the XRF samples had been sieved; paint chips were removed prior to analysis. The total digestion of sample by the AAS method incorporated the paint chips into the sample analysis.

To confirm the effect of sieving on high concentration samples, twenty (20) samples were reanalyzed by both procedures, using a single sieved sample. In the second round of analysis, the soil sample was dried and sieved as in the XRF procedure with a 60 mesh screen. The data included in Table 1 illustrates two AAS results and two XRF results for each site. The AAS samples differ only in sieving; the XRF results should be from similar samples with similar procedures. These comparisons indicate very comparable results between the two analytical methods when sieving occurs. The lower concentration in several of the AAS results may be explained by inadequate digestion time or use of too weak an acid during digestion.

The XRF procedure analyzed high concentrations of lead with good precision, was useful in screening large quantities of samples, and was quite adequate for differentiating low, moderate, and high lead concentrations in soil. The XRF data on all one hundred sites has been used as the data base for this study.

One hundred composite samples were collected and analyzed. Of the 100 samples, 50 samples were taken from private dwellings and 50 samples were taken from public dwellings. Public areas included public housing, parks, playgrounds, and schools. Of the 100 samples taken, 75% were taken from high risk areas and 25% were taken from low risk areas.

For analysis purposes the lead levels (measured in ppm) of the soil were grouped into three ranges according to potential risk. Samples containing lead levels between 0 ppm-499 ppm were considered low in contamination; samples with lead levels of 500 ppm-999 ppm were considered moderate in contamination, and samples with lead levels of 1000 ppm or greater were considered high in contamination. In this series, 60% of the samples were low, 12% moderate and 28% high in soil lead concentration.

Table 1 Comparison of analytical methods for soil lead

| Sample # | Initial[1] AA | Initial[2] XRF | Repeat[3] AA | Repeat XRF |
|---|---|---|---|---|
| 1 | 1850 | 800 | 911 | 950 |
| 2 | 200 | 400 | 356 | 530 |
| 3 | 1040 | 650 | 533 | |
| 4 | 2510 | 1050 | 1233 | 1250 |
| 5 | 6380 | 4800 | 4178 | 5000 |
| 6 | 230 | 300 | 67 | |
| 7 | 14800 | 7200 | 12255 | 11520 |
| 8 | 29400 | 8000 | 11440 | 12800 |
| 9 | 33500 | 4000 | 3667 | 6400 |
| 10 | 1080 | 1800 | 1167 | 1850 |
| 11 | 2000 | 2000 | 3322 | 3200 |
| 12 | 2600 | 2200 | 1722 | 2900 |
| 13 | 4010 | 1600 | 1156 | 2150 |
| 14 | 830 | 600 | 411 | 700 |
| 15 | 1540 | 400 | 311 | 500 |
| 16 | 1690 | 1400 | 844 | 1600 |
| 17 | 12700 | 4500 | 3830 | 5700 |
| 18 | --- | --- | 511[4] | 490[4] |
| 19 | --- | --- | 189[4] | 270[4] |
| 20 | --- | --- | 456[4] | 700[4] |

1) Using initial method and without sieving the sample
2) Using method described
3) Using the initial method except the sample is sieved
4) Assayed reference samples. Number 20 is NBS Standard reference material from river sediment with a true value of 714 ppm. Samples 18 and 19 are sludge with true values of 755 and 300 ppm respectively.

Table 2 Number of samples, by location and risk

| Sample Location | # High Risk | # Low Risk |
|---|---|---|
| Public dwellings samples | 38 | 12 |
| Private dwellings samples | 37 | 13 |

Table 3 describes the actual lead concentrations in high risk and low risk sample sites. In the suspected high risk sites, 37% had highly contaminated lead levels, whereas none of the low risk areas had high lead levels. In the suspected low risk sites, 92% had low lead levels, whereas only 50% of the suspected high risk areas had low contamination levels.

Table 3 Lead concentration by site risk

| Site Risk | Lead Level Ranges<br>%Low<br>0-499 ppm | %Moderate<br>500-999 ppm | %High<br>> 1000 ppm |
|---|---|---|---|
| High Risk | 50 | 13 | 37 |
| Low Risk | 92 | 8 | 0 |

Table 4 gives a brief statistical summary of the lead levels in <u>sieved</u> soil at the two types of site risk.

Table 4 Statistical summary of lead at risk sites

| Site Risk | Minimum Lead Level | Maximum Lead Level | Mean Lead Level |
|---|---|---|---|
| High | 50 ppm | 10,900 ppm | 1275 ppm |
| Low | 50 ppm | 700 ppm | 205 ppm |

Samples were also categorized by type of dwelling: private vs. public. The public locations were further broken down according to public housing vs. public locations. Of the 50 public samples taken, 33% were taken from public housing dwellings and 66% were taken from public locations. The category with the largest percentage of highly contaminated soil was private dwellings; 44% of the private dwellings had high lead levels in their soil. This compares to 17% of public housing samples and 10% of the public locations samples.

Table 5 Lead concentrations by housing types

| Type of Housing | Lead Level Ranges<br>%Low<br>0-499 ppm | %Moderate<br>500-999 ppm | %High<br>> 1000 ppm |
|---|---|---|---|
| Public Location | 84 | 6 | 10 |
| Public Housing | 71 | 12 | 17 |
| Private | 40 | 16 | 44 |

As a final comparison of data collected in this study, an age distribution of housing and soil lead levels was made. Tables 6 and 7 summarize this data. As expected, dwellings built prior to 1950 had the largest percentage of highly contaminated soil, while dwellings built after 1978 had no contamination.

Table 6 Age distribution of housing

| Date Built | Age | Percent |
|---|---|---|
| After 1978 | 0-9 yrs. old | 6 |
| 1950-1978 | 9-37 yrs. old | 18 |
| before 1950 | 38 yrs. old or > | 50 |
| not available | | 26 |

Table 7 Comparison of age and soil lead concentration

| Age | %Low 0-499 ppm | %Moderate 500-999 ppm | %High > 1000 ppm |
|---|---|---|---|
| not available | 96 | 4 | 0 |
| After 1978 | 100 | 0 | 0 |
| 1950-1978 | 88 | 6 | 6 |
| before 1950 | 26 | 20 | 54 |

In summary, the results of this study confirm a number of points: (1.) there is significant lead contamination adjacent to urban painted framed buildings built prior to the 1950's, (2.) the lead in paint chips remains relatively intact, close to the original location with little leaching, (3.) non-homogeneous soil can be sampled and analyzed with good accuracy and precision by using a simple field sampling and mixing scheme, (4.) XRF offers fast and good indications of relative lead concentratons but does not recover paint chips that are analyzed by AAS. The significance of lead contaminated dust or paint chips is the subject of further investigation.

Other, more populated Northeastern States, have documented soil lead contaminations (Cohen,Bowers,Lepow 1973). Maine's lead contamination does not appear to be reduced because of its lower population density. The extent of contamination around similarly aged structures in more rural Maine can be theorized; future study is necessary. Likewise, the impact on special needs and learning for impaired children in the state can only be estimated.

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