ENVIRONMENTAL PROJECT REPORT
LEAD-BASED PAINT

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Abstract

Lead is a neurotoxin that accumulates both in soft tissues and the bones. Lead can affect almost every organ and system in the body. Lead poisoning has been documented from ancient Rome, ancient Greece, and ancient China, yet lead paint was introduced for residential use in the 19th century.

Typical lead-based paints in the early 20th century could contain as much as 40 to 50% lead, however by the mid 20th century the use of lead in paint pigments was sharply reduced and replaced with titanium dioxide and zinc oxide.

On analysis of soil and paint samples, using atomic absorption spectroscopy, from an old farm house in south-eastern New South Wales I have shown that the exterior paint used on the house contained approximately 17% lead, by mass, and that the degradation of this paint has contaminated the soil surrounding the house to possibly as far as 40cm from the house, and to a rate almost three times as high as the environmental investigation 'trigger levels' set by the Australian and New Zealand Environment and Conservation Council (ANZECC) in 1997[4][5].

Introduction

Lead is one of the largest environmental medicine problems in terms of numbers of people exposed and the public health toll it takes. The introduction of lead paint for residential use in the 19th century increased childhood exposure to lead; for millennia before this, most lead exposure had been occupational.

Lead paint or lead-based paint (LBP) is paint containing lead, a heavy metal, that is used as pigment, with lead(II) chromate ($PbCrO_4$, "chrome yellow") and lead(II) carbonate ($PbCO_3$, "white lead") being the most common. Lead was added to paint to speed drying, increase durability, retain a fresh appearance, and resist moisture that causes corrosion.

Leaded paint can chip, peel, or chalk, leading to contamination of dust and soil. Since the lead does not dissipate or biodegrade, the lead in dust and soil can become a source of long-term exposure.

Lead is especially damaging to children under age six whose bodies are still developing, and to pregnant women. Lead can harm the hematopoietic, neurologic, gastrointestinal, and reproductive systems. However, lead toxicity mostly affects the nervous system. In pregnant women, exposure to high levels of lead may cause miscarriage. In men, exposure may affect sperm production.

Lead can affect a child's mental and physical growth. Unborn children can be exposed through their mothers. Harmful effects include premature birth, smaller babies, decreased mental ability in the infant, learning difficulties and reduced growth in young children.

The quantitative determination of lead in environmental samples is commonly performed using atomic absorption spectroscopy, which exploits the ability of atoms to emit and absorb light at specific discrete wavelengths.

Project Outline

For this project an Atomic Absorption Spectrophotometer (AAS) will be used to determine the lead content of paint and soil samples from an old house which is very likely to have been painted with lead-based paint.

The lead content of the paint will be determined, and also whether there is any lead contamination of the soil and how far this contamination extends from the house.

Experimental

Method

a) Preparation of standard lead solutions

6 standard solutions of known concentrations were prepared from a stock solution of lead (0.1246g Pb/0.500L). The concentrations of these 6 solutions were: 4ppm Pb, 8ppm Pb, 12ppm Pb, 16ppm Pb, 20ppm Pb, and 25ppm Pb.

b) Preparation of dried paint scrapings

Duplicate samples of 0.30g of external household paint scrapings were dried in a furnace then made into solution with 2mL concentrated nitric acid, and made up to 100mL with distilled water.

c) Preparation of soil samples

4 soil samples, of approximately 100g, were collected from the top 2cm of soil at the site in the following locations:

0 – 5cm from outside wall of house
10 – 15cm from outside wall of house
20 – 25cm from outside wall of house
2.8m from outside wall of house

These 4 samples were dried in an oven (60 – 80^{o}C) then digested using aqua-regia (HNO_3:HCL, 1:3). The samples were then filtered and quantitatively transferred to volumetric flasks made up with distilled water to a total volume of 250mL.

d) Measurement of absorbance of samples

Atomic Absorption Spectrophotometer was set to wavelength 217nm with a slightly oxidising air-acetylene flame.

The solutions were aspirated into the spectrophotometer and 5 absorbances per sample recorded for each of the standard solutions, duplicate paint sample solutions and soil sample extract solutions.

e) Calculations

A calibration curve was constructed using the average absorbances for each of the six standard solutions of known concentration, thereby allowing the lead concentration of the paint and soil samples to be determined.

Results

Table 1 gives the original dry weight of each of the soil samples along with the volume of extract obtained after digestion with aqua-regia and filtration.

Soil Sample	Dry weight of soil sample (g)	Volume extracted after digestion and filtration (mL)
Soil sample 1	82.1	125.0
Soil sample 2	102.08	109.0
Soil sample 3	96.72	113.5
Soil sample 4	85.12	85.0

Table 1: Weight and volume of soil samples during preparation

Table 2 gives the absorbance readings taken for all of the samples on the atomic absorption spectrophotomer.

	Absorbance readings					
Sample	1st reading	2nd reading	3rd reading	4th reading	5th reading	**Average**
4ppm standard	0.014	0.016	0.017	0.018	0.017	**0.0164**
8ppm standard	0.092	0.093	0.090	0.088	0.085	**0.0896**
12ppm standard	0.145	0.143	0.139	0.142	0.143	**0.1424**
16ppm standard	0.198	0.195	0.190	0.196	0.201	**0.196**
20ppm standard	0.247	0.249	0.245	0.248	0.251	**0.248**
25ppm standard	0.300	0.300	0.299	0.298	0.296	**0.2986**
Paint sample 1	0.240	0.246	0.244	0.252	0.243	**0.245**
Paint sample 2	0.240	0.237	0.236	0.241	0.241	**0.239**
Soil sample 1	0.277	0.272	0.270	0.277	0.279	**0.275**
Soil sample 2	0.279	0.283	0.281	0.277	0.280	**0.280**
Soil sample 3	0.205	0.208	0.204	0.204	0.202	**0.2046**
Soil sample 4	0.025	0.021	0.019	0.021	0.020	**0.0212**

Table 2: Absorbance readings for all samples

Figure 1 is the graph of absorbance versus lead concentration for the six standard lead solutions.

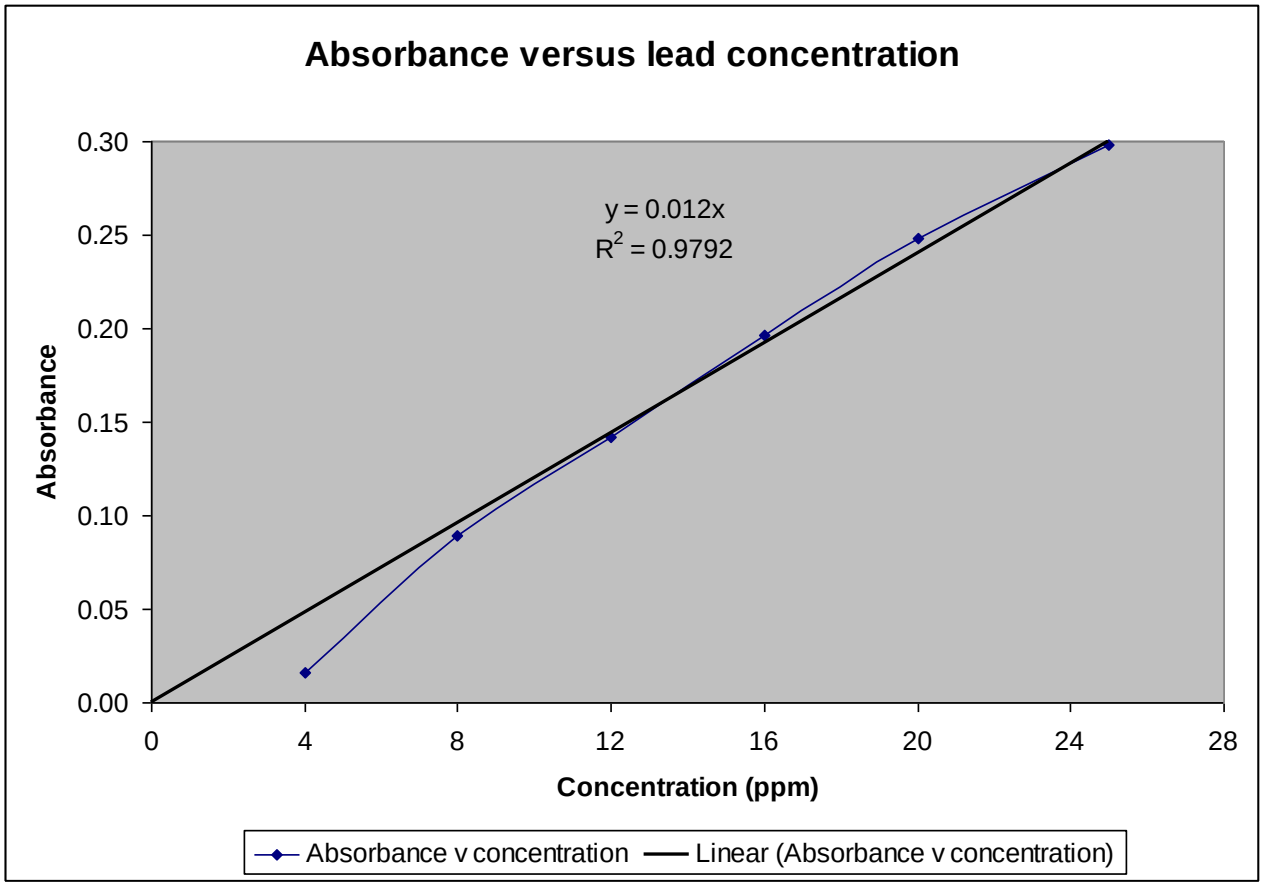

Figure 1: Graph of absorbance versus lead concentration

Using the equation from the graph, y = 0.012x, we can determine the value of x (concentration) from the value of y (absorbance) for our soil and paint samples. These values are shown below in table 3.

Sample	Concentration of lead
Soil Sample 1: 0 – 5cm from house	22.92ppm
Soil Sample 2: 10 – 15cm from house	23.33ppm
Soil Sample 3: 20 – 25cm from house	17.05ppm
Soil Sample 4: 280cm from house	1.77ppm
Paint Sample 1: 0.30g	20.42ppm
Paint Sample 2: 0.30g	19.92ppm

Table 3: Concentration of lead in paint and soil samples

The percentage, by mass, of lead in the paint samples was calculated taking into account dilutions of samples. The calculated percentages are shown below in table 4.

For example, paint sample 1 = 20.42ppm = $20.42 mgL^{-1}$ x (0.025L/0.001L) x 0.100L = 51.05mg Pb / 300mgPb = 16.8% Pb, by mass, in original sample.

Sample	Mass Pb in sample	Percentage Pb in original sample
Paint Sample 1: 0.30g	51.05mg	17.0 %
Paint Sample 2: 0.30g	49.80mg	16.6%

Table 4: Mass percent of lead in paint samples

The concentration of lead, in milligrams lead per kilogram soil, was calculated taking into account dilutions of samples. The concentrations are show below in table 5.

For example, soil sample 1 = 22.92ppm = 22.92mgL^{-1} x (0.025L/0.002L) x 0.250L = 71.63mg Pb / 0.0821Kg soil = 855mg Pb per Kg soil.

Sample	Mass Pb in sample	mg Pb per kg soil
Soil Sample 1: 82.1g	71.63mg	872
Soil Sample 2: 102.08g	72.91mg	714
Soil Sample 3: 96.72g	53.28mg	551
Soil Sample 4: 85.12g	5.53mg	65

Table 5: Lead in soil samples

Conclusions

The Australian and New Zealand Environment and Conservation Council (ANZECC) determined soil contamination thresholds, called environmental investigation 'trigger values'. The trigger value for lead in a residential yard is 300mg Pb/kg soil (ANZECC 1992)[5].

Based on my results the soil tested in this project would be subject to detailed investigation given it far exceeds the trigger value of 300mg Pb/kg soil.

The soil sample taken from 0-5cm away from the house was found to have a lead concentration of approximately 872mg Pb/kg soil. This value drops by about 18% as we progress to 10 – 15cm from the house and a further drop of about 20% at 20-25cm from the house. The general background concentration of total lead in soil is less than 50mg Pb/kg soil according to NSW EPA (1994)[5], and thus the representative soil sample taken at 2.8m from the house which shows 65mg Pb/kg soil seems a reasonably standard figure, though perhaps a little high.

Given more time in the laboratory it would have been useful to test further samples of soil to determine more accurately how far the lead contamination extends from the house. Based on the tested samples it seems reasonable to conclude that the lead contamination of the soil would extend up to 40cm from the house.

The maximum lead content for domestic paint (since December 1997) is 0.1% as per the Uniform Paint Standard – Appendix I of Standard for the Uniform Scheduling of Drugs and Poisons[7]. The paint samples at this residence have been determined to contain approximately 17% lead, by mass. This value would indicate that the paint used was most likely produced in the 1950's or 1960's when manufacturers had started to use titanium dioxide and zinc oxide as substitutes for some of the lead in paints.

Further research

Though it is beyond the scope of this assignment, I would have been interested to conduct further research into possible effects of lead paint at this particular residence by testing my brother-in-law, who lived in this house from birth to age 10, my father-in-law, who lived in this house from age 10 to 38, and my mother-in-law who lived in this house from age 18 to 28. It would be interesting to see if they have any 'lead lines' on x-rays and also what their blood lead-level is and whether it was ever tested before. Do they exhibit any of the symptoms common to lead exposure as a child/adult? After the birth of their first child, they had trouble conceiving for 10 years and in fact didn't get pregnant until they moved to a different house. Could this have been due to the effects of lead exposure? The child who lived in the house from birth to 10 years of age cannot, as an adult, have any children, could lead exposure be, in part, responsible for this?

References

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