Heavy Metal Pollution in Nassau County: Are Street Trees Helping Keep Streets Clean?

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Abstract:

In recent years, the role of urban trees in improving air quality has received increasing attention, as trees have relatively higher capacity of metal accumulation compared with other types of vegetation. Since different plant species differ greatly in their sensitivity to pollutants, it is necessary to test a variety of trees to determine which species are the best at taking in pollutants; since there is no simple or effective way of getting rid of high lead concentrations. In this project, I investigated which tree species could potentially help absorb lead contaminants from the soil and reduce the lead levels. The trees presented two benefits in this project: Not only do certain species help to reduce lead in soils by up taking lead, they also provide environmental, social and economic benefits. Planting a new tree in the contaminated soil on a residential property is significantly less expensive than either cementing or trying to cover up the contaminated soil.

Introduction:

This experiment was undertaken to determine if trees can absorb heavy metals such as lead. There are many ways in which lead can be exposed to soil. Many residential properties today were once painted with lead paints. Unless the initial layer of paint was removed, it will still be there under layers of newer paint. Lead is released during combustion of fossil fuels and many manufacturing processes produce or release lead. Soil may become contaminated with lead if it is exposed to any of these processes. Lead in soil does not biodegrade and it does not leach easily, so even buildings that have had all lead paint removed may have lead contaminated soil in this area as a result of previous exposure (Wade,2019).

Lead is particularly dangerous for children. Even low levels of lead in the blood of a child can severely affect IQ and attention. Lead can pass through the placenta, so pregnant women who are exposed to lead can expose their child to the lead where it can damage the baby's nervous system. Significant lead exposure can also cause miscarriage, stillbirths, and infertility in both men and women (Wade, 2019). Soil clings to hands, fingers and toys, all things young children tend to put in their mouth. If that soil is contaminated with lead, children will intake the lead. Lead is not only dangerous for children. It can be stored in bones, blood, and a variety of tissues whereby it can produce a wide range of effects no matter the age they were exposed at. Large doses of lead can cause symptoms of lead poisoning, in children and adults. Symptoms consist of abdominal pain, constipation, fatigue, weakness, headaches, irritability, loss of appetite, memory loss, pain or tingling in the hands and feet, anemia, kidney and brain damage and even death (Gulson BL etal, 2000).

The trees presented two benefits in this project: Not only do certain species help to reduce lead in soils by up taking lead, they also provide environmental, social and economic benefits. Planting a new tree in the contaminated soil on a residential property is significantly less expensive than either cementing or trying to cover up the contaminated soil. Trees reduce urban runoff and erosion by storing water and breaking the force of rain as it falls. The USDA reports that 100 mature trees can reduce runoff caused by rainfall by up to 100,000 gallons! Trees also absorb sound and reduce noise pollution. This is especially important for people who live near freeways. In some cases, a strategically planted group of trees can reduce noise pollution by up to 10 decibels. (Liu, Yan-Ju 2006).

There is limited research on trees' abilities to absorb heavy metals such as lead. There are a few challenges associated with the lack of research related to trees' abilities to absorb heavy metals in the few papers that exist. The main challenge is being able to measure the lead uptake without harming the tree. Many of the studies required long processes, which included cutting out large pieces of the tree or using scrap wood. In one paper, tree cores were taken at breast height (1.5 m) from the south-west-facing aspect (facing the town center) of each tree. Samples were immediately sealed in dry, plastic straws and were stored at y10 8C prior to analysis. Each core was divided into 5-year increments dating back to 1922, and 10-year increments in wood formed prior to 1922 (Watmough 2001). This process is time consuming and causes harm to the tree.

The portable XRF (X-ray florescence) was the device used to measure the lead levels found in trees. The XRF is a device which is commonly used to measure the elemental composition of soil. There was one paper that featured the XRF, a device used to measure the elemental composition of samples found in trees, from that paper the best estimate of the XRF's depth analysis was learned. The results thus emphasize the need to increase the analysis times for samples characterized by low lead concentrations. In particular extremely weathered samples of wood for which a large fraction of the initial preservative treatment may have been lost (Block et al, 2007). The conclusion that they came to determined that the XRF had better detection limits when the wood was preserved. Since my data was taken from live trees' we could not preserve the wood. The more weathered the tree, the more the XRF loses its ability to detect high levels of heavy metals. Based on the information learned, it was decided to use the bark as an indicator of lead as opposed to the core of the tree, which would be very difficult, if not impossible to read with a portable XRF. Since previous methods to measure lead levels in trees were time consuming and harmful, I used the XRF. There were a few unknown variables using the XRF to measure lead in trees, the main reasons being not knowing its accuracy or the depth of penetration of the XRF emissions. Currently there have been no studies done on using an XRF to measure heavy metals on live trees.

Figure 1: On-site measurements of lead using a PXRF (image: Fisher Scientific)

In this project, we investigated which tree species could potentially help absorb lead contaminants from the soil and reduce the lead levels. In recent years, the role of urban trees in improving air quality has received increasing attention, as trees have relatively higher capacity of metal accumulation compared with other types of vegetation (Block et al., 2007). Since different plant species differ greatly in their sensitivity to pollutants, it is necessary to test a variety of trees to determine which species are the best at taking in pollutants; since there is no simple or effective way of getting rid of high lead concentrations.

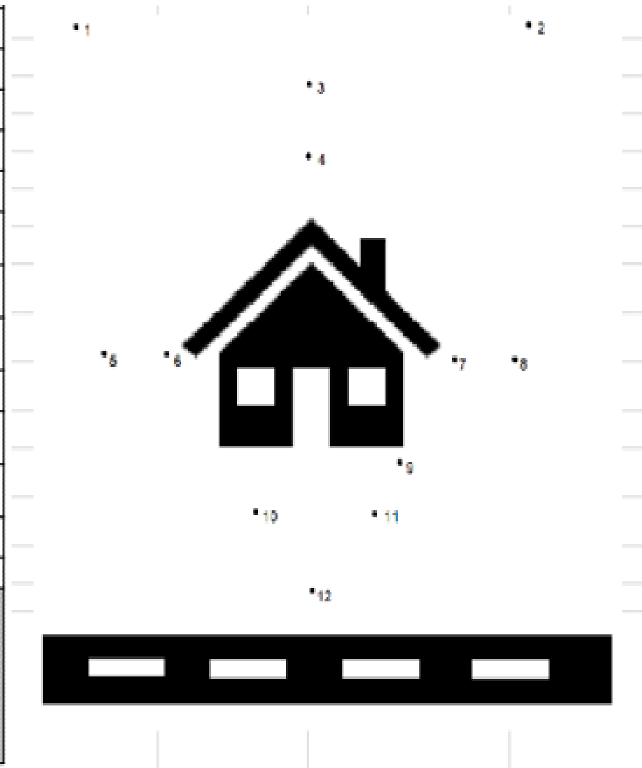
<u>Materials and Methods:</u>

Scouting and Mapping out Sampling Locations:

To determine which houses to take soil and tree samples from the soil lead data that was collected at Hofstra University last summer, was put into a spreadsheet. The data was then separated into three different categories: high lead levels (400ppm-400+ppm), medium lead levels (200ppm-400ppm), and low lead levels (30ppm- 200ppm). To determine the most ideal locations for sampling Google Earth Satellite was used for virtual scouting. Based on this scouting, it was recorded whether the property had street trees or yard trees in the spreadsheet. Street trees were chosen over residential trees for logistical reasons (less coordination was required with the homeowners who participated in the study) and for consistency among locations. There were selected 15 houses (5 from each category) from which to sample.

Sample ID	Pb (ppm)
1	20
2	28
3	35
4	22
5	42
6	42
7	70
8	45
9	30
10	46
11	282
12	21

Sample ID = Location of measurement (see "map" at right)
* = Too low to measure: less than 10 ppm.
N/A = Not Applicable. This is usually because there was no accessible soil at that location.



A) **B)**

Figure 1: The figure above shows how the lead levels found on residential properties were recorded, labeled, and mapped out. Note that each house had its own copy of the above map, and they were filed by address, which could not be included in this image due to the privacy of participants. The backyard was numbered 1-4, the side yard was numbered 5-8, the front yard was numbered 9-11, and the verges were numbered 12 and 13. If the side of the house was cemented, N/A would be written in the column for the appropriate location, and the same would be done for any other not easily accessible locations surrounding the property.

The residential properties that were selected to revisit were based on the lead levels found in the soils from last year, the distance from Hofstra University, and the accesibility, meaning that permission was not required. Google Earth imaging was used to determine if there was a tree on the property and then I recorded in the data sheet if it was a street tree, property tree, a sapling or an old tree.

Once it was determined which residential properties, to visit a route for the most efficient use of time was mapped out. The starting location was at the furthest property and continually worked back toward Hofstra University. The data sheet was used to easily record the information. On the spread sheet the address, GPS coordinates, tree type (as in street tree or property tree), tree DBH (diameter breast at height), tree species, XRF ID number, lead found in the tree and lead found in the soil were recorded.

tree Species	Tree Type	GPS Coordinates	XRF ID	Pb (ppm) in Soil	Pb (ppm) in Trees	Tree DBH
red bud	street tree	40° 42'47N 73° 34'59W	5096	81	ND<3	58.5
Norway Maple	street tree	40° 42'49N 73° 35'1W	5097	72	ND<2	26
Norway Maple	street tree	40° 41'19N 73° 31'1W	5098	79	ND<4	11.5
Balsam Poplar	street tree	40° 42'23N 73° 31'13W	5099	52	ND<3	34
Balsam Poplar	street tree	40° 43'47N 73° 28'37W	5100	17	ND<3	41
Balsam Poplar	street tree	40° 43'47N 73° 28'37W	5101	55	ND<3	38
Red Maple	street tree	40° 39'33N 73° 25'33W	5102	25	ND<2	20.5
Black Ash	street tree	40° 39'41N 73° 38'10W	5103	152	ND<2	68.25
Paw Paw	street tree	40° 38'54N 73° 40'42W	5104	216	ND<2	50.25
Syccamore Maple	street tree	40° 38'30N 73° 40'45W	5105	43	ND<2	61
Choke Cherry	street tree	40° 38'43N 73° 40'40W	5106	33	ND<2	30
Choke Cherry	street tree	40° 38'43N 73° 40'40W	5107	67	ND<2	7.5
American Peach	street tree	40° 39'18N 73° 41'9W	5108	53	ND<2	28
American Peach	street tree	40° 39'18N 73° 41'9W	5109	46	ND<2	28
Syccamore	street tree	40° 39'23N 73° 43'5W	5110	41	ND<2	64.5
Syccamore	street tree	40° 39'23N 73° 43'5W	5111	82	ND<2	54
Pin Oak	street tree	40° 43'14N 73° 42'29W	5112	578	ND<3	54.25
Pin Oak	street tree	40° 44'9N 73° 42'6W	5113	122	11	86.5
American Elm	property tree	40° 42'49N 73° 35'55W	5250	36	ND<3	86.5
Pin Oak	property tree	40° 50'44N 73° 36'49W	5251	57	56	81.5
Dawn Redwood	property tree	40° 42'51N 73° 35'60W	5256	12	ND<2	80.5
Sycamore	property tree	40° 42'49N 73° 36'5W	5258	65	ND<2	65
Pin Oak	property tree	40° 42'51N 73° 36'4W	5260	81	3	79
London Plane	property tree	40° 42'52N 73° 36'1W	5262	30	ND<2	61.5
Silver Deoder Cedar	property tree	40° 42'52N 73° 35'59W	5264	70	ND<3	49
Chamaecyparis Pisifera	property tree	40° 42'51N 73° 35'58W	5266	53	ND<2	55.5
Upright blue atlas cedar	property tree	40° 42'52N 73° 35'59W	5268	33	ND<2	42
European beach	property tree	40° 42'51N 73° 35'57W	5270	59	ND<3	101

Figure 2: The figure above is a photo of the data sheet used to collect the information about the trees and soil. The addresses were once again not included in this figure due to the privacy of the participants.

To further expand the study, an additional 15 samples were collected on Hofstra Universities campus. The same method was used, but instead of recording the street address, the trees were labeled as tree #1, #2 etc. Due to the limited amount of time the number of residential properties to visit had to be reduced and some samples were taken from some on site trees at Hofstra University.

To determine the GPS coordinates, the compass app on the iPhone was used. Then It was determined if the tree was a street tree or a property tree. Then the DBH of the tree was measured. To measure the DBH, a measuring tape was wrapped around the tree, and then the DBH was recorded in cm. Measuring the DBH of the tree aided in the identification of the tree species. To assist with identification, photographs were taken of the leaves, the bark, and the full tree, then a tree identification book was used to determine the tree species. Each of the trees from which we collected was identified with the help of my mentor.

XRF Process:

To find the lead levels in the trees and soil a tool called the XRF was used. The XRF is a portable device used to measure the elemental composition of a sample. It does this by measuring the fluorescent (or secondary) X-ray emitted from a sample when it is excited by a primary X-ray source. Since the XRF emits X-rays, I could not use the portable device due to safety reasons. The XRF ID would be recorded. Then my mentor would direct the XRF beam at the soil or the tree, and then the concentration of lead in ppm (parts per million) in the sample would be recorded. The XRF is usually used in soil or leaves. There are very limited studies using the XRF on trees. Due to the limited research, it was concluded that the X-ray beams only went approximately through the bark and no further, meaning they did not reach the core of the tree. In the future, the power of the XRF should be further researched. For this project, it was assumed that the beams reached no further than the outer bark of the trees.

Data Analysis:

To analyze the data, I used a one sample t-test and excel. Since our sample size was limited, we had to use a one sample t-test. With the one sample t-test I set a test value of zero, I choose zero as the test value because the number of trees that contained lead were limited. I did two separate tests; one tested the significance of the tree species that contained lead and the second one tested the significance of the lead levels found in the trees. I used excel to visualize the results shown in the one sample t-tests.

Discussion of Results:

In the following section the data I collected will be analyzed and discussed through graphs and charts. We had a total of 15 different tree species and there were 2-3 specimens sampled for each species. The soil samples were taken approximately 1 meter from the trunk with a depth of approximately 10cm from the topsoil.

This graph shows that the soil near the Pin Oak trees has a higher concentration in lead. There were also higher lead levels found near Balsam Poplar, Sycamore, and Choke Cherry. The tree species below were chosen at random and are commonly found in New York State, particularly in Nassau County.

Figure 3: Lead in Soil vs. Tree species

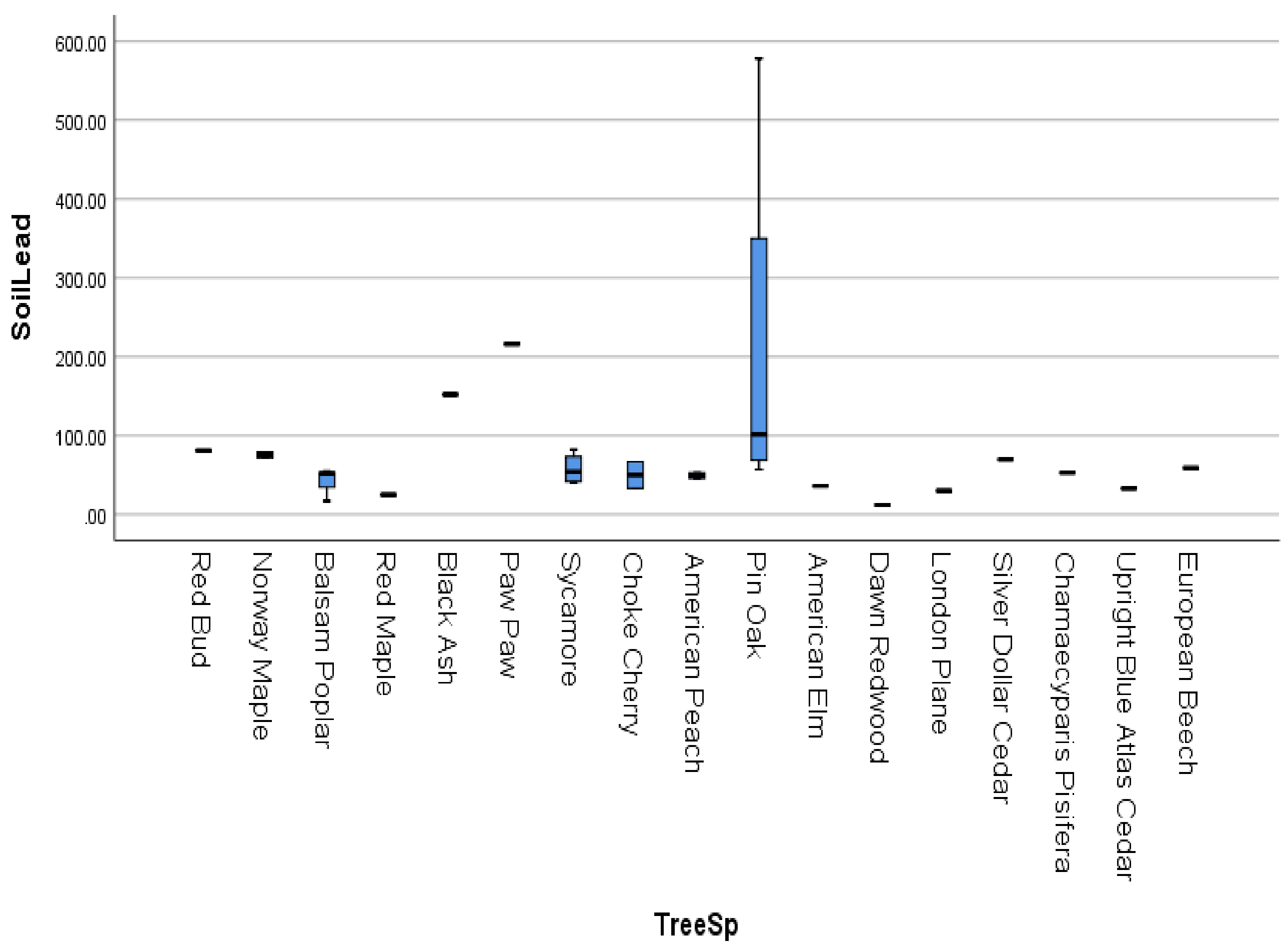


Figure 1: Tree species and lead found in soil (ppm)

This graph shows that there were only significant lead levels found in the Pin Oak trees. All the other trees had undetectable levels of lead (i.e. less than approximately 4.0 ppm). The lead levels found in these tree species ranged from 15.0ppm-60.0ppm. It is believed that the lead levels found in these trees were due to the spices ability to up take lead from soil.

Due to Pin Oak trees containing detectable lead levels they could potentially be used as a method of reducing lead levels found in soil. The lead levels in the soil around the Pin Oak trees was also higher than the other tree species.

Figure 4: Lead in Trees vs. Tree species

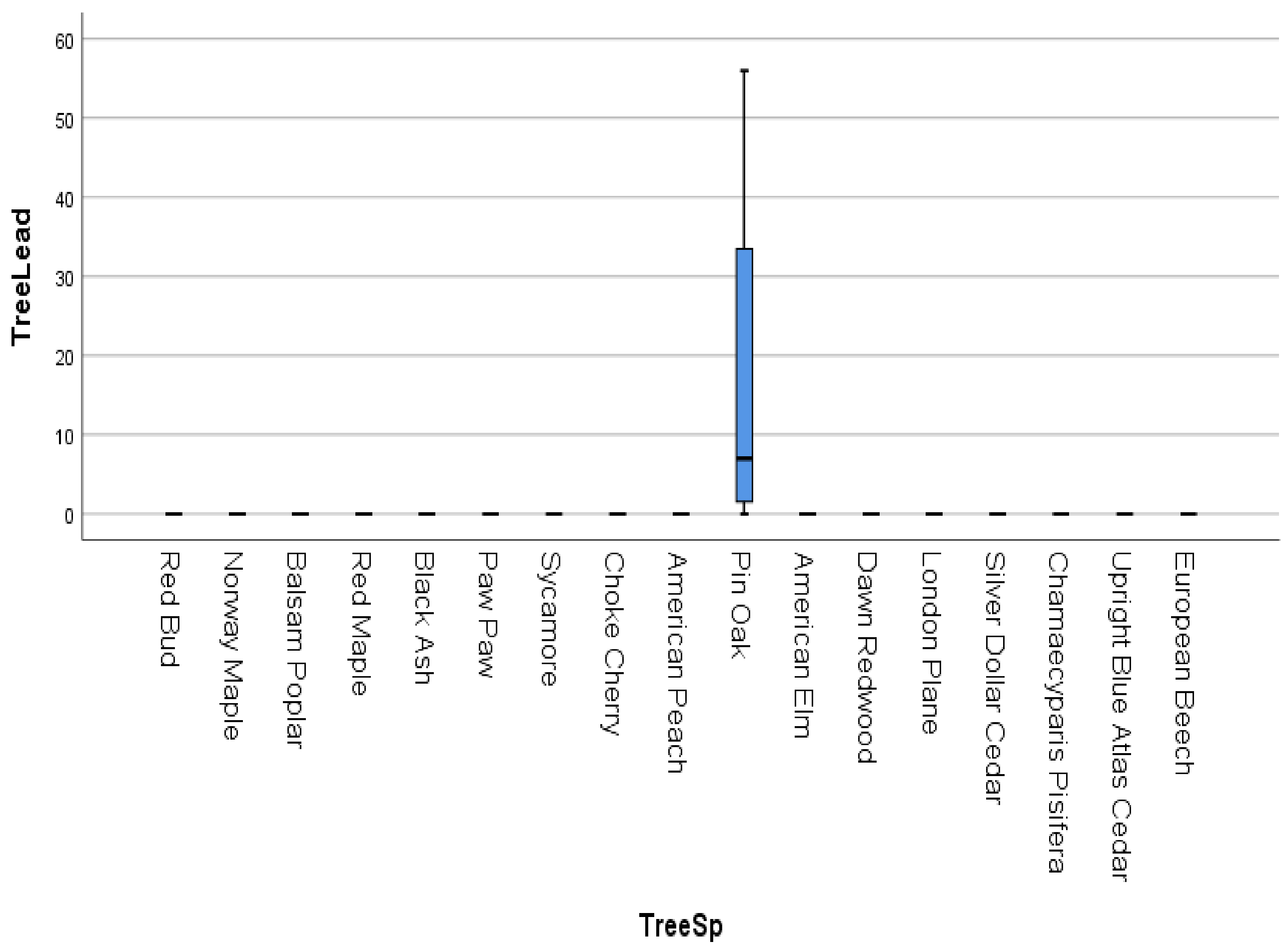


Figure 2: Tree species and lead found in tree (ppm)

These results show that the Pin Oak trees could potentially be a natural and safe way of reducing lead levels in residential and street trees. The single sample T-test results suggest that the Pin Oak trees are significantly better at absorbing lead then the other trees in this study.

In figure 1 the graphs showed that the soil surrounding the Pin Oak trees had above average lead levels. In figure two the graph shows that the Pin Oak trees were the only trees to absorb detectable levels of lead. The high lead levels in the soil might have been even higher if the tree wasn't there to absorb some of the lead.

Figure 5: One sample T-test results.

One-Sample Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
TreeSp	9.804	27	.000	8.17857	6.4669	9.8902
TreeLead	1.236	27	.227	2.500	-1.65	6.65

Figure 3: One sample T-test

There were two different one sample t-tests done, the first one was done to test the significance of the tree species found wit lead contamination. The second one was done to test the significance of lead levels found in the trees. The tree species were statistically with a p-value of >.001. The pin oak trees were the only tree species of the sixteen different species we took samples from that contained lead.

Conclusion and Future Work:

Based on the analysis of the data I was able to conclude that the Pin Oak tree species can absorb the most lead. The results show that the Pin Oak trees could be a natural and safe way of reducing lead levels in residential and street trees. The single sample T-test results suggest that the Pin Oak trees are significantly better at absorbing lead then the other trees in this study. Knowing this is important; Since there is no easy or simple solution to having high lead concentrations in soil: Pin oak trees could potentially be planted to help absorb and limit the lead levels found in the soil. Limiting the lead levels found in the soil will also reduce exposure to the lead.

Due to having such limited time to collect data the sample size is relatively small. With such a small sample size the data may not be completely accurate so a larger sample size would allow for better more accurate results. In the future I would like to go out and collect more data, to see if there are more tree species that could potentially help in reducing the lead levels in the surrounding soils. If we could go out and take more samples from a greater variety of tree species the results could slightly differ. There could be more tree species that are able to absorb lead from the soil and reduce exposure to lead.

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