Analyzing Lead Concentration in Soil for Urban Garden Planning in Springfield, Ohio

Kaitlyn McGee
Dr. Sarah Fortner
Environmental Research Methods
8 December 2020

Introduction

The term “redlining” originated from the New Deal, where the federal government mapped every metropolitan area in the United States based on where it was safe to insure mortgages (Gross). However, in communities with predominately people of color, the areas were colored red to inform insurance owners it was too hazardous to insure mortgages (Gross). This was a de facto method to justify segregation in communities and propagate inequality without consequence. The Home Owners’ Loan Corporation (HOLC) originally mapped these different sections of the city after the Great Depression, but as time progressed, the colored community became stuck, as housing policies remained stagnant. Redlining is still a problem today, and for the city of Springfield, hazardous areas are affecting the population on a deeper level.

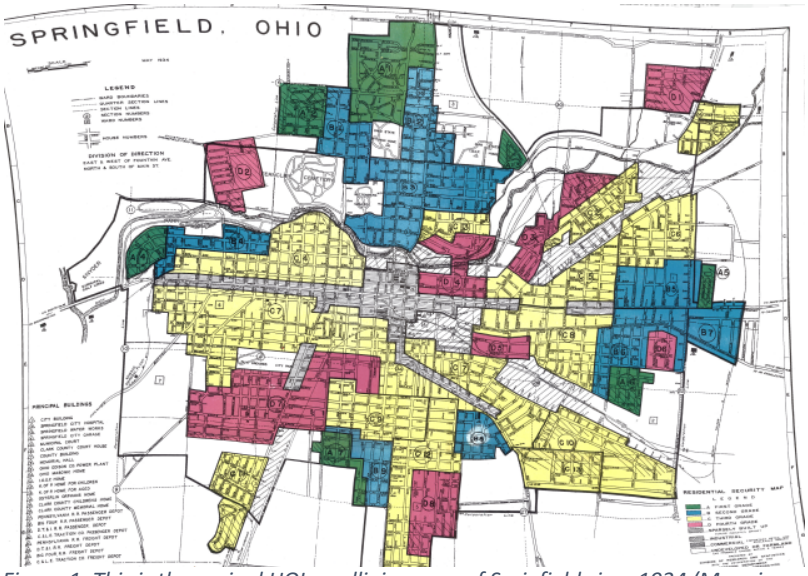


Figure 1: This is the orginal HOLc redlining map of Sprinfield circa 1934 (Mapping Inequality).

Lead is a potent contaminant most often stemming for paint and water pipes pre-dating the 1960’s, both of which are very prominent throughout Springfield. According to certain censuses, more than 20% of children under 6 years of age have experienced lead poisoning

("Springfield Lead"). Long term exposure can lead to severe health problems. Health effects include irreversible neurological damage, kidney failure, cardiovascular issues, and reproductive toxicity (Lead Toxicity). These issues are disproportional in Black and Hispanic children compared to White children based off of the demographics of redlining due to lower income and even lower education level (Whitehead). However, community outreach programs such as The Conscious Connect in Springfield are passionate about providing the necessary resources to allow children to succeed, as well as being in contact with the communities most affected by redlining. One aspect of their initiative is to close the equity gap in Springfield by removing abandoned houses, providing books around the community with the Houses of Knowledge (HOK), and creating greenspaces and family parks (The…Connect).

One covert challenge to the greenspaces is the variable carbon content in the soil (SOC). Most of the current spaces that were converted into parks and natural areas were sites where abandoned houses once stood. When they were knocked down, the soil was filled with excess debris like wood and concrete. However, plants need soil with good carbon levels (natural plant and animal matter that has been broken down) in order to sustain growth. This is one problem of urbanization in relation to sustainability and health. According to one study, it was found that urban soils tended to be generally fine textured and tended to have a lower carbon percentage than soil in rural areas (Herrmann). This is often attributed to urban debris such as concrete and other building materials but can be detrimental to the ecosystems that rely on high carbon content and natural till in the soil. However, carbon rich soil creates an unstable foundation for urban development (Herrmann).

The goal of the project is to determine and compare the differences between lead and carbon content in knockdown sites and locations with Houses of Knowledge (HOK), as well as

determine the best locations for urban gardens out of the tested House of Knowledge sites. It is important to compare both variables because lead can be absorbed by vegetables from the soil, and soil carbon in necessary to maintain good growing conditions. Additionally, it is integral to determine how lead and carbon content effect the community. Communication and cooperation are necessary in creating a better dialogue between the citizens and outreach organizations to ultimately build a better future in the redlined areas of Springfield.

Methods

In Springfield, there are 13 locations where Conscious Connect built Houses of Knowledge. These were split up amongst the class based on general proximity on the map. Two of the groups sampled from four of the locations, and one group sampled from five locations. The sites that were sampled were as follows: Snyder Park Elementary, Clark Preschool, Fulton Elementary, Robert C. Henry Funeral Home, and Lagonda Elementary. At these locations, five samples were taken from different areas that were open and void of trees, as to mimic the placement of a possible garden. From these locations, the latitude and longitude were found by dropping a pin using the Google Maps phone application. The coordinates were recorded on a plastic bag, as well as the location and sample number. Then, using a small hand spade, a hole was dug approximately 10 cm in depth to collect dirt. Grass and other vegetation were taken out of the collected sample.

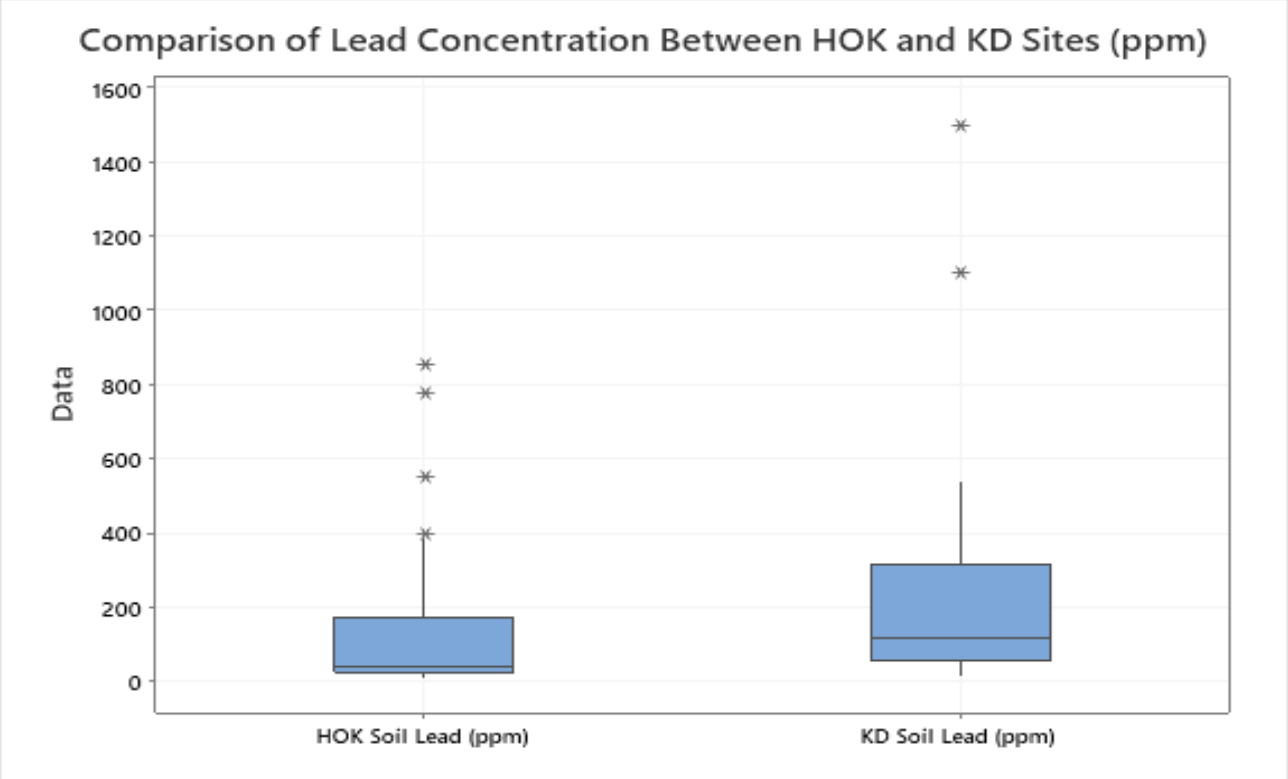
Once all of the samples were collected (n=25), they were allowed to dry for five days. After the five days, three samples were randomly picked for carbon sampling. The soil from the 15 samples chosen were added to their own individual tins (labeled with location and sample number) to finish drying completely. The tins were weighed prior to having the soil added and

then after. These numbers were recorded in an Excel spreadsheet. After another two days of drying, the samples (still in bags) were analyzed for lead content using an XRF Lead Analyzer. Three were sampled one additional time and these two numbers were averaged. The lead content (in ppm or parts per million), standard error, and maximum possible lead content were also recorded in the spreadsheet. Once the soil in the tins was allowed to dry completely, they were baked in an oven (a method referred to as loss on ignition) in order to burn any carbon present in the soil. After this process was completed, they were weighed, and the values were recorded in the spreadsheet. Dry and burned soil weight was calculated by subtracting the tin weight, and the organic carbon percent was calculated by the following equation: $\frac{(Dry-Burned)}{Dry(.45)}(100)$.

These values were also added to the spreadsheet. The data was then imported into ArcGIS to create a site map with the locations of all the samples and Minitab to calculate statistical figures (mean, standard deviation, and range). The aforementioned statistical data and variables were interpreted appropriately in graphs, specifically a histogram and boxplot. The methods used were derived from academic instruction, and the mapping was based on those from "Springfield Lead".

Results and Analysis

After collection, the data imported into ArcGIS and Minitab was used to create the site map and statistical figures. After analyzing that data, the HOK sites had a lower lead content. Of the 48 samples tested for lead, the results yielded a mean concentration of 130 ppm. The



Variable	Mean	StDev	Minimum	Median	Maximum	Range
HOK Soil Lead (ppm)	130.2	190.0	5.4	38.5	851.9	846.5
KD Soil Lead (ppm)	209.6	266.9	11.8	113.7	1500.0	1488.2

Figure 2: Boxplot comparing the lead concentration from the HOK and Knoackdown sites.The y-axis is the lead concentration in parts per million, in 200 point intervals. The statistical summary of the data is included.

knockdown sites (n=50) yielded a mean concentration of 210 ppm. The knockdown sites had a greater spread in the data as well as range, with the highest lead concentration being 1500 ppm. These concentration levels are significantly higher than those found at the HOK sites, with the

highest lead concentration being 852 ppm. The EPA standard for lead concentration acceptable for gardening is below 200 ppm. For the HOK locations, 10 out of the 48 samples were higher than 200 ppm (outliers). The knockdown locations tended to have higher concentrations, the uppermost sample exceeding 1200 ppm, which is the EPA standard for safe bare-soil play areas.

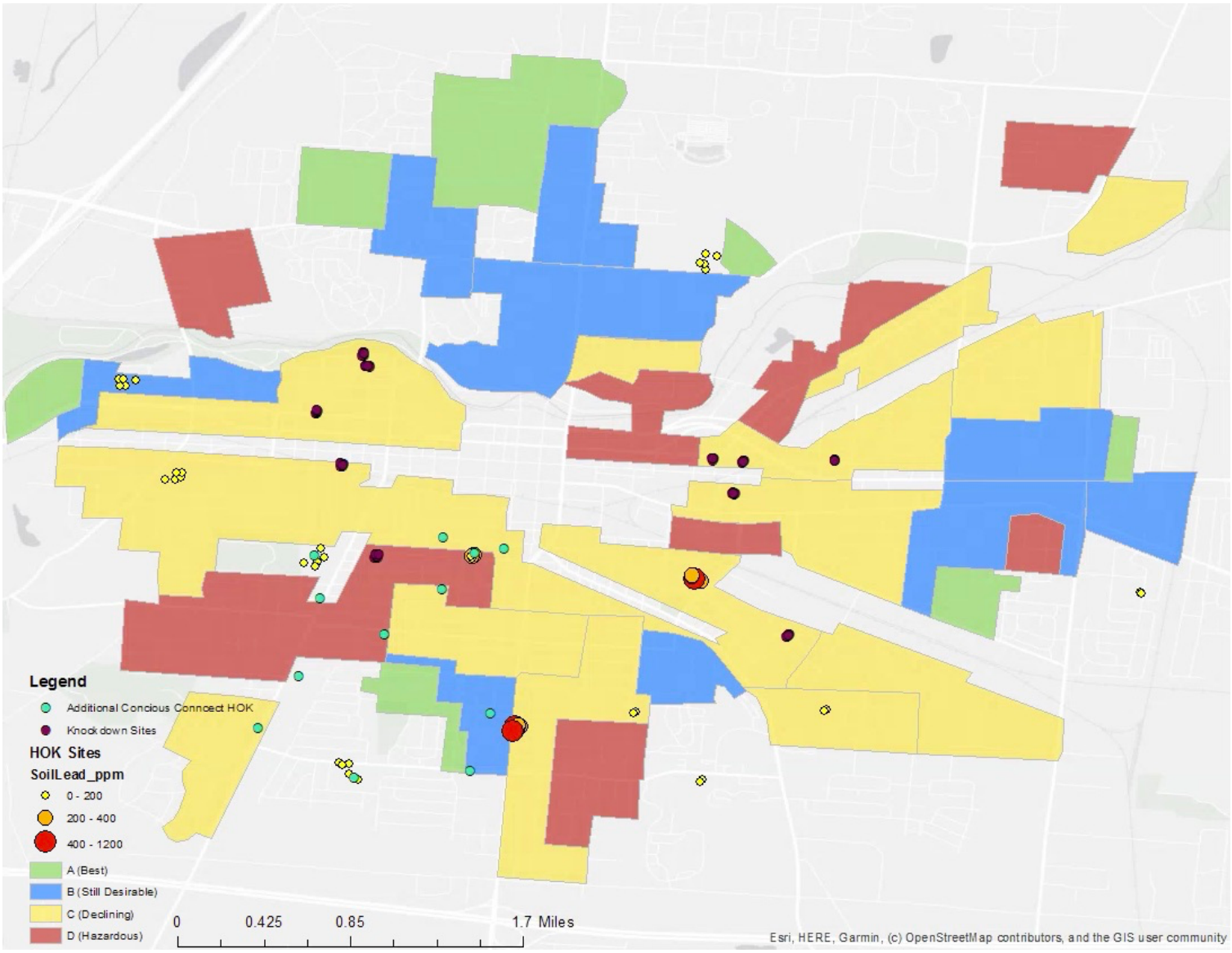


Figure 3: Map of Springfield, OH overlayed with the HOLC redlining zones. The samples HOK locations are indicated with the yellow, orange, and red circle by lead concentration. The locations of the knockdown sites are indicated by purple points. The HOK sites that were not tested are indicated in light blue.

The knockdown sites were located only in the Declining and Hazardous areas of the city, but the location did not necessarily determine the lead concentration, with some locations being

almost void of lead to incredible hazardous. The HOK sites that were tested were in a variety of zones in Springfield, 5 of which had no specified zone. The only two locations that had high lead concentration were in Declining zones of the city. All of the other sites had a low concentration level, including the one site in a Hazardous zone.

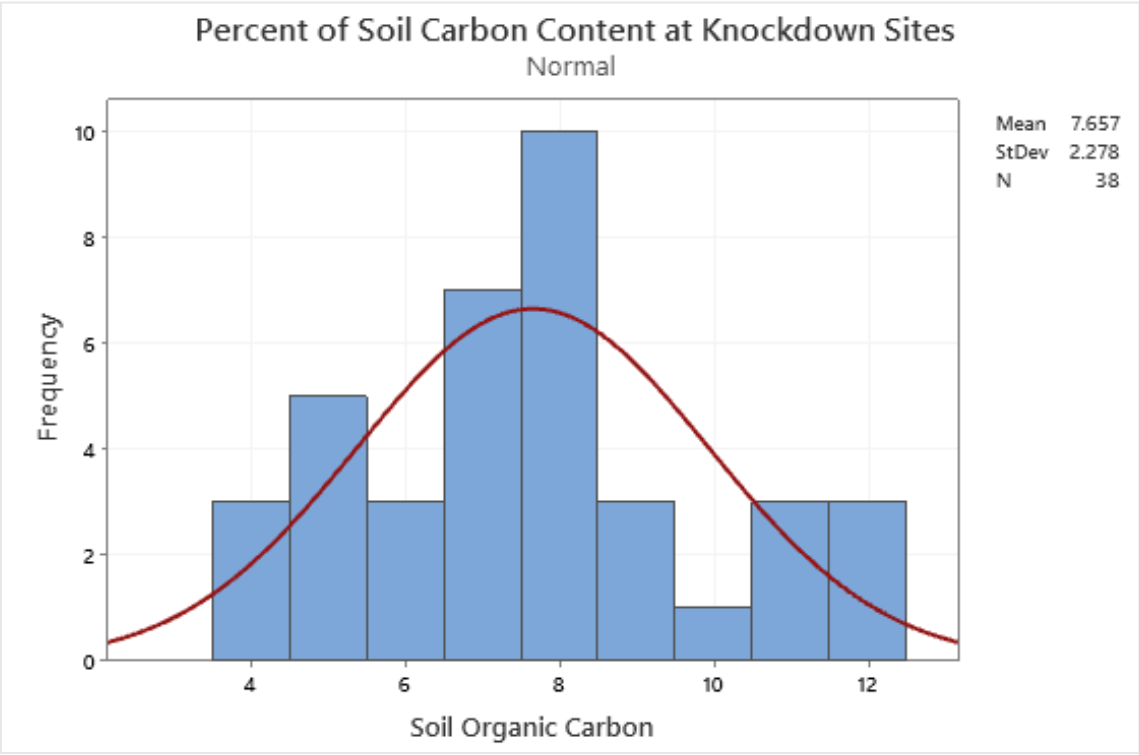


Figure 4: Frequency of the soil organic carbon percentages from the Knockdown site locations

Besides lead concentrations, one important aspect when looking at future gardening plots is the percent of organic carbon in the soil (SOC). The knockdown sites had an overall higher SOC percent, with a mean of 7.6%. The HOK sites tended to have lower percentages (mean= 6.9%), with the majority of the samples from 1.5-5%; however, there was a greater range of percentages than for the knockdown sites. Additionally, the samples from the HOK locations were composed predominately of clay and were very compact and hard. One reason for this may

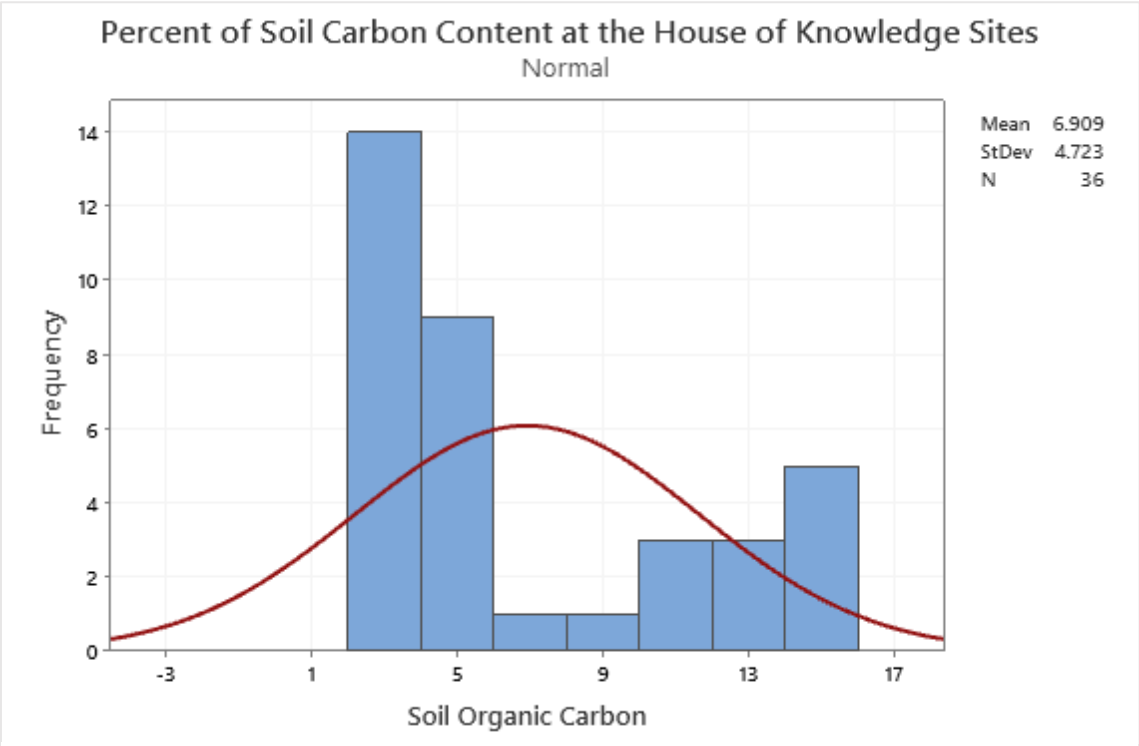


Figure 5: Frequency of the soil organic carbon percentages from the House of Knowledge locations

be because the majority of the HOK sites were located in the middle of field or near a field. Unlike the soil at the knockdown sites, the HOK soil would be less homogenized due to less outside influence like heavy equipment.

From the gathered data, the average lead content was found to determine which House of Knowledge have safe levels of lead in accordance with EPA standards for gardening, which is

Location	Average Lead (ppm)	Safe
Horace Mann Elementary	18	Yes
Kenwood Elementary	25	Yes
Miami Valley Child Development Center (East John Street)	104	Yes
Lincoln Elementary	108	Yes
Miami Valley Child Development Center	407	No
Perrin Woods Elementary	15	Yes
AJT Peace Garden	392	No
Snyder Park Elementary	33	Yes
Clark Preschool	35	Yes
Fulton Elementary	29	Yes
Robert C. Henry Funeral Home	204	No
Lagonda Elementary	32	Yes

Figure 6: The average lead concentration from each of the House of Knowledge sites and whether or not they are safe in adherence to the EPA standards for gardening (200 ppm). Only 12 out of the 13 sites yielded results.

less than 200 ppm. The sites that exceed this level are the Miami Valley Child Development Center, AJT Peace Garden, and Robert C. Henry Funeral Home. The sites that are best for a garden, having taken into account both lead concentration as well as carbon percentage, are Horace Mann Elementary and Kenwood Elementary. Horace Mann had an average lead concentration of 18 ppm and carbon percentage of 12.78%. Kenwood Elementary had an average lead concentration of 25 ppm and carbon percentage of 12.108%.

While the average lead concentration for each site is a good baseline for determining the safety of a location, there is variance in those numbers due to a standard error. For the sites near or approaching the EPA standard (200 ppm), I would suggest taking more samples to determine whether the lead concentration is actually safe or hazardous for gardens. The three sites I would recommend looking further into are Miami Valley Child Development Center East John Street, Lincoln Elementary, and Robert C. Henry Funeral Home (Figure 6).

Discussion

From the Analysis, the key point was that sampling at a House of Knowledge site or knockdown site does not completely determine lead levels or carbon content. However, the higher lead concentrations were in areas that were either categorized as Declining (yellow) or Hazardous (red), but many of the concentrations were within healthy EPA standards in the same areas. However, it is integral that all areas of Springfield are safe.

Based on the analysis of the samples and the synthesized research, the recommendations to Conscious Connect would be to consider creating gardens at Horace Mann Elementary and Kenwood Elementary, which have the highest soil carbon levels and the lowest lead concentration of all the House of Knowledge locations tested. Horace Mann is outside of the

redlining map, but is still near a Hazardous zone, and Kenwood is located in a Declining zone. Having gardens in these areas not only encourages community engagement, but also gives people who have been traditionally void of safe outdoor parks and gardens the opportunity to utilize these spaces. Additionally, I would recommend finding plants and vegetables that thrive in low carbon environments, so the community gardens are not limited to areas with high soil carbon percentages.

For further studies, I would suggest that additional House of Knowledge locations be tested for carbon and lead concentration, especially those closer to the urban center of Springfield. This will ensure that more people are able to use the community gardens and parks. Additionally, I would advise taking more samples at each of the locations and doing lead and carbon testing for each sample in order to yield more accurate results.

Regardless of the results, it is imperative that the community has an equal voice in decision making. One opportunity to increase conversation between the community and outreach organizations, like Conscious Connect, is to hold open forums where community members are able to freely attend and voice questions and concerns to a panel of outreach representatives. Another suggestion is to increase the number of people receiving surveys because it is necessary that as many people as possible are listened to. Transparency is the most important aspect when communicating with the community about health statistics and civic actions. Ultimately, if these steps are taken, Conscious Connect, in junction with the community, will help reduce the gap between redlined zones in Springfield and create a better environment for the next generation to flourish.

Bibliography

The Conscious Connect, Inc., theconsciousconnect.org/.

Gross, Terry. “A 'Forgotten History' Of How the U.S. Government Segregated America.” *NPR*, NPR, 3 May 2017.

Herrmann, Dustin L., et al. “Urbanization Drives Convergence in Soil Profile Texture and Carbon Content.”

“Lead Toxicity.” *Centers for Disease Control and Prevention*, Centers for Disease Control and Prevention, www.atsdr.cdc.gov/csem/csem.asp?csem=34.

“Mapping Inequality.” *Digital Scholarship Lab*, dsl.richmond.edu/panorama/redlining/.

“Not Even Past: Social Vulnerability and the Legacy of Redlining.” *Digital Scholarship Lab*, dsl.richmond.edu/socialvulnerability/map/.

Schwarz, Kirsten, et al. “Growing Gardens in Shrinking Cities: A Solution to the Soil Lead Problem?” *Sustainability,* vol. 8, no. 141, 2016.

“Springfield Lead.” *Redlining Education and Change Coalition*, 16 Apr. 2020, serc.carleton.edu/earthconnections/networks/metal_redlining/wittenberg/springfield_lead.html.

Whitehead, LaToria S., and Sharunda D. Buchanan. “Childhood Lead Poisoning: A Perpetual Environmental Justice Issue?” *The Journal of Public Health Management and Practice*, vol. 25, no. 1, 2019, pp. 115–120.