Assessing the Concentrations of Lead and Carbon within the Soils at the Houses of Knowledge partnering with The Conscious Connect in Springfield, Ohio

- **Introduction**

Several soil content problems boil down to *redlining*, a biased evaluation method for mortgage markets based on neighborhoods' quality (Rutan 2018). The technique used was present back in the 1930s and 1940s among cities throughout the United States. Communities had a security grade that ranged from A-D (Rutan 2018). "A" usually meant an ideal neighborhood, while "D" was usually the worst setting type. The qualities of communities remain based on race, income level, and home value (Rutan 2018). Appraisals of homes often rejected investment in areas that were considered unstable and integrated but paid further attention to racially segregated communities (Rutan 2018). White neighborhoods often received more attention by having more access to mortgage loans, making the house more desirable to sell. Examples like this are racial injustice, which has a lasting impact.

Many redlined communities composed of older homes did not receive the necessary attention because of disinvestment leading to exposure of lead within paints, making their way into the urban soil. The health concern is primarily directed towards children, which are more vulnerable than adults. Prolonged exposure to lead in children can have detrimental health effects on them. Children who may have a small amount of lead in their body can experience problems with developing the nervous system and the brain (Whitehead et al., 2019). Both of these parts of the human body remain very crucial, especially during development. Another problem the children face is that they can experience difficulties regarding learning and behavior during their early years (Whitehead et al., 2019). Since redlined neighborhoods have worse environmental conditions and have more blacks, most of the children affected by lead exposure are black. Past research findings indicate that black children may have more lead within their blood than white children (Whitehead et al., 2019). Therefore, it ties back to that it is a health concern and an environmental justice issue.

However, issues such as lead poisoning have the capability of mitigation. Public health officials can use an environmental justice framework to improve families' current living conditions in redlined communities, as seen in figure one. Such a framework may incorporate that healthy environments should be available to anyone to ensure fairness and have non-discriminatory behaviors (Whitehead et al., 2019). Therefore, new measures had to take place. Residents of a community and scientific experts work together to consult with policymakers to reduce the risk of lead poisoning to those who remain vulnerable (Whitehead et al., 2019). Fortunately, other measures took place to control issues of racial discrimination. Such an example includes Title VIII of the Civil Rights Act of 1968. The act banned the use of racial discrimination through housing (Whitehead et al., 2019). However, it was still present even after the act took place. It was not as prevalent as before.

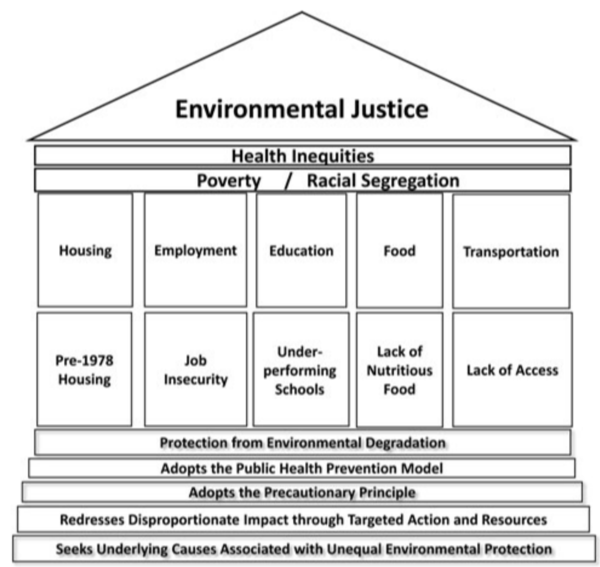


Figure 1: The depiction above shows an illustration of the Environmental Justice framework. Some of these methods may have a usefulness when handling environmental issues coming from *redlining*.

The next subject to investigate includes the topic of urbanization and soil organic carbon. Soils can reshape and alter ecological functioning when subjected to urbanization which drives homogenization among the soil layers (Herrmann et al., 2020). The process of urbanization connects with how much organic carbon lies within the soil. The connection remains highly present, especially among finely textured soils. Findings indicate that this type of urban soil had less organic carbon (Herrmann et al., 2020). Shifts in both ecological functioning and structure type of the ground can pose a couple of challenges. The changes come from the fact of the short-term development of new buildings or landscapes. For soils to maintain versatility, sustainability, and other outcomes, the shifts need to be understood by urban planners (Herrmann et al., 2020). As an additional note, the organic carbon content remained present in the intermediate layers after the shifts. Such changes are not ideal because that would mean the topsoil lacks certain nutrients to promote plants' further growth.

As mentioned earlier, urbanization promotes soil homogenization. When soils remain isotropic (unweathered soil), most intermediate layers typically have clay content, while topsoil layers contain finer particles and more carbon content (Herrmann et al., 2020). However, when soils homogenize, the order of soil profiles usually reverse and alters the soil properties. Different variables can change the vertical distributions of soils. One of them is how soil properties spread throughout a natural development profile (Herrmann et al., 2020). The other variable has to do with management. After a moving event, there has to be an assessment of how urban ecosystem management affects the soil layers (Herrmann et al., 2020). The general topic must receive more research as it is vital to know for any urban development plans.

Background information can provide a means of setting up goals for the city of Springfield, Ohio. The first goal is to ensure that new community health standards in redlined neighborhoods remain feasible. Such criteria can improve the living conditions in these types of settings. The idea is to begin avoiding contact with potential lead in the soil, especially among

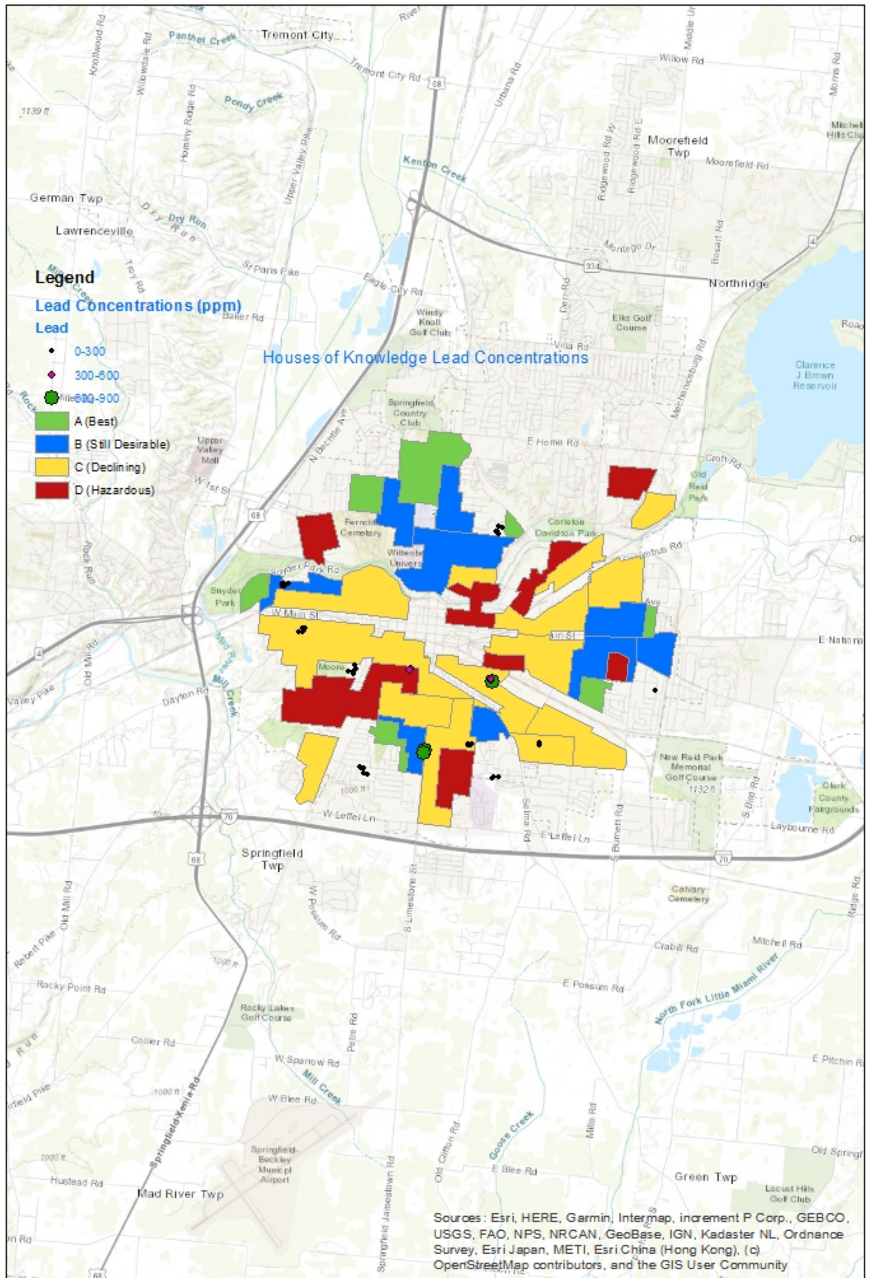


Figure 2: The image depicts the soil lead concentrations (ppm) in the Houses of Knowledge (HoK) locations on the Springfield Redlining map. The HoK were built by a non-profit organization called the Conscious Connect. Five samples were collected from a total of twelve HoK locations. Most of the soil lead concentrations ranged between 0-300, which is a good sign for future gardening practices according to the EPA. The legend indicates three different intervals ranging from zero to 900 ppm of soil lead concentration. The map also shows the security grades of A-D, which rated the quality of neighborhoods according to the Homeowners Loan Corporation (HOLC) back in the 1940's.

the children, as they are more vulnerable. The study intends to investigate the Houses of Knowledge (HoK) thirteen locations associated with the Conscious Connect. This non-profit organization promotes health, education, and peace among underutilized spaces (Conscious Connect 2020). The Houses of Knowledge were found at several elementary schools and other vacant lots throughout the city. They are boxes that have children's books that kids with less access to books can use. Each HoK location remains listed on the Conscious Connect website. Adam Brown, one of the co-founders of the Conscious Connect, had an interest in understanding the soil lead and organic carbon distribution at the HoK locations. Depending on the distribution, Adam would like to place community gardens in these areas. Such an opportunity would allow the kids to have more learning opportunities, especially when it comes to food production and learning more about the planet. The opportunity would also allow community members to become more involved with one another. Understanding the lead and carbon content in these soils will let decision-makers and stakeholders take the initiative to provide future land use and community development.

- **Methods**

Throughout the project, a collection of soil samples took place in the city of Springfield, Ohio. The study was in consultation with Conscious Connect. Specifically, the group worked with Adam Brown, who is one of the founding members. As mentioned earlier, the Conscious Connect has twelve Houses of Knowledge (HoK) locations distributed throughout Springfield. Most HoK locations filled vacant areas near elementary schools, parks, and vacant lots that provided under sourced children with books. A collection of five soil samples distributed at each location took place, adding up to a total of sixty samples.

Materials for collection included Zip-Lock plastic bags, pens, trowels, burners, XRF analyzer, and metal tins. The trowels had the usefulness to dig up to ten centimeters of the surface soil (Yuhong et al., 2020). Once dug, the zip-loc bags provided storage for the soil samples to dry for future carbon and lead content analyses. The pens allowed groups to write the coordinates of each soil sample location. Metal tins permitted the use of measuring the mass of each soil sample that would burn. Once the soil had a chance to air-dry and remove impurities, carbon content measurement could occur (Yuhong et al., 2020). There is a particular method that allows for the reception of soil organic carbon remnants. The possibility of calculating carbon content took place by using the loss on ignition method with temperatures ranging around 900 degrees Celsius (Magar et al., 2020). Burning the samples allows other impurities not to be present. Once the soil burns, there should only be carbon as the remaining material. A formula helped calculate the exact carbon content in percentage. The procedure was ((Dry-Burned)/Dry * 0.45*100), which gave the precise measurements (Magar et al., 2020). Other masses had to be known to calculate the carbon amount in the soil successfully. Three of the five samples of each location measured organic carbon, and the remaining two samples measured lead content separately.

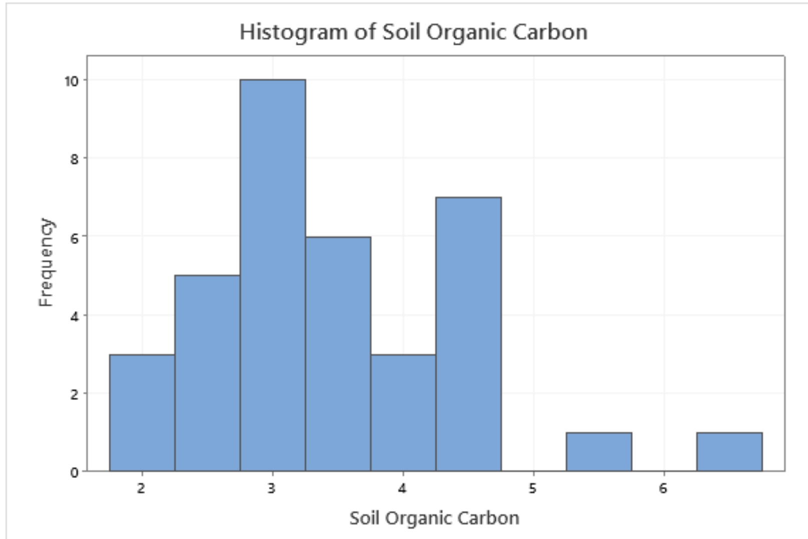
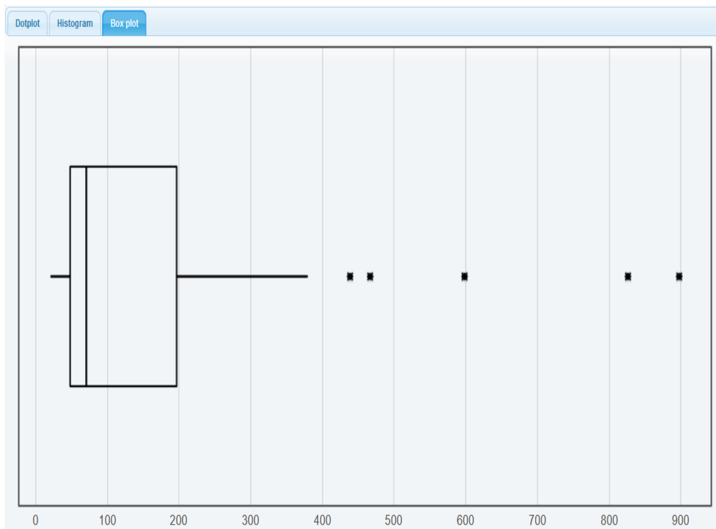


Figure 3: Above refers to the amount of Soil Organic Carbon (percent) from the given samples that were tested from the HoK locations. Soils that had approximately three percent of organic carbon appeared the most frequent and measurements between four and five percent fell second. Soils with five or more percent carbon content only appeared once.

Lead content remained another concern when examining the soil samples. Past land use and characteristics remained unknown at the sites because such information had no accessibility. However, there is a method that helps receive lead concentration immediately. The technique was to use an XRF (X-Ray Fluorescence) analyzer and a soil testing feature that comes with it and remains useful to the U.S. EPA (Markey et al., 2008). The analyzer used was within the NITON 300 series. Such a method can make the procedure portable and less time-consuming. Immediate results and reliability allow the process to be adequate for such measurements. All of the soil samples had to be dried before analysis to have more accuracy (Markey et al., 2008). The soil bags lay within a box and would press up against the analyzer. Measurements also included error bars because there could be some uncertainty in the lead concentration (Markey et al., 2008). Error bars assist with having accurate results. After both values had consideration, they added up together to get the total lead concentration. Once the analyzer gave measurements, it was possible to begin analyzing and recording the samples' data. The study lacked adding replicate samples, which was a way to examine a soil sample a second time for precise lead content measurements. Studies like this can use replicate samples in the upcoming future as they provide excellent sample agreement.

Results/Analyses

Analysis during the study investigated *redlining*, which was once used in the city of Springfield. Each neighborhood had its security grade, according to the Homeowners Loan Corporation (HOLC). Even though *redlining* deems illegal, you can still see the side-effects that came from the practice. The specific divisions and security grades of the neighborhoods remain visible in figure two for further reference. Another aspect investigated in the study were each of the locations where the samples came belonged. ArcGIS helped incorporate the coordinates of each soil sample on the map of Springfield, Ohio. The



Summary Statistics

Statistic	Value
Sample Size	48
Mean	162.856
Standard Deviation	198.558
Minimum	21.1
Q_1	47.900
Median	70.450
Q_3	196.500
Maximum	897.6

Figure 4: The figure above indicates a boxplot for the total soil lead content (includes error bars) coming from a total of forty-eight. Not all samples had a measurement of lead content. The values are as follows:

1. Minimum: 21.1 ppm
2. Q1: 47.9
3. Median: 70.45
4. Q3: 196.5
5. Maximum: 897.5

The data has up to five outliers in the data. It proves the point that not all areas will have a similar soil lead content amount. Some may be very high or very low.

measurements only calculated soil lead content without the error bars. The samples ranged from zero to 851.9 parts per million. Figure two presents the volume of lead content and each soil sample's distribution from the HoK locations in Springfield, Ohio.

The analysis also covered two more variables during the study, including soil organic carbon content and the total soil lead content (includes error bars). Soil Organic Carbon refers to how much carbon lies within a soil sample after receiving a burning treatment. It only leaves carbon as a by-product afterward. Higher organic carbon content may indicate healthier soil. As seen in Figure 3, most soil samples had approximately three percent organic carbon content, which seems quite average. Other soil samples had either lower or higher carbon content but not at significant frequencies. Many of the samples were light brown after burning, which could mean that there may not be much carbon. More details of the exact distributions lie in figure three. Total lead content (includes error bars) received investigation during the study. The boxplot of the data lies in figure four. It turns out that there were a few outliers in the data. The results went to show that not all locations will have similar levels of soil lead. Levels depend on several variables, including past land use, lead paint, and other reasons. However, it doesn't remain easy to know the one-time land use as that was not an aspect of the study when visiting the Houses of Knowledge locations. The five values of the boxplot also lie within figure four, and more information on the data. It gives a statistical perspective on the lead content. However, interpretation of these results remains essential.

Discussion

The first aspect to look at is perhaps the connection between the *redlining* map and the soil lead concentrations at all HoK locations. After examining figure two, there seems to be a random pattern. It turns out that only one HoK location was within a hazardous neighborhood.

The soil lead levels were mostly lower (between 0-300 ppm) in South Springfield. However, the other sites were not in *redlined* neighborhoods. The remaining HoK locations were within the "C" security grade neighborhoods (declining), categorized as low-income neighborhoods with minority residents. Thus, we cannot say that soil lead levels are not only present in *redlined* neighborhoods. There was one site that was in the "still desirable" neighborhood.

The other aspect that received investigation had to do with the soil organic carbon content and total soil lead content in the study samples. Soil organic carbon (SOC) can illustrate how much carbon lies within the soil. In other words, it helps researchers understand how organic the soil is for future use, especially for the topsoil. If there is plenty of topsoil with humus (organic matter), gardens have more growth potential (Magar et al., 2020). According to the data, soils that had around three percent of SOC were the highest frequency. More soil samples had higher SOC than having a lower SOC. Such numbers give a good sign because that means there is potential for such soil for future gardening. SOC can vary among each site because it may depend on what was the past land use. Since majority of the sites had a moderate amount, it can indicate that the soil may not have too much homogenization.

The other aspect under investigation included total soil lead concentrations (including error bars) within forty-eight samples. As noted in figure four, not all of the samples had testing for lead levels. There were up to five outliers in the data given. The outliers come from the fact that some soil samples had higher concentrations than that of the other majority of samples. There was also quite a broad range, which went from 21.1 to 897.5 parts per million, as seen in figure four. Perhaps the reason for such ranges could come from past land use. However, that may not be the only reason. There could have also been inaccurate results coming from the NITON analyzer. That is where replicate samples will be important for future study. Given the results, members from the Conscious Connect may receive some advice from the EPA and Adam Brown (from the Conscious Connect) if the children's gardens become the next project for the Houses of Knowledge locations.

It remains important to note some of the recommendations from the EPA regarding soil lead levels. The EPA has a standard that there can only be a maximum of four-hundred parts per million in land sections where children will play and garden use (Markey et al., 2008). As mentioned earlier, the soil lead levels must remain lower because children have a greater risk of exposure because of development. However, soil lead levels have a different standard for other land uses. The maximum soil lead levels deemed safe for another yard use to stay below 1200 ppm (Markey et al., 2008). Even though some of the areas from our study feel safe, specific measures should still have consideration. According to the EPA, any organization should always examine the mitigation methods to reduce soil lead exposure (Markey et al., 2008). Fortunately, several HoK locations had lower soil lead levels deeming it a bit safer for both play and community garden use at those locations as many were below 400 ppm.

However, sites with higher lead concentrations need more attention and maintenance. If Conscious Connect aims to provide gardens in the HoK locations in the future, such measures need consideration. The most recommended action to take is to regularly test the soil's quality, especially for lead content (Schwarz et al., 2016). Another consideration to take is the use of raised garden beds (Clark et al., 2008). Perhaps such actions may reduce lead ingestion because there is no direct contact with the soil on the ground. However, such efforts need regular maintenance. A useful method could be using compost as a replacement of the top three to five centimeters of the soil (Clark et al., 2008). The practice will promote decomposition of materials such as leaves, fruits, and vegetables. Thus, more organic matter will absorb the soil lead content in the future. Manures with nitrogen may also help with reduction by binding the lead and making it less bioavailable (Schwarz et al., 2016). Doing so may prevent further accumulation of soil lead content. That is why testing is so important before making use of a vacant lot.

Conscious Connect aims to ensure that vacant areas in Springfield, Ohio, promote education, culture, health, and peace among the children (Conscious Connect 2020). Some of those spaces include the Houses of Knowledge. They refer to reading locations where children can access a book to read, which encourages further learning (Conscious Connect 2020). Throughout the study, the HoK locations were near public schools, residential homes, and churches. They wanted to offer a variety of places so that anyone could have access. There is a particular recommendation that future Wittenberg students should use when working with Conscious Connect. Students should continue testing both types of parks for both carbon and lead content so that there is more information about whether or not gardens can coexist in these areas and are safe for children. It would also be a great way to double-check if concentrations have changed in a year. Students should also research the health effects of long-term lead exposure and present that information over to the Conscious Connect members to better understand the issue, especially in the vacant lots. Students should also take the time to understand further the practice of *redlining* and what it left behind. The method is one of the main reasons for the results of environmental injustice in Springfield.

Taking the time to research will provide the students with empathy, which Adam Brown emphasized in his meetings. Having empathy will also make spreading the message easier, especially among the residents of Springfield. Even though there is plenty of potential for further expansion, research and communication on environmental injustice, soil carbon, lead concentrations, and future solutions need consideration. Doing so will help reframe the urban gardening approach and improve urban sustainability and environmental justice goals (Schwarz et al., 2016). Such care should take place among the communities, private or public organizations, universities, and stakeholders. The efforts will help promote nutritional poverty alleviation and increase access to more local food (Schwarz et al., 2016). Having all parties involved in their roles ensures that everyone is on the same page and that the strategy may improve urban neighborhoods' conditions amid prolonged social inequality.

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