DePaul Discoveries

Volume 11 | Issue 1 Article 6

2022

What's in Your Soil? A Comparative Assessment of Total Lead in Soils in Southwest Side and North Side Chicago Communities

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Acknowledgements

Financial support for data collection was provided by the Undergraduate Summer Research Project (USRP) Award from DePaul University's College of Science and Health. Lakeview data was collected and provided by Benjamin Goedert (DePaul University). Thank you to citizen scientists from Muchin College Prep for assisting with sample collection in West Elsdon and Garfield Ridge. Thank you to our local collaborators at The Southwest Collective. I would like to thank my faculty advisor Dr. James Montgomery for supporting and guiding me throughout the entire process of this project. Lastly, thank you to my ENV peer Zoharia Drizin for her time during the sample preparation process.

What's in Your Soil? A Comparative Assessment of Total Lead in Soils in Southwest Side and North Side Chicago Communities

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ABSTRACT In Chicago, city officials continue to locate polluting industries in predominately Black and Hispanic/Latinx neighborhoods. Lower income families are disproportionately exposed to greater amounts of toxic chemicals such as lead (Pb). While the City of Chicago focuses its effort in removing industrial sites from the North Side, a predominately white community area, sources of industrial pollution are more likely to be found in communities of color. Due to the prevalent sources of Pb on the Southwest side, residential soil is often highly disturbed and contaminated. Pb is a serious neurotoxin, and ingestion or inhalation of Pb contaminated soil and dust can affect all organ systems (e.g., cardiovascular, nervous, renal, immune, reproductive). The goal of my project is to measure, map, and compare spatial patterns of total soil Pb within and among three community areas in Chicago: West Elsdon (WE) and Garfield Ridge (GR), located on the Southwest Side, and Lakeview, located on the North Side. I trained a team of citizen scientists to collect soil samples from randomly determined points located in parkways in WE/GR census tracts. Samples from Lakeview were collected by a former ENV student. Samples were digested and analyzed for total Pb following EPA Method 3050B. Results of this project indicated that mean total Pb concentrations in WE/GR were not significantly higher than total Pb concentrations from Lakeview.

INTRODUCTION

While lead (Pb) is a naturally occurring element in the earth's crust, urban areas are at risk for lead poisoning due to elevated levels of lead in the environment. Exposure to lead in urban cities like Chicago are due to human activities and the historic use of lead-based paint and leaded gasoline. When ingested or inhaled lead can have negative health impacts on all organ systems and is associated with a range of chronic diseases (e.g., cataracts, kidney function, diabetes, osteoporosis) (Mielke et. al, 2007). Lead is a neurotoxin that is particularly dangerous for children, as it can cause developmental and behavioral issues that affect their growth, learning, and sleep.

Lead contamination is a threat to the public health of residents in urban environments

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Research Completed in Winter 2022

because lead emitted in past decades still exists in urban areas, particularly in soils (Sung et. al 2018). Lead in soil does not decompose over time, so previously deposited lead will remain in soil for thousands of years. Lead accumulates in soil as a result of nearby industrial activity, freight yards and intermodal terminals, lead pipes and plumbing material in homes, ceramics, and batteries (U.S. EPA). Lead dust generated from soil erosion can be tracked into homes on shoes and clothing and becomes a household exposure to lead (Farfel et. al, 2005). Children can ingest lead from soil through hand-to-mouth activity and from eating vegetables that have taken up lead from contaminated soil. Even low levels of lead exposure and moderately elevated blood lead levels can cause severe deficits in neurobehavioral functions in children (Tong et. al 2000).

Black and Hispanic/Latinx Chicago residents are disproportionately experiencing the effects of soil lead contamination (Steele 2022). Recently identified soil lead hotspots are consistent with the location of industrial activity on the South side in the early 20th century, where several steel plants were located along the Calumet River and Lake Michigan before closing in the 1980s (Watson et. al 2022). Today, city officials continue the common practice of locating lead polluting industries in communities with large populations of Hispanic/Latinx and African American residents (Chase 2022). Many residents experience underlying health conditions and do not have access to quality health care or well-paying jobs, making it harder to mitigate negative environmental impacts (Chicago Department of Public Health, 2020).

A cleaner environment for already vulnerable communities is constantly being sacrificed. The goal of this study was to compare total soil Pb concentrations, and the spatial patterns of these concentrations, between West Elsdon and Garfield Ridge on Chicago's Southwest Side with Lakeview on the North Side. West Elsdon's population is more than 80% Hispanic/Latinx and Garfield Ridge's population is more than 50% Hispanic/Latinx. Lakeview's population is over 77% white (non-Hispanic) (CMAP 2021). Further inspection of polluting industries in WE/GR indicated that few were actually Pb emitters. Nearby industrial sites and manufacturers, brownfields, and railyards are still polluting the area with chemicals such as methanol, nitric acid, nitrate compounds, chromium, zinc compounds, manganese, nickel, ammonia, and more (Cailas 2021).

METHODS

Citizen Science for Sample Collection

I collaborated with my high school and a neighborhood organization, The Southwest Collective,[1] to recruit citizen scientists to collect soil samples from parkways located in WE/GR Community Areas. Census tract boundaries were overlain on a map of these Community Areas, and five sampling sites were randomly located in parkways in each tract using the *Create Random Points* tool in ArcMap. Sample points were referenced by latitude and longitude. I assembled soil sampling kits consisting of a 1-gallon Ziploc bag labeled with the census tract, a garden trowel, five quart-size Ziplocs labeled with the sample location coordinates, and soil sampling instructions. The citizen scientists were assigned to a census tract block and provided with a sampling kit. They collected soil samples to a depth of 7-15 cm from the parkways at the five random locations. Samples were stored in Ziploc bags, then taken to the Environmental Soil Science Laboratory in McGowan South for processing and analysis.

A former ENV major collected and analyzed soil samples from five random points in parkways located in the 34 census tracts in the Lakeview Community Area. The random points were located using the ArcMap GIS software and georeferenced by latitude and longitude. West Elsdon, Garfield Ridge, and Lakeview soil samples underwent the following preparation and analysis.

Soil Pb Sample Preparation

[1] The Southwest Collective, accesses 2021, https://www.swcollective.org/.

Samples were dried at 105 °C in a convection for 24 hours. After drying the samples were

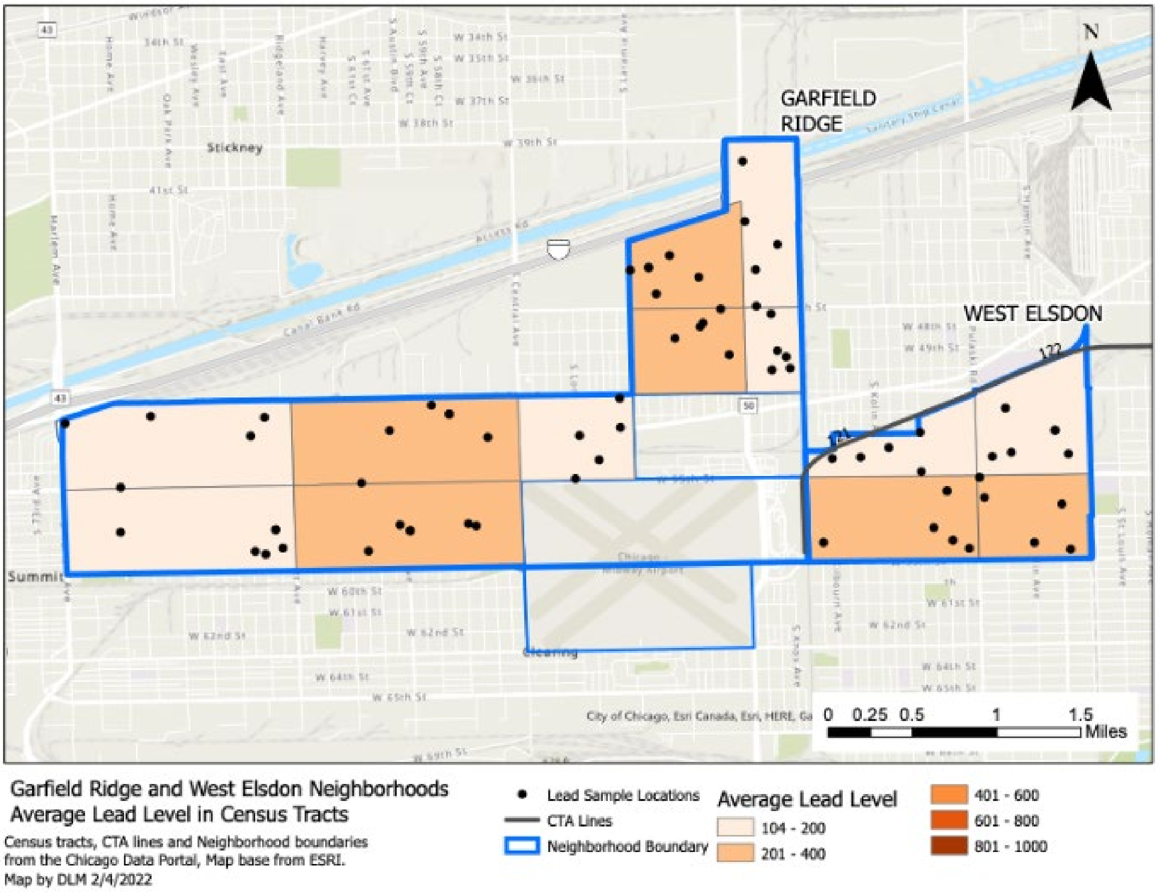

Figure 1. Map displays average lead levels in West Elsdon and Garfield Ridge census tracts on the Southwest side of Chicago in ppm.

ground using a rolling pin and passed through a #10 sieve to collect the fine-earth (<2.00 mm) fraction. These samples were then pulverized using a ball mill to pass through a #325 sieve (270 microns) for Pb analysis. One gram of each sample was weighed out and labeled in 50 mL volumetric flasks. Samples were then extracted and digested for total Pb following EPA Method 3050B utilizing flame atomic absorption spectrometry (FLAA) analysis.[2] I used the FLAA spectrometer in the Department of Chemistry. Quality analysis and quality control (QA/QC) was performed by measuring total Pb concentration in a 10 ppm Pb standard, in a Standard Reference Material (Montana-II soil). Replicate FLAA analysis was performed on every tenth sample.

Spatial patterns of total Pb concentrations were mapped using ArcMap GIS software.

Data Analysis

Data for WE/GR were combined and tested as one group. Data for West Elsdon, Garfield Ridge and Lakeview were tested for normality in RStudio (RStudio Team).[3] The Lakeview data was not normally distributed. I ran a series of distributions found in R libraries *logspline* and *fitdistraplus* and found that a gamma distribution best represented the Lakeview data. The gamma distribution was used to run a generalized linear model (GLM) to determine whether there was a significant difference in Pb by location (WE/GR vs Lakeview) without the difference in sample sizes influencing statistical analysis.

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[2] U.S. EPA, "Methods 3050B: Acid Digestion of Sediments, Sludges, and Soils," 1996, https://www.epa.gov/esam/epa-method-3050b-acid-digestion-sediments-sludges-and-soils.

[3] RStudio, accessed 2022, https://www.rstudio.com/.

RESULTS

Average total Pb concentrations in WE/GR census tracts ranged between 104 ppm and 400 ppm. Six census tracts had average Pb concentrations ranging from 201-400 ppm (Figure 1). The maximum Pb concentrations in WE/GR ranged between 193 ppm and 800 ppm (Figure 2). Three census tracts had maximum Pb concentrations ranging from 601-800 ppm.

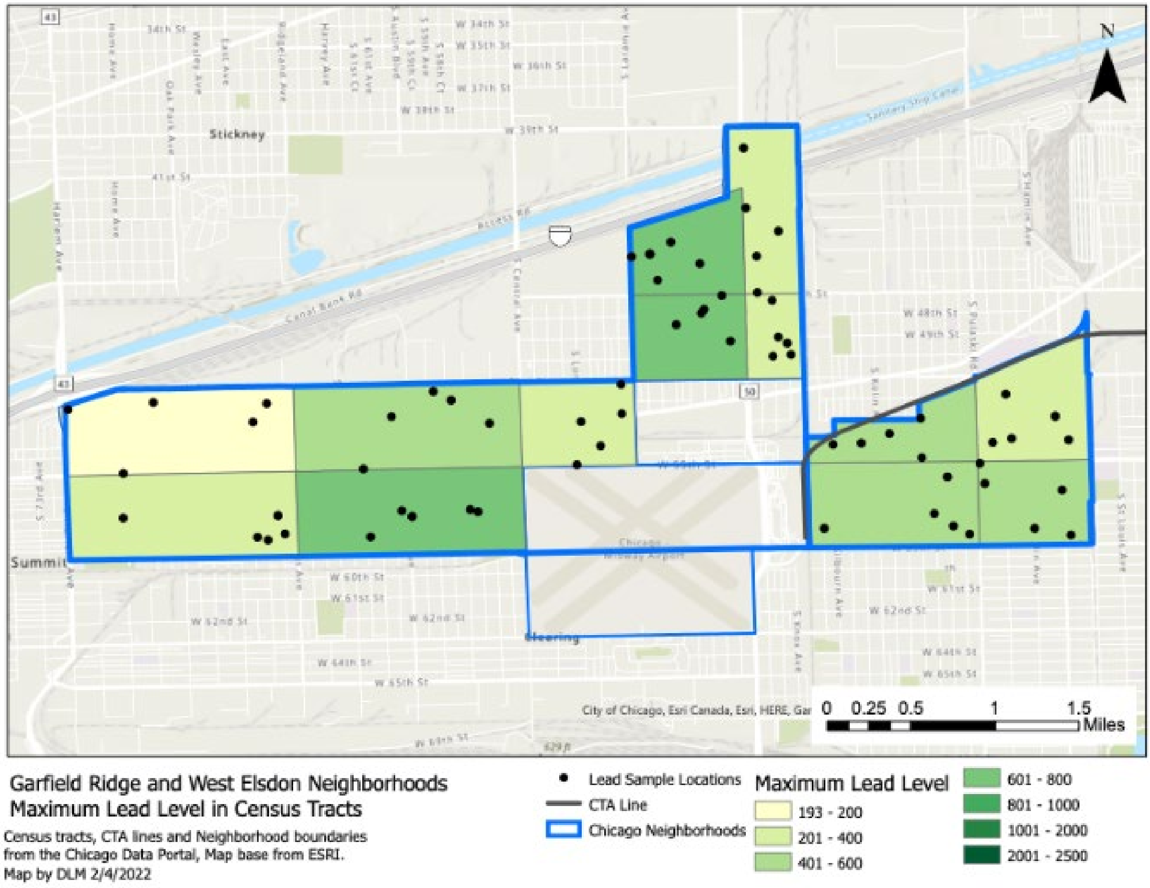

Figure 2. Map displays maximum lead levels in West Elsdon and Garfield Ridge census tracts on the Southwest side of Chicago in ppm.

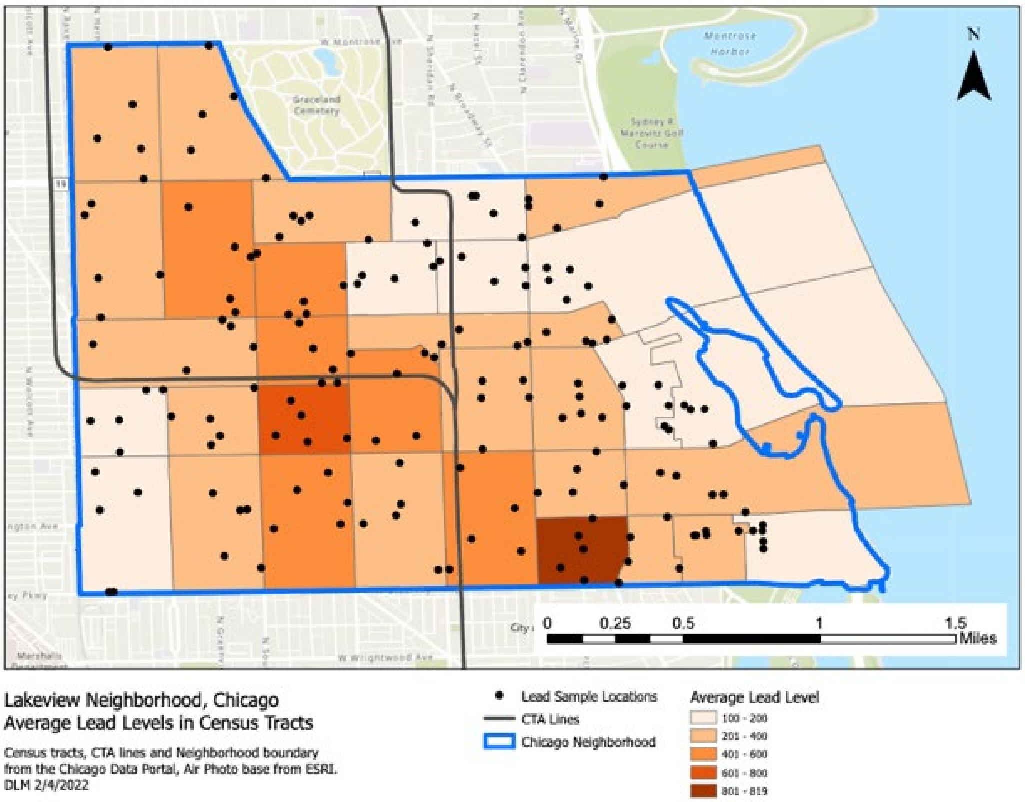

Figure 3. Map displays the range of average lead levels in Lakeview census tracts on the North side of Chicago in ppm.

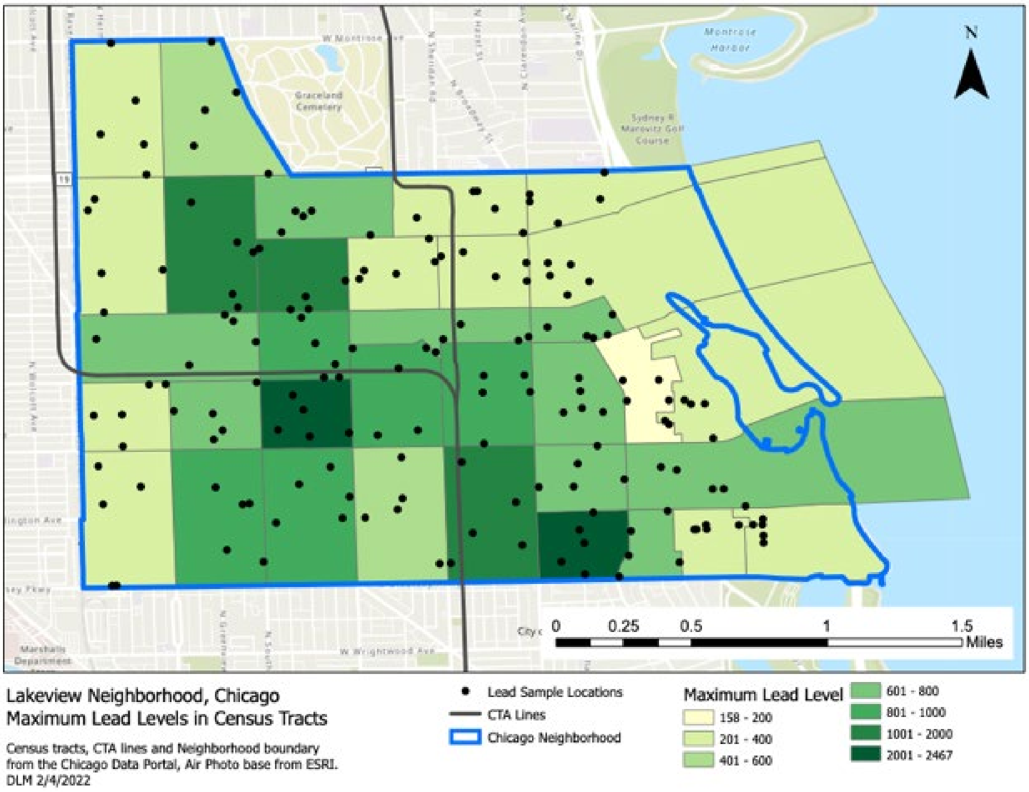

Figure 4. Map displays the maximum lead levels in Lakeview census tracts on the North side of Chicago in ppm.

Average total Pb concentrations in Lakeview census tracts ranged between 100 ppm and 819 ppm. One census tract had an average Pb concentration ranging from 801-819 ppm (Figure 3). The maximum Pb concentrations in Lakeview ranged between 158 ppm to 2467 ppm. Twelve census tracts had total Pb concentrations ranging from 158-200ppm (Figure 4).

Table 1 displays the calculated averages and medians for each Community Area, as well as the percentage of sites in each Community Area that have total Pb concentrations greater than or equal to 400 ppm. The U.S. EPA's standard for Pb in bare soil in play areas is 400 ppm by weight and 1200 ppm in non-play areas.

	West Elsdon	**Garfield Ridge**	**Lakeview**
Average Pb (ppm)	221.8678	206.2927	319.7636
Median	187.7692	163.8856	229.2667
Min.	26.9139	27.9761	23.1439
Max.	451.4230	782.9039	2466.8538
MSE	29.5760	24.4238	29.3064
Percentage of sites ≥ 400 ppm	15	11	21

Table 1. Data Summary for West Elsdon, Garfield Ridge, and Lakeview. Data summary for the three community areas includes average Pb (ppm), minimum and maximum values, mean squared error (MSE) and the percentage of sites with Pb concentrations greater than 400 ppm. MSE assesses the average squared difference between observed and predicted values.

The average total Pb concentrations in Lakeview Community Areas were statistically significantly greater than WE/GR Community Areas. The p value was p=0.025 and the standard error was 6.963e-04.

DISCUSSION

The results of this study indicated that mean total Pb concentrations in the WE/GR Community Areas were not significantly greater than the total Pb concentrations in the Lakeview Community Area. The EPA has declared a soil lead hazard "…as bare soil on residential property or on the property of a child-occupied facility that contains total lead equal to or exceeding 400 parts per million (ppm) in a play area, or an average of 1,200 parts per million of bare soil in the rest of the yard based on soil samples" (U.S. EPA 2020). Of the 65 parkway sites sampled in WE/GR, eight had total Pb concentrations equal to or exceeding 400 ppm. In Lakeview, 34 of the 170 sites collected from had total Pb concentrations equal to or exceeding 400 ppm.

There was an imbalance in sample sizes between Lakeview and WE/GR. The GLM allowed us to test the significance between mean total Pb concentrations without the influence of sample size. However, the Lakeview data had missing Pb concentration values. Missing values could ultimately cause bias in our ability to describe patterns in the data and estimate causal effects. Some census tracts in Lakeview had outliers of high Pb (>2000 ppm). One very high concentration could outweigh the other concentrations in that tract, resulting in a skewed mean. However, a soil Pb distribution study by Watson et. al also shows high Pb concentrations in parkway soil in Lakeview.

West Diversey Parkway is a major street on the North Side of Chicago that separates Lakeview and Lincoln Park neighborhoods. Diversey stretches along the south border of Lakeview and encounters plenty of foot and vehicle traffic. Some census tracts along Diversey had large total Pb concentrations, indicating traffic as a major source. These large concentrations were possibly derived from atmospheric deposition of Pb aerosols created during combustion of leaded gasoline in automobiles prior to it being phased out by the mid-1990s. Brown and Purple CTA lines run through Lakeview. Some census tracts near the elevated train lines have high total Pb concentrations. CTA elevated track structure columns may contribute to total Pb concentrations in the area. The structure columns are coated with layers of Pb paint that has probably chipped off and been deposited on the soil below during structure repair/repainting.

While the results of this project show less total Pb concentration in soil in WE/GR compared with Lakeview, several hazardous sources are likely to be concentrated in low-income communities with predominately Hispanic/Latinx residents (Cailas 2022). As increasingly unsafe land use imposes environmental threats to the public health of all communities, residents of Southwest community areas in Chicago still experience a lot of the burden (Geertsma 2018).

ACKNOLWEDGEMENTS

Financial support for data collection was provided by the Undergraduate Summer Research Project (USRP) Award from DePaul University's College of Science and Health. Lakeview data was collected and provided by Benjamin Goedert (DePaul University). Thank you to citizen scientists from Muchin College Prep for assisting with sample collection in West Elsdon and Garfield Ridge. Thank you to our local collaborators at The Southwest Collective. I would like to thank my faculty advisor Dr. James Montgomery for supporting and guiding me throughout the entire process of this project. Lastly, thank you to my ENV peer Zoharia Drizin for her time during the sample preparation process.

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