The Impact of Local Anthropogenic Activities on Soil Health within a Retired Farm: Implications for Urban Gardens

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Abstract

Americans are implementing private food gardening for food access and affordability. A report by the National Gardening Association (2020) reveals a notable increase in food gardening in the past decade among urban households, especially millennial households. These national trends reflect an increasing interest in healthy living, sustainable gardening practices, and mitigating food insecurity within communities. Nonetheless, little is being done to assess soil health, especially for soils utilized for private and community gardens. Soil contamination can harm the health of those who use contaminated soils for food gardening. Thus, this study investigates soil health within a retired farm that is situated in close proximity to a firearms range and a county highway department. Fifteen soil samples were collected from the farm's garden plots and analyzed for heavy metals (e.g., Pb, Zn, Cr, and Cu) using a Bruker CTX benchtop XRF unit. Elemental analyses of these soils reveal variable, but low concentrations of Pb (37 - 189ppm), Zn (119 - 382 ppm), Cr (27 - 81 ppm), and Cu (24 - 70 ppm). These heavy metal concentrations are significantly below EPA-defined thresholds, indicating that the soils pose no immediate health concern to gardening. However, many samples yielded Pb, Zn, and Cu concentrations that are elevated relative to local background values. The soil samples closest to the road, firearms range, and the highway department facility contained the most elevated concentrations, suggesting that proximity to local anthropogenic activities can degrade soil quality.

Significance and Hypothesis

Soil is the foundation to most terrestrial life on Earth, both as a habitat and through cycling of nutrients. Unfortunately, current anthropogenic activity deposits harmful heavy metals into the soil (Brevic and Burgis, 2014). Some sources of contamination include industrial activity, emissions from the transportation sector, and use of fossil fuels. Heavy metals such as Pb and Zn can leach into the soil and further enter the body through inhalation, ingestion, and dermal contact (Wuana and Okieimen, 2011). Consequences of contact with these contaminants include cancer, fertility issues, nervous system diseases, and other life-threatening health complications (Hodson, 2010). The many pathways for contamination and the clear impacts of these heavy metals on human and animal health necessitate that communities investigate soil health before using it for agricultural purposes.

HYPOTHESIS: Given the proximity of the DePauw Campus Farm to potential sources of anthropogenic contamination (i.e, firing range, highway department, old city dump), we hypothesize that the soils within the campus farm may have elevated heavy metal (i.e., Pb) concentrations relative to natural conditions.

FIG. 1: Students plant cover crops on the DePauw campus farm. (Photo credit: Malorie Garbe)

Background

The retired farm location once bolstered 15 plots for growing fruits and vegetables, but is now overgrown with brush. It sits just outside DePauw's campus, less than 1,000 feet from a shooting range and approximately 50 feet from a country road. The county's highway development department and emergency operation center are within a 100-ft radius of the once farmland (see map). Given its surroundings and previous usage, this study aims to assess current levels of heavy metals and their distribution throughout the farm. It is the first of its kind in the area, modeled after soil geochemical surveys conducted worldwide.

FIG 2. Map Key (right)

Residency	DePauw Nature Park
Retired farm	Highway Development Dept.
Road	Fire Dept. Training Center
Firing Range	Emergency Operations Center

Methods

FIG. 3: Fifteen soil samples were collected from the campus farm's previous garden plots. At each sample location, five random subsamples were collected from a 1x1m area using a stainless steel probe. These subsamples were amalgamated for further analysis.

FIG. 4: The fifteen amalgamated samples were air dried in a fume hood for 72 hours, then lightly crushed and homogenized using a high-alumina mortar and pestle, and then sieved to < 180 µm.

FIG. 5: Samples were analyzed for elemental concentrations using a Bruker CTX benchtop XRF. Samples were analyzed for 60 seconds using a bracketing approach that alternates between a soil standard and unknown soil samples. Analytical accuracy and precision were monitored and evaluated using soil standard CSM2.

Results

FIG. 6: (Above left): Histogram plot of lead (Pb), zinc (Zn), and copper (Cu) concentrations from the fifteen soil sample sites relative to their distance from the Captain Jim Baugh Firing Range. (Above right) Histogram plot of lead (Pb), zinc (Zn), and copper (Cu) concentrations from the fifteen soil sample sites relative to their distance from the nearby county road (W County Rd. 225 S). All concentrations are below EPA threshold values (Pb = 420 ppm; Zn = 7500 ppm; and Cu = 4300 ppm, EPA, 1993).

FIG. 7: A) Plot of lead (Pb) concentrations normalized to average IN background value for Pb (EPA, 2010). B) Plot of copper (Cu) concentrations normalized to average US background values for Cu (EPA, 2007). C) Plot of zinc (Zn) concentrations normalized to average IN background value for Zn (Stallings et al, 2021). Samples are normalized to background concentrations using the following values: Pb = 84 ppm; Cu = 60 ppm; Zn = 150 ppm. These values are plotted with respect to varying distance from the firing range.

Spatial Analysis

FIG. 8: ArcGIS maps of the retired campus farm illustrating the spatial distributions of farm plots and the concentrations of lead (Pb), zinc (Zn), and copper (Cu). Symbol colors and sizes vary with concentration. Lighter tones (colors) and smaller symbols suggest lower concentrations, while darker tones (colors) and large symbols suggest higher concentrations. Elevated concentrations of Pb (37-189 ppm) are observed at sample locations closer to the county road and firing range. These observations suggest a combined anthropogenic input from these nearby sources. Similar spatial patterns are also observed for Zn (119-382 ppm) and Cu (24-70 ppm). Concentrations do not exceed EPA threshold levels (Pb = 420 ppm, Zn = 7500 ppm, Cu = 4300 ppm). Additional soil samples and analyses are needed to confirm these spatial patterns (EPA, 1993).

Conclusions and Future Work

Conclusions:

Soil geochemical surveys can help ensure soil safety, especially those soils that grow crops for human consumption. Assessing farmland in this manner aids in identification of anthropogenic inputs that may contaminate these soils.

Concentrations of Cu, Pb, and Zn are relatively low and below EPA threshold levels (see Fig. 6 & 7). The measured concentrations pose no immediate risk to residents or to the fruits and vegetables previously grown on the farm.

The highest concentrations of Cu, Pb, and Zn (70ppm, 382ppm, and 189ppm, respectively) are observed within samples taken from locations nearest to the road and firing range, suggesting there has been influence on the soil from these anthropogenic sources.

These findings allow us to accept our hypothesis that the firing range and/or road have impacted the soils in this area by elevating the concentrations of heavy metals such as Cu, Pb, and Zn relative to background values.

Future Work:

Farmers should consider the proximity to anthropogenic sources of pollution before choosing farmland. While all concentrations observed within this study are deemed safe, prolonged exposure to even low amounts of heavy metals may still impact human health.

We suggest that farmers conduct a soil geochemical survey of their intended farming area prior to crop growth, as opposed to after (as was done in this study).

Further, soil geochemical surveys can extend beyond farmland to include all land humans contact, with special attention given to farmland in urban areas.

FIG. 9: Students plant microgreens in the DePauw greenhouse. (Photo Credit: Malorie Garbe)

Contact & References

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References: