Dynamic Soil Properties Across a Suburban Landscape, Ankeny, Iowa

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Introduction: Humans have a long history of modifying the landscape around them to fit our needs. Whether it is building roads, tilling for agriculture, mining, installing a dam, or putting up homes for shelter, soils are affected. Hans Jenny[3] identified the soil forming factors of time, biota, topography, parent material, and climate. He recognized that humans impact soil formation and included humans in the soil forming factor biota. Humans were also recognized as being able to affect the five soil forming factors[1]. Other soil scientists, Dudal[2], have considered humans the sixth soil forming factor. The United States Natural Resources Conservation Service[7] produced three soil quality-urban technical notes. These notes provided information on:

1) erosion and sedimentation on construction sites;
2) urban soil compaction; and
3) heavy metal soil contamination.

Soil organic carbon is related to soil organic matter in soils. Soil organic matter is an important component of soil because it provides plant nutrients, improves soil physical properties like structure, porosity, and moisture-holding capacity, and supports soil biodiversity[9]. Often, surface soil is highest in organic matter and is the first to be removed or eroded during construction activities.

Soil compaction relates to an increase in soil bulk density, the latter of which is expressed as the oven dry mass of soil for a given volume. Soil compaction results in an increase in soil bulk density and can make root growth more difficult, slow water infiltration rates[8], reduce available water holding capacity, and reduce biological activity[6]. Compaction can also lead to increased surface runoff and loss of fertilizers applied to lawns[4].

Urban soils often have higher concentrations of heavy metals than rural soils due to higher inputs from wastes, industry, and burning of fossil fuels. Background concentrations of heavy metals are present in the environment due to natural concentrations in geologic deposits or soil parent material[5]. Heavy metal concentrations in air, water, and soil have increased beyond background levels due to human activities including mining and processing of these metals to use in industrial products such as gasoline, paint, pesticides, fertilizers, batteries, tires, and brake pads. As a result of industrialization and production processes, human exposure to these heavy metals has increased.

Objectives: The objectives of this study were to 1) to determine the bulk density, percent age organic carbon (% OC), and concentrations of Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Nickel (Ni), Lead (Pb), and Zinc (Zn) as a function of time of development; 2) to examine the depth (0-5, 5-10, and 10-20 cm) distribution of these properties; 3) to use correlations of these soil properties along with pH, texture and percent inorganic carbon (% IOC) to explain trends, and 4) to compare results obtained with Soil Survey information to help explain trends.

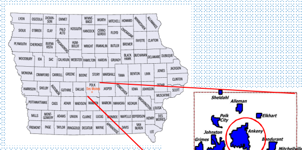
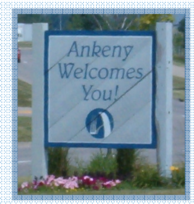


Figure 1: Location of Ankeny, IA.



Site Selection and Sampling: Aerial photos of Ankeny, Iowa (Figure 1), were obtained from the University of Northern Iowa and georeferenced using ArcMap. ArcMap was then used to delineate residential areas within the Ankeny City limits for the following nine time periods of development: Pre 1939, 1940-1955, 1956-1961, 1962-1967, 1968-1974, 1975-1982, 1983-1990, 1991-2002, and 2003-2005. Ten random points were generated for each time period and the front yards of homes closest to the points were chosen as sampling sites (Figure 2). Front yards of 90 homes were sampled in November 2005, April 2006, and May 2006. Soil samples were collected at three depths (0-5, 5-10, and 10-20 cm). A composite of five- 1.75 cm diameter cores were mixed and sub-sampled for analysis.

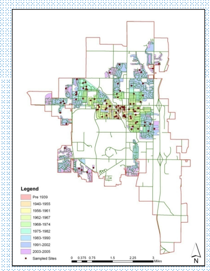


Figure 2: Nine residential time periods of development with sampling sites.

Analyses: Samples were analyzed for particle size distribution, pH, total carbon, inorganic carbon, bulk density, and Co, Cr, Cd, Cu, Ni, Pb, and Zn. SAS 9.1 was used to analyze the data and significant correlations were determined. Results were considered significant if the p-values were less than 0.05.

Results and Discussion: Soils adjacent to older homes could be recovering from disturbance that occurred during construction. Bulk density ranged from 0.68 to 1.88 g/cm^3 for the entire study area with a mean for each time period at each depth given in Figure 3. The bulk density was positively correlated with the sand content, the latter of which contributed to the higher bulk density in soils from the most recent time periods of development. The lower bulk density values of soils adjacent to older homes could also be due to recovery from compaction that may have occurred during construction. The organic carbon content ranged from 0.01 to 8.41 % for the entire study area with a mean for each time period at each depth given in Figure 4. The oldest time periods of development had the highest amount of organic carbon. Concentrations of Cu and Pb were higher in soils from older residential areas (Figures 5 and 6). Nickel concentrations increased with depth (Figure 7). Organic carbon was positively correlated with concentrations of Pb, Cu, and Cr. All the heavy metals were positively correlated with one another except Zn. The data suggests that all the metals except Zn have a common origin, parent material. Higher concentrations of Cu and Pb could be anthropogenic.

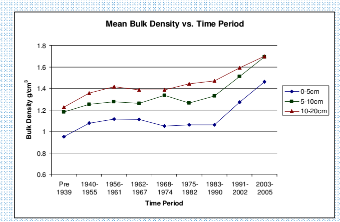


Figure 3: Mean bulk density vs. time of development

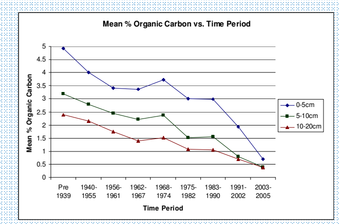


Figure 4: Mean % organic carbon vs. time of development

Columns with the same letters are not statistically different.

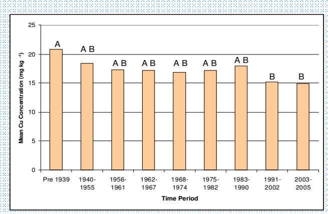


Figure 5: Mean Cu concentration for each time period.

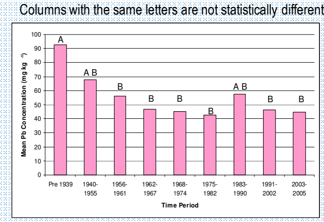


Figure 6: Mean Pb concentration for each time period.

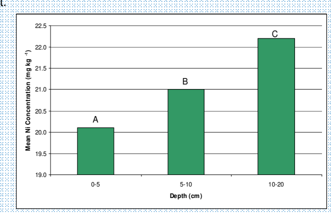


Figure 7: Mean Ni concentration at each depth.

Conclusions:

1) Bulk density decreased and soil organic carbon increased in soils adjacent to older homes. Soils could be recovering from construction activities.
2) Cu and Pb concentrations increased in soils adjacent to older homes. Concentrations could be anthropogenic. Most heavy metal concentrations were a result of parent material.

References

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