Estimating Soil Zinc Concentrations in Los Angeles County

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INTRODUCTION

The two main sources of heavy metals like Zn in urban environments are the natural parent material that forms the soil and metals introduced by man. While it is possible to find concentrations of a single native metal species that are above normal, it is unlikely that soil samples from a specific site contain multiple metal species that are all above normal concentrations. Therefore, it needs to be determined if metal contamination exists in this urban environment. To understand the nature of metals and why some are toxic to organisms in the environment, an examination of the periodic table is necessary. The periodic table reveals that the majority of heavy metals are classified as transition metals and that heavy metals have densities greater than 5 g cm^{-3}. Of the 90 naturally occurring elements, 53% are considered heavy metals, and based on physiological solubility, around 17 heavy metals are considered important to organisms and ecosystems (Weast 1984).

Heavy metals that are essential to plant metabolism are classified as micronutrients. Zinc, Ni, and Cu are important microelements. It is well understood that Zn binds to organic, inorganic and humic compounds and that Zn solubility and mobility are affected by soil types. The sorptive and desorptive processes of Zn are complex and dependent on the soil type. Thus, the availability of Zn depends on many factors that include the interface between the soil, microbial and plant processes (Schutzendubel and Polle 2002).

METHODS

A research trial was conducted to study the level of Zn concentrations in an urban environment. An initial stratified sampling design was developed using a Neyman allocation scheme. A refined Geographical Information System (GIS) analysis was performed to determine exact sample locations and to calculate sampling areas accurately for each site. The GIS coordinates used to locate each sampling site were generated by ArcMap (ESRI, Redlands, CA) and downloaded into a handheld Global Positioning System (GPS) unit (Garmin, USA). The GPS unit was used to locate the sampling sites at each location. These calculations were used to revise the second-stage sampling scheme associated with the statistical analysis. A final sampling plan containing 361 sampling locations from 70 sites was developed. Each top soil sample (0-5 cm) was analysed to quantify Zn levels. A basic univariate statistical analysis summarized Zn-concentration data for all 361 topsoil samples. A preliminary experimental analysis of sampling depth effect was conducted based on the initial 43 sites. Statistical analysis using paired t-tests and sign-rank tests indicated that there was no significant difference in metal levels between samples collected at 0-5 cm and 5-10 cm sampling depths.

Soil samples were analysed by Inductively Coupled Plasma - Optical Emission Spectrometry (ICP-OES). Analysis by ICP-OES is known to be reliable for major and minor elements in a wide variety of samples as demonstrated by its widespread use in environmental testing. The ICP-OES device used in this study was an Optima DV 2000 manufactured by Perkin-Elmer Inc.

RESULTS AND DISCUSSION

The raw data (M) of Zn concentrations in soils were natural-log transformed, and the transformed data were defined as Y = ln(M+1). The histograms and quantile plots of log-transformed metal data appeared to be approximately symmetric, while in some cases moderately heavy-tailed.

Two types of data-analysis plots (quantile maps and robust variogram plots) were used to assess the degree of spatial structure present in Zn concentrations. Quantile maps suggested that a substantial amount of short-range, local variation was present in the metal concentration data. Both, quantile maps and variogram plots, suggested that distinct location effects may have been present. Samples gathered from one location may have been more similar (less variable) than samples gathered from different properties.

Finally, a mixed linear spline model was proposed for modelling the Zn concentrations in soils. Fitted spline models were used to estimate the baseline, facility, and proximity effects. The baseline effect estimated the background-(log)-contamination level across the survey region.

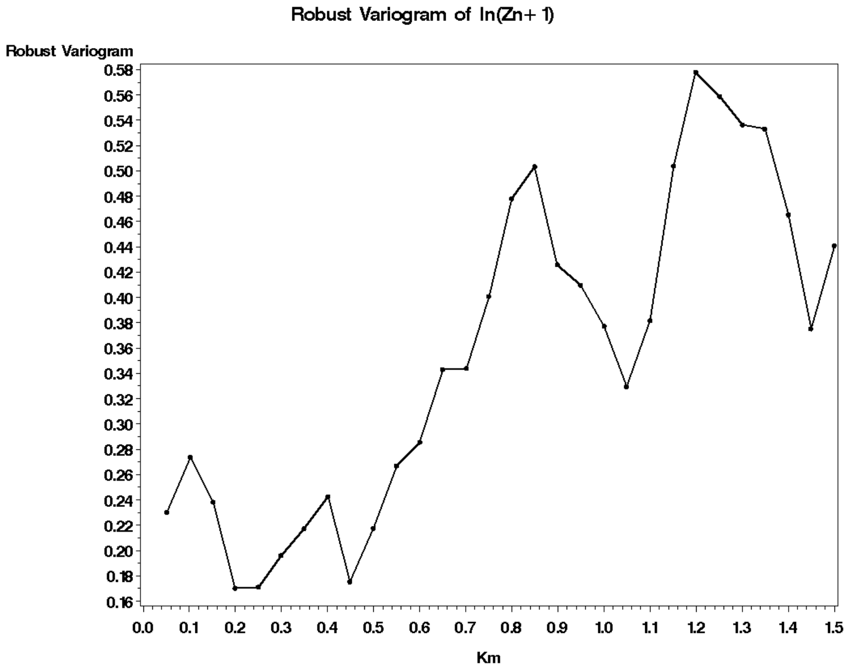

Fig. 1. Exploratory spatial plot (variogram) for Zn in soils.

CONCLUSIONS

Zinc concentrations could be predicted in soils using the following equation: $y_i = \beta_0 + \beta_1(\min[d_i, 2]) + \beta_2(f_i) + \beta_3(alt_i) + \beta_4(fway_i) + \eta_i$, where y_i is the Zn concentration and β_0 and β_1 are parameter estimates.

REFERENCES

Schutzendubel, A. and Polle, A. (2002) Plant response to abiotic stresses: heavy metal induced oxidative stress and protection by mycorrhization. J. Expt Botany 53: 1351-1365.

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