

Estimating the frequency of polluted soils in allotment gardens and mapping their spatial distribution using proxy data

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Abstract

Several studies have shown that soils in allotment gardens are sometimes quite strongly polluted by heavy metals and organic compounds. The extent of the pollution may reach a level, where remedial or protective action is required to mitigate health risks for gardeners. The extent by which the plots are polluted may differ strongly within one area. It further appears that areas with a long history of allotment use tend to be more strongly polluted than areas that have been established more recently. This points to the (historical) management practices of the gardeners as a source of the pollution. Since the historical management can hardly be established retrospectively, the responsible agency of the city council of Zürich was interested to collect further data on the pollution of soils in allotment gardens in the city.

In summer 2003, the agency and an analytical lab company sponsored a field course in survey sampling of a group of students of the Department of Environmental Sciences of ETH Zürich. The students were asked to survey two areas with allotments for which no data were available so far. The students had to estimate the frequency of plots in the areas for which the concentration of the pollutants exceeded the trigger and clean-up values of the Swiss soil protection ordinance. To avoid any sampling bias and to allow a quantification of the sampling error, the students used a stratified random sampling design where the duration of the allotment activities was used for stratification. The students designed the survey in a way that the precision of the estimate could eventually be improved later by surveying the pollution of all the plots in the area by some proxy method. Provided that the proxy variable is correlated with the pollutant then the precision of the estimate can be improved by a regression estimator.

The students sampled 29 of 112 plots in one area and 58 of 319 plots in the other. The content of heavy metals, of polycyclic aromatic hydrocarbons and some chlorinated pesticides were measured by the sponsoring lab company. In addition, the content of Pb, Cu and Zn was measured by a fast, inexpensive x-ray fluorescence technique, and the magnetic susceptibility of the soil samples was determined as well. It turned out the magnetic properties of the soil correlates with its heavy metal content. Therefore, another group of students surveyed in late autumn the magnetic susceptibility of all the 112 plots of the first area.

Apart from efficiently estimating the frequency of the plots with concentration above the trigger or the clean-up value by a regression estimator, the proxy data can be used to map the pollution of the plots by external drift kriging. In our talk we present the statistical analysis of the results of the two surveys, and we show what gain in precision results when in addition to the direct measurements of the pollutants proxy data are available.