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Relationships between soil properties and contents in trace elements in a landscape impacted by atmospheric fallouts in Belgium

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Examples of sites contaminated by atmospheric fallouts are numerous across former industrial areas, among which the valleys of Sambre and Meuse in Wallonia hosted metal ore treatment factories. Trace contaminants that fell on soil surface can migrate in the landscape under soluble or particle forms through various processes such as erosion, lixiviation, biological transportation, aso. We first investigated the spatial distribution of some metallic trace elements in soils around a former zinc-ore treatment plant to a distance of 3km. In a second stage, we studied the relationships between trace contents and soil properties, in order to evaluate the risks of mobility.

The sampling strategy aimed at (i) verifying that the main source of trace elements was the plant chimney, (ii) assessing the impact of the wind directions on fallout dispersion and (iii) evaluating whether there were differences of contents according to soil types and to soil occupation. Two hundred and fifty topsoil samples were collected according to a stratified design dealing with distance to the chimney, direction of dominant winds, soil type (loamy soil with good drainage, loamy soil with poor drainage and loamy-stony soils with gravels), and land use (crop, grassland and forest). Pseudo-total and available contents in trace and major elements, pH, TOC, and N were determined in the laboratory. Besides classical statistical analysis, (i) correlations between different parameters of soil, (ii) ANOVA (two or three way), (iii) ANCOVA (three-way ANOVA with the distance as a co-variate), (iv) regressions and (v) Principal Component Analysis were also performed.

First results show that (i) contaminants (Cd, Pb, Zn and Cu) contents are closely correlated to each other and (ii) Cd, Pb and Zn are negatively correlated with the distance ($R2 > 0.5$; p-value < 0.001). So, the geographical location explained by the “distance” factor is the main driving factor of trace elements contents in soils. Moreover, the second explanation is wind direction because the spatial distribution of trace elements follows perfectly the axis of the dominant winds. The two last factors are soil type and land use, the stony loamy soils and the forests present higher levels of contaminants than the other soils types and land uses.

The studied soil properties are differentially related to the trace element contents. The soil fertility (pH, TOC, N, available major elements) are weakly correlated while available versus pseudo-total pearson correlation R are very highly significant. Pseudo-total potassium, aluminium and calcium contents are also related with Cd, Pb, Zn and Cu available contents. This could reflect a lithological factor. The available:pseudo-total ratios are linked to organic carbon and clay contents (estimated through Al and Fe contents) but not with pH. Agricultural practices don’t seem to impact contaminant levels in the landscape. A relationship was found however with the forest occupation, in which the ratios were higher for Cu, Zn, and Pb. The risks of trace elements mobility in these environments deserve further investigations.