Relevance of soil mapping criteria to predict geochemical background of trace elements in soils from local to regional scales.

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Introduction

Among natural factors driving the soil content in metallic trace elements (MTE), the geochemical background is often deemed as a sound base for the detection of contaminations. Numerous studies have shown the difficulties to take into account the multi-dimensionnality of the spatial variability of most soil properties.

As far as a detailed soil map is available for Belgium, the relevance of its information was investigated at various spatial scales in the Walloon Region (Southern Belgium), from the plot to the entire region, to evaluate the feasibility of a multi-scale mapping of geochemical background.

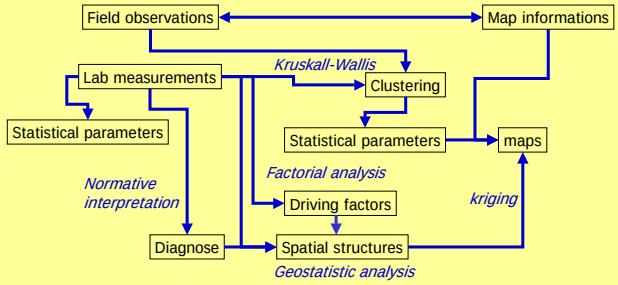
Methodology (fig.1) :

A database of soil profiles (gathering both agricultural and forest soils) was used to analyse the relationships between the MTE total content and other general characteristics such as pH, Total Organic Carbon content (TOC), Particle Size Distribution (PSD), and cationic exchange capacity (CEC). The relevance of soil characteristics, quantitative and qualitative, to stratify the population is evaluated through Kruskall-Wallis tests of medians.

The factors of MTE spatial distribution inside and between solums were investigated through multivariate statistical analysis according to the land use (forest, culture) and the type of horizons (surface, subsurface).

The spatial dependence of the trace contents, as well as factors and normative interpretations, was then studied over plot, field, farm, county and region scales, and compared to the spatial structures of the soil map parameters.

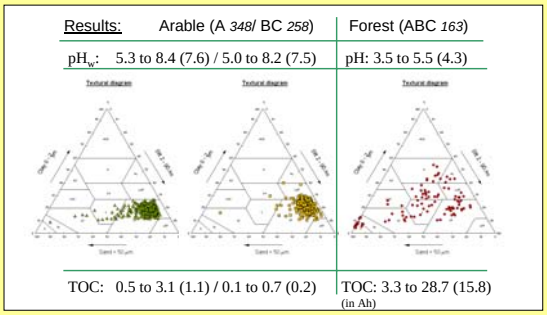
Fig.1 : General methodology for data processing:



Main results:

The selected soil samples are representative of the most frequent soils from forest and arable lands in southern belgium, Cambisols, Luvisols and Inceptisols. The ranges of magnitude for pH, TOC, PSD (fig. 2), and CEC are rather broad and guarantee the representativity of the samples.

Fig. 2 : Main characteristics of the studied soils



At the solum level, strong relationships between most of the studied MTE were found, as well as between stone charge and fine earth contents (fig.3). The PSD is the main driving factor of MTE content in non-carbonated soils, whatever the land use (fig.4).

Fig. 3 : Factorial analysis of trace content and soil properties.

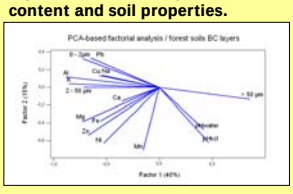
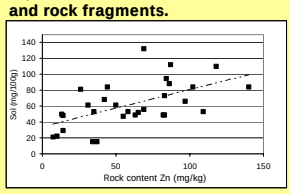
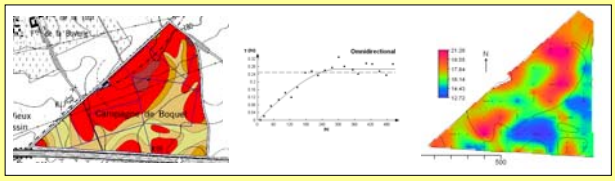


Fig. 4 : Total Zn content in soils and rock fragments.



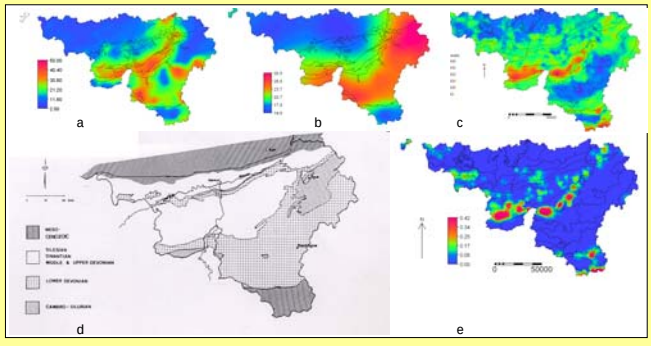
When considering soil associations, such as catenas, the slope redistribution processes must be taken into account. However, the PSD remains the main driving factors (fig. 5) and, as the soil map contains information about that property (mainly the textural class and the profile development), a cartography of the geochemical background based on the use of the soil map and pedotransfer functions or regression models appears relevant.

Fig. 5 : Local mapping of Total Ni (mg/kg), (a) existing soil map, (b) variogram, and (c) kriged soil map



At the regional scale, some long-range spatial structures could be identified. An example is given at the figure 6 for Ni content and explicative factors.
These structures result mainly from the geological structure of the Walloon region, where the lithological zonation is rather clearly marked. The soil map (texture and nature of stone charge) appears relevant at that scale too but does need a generalization process and fails however to differenciate the intra-type soil spatial variability.

Fig. 6 : regional mapping of (a) Total Ni (mg/kg), (b) cationic exchange capacity (cmolc/kg), (c) clay content (%), (d) geology, and (e) probability that Ni content overrides the regulation threshold.



Perspectives

Some basic processes of integration of point measurements and qualitative information have been explored. More sophisticated approaches should be investigated in the future in order to refine the various predictive maps.