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Importance of pedogenic factors in the spatial distribution of some soil properties in the Belgian Loess Belt: II. some loess-substratum contacts

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ABSTRACT

The geochemical influence of parent material on soil content in some metallic trace elements (MTE) is studied in the Belgian loess belt. The first results show straight sharp transitions between loess and substratum. This leads to the conclusion that most soils should have the same range of natural values of MTE content.

KEYWORDS

Geochemical background, loess, soil, trace elements

"Natural values" of metallic trace elements in soils

Assessing the fate of metallic trace elements (MTE) brought into agricultural soils requires that a distinction is being made between natural and human-due content in MTE. The geochemical background values along with an evaluation of the intensity of pedogenic redistribution processes form thus the basement of reference systems about "natural values", which are also called "pedogeochemical background" values (Baize, 1997). In this study, both content values as well as explicative parameters were measured: pH, texture, cationic exchange capacity (CEC), total organic carbon (TOC), carbonates, and triacid total content in Ca, Mg, K, Na, Al, Fe, Mn, Cu, Zn, Cr, Ni, Pb, and Co.

Lithological considerations

The term "Belgian loess belt" refers to a natural region where Quaternary eolian silt deposits cover older geological formations: Palaeozoic slates, quartztites, shales, sandstones, and limestones, Cretaceous carbonated formations, or Caenozoic tabular clayey and/or sandy formations. Prequaternary formations only outcrop in the main valleys such as in the Orneau Valley near Gembloux.

A first study, dealing with the pedogeochemical background in Quaternary loess parent material, has shown the importance of the intensity of the current or past pedogenesis processes on the vertical distribution of most elements. The variability of MTE content within loessic material seems actually being linked to clay migrations (Colinet *et al.*, 2000).

As a logical continuation, this study deals with the contacts between the loess deposits and the substratum. According to the Belgian soil map, numerous slope soils bear the print of their substratum in the profile (Fig. 1).

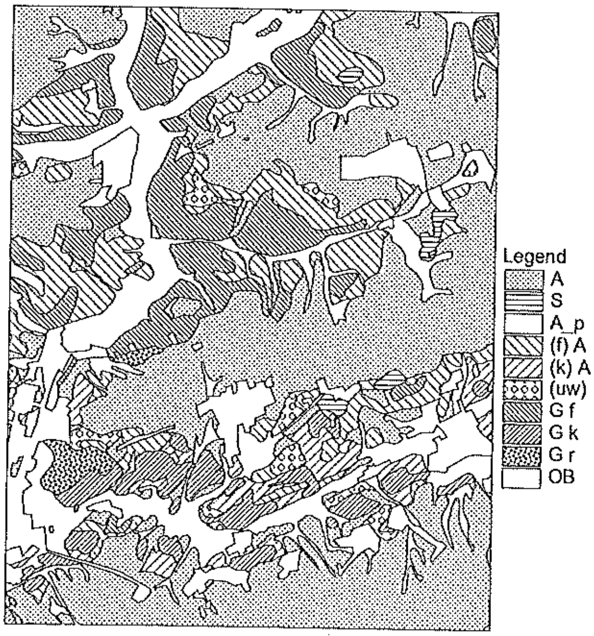

Fig. 1. Modified extract of the Belgian soil map (original scale: 1/20 000) at the south of Gembloux. Loam soils: A; sandy-loam soils: S; soils on colluvium/alluvium: A_p; loam soils on substratum: on shale: (f)A, on limestone: (k)A, on clay/sand: (uw); stony-loam soils containing shale (G f), or limestone (G k), or shale and sandstone (G r) fragments.

The elemental content of various lithological units (shales, sandstones, limestones, dolostones, clays and sands) was first determined and compared with loess (example for Zn in Fig. 2). For what concerns MTE content, clear differences appear between lithologies. Compared to loess, shales and clays appear to be richer in every MTE but Pb. Limestones are richer in Ni and Cu, and poorer in Mn, Zn, Pb and Co. Sands and sandstones are poorer in every element. The lithology should therefore be considered as a potential source of variability of MTE content in soils. This long-time evidence has now been partly quantified for the Orneau Valley.

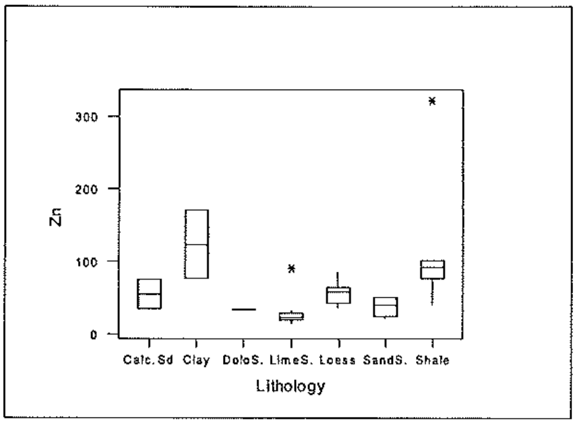

Fig. 2. Distributions of total Zn values (in mg/kg) in various lithological material from the Orneau Valley (Calc. Sd: calcareous sandstones; DoloS: dolostones; LimeS: limestones; SandS: sandstones). Box lower, middle, and upper horizontal lines correspond to respectively percentile 25, 50 and 75 of the distributions. Stars mark the outliers.

Loess-substratum contacts

In a further stage, three reference zones were studied through toposequences in order to characterize the transitions between "loess soils" and "substratum soils". The three substratum chosen were a Silurian shale (Fig. 3), an upper Devonian limestone and a Lutetian sand. A common trend emerges from all the results. The boundaries between loess material and substratum appear to be fairly sharp. Moreover, if present in the profile, the weathering B horizons are very thin.

Thus, regarding the substratum weathering, it seems that to the exception of very superficial soils (<40cm) the loess cover acts as a protective mantle. The geochemical properties of the plough layer originate exclusively from the pedological evolution of Quaternary silt deposits.

Conclusion

An important implication of the results of this study is that all the loamy soils around the Orneau Valley whatever their thickness should be attributed the same range of natural values of MTE content. A probability distribution function was built for the plough layer of loamy soils (Fig. 4). Within the Orneau Valley, it should be considered as applicable to any soil but very superficial ones (depth of substratum less than 40 cm). The valid area represents 88% of the total area (Fig.5).

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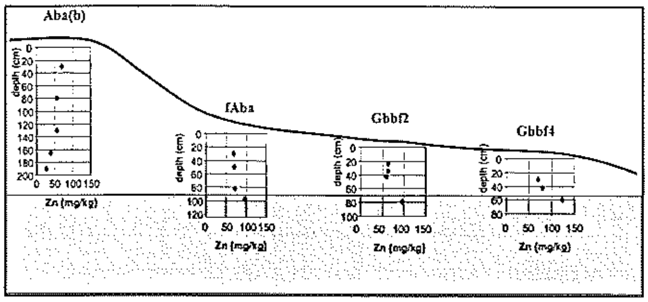

Fig. 3. Soil organization on a loess-shale transition (Orneau Valley) and total Zn content (mg/kg). The Zn content of upper horizons (white colour) of soil profiles is not under substratum's influence (grey colour).

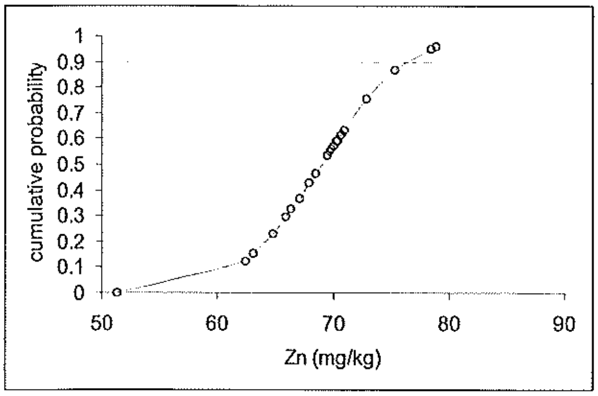

Fig. 4. Probability distribution function of total Zn content (mg/kg) in the plough layer from loam soils.

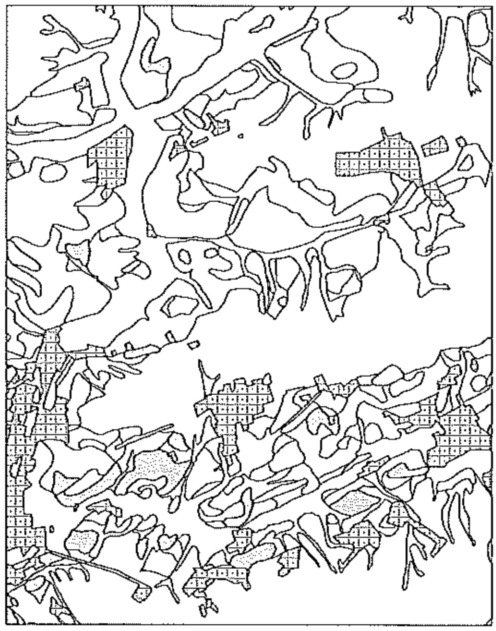

Fig. 5. Identification of the validity area of the "loamy probability model of Zn natural values" from Fig. 4. The soil types from Fig. 1 have been classified into valid (white colour), or non-valid (grey) areas (squared pattern is non-soil).