Case study 30: The disposal of waste in deepened soils in Scotland, the Netherlands and Denmark

G. Dercon, D. A. Davidson, K. Dalsgaard, T. Spek and I. Simpson

Introduction

This research investigates the cultural records that are retained in anthrosols. Anthrosols are soils that result from past land management practices, such as the addition of plaggen from heath land or meadow land, or the fertilisation by the use of seaweed. Anthrosols are important in soil protection strategies due to their cultural value.

The aims of this research can be subdivided in two. The first aim is the detailed comparative study of the nature and role of the inputs in anthrosols in different areas of NW Europe. Three study areas were selected (Figure 1): Northern Scotland at Nairn, close to Inverness; Western Jutland, near Ulfborg; and the Eastern Netherlands, close to Deventer. The second aim regards the protection of cultural records, and a first assessment was made of the influence of actual land use on the cultural record of anthrosols.

Methodology

The study areas in Scotland, Netherlands and Denmark were selected from historical information based on accounts, soil maps, land use maps, and results from former and actual research. These study areas were characterised by the presence of anthrosols, on poor sandy parent material, and formed through extraneous additions and intensive fertilisation of different origin.

Figure 1: Map showing the study areas.

Within the study areas, sites with different land uses were selected, such as pasture, arable land and woodland. In order for comparison between the sites, profiles were selected within a landscape unit.

Once the sites were selected, soil augering was carried out to know the spatial variability of the depth of the anthrosols. Based on this information, soil profiles were located, dug, described and precise samples taken for particle size distribution, standard soil analysis such as pH, Loss On Ignition (LOI), Effective Cation Exchange Capacity (ECEC), Base Saturation (BS), and more specific analysis, such as Total Phosphate (P), some micro elements (Pb, Zn, Cu, As) and molecular biomarkers.

Figure 2: Soil profile from Ulfborg in Denmark.

Figure 2 is an image of the profile dug into arable land at Ulfborg in Denmark. The profile is located just a few kilometres from the west coast of Jutland. The anthropogenic horizons overlay remnants of Viking age houses.

Hypothesis about the input indicate the use of seaweed, and plaggen mixed with cattle manure. High quality meadows are close to the site. The parent material is well-sorted sand of Eemian age and marine or lacustrine origin. The area is influenced by aeolian processes.

Figure 3 shows the profile of Nairn in Scotland with pasture as land cover. It is located a few kilometres from the coast. The parent material is well sorted sand of fluvioglacial origin. The area is influenced by aeolian processes. Just to the east the

Culbin Sands are found, which were formed in the 17th and 18th century. Historical information records that seaweed was used until the 1950s, and also the use of turf.

Figure 3: Soil pit at Nairn in Scotland.

Results

The standard soil analysis allowed the anthrosols of the three study areas to be characterised, and to analyse the effect of land use on the soil characteristics (Table 1).

The uniformity of the anthropedogenic horizons regarding particle size fractions can be observed, which was expected as the anthrosols are located on similar sandy poor parent material. Other characteristics could also be considered uniform, such as LOI, Total P and ECEC. However, pH and BS were less uniform.

At Nairn in Scotland, with pasture as land use, anthropedogenic horizons were found at a depth of more or less 85cm (Figure 4). The presence of charcoal, ceramic fragments and high total P indicates the anthropogenic origin of this soil.

		Mean	Std. deviation
Clay	%	3	1
Silt	%	15	5
Fine Sand	%	57	8
Coarse Sand	%	25	10
LOI	%	3.7	1.5
ECEC	cmol.kg^{-1} Soil	3.4	1.3
Total P	Mg.kg^{-1} Soil, Fine earth	706	271
BS	%	71	31
pH		5.0	0.7

Table 1: Soil characteristics of the anthropic horizons in the study areas: The Netherlands, Scotland and Denmark (N = 37).

In addition, particle size distribution of the anthropedogenic horizons shows the different nature of the dark horizons in comparison with the buried parent material. On Figure 4, X-axis represents the particle diameter in microns, having a logarithmic scale going from 0 to 2000 microns (or 2mm). The Y-axis is volume percentage.

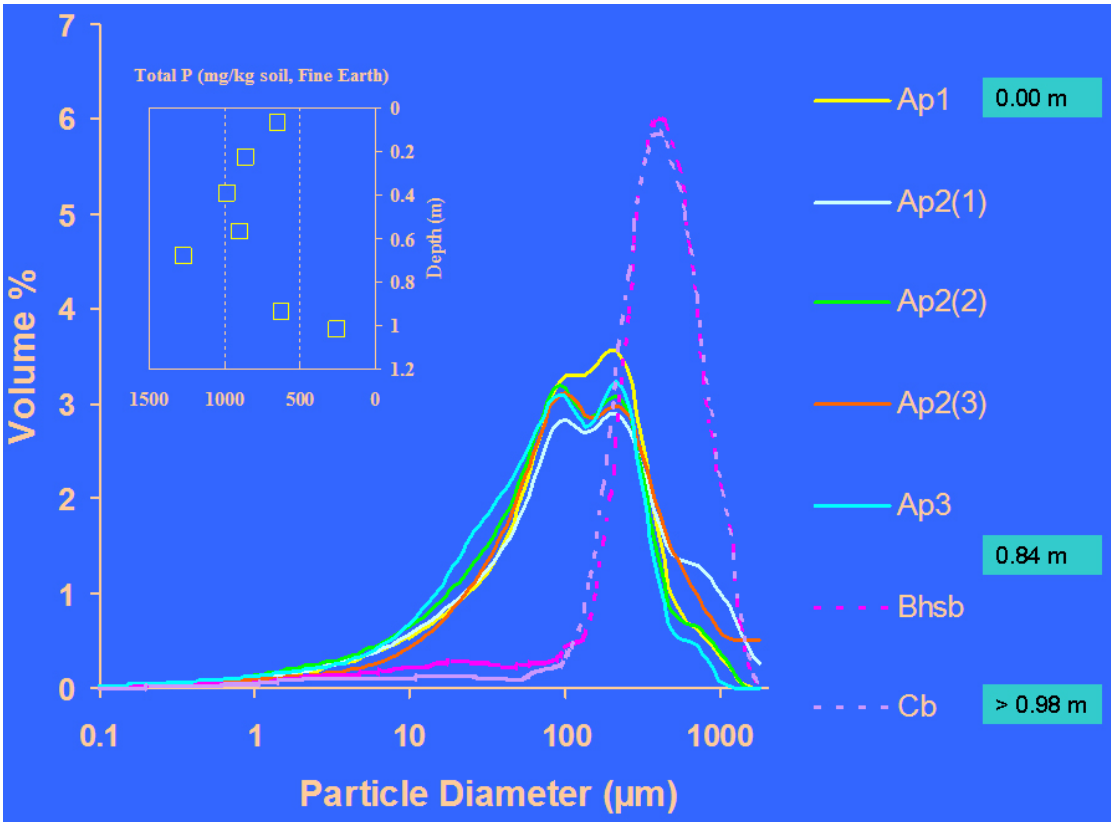

Figure 4: Pasture land at Nairn in Scotland.

Two clear particle size distribution patterns could be detected: the buried parent with a normal distribution of well-sorted material, and the anthropedogenic horizons with a bimodal distribution.

The patterns of particle size distribution might suggest or identify the area, where the extraneous additions to the soil came from. With regards to the profile in Denmark from arable land, peaks in the anthropedogenic horizons can be related with the buried parent material (Figure 5). Continuous mixing of the inputs (plaggen) by the farmer with the fine parent material might create these patterns.

A clear and steady decrease occurs of the fine sand fraction between, more or less, 90 and 250 Micron. This characterises the buried parent material, and on a symmetric basis the steady increase of the fine and medium silt fraction were found. It is possible that this indicates the input through plaggen of lower meadows. Only the two samples of the plough layer, Ap1, didn't show this pattern, of steady decrease. Probably mixing processes by actual modern farming practices might be the reason to it.

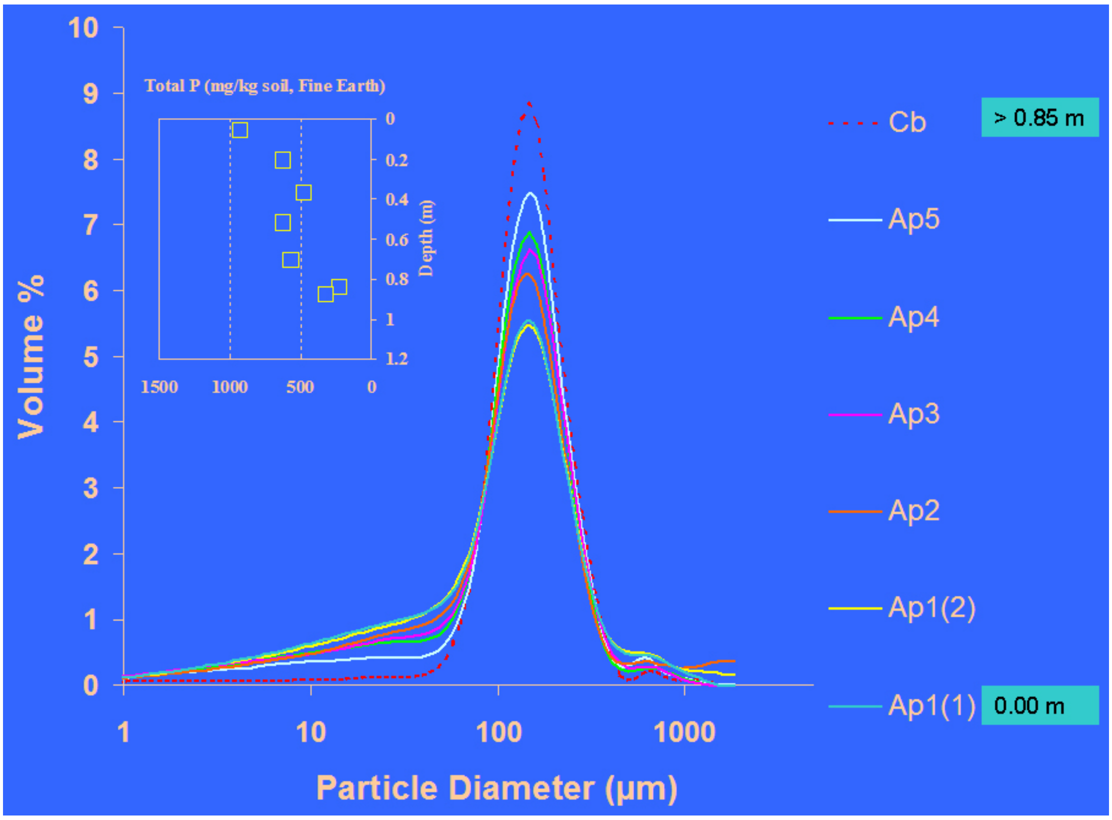

Figure 5: Arable land at Staby in Denmark.

The particle size distribution for the samples of the profile in Epse, from arable land, showed a similar decrease of the fraction. This characterises the buried parent material (Figure 6). There was an increase for the clay/silt fraction possibly through the input of plaggen from meadowland. In addition, an increase for a fraction around 80 microns could be detected. This might be related to another area, which may have served as a source for inputs.

However, the decrease we can detect is not steady, and the peaks aren't located at the same particle diameter, as was the case in the Danish profile. It could be that aeolian inputs covered fields and masked inputs transported by farmers. It is also possible that the patterns might have been altered by mixing processes, such as modern agricultural practices or biological activity.

The patterns can appear very similar for particle size distribution in the profiles of the Netherlands and Scotland for the actual plough layer, but probably the processes or the landscape history behind it might be different.

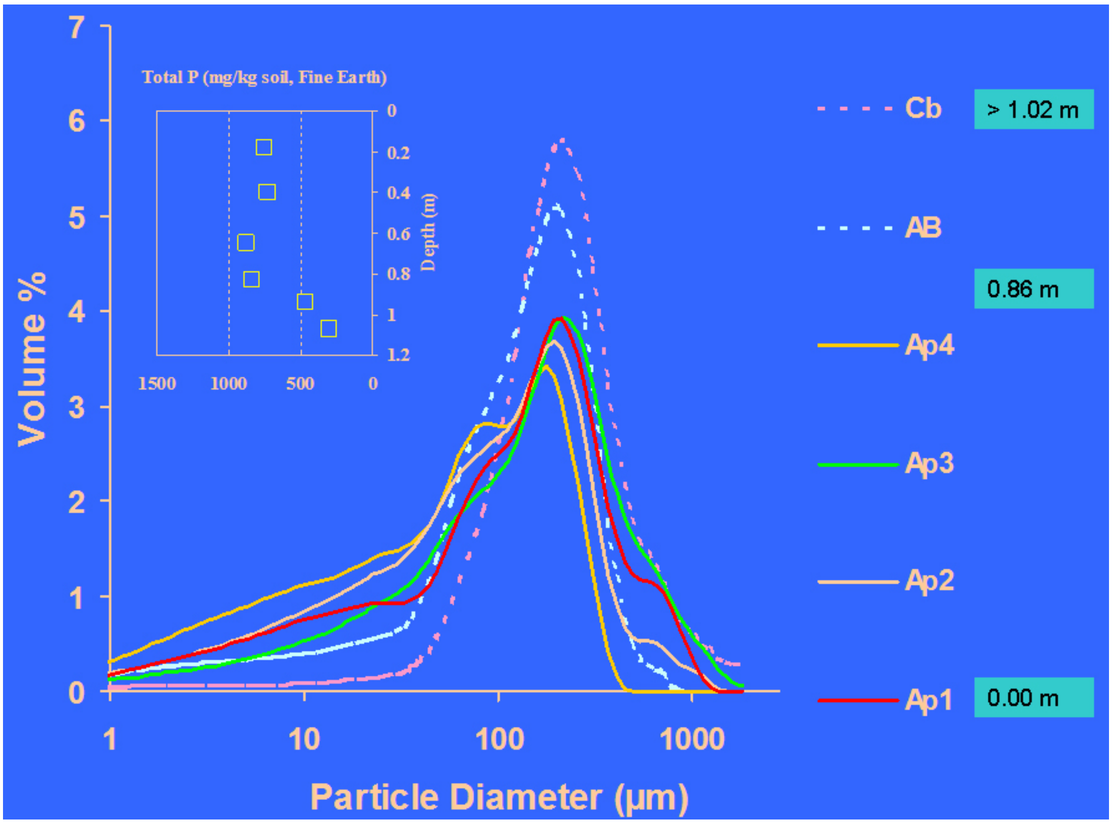

Figure 6: Arable land at Epse in the Netherlands.

Conclusions

- The deepening of the anthropedogenic horizons is due to a combination of processes including disposal of urban waste, aeolian inputs, turf materials.
- Such soils are thus very distinctive from cultural and scientific standpoints.
- Despite different land management systems in the past at the study areas, the resultant anthrosols are remarkably similar in field and analytical properties.
- At two of the sites, deciduous trees on the anthrosols influenced soil pH. In addition, Total Phosphate was higher in the anthrosols from woodland.
- Perimeter of charcoal - often a concentration of phosphorus - important in terms of fertility status of soil.
- High fertility of these soils today due to the inputs in the past has caused modern ‘mining’ of this cultural resource. However, as anthrosols are often at the border of fast growing villages and towns, the building industry is probably a more important danger to be taken into account.