Introduction

In North-West Germany (Klamm 1993), The Netherlands (Pape 1970) and Belgium (Conry 1974) plaggen management has been carried out for about 3000 years and increasingly since the early Middle Ages, which caused deep humiferous plaggen soils on the so-called „Eschfluren“ near the villages. Heather or grass sods were used for animal bedding in stables or together with farmyard manure, for composting, and then applying to the fields (Meyn 1858; Niemeier & Taschenmacher 1939). In this way the fertility of the intensely cultivated aerable soils significantly improved. In contrast to this effect, however, a strong devastation occurred on those areas, which were used for removing the plaggen. Recognizing this problem, the state sovereigns restricted this practise in some areas (Klöntrup 1798).

The following sections will describe reasons, methods and consequences of plaggen management as well as plaggen soil properties, their classification and distribution.

Objectives and methods of plaggen management

Plaggen were used for bedding in stables and barns and/or as soil fertilizers. The classical plaggen of North Germany consisted of heather sods of 40 cm width and 100 cm length with dense root hair and soil material, which were stripped off and rolled up by a „Quicke“ (i.e. a crescent-shaped, inside sharp-edged iron tool) (Meyn 1858). In the Netherlands plaggen were 25-30 cm square and 3 cm thick (Pape 1970) and were used in stables or open folds for sheep and cattle as a bedding, and then applied to the surrounding fields (so-called „Eschflure“) in form of manure. Alternatively, plaggen were removed in summer, mixed with 1/10 to 1/3 manure in clamps and after some weeks or months of decomposition, applied to the fields (Meyn 1858). Plaggen management allowed repeatedly growing ray on sandy soils and was considered to be more effective than fertilizing only by manure or only by plaggen, respectively (Meyn 1858).
In the Netherlands (after Pape 1970) plaggen were removed in intervals of 5-15 years, and 5-10 ha „Plaggenmatt“ (wild land or extensive used grazing ground) were needed to supply 1 ha „Eschflur“ regularly. Besides heather-plaggen, gras-sods were used, too, which, however, could less easily bind the animal excrements, but could more intensely improve soil fertility (Meyn 1858; Pape 1970). Since their removal prevented a more intensive use of the grazing grounds, this practice was not or only restrictedly allowed by some sovereigns (Klöntrup 1798).

Plaggen-fertilizing for centuries has caused 30-130 cm thick, humiferous plaggen epipedons, which in Germany are known as „Esch horizons“ (Eschhorizonte).

Besides heather- or grass- plaggen, forest litter or turf was used for bedding as well (Eckelmann 1980; Pape 1970), of which the low mineral content may not have caused thick Esch horizons. The addition of sand and till is subject of literature about plaggen management, too (Conry 1974). This method may be justified, if e.g. sand was used in stables for binding the animal excrements, but frequently till or calcareous sands were applied directly to the topsoil for obtaining a liming effect or for improving tillage. So in North-West Germany, in decalcified marsh soils, blue sand (calcareous, marine sands) was taken from the subsoil from holes of 3-4 m depth, and then directly applied to the topsoil (Müller & Benzler 1971). In the twentieth this procedure was also carried out by machines: „Wühlerde“ (i.e. stirred soil) was taken from the subsoil to cover the ground up to 15 cm (Freckmann 1931). In Hungary similar techniques were used since the 18th century for amelioration of the szik soils (Freckmann 1931), and even the Elder Plinius reported in his „naturalis historia“ during the Roman Empire of applying marl to the land (Klamm 1993). It is true that such practices partially caused deep, humiferous anthropogenic soils, but they should not be called plaggen soils.

History and distribution of plaggen management

The oldest, safely proved plaggen soil was found under a mound of the Late Bronze Age on the Isle of Sylt (see fig. 1; Blume & Kalk 1986), and is more than 3000 years old (Kossack et al. 1987). Archaeologists found wide areas of plaggen soils on the islands Sylt and Föhr, the oldest having been applied since the pre-Roman Iron Age, the recent since the Viking age (Brunnacker 1975; Kossack et al. 1987). So the North Friesians are supposed to be the first farmers, who used this method of soil improvement. The reason for this may be that on the Northfriesian Islands productive Land had become rare very early. For the Netherlands a plaggen soil with an age of 500 BC - 100 AC has been described (Hammen 1965). Since the Middle Ages the plaggen management increased mostly in Westfalen, Lower Saxonia, the Eastern Netherlands and North-East Belgium (Bruchhausen 1790; Meyn 1858; Niemeier 1959; Pape 1970; Eckelmann 1980). For the Danish Jutland and the sandy coastal moorlands of Schleswig-Holstein already in the 18th century increased, deep humous soils near the villages were described by Pontoppidan (1763/81). The most Eastern occurrence of plaggen soils was described in the Altmark on the Elbe (Käubler 1966). Conry (1974) reports of plaggen soils in the coastal regions of Ireland, but those are anthropogenic soils of calcareous coastal sands, which cannot be compared with classical plaggen soils. So it seems as if plaggen management has been started by the North Friesians and has lateron been taken over by
the Saxons and Friesians of the Netherlands. Then it has partly been used until into the 20th century.

Obviously the most intensive use took place in the Eastern Netherlands, for there after Pape (1970) 30% of the sandy soils are influenced by plaggen management. There are 2210 km² with more than 50 cm plaggen layer applied and further 1260 km² with 30-50 cm plaggen layer. For North-West Germany there are no respective data available, but because only in the district of Osnabrück more than 400 km² of plaggen soils were found by Eckelmann (1980), there may be significantly more than 2000 km² as a total. For North East Belgium about 550 km² are considered (Conry 1974).

Mainly sandy soils near villages got a plaggen layer, which can be seen from the soil map of the sandy parts of the island Föhr (fig. 2), where the applied, more than 50 cm thick layers are concentrated around recent and former villages. On the North-Friesian islands only the soils of pleistocene sands got a plaggen layer, while the plaggen were taken from the deeper situated silty marsh soils. In Lower Saxonia, however, the sandy loess areas were included as well, and in the district of Osnabrück even the loess areas (Eckelmann 1980).

By plaggen application the soil surface became higher by 30-130 cm. For the „Plaggenmatt“ was removed in the neighbourhood, level differences occurred up to 2 m, which partly have a sharp-edged profile (see e.g. fig. 3). For settlements in North-Western German fluvioglacial landscapes were situated in a distant from the groundwater level, higher relief position, the levels of the flat ridges were continuously increased by plaggen management, while the levels of the depressions in the neighbourhood, where plaggen had been removed, got continuously deeper, and the natural level differences of a landscape were intensified by plaggen management.

Intensive removal of plaggen from sandy soils have - besides removal of litter from the forests - promoted the heathering of wide areas of the North German lowlands. Since the Viking Age until into the 18th century, large heather areas developed, which were mostly reforested in the 19th century and were partly used agriculturally in the 20th century. The removal of plaggen and the use of litter increased a podzolization and many Cambic Arenosols were changed into Podzols.

Plaggen soil properties

Plaggen soils are characterized by a humiferous anthropogenic horizon, which in Germany is known as Eschhorizont (see e.g. table 1). For a single application of plaggen is only few mm thick and mixed with the surface by ploughing, the Esch-subhorizon normally consists of the original soil material, while the upper part as well as the recent ploughing or Ap-horizon respectively, mainly contains anthropogenic material (see e.g. in table 1d the horizon texture).

Sand dominates as a texture of the Esch horizons (e.g. table 1a and 1b). If not heather-but grass-plaggen were used, loamy sands, sandy loams (e.g. table 1c and 1d), silts-loams (e.g. table 1e) and silt (fig. 4) occur. Table 1c shows an example for an originally sandy
Cambic Arenosol, which - by use of silty marsh soils - besides the plaggen of sandy soils became significantly more silty, which was confirmed with comparable soils by pollen and large-residue analysis (Kroll 1987).

The Esch horizons derived from sand are characterized by a black to dark grey colour, while the Esch horizons derived from loess and till, have a dark brown to yellow brown colour (fig. 5 and de Bakker 1979). Sandy Esch horizons have a humus content between 1 and 8%, silty Esch horizons between 1 and 3% (Eckelmann 1980; Pape 1970). Original Esch horizons, where the plaggen have been mixed with animal excrements, are phosphate-rich and so contain similarly high P-contents like fertilized Ap-horizons (Pape 1970; Eckelmann 1980). Normally Esch horizons are acid (pH CaCl$_2$ 3.5-5) and show a low base saturation, if not the pH has been increased by a recent liming (table 2; Fastabend & Raupach 1961; Eckelmann 1980). Silty plaggen soils, however, can have higher pH-contents (Eckelmann 1989). Archeologists identify plaggen soils by their dark-coloured humus, their high P-content and the evidence of former digging and ploughing as well as of artefacts (e.g. pieces of pottery). The plaggen origin is proved by pollen analysis.

By applying a thick layer of humiferous soil material, regularly not only the contents of plant-available nutrients and nutrient reserves were improved, but even the nutrient and water cohesiveness (see e.g. CEC and nFK in table 1; Eckelmann 1980; Blume & Kalk 1986).

In the Netherlands plaggen soils were named Enk soils (Bakker 1979), in Belgium plaggen-gronden (De Coninck 1959), in Germany first Esch soils (Stremme 1930) und nowadays Plaggenesche (Wittmann 1997), where Ap- and Esch horizon together have to be at least 40 cm thick. After FAO-Unesco (1994) they belong to the Fimic Anthrosols, and after US Soil Survey Staff (1996) to the Plaggepts. Then the fimic horizon or plaggen epipedon respectively, are at least 50 cm thick and have to contain at least 250 mg/kg citratextr. P$_2$O$_5$. Garden soils, however, belong to this group, too, which occur especially in China and are in Germany named hortisols. In contrast to this term the classification design of the ISSS restricts the Plaggi-cumulic Anthrosols on classical, sandy plaggen soils, because a plaggen epipedon has not only to be thicker than 50 cm, humous (>0.6 org. C) and very dark grey (brown) to black (Colour value and chroma moist ≤3), but has to have a low basesaturation, too (b.s. < 50%) (Spaargaren 1994).

**Literature**


CONINCK, de Fr. (1957): Formation of deep himiferous soil in the Antwerp Campine. Pedologie 7, 102-106 (Fr.fl.)


MEYN, L. (1858): Ueber die Plaggenwirtschaft. C. Mohr, Kiel (Nachdruck aus dem Landw. Wochenblatt für die Herzogtümer)


Keywords: «plaggen», turf, «Eschflur», anthropogenic soils, soil transformation, impoverishment, Europe  
Mots clés : «plaggen», horizons O et A, «Eschflur», sols anthropiques, transformation, appauvrissement, Europe

### Table 1: Typical Plaggen soils in Northwest Germany

<table>
<thead>
<tr>
<th>Hor.</th>
<th>Depth cm</th>
<th>nFK in %</th>
<th>Texture</th>
<th>pH CaCl₂</th>
<th>C/N</th>
<th>CEC cmol/kg</th>
<th>B.s. P mg/kg</th>
<th>Fe₃⁺ mg/g</th>
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<tbody>
<tr>
<td>Ah</td>
<td>0-11</td>
<td>1.20</td>
<td>sand</td>
<td>8.6</td>
<td>94.5</td>
<td>3.9</td>
<td>1.6</td>
<td>3.7</td>
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<tr>
<td>Esch</td>
<td>-66</td>
<td>1.58</td>
<td>sand</td>
<td>20.0</td>
<td>94.0</td>
<td>4.4</td>
<td>1.6</td>
<td>3.9</td>
</tr>
<tr>
<td>fAh</td>
<td>-75</td>
<td>1.48</td>
<td>sand</td>
<td>17.1</td>
<td>94.3</td>
<td>4.6</td>
<td>1.1</td>
<td>3.7</td>
</tr>
<tr>
<td>E</td>
<td>-105</td>
<td>1.48</td>
<td>sand</td>
<td>6.4</td>
<td>97.8</td>
<td>2.0</td>
<td>0.2</td>
<td>4.1</td>
</tr>
<tr>
<td>Bsh</td>
<td>-130</td>
<td>1.43</td>
<td>sand</td>
<td>0.8</td>
<td>4.0</td>
<td>1.5</td>
<td>18</td>
<td>15</td>
</tr>
</tbody>
</table>

a) Plaggen soil from dune sand above Podzol beneath heather; Seeth
Ah 0-11 1.20 8.6 94.5 3.9 1.6 3.7 1.3 17 7.2 3 1.2
Esch -66 1.58 20.0 94.0 4.4 1.6 3.9 .78 12 4.9 2 1.2
fAh -75 1.48 17.1 94.3 4.6 1.1 3.7 2.8 34 17 2 0.8
E -105 1.48 6.4 97.8 2.0 0.2 4.1 .15 38 0.8 11 0.1
Bsh -130 1.43 0.8 4.0 1.5 18 15 4 2 1.0 1.6

b) Plaggen soil from dune sand above Podzol beneath arable l.; Vörden

<table>
<thead>
<tr>
<th>Hor.</th>
<th>Depth cm</th>
<th>nFK in %</th>
<th>Texture</th>
<th>pH CaCl₂</th>
<th>C/N</th>
<th>CEC cmol/kg</th>
<th>B.s. P mg/kg</th>
<th>Fe₃⁺ mg/g</th>
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<tbody>
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<td>Ap</td>
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<td>90.1</td>
<td>sand</td>
<td>5.3</td>
<td>4.8</td>
<td>4.8</td>
<td>2.9</td>
<td></td>
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<tr>
<td>Esch</td>
<td>-65</td>
<td>1.44</td>
<td>sand</td>
<td>12.6</td>
<td>87.9</td>
<td>7.3</td>
<td>4.8</td>
<td>4.0</td>
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<tr>
<td>fAE</td>
<td>-75</td>
<td>87.7</td>
<td>sand</td>
<td>7.3</td>
<td>90.3</td>
<td>3.8</td>
<td>4.9</td>
<td>1.3</td>
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<tr>
<td>Bs</td>
<td>-90</td>
<td>86.6</td>
<td>sand</td>
<td>3.4</td>
<td>4.5</td>
<td>1.0</td>
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</tbody>
</table>

c) Plaggen soil from marine sed. above Cambic Arenosol beneath bronze t. grave hill; Sylt
fAh 0-18 1.66 8.0 73.2 19.6 7.2 5.6 .48 11 7.0 .76 6.5
Esch 1 -34 1.61 9.0 66.7 23.8 9.8 4.9 .97 12 12 .98 8.1
Esch 2 -58 1.50 8.0 73.0 18.8 8.2 4.8 .71 15 8.0 .66 7.3
fAE -70 96.5 3.5 4.2 .80 5.2 5.2 2 4.5 0.4
Bw -80 1.77 4.5 90.3 3.8 4.9 .13 16 2.0 .18 3.9

d) Plaggen soil from river loam above Podzol beneath arable l.; Quackenbrück

<table>
<thead>
<tr>
<th>Hor.</th>
<th>Depth cm</th>
<th>nFK in %</th>
<th>Texture</th>
<th>pH CaCl₂</th>
<th>C/N</th>
<th>CEC cmol/kg</th>
<th>B.s. P mg/kg</th>
<th>Fe₃⁺ mg/g</th>
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<tbody>
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<td>59.7</td>
<td>sand</td>
<td>24.8</td>
<td>15.5</td>
<td>6.2</td>
<td>1.8</td>
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</tr>
<tr>
<td>Esch 1 -40 1.50 18.2 56.2 27.0 16.8 4.2 1.8 19 25 1.4 3.0</td>
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<tr>
<td>Esch 2 -50 1.42 20.5 74.2 15.6 10.2 4.0 1.3 11 11 .94 1.5</td>
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<tr>
<td>fAE  -70 96.5 3.5 4.2 0.80 5.2 5.2 2 4.5 0.4</td>
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<tr>
<td>Bh   -75 95.0 4.3 4.5 1.2 13 6 6 .69 0.3</td>
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</table>

e) Plaggen soil from loessloam above Luvisol beneath arable l.; Osnabrück

<table>
<thead>
<tr>
<th>Hor.</th>
<th>Depth cm</th>
<th>nFK in %</th>
<th>Texture</th>
<th>pH CaCl₂</th>
<th>C/N</th>
<th>CEC cmol/kg</th>
<th>B.s. P mg/kg</th>
<th>Fe₃⁺ mg/g</th>
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<tbody>
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<td>0-28</td>
<td>8.1</td>
<td>sand</td>
<td>81.3</td>
<td>10.6</td>
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<td>1.8</td>
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<tr>
<td>Esch -100 1.27 26.2 4.8 84.7 10.5 5.2 .75 9.8 36 .55 6.0</td>
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<tr>
<td>fAp  -120 4.4 91.0 4.6 50.0 .40 7.1 14 .34 3.6</td>
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<tr>
<td>E    -140 4.6 90.6 4.8 5.0 .17 5.0 18 .25 2.7</td>
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<td>Bt   -165 1.57 19.4 2.7 84.8 12.5 4.9 .11 9.4 52 .28 7.4</td>
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SOIL COLOR NAMES

HUE 10YR

- Dune sand
- Sandy soliflux deposits
- Till
- 7.5YR River sediments
- Sandy loess
- Loess

Fig. 5
**Fig. 1:** Proved and supposed occurrence of plaggen soils in North Germany, The Netherlands and Belgium (after Niemeier 1959; supplemented)

**Fig. 2:** Thickness of humiferous horizons of the pleistocene South of the Isle of Föhr (from Johannsen & Stremme 1954); A-horizon larger 50 cm: Plaggi-cumlic Anthrosols; 30-50 cm Plaggi-cambic and Plaggi-gleyic Arenosols; <30 cm: Spodi-cambic and Cambigleyic Arenosols (after Spaargaren 1994)

**Fig. 3:** Removed Stagnic Luvisols (= Plaggenmatt, I), plaggen soils (II) and anthropogenically changed valley edge of a loess landscape near Osnabrück (from Eckelmann 1980)

**Fig. 4:** Texture of the plaggen epipedons of North German plaggen soils (after Eckelmann 1980; supplemented)

**Fig. 5:** Munsell-colours of the Esch horizons of different origins of typical North German plaggen soils (after Eckelmann 1980)