Evolution of soil acidity during the past 36 years (1960-1996) under coniferous forest in a region of high livestock production in Flanders

DE SCHRIJVER A. *, NACHTERGALE L. *, DE TEMMERMAN L. **, FRECHILLA J. M.F. *, MUSSCHE S. *& LUST N.*

* *Laboratory of Forestry, University of Ghent, Geraardsbergse Steenweg, 267, 9090 Gontrode, Belgium*

** *Centre for research on zoology and agricultural chemistry, Leuvense Steenweg, 17, 3080 Tervuren, Belgium*

1. Introduction

During the last decade, acidification of European forest soils has been reported in several studies. The results of these investigations show a considerable increase of acidification in the humus as well as in the mineral soil layers during the past 10 to 30 years (Berdén et al. , 1987, Billet et al. 1990, Ronse et al. 1988, Falkengren-Grerup & Tyler 1991). These high increases of acidification are difficult to explain only by biological acidification processes as soil forming processes, the influence of forest type (by means of amount and type of organic matter produced, micro-climatological effects and differences in ion uptake) and forest age. At the moment, an international consensus exists that the present state of soil acidity is mainly caused by high amounts of acid depositions by form of sulphur- and nitrogen components (de Vries & Breeuwsma 1985, Falkengren-Grerup & Tyler 1991)

In Flanders (Northern part of Belgium), over 60% of the forest area is located on very poor and originally acidic sandy soils, which are known to be very vulnerable for atmospheric depositions. Because of the low fertility of these soils, characterised by low buffering capacity and originally low levels of available nitrogen, the main agricultural practise in these regions is semi-industrial livestock breeding. This live-stock production is the dominant source of atmospheric NH_3 and the considerable rise of it during the last decades has caused a significant increase in NH_x-depositions (Dams et al. 1996). Since the deposition velocity of ammonia is very high and consequently the transport distance is very low, ammonia and ammonium are deposited mainly in a radius of 10 km around the sources.

The forests on these sandy soils mainly consist of coniferous trees as Scots pine (*Pinus sylvestris*) and Corsican pine (*Pinus nigra ssp. laricio*). The deposition of NH_x on these coniferous forests is far higher than the national average. This is not only due to the proximity of important sources of NH_x, but also because of the high filtering capacity of the tree canopies, caused by the large needle surface area, in comparison to other vegetation types (Frank 1994).

Part of the ammonium deposited on the forest floor is consumed by tree roots and another part is nitrified by bacterial activity (Van Breemen et al. 1988). Since both processes result in proton release, strong acidification may occur, especially in soils with low buffering capacity. The natural acidification process is highly accelerated in these soils. For Flanders, exact information of the present state of soil acidification and on its evolution during the last decades is lacking.

2. Background and methodology

Between 1953 and 1967, soil profile samples were taken all over Flanders for soil cartography by the Soil Cartography Committee, sponsored by the Institute for the Promotion of Scientific Research in Industry and Agriculture (IWONL/IRSIA, unpublished results). On these samples, acidity was determined as well as organic matter content, cation exchange capacity (CEC) and physical parameters (texture, soil moisture, consistency, etc.). The humus layer was not taken into account. Of each location, the exact sampling position (accuracy one meter) was indicated on ordnance survey maps (scale 1:25.000) and a description of vegetation and relief was noted. The methods of chemical analysis were also described in detail.

In 1985 soil profile samples were taken in about 100 forests and heather in Flanders and were analysed on soil acidity, cation exchange capacity, organic matter content and physical parameters. All analyses were performed by the same methods as in 1960. All the locations were situated on sandy (± 90 points) or loamy (± 10 points) soils and under forest or heath land. For the sandy soils, a distinction has been made between podsols, regosols and brown posolic soils. Within the loamy soils, grey podsolic and brown podsolic soils were the dominant profile types. The sandy soils are divided into podsols, brown podsols and regosols. The loamy soils were divided into grey and brown podsols. For more information we refer to Ronse et al. (1988).

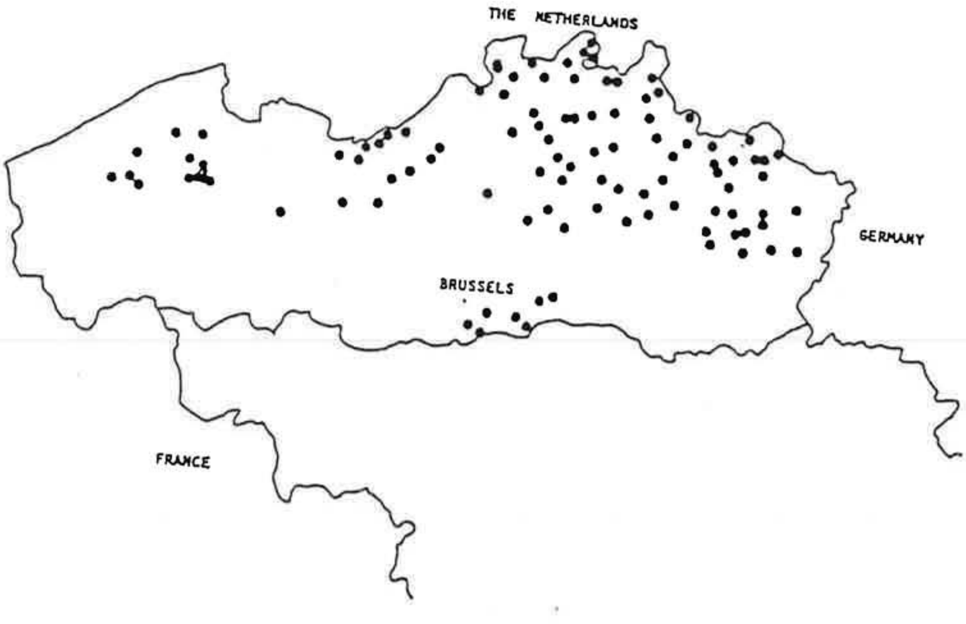

Figure 1. Location of the 100 soil profile sampling points 1985 (Source: Ronse et al., 1988)

During the period 1960-1985 a significant acidification of the soil had occurred (Ronse et al. 1988). The average pH-H_2O and pH-KCl decreased for all soil types and at all depths with respectively 0.6 and 0.15 pH units. This acidification coincided with an accumulation of organic matter in all soils and with a decreasing respectively increasing CEC in sandy and loamy soils. Fig. 2 shows the evolution in soil pH on different depths of the soil during the period 1960-1985 for the sandy podsol soils.

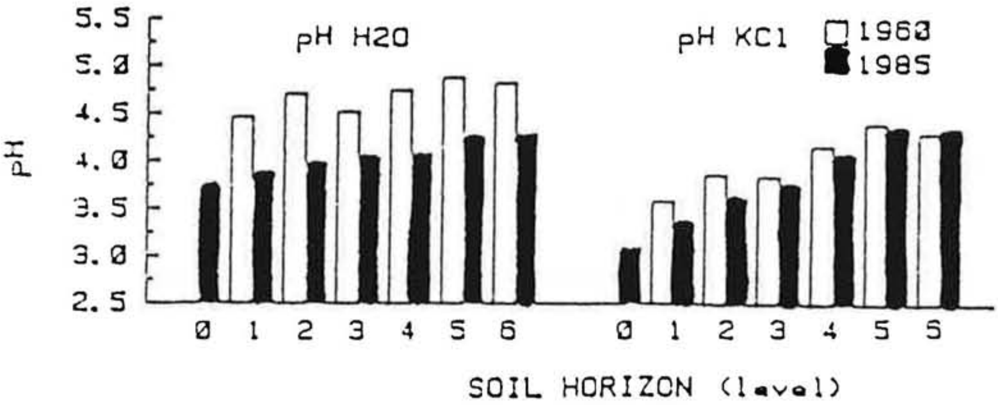

Figure 2. Evolution of pH in podsols (n = 67) between 1967 and 1985 (Source: Ronse et al., 1988).

This article gives the preliminary results of a reinvestigation of the status of soil acidity in Flanders. On 4 locations in coniferous forest, situated in the north-western part of Flanders, soil profile samples were taken and analysed on pH-KCl. The sampling points were located on very poor sandy soils in a region of high intensive livestock production. The sampling points at Wingene are situated in a forest with *Pinus sylvestris* and *Larix decidua*. The location at Beernem is an *Abies alba*. stand and at Sysele a *Pseudotsuga taxifolia* stand.

3. Results

Frechilla (1996) observed a decrease in pH during the last decade and concluded that even an acceleration in the acidification process is going on. Fig. 3, 4, 5 and 6 give a clear view on the evolution of proton concentrations in the different depths of the soil for the period 1960-1996 in Wingene (2 forests), Beernem and Sysele.

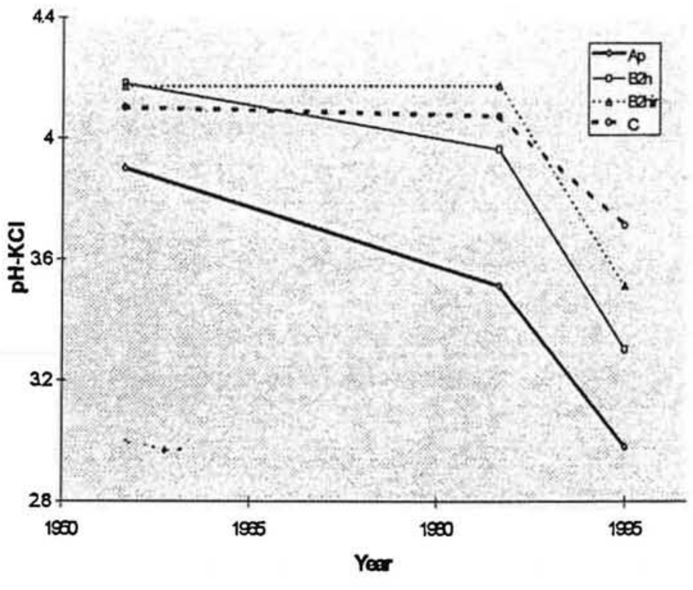

Figure 3. pH KCl-values of the different horizons in 1953, 1985 and 1996 at Wingene

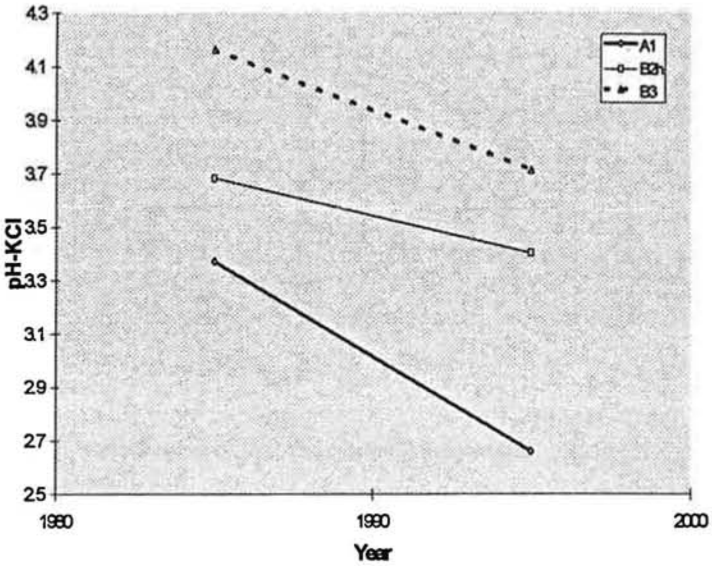

Figure 4. pH-KCl values of the different horizons in 1985 and 1996 at Wingene

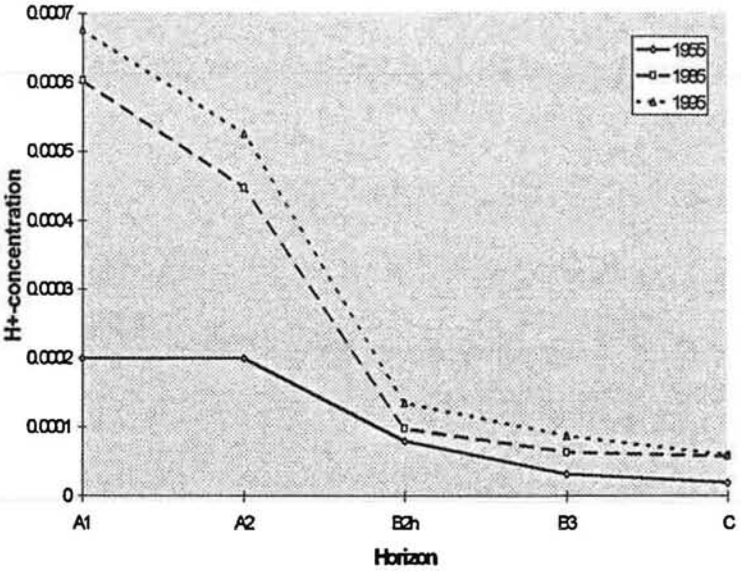

Figure 5. pH-KCl values of the different horizons in 1983, 1985 and 1996 at Beernem

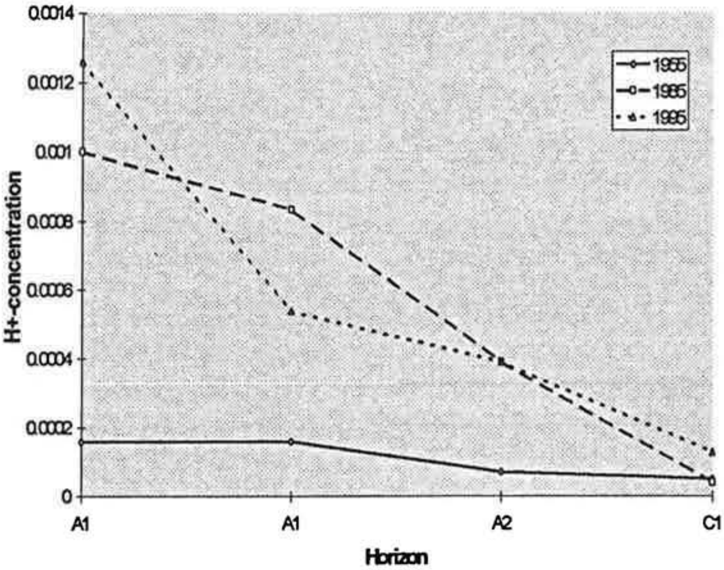

Figure 6. pH-KCl values of the different horizons in 1983, 1985 and 1996 at Sijsele

4. Discussion and conclusions

The preliminary results of this research indicate clearly that the high and rapid increase of soil acidity is at least alarming. From the figures it can be concluded that the pH-KCl-values have decreased in all cases during the past 45 years. The maximum decreases occur in the upper mineral soil: during the past 11 years the pH-KCl value at Wingene decreased with 0.87 units and 0.53 units, at Beernem with 0.10 units and at Sysele with 0.05 units. In general in the other mineral horizons, the pH decreased but to a lesser extent as in the upper horizon.

It is obvious that the decrease of soil pH values as has been noticed in the four coniferous forests, is difficult to explain without taking into account the influence of acid deposition. An important source of acidifying components in these region of Flanders is the intensive livestock production which produces high amounts of ammonia. Coniferous trees are very effective in catching this ammonia. Furthermore it is known that in regions with high emissions of ammonia, depositions of sulphate increase. Due to the synergistic effects of NH_3 on the dry deposition of SO_2 (co-deposition), also high amounts of SO_2 are deposited in forests. The interaction of ammonia (volatilized from manure) and sulphur oxide (from fossil fuels) in the air, forms ammonium sulphate which is deposited on the forest. After leaching by rain water, the ammonium sulphate on the forest soil oxidises rapidly to nitric and sulphuric acid, producing high amounts of protons and consequently very low pH-values. The protons from the nitrification of ammonium sulphate are buffered by the clay minerals through the release of aluminium. In these acid soils, aluminium nitrate is formed which leaches and can pollute the ground water.

5. Bibliography

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