Characterization of soil change by erosion in the German-Polish moraine regions
Caractérisation des modifications du sol par érosion dans les régions morainiques germano-polonaises

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INTRODUCTION

The investigation soil profiles in the young moraine region of late pleistocene origin in North-East Germany and North-West-Poland have yielded a distinct heterogeneity of the soil cover. That effects the vertical and horizontal variability of soil and relief characteristics such as texture and horizontation. This substratum differentiation was caused by glacial and periglacial processes in the last cold period. This development became strengthened by soil erosion since ca 5,000 years caused by human activities and land use. A further increase of the site differences occurred during the agrarian land use the last 300 to 800 years (Bork et al., 1998). Known are strong erosion events from the late Middle Ages under extreme rain intensity (Bork, 1988). During Modern Time periods with intensive erosion occurred, too. Because the new soil formation proceeded only slowly in agro-ecosystems during the last 300 years, the compensation of soil erosion rate could not be equalized. On eroded there are a high rate of soil loss but not new soil formation. For the recognition of the soil pattern in landscapes now urgently necessarily, to find certain association for an indication of the degree of soil change. The results should be transferable from a single catena type to larger soil landscapes (Frielinghaus, 1988). A high differentiation has to be recognized between eroded soil profiles upslope and profiles with colluvial deposits downslope. All catena types show comparable differences. Not eroded profiles that remained permanently under forest use can procure for comparison, because there the soil erosion is very low usually. If it is successful to compare the profiles changed by erosion with not eroded profiles, then the changes can be described qualitatively and quantitatively. Up to now the appraisal of the risk is joined widely with the term „tolerable soil loss value“. That is not correct. Changed eroded soils losted the availability to realize the soil functions in agro-ecosystems.
Therefore, other indicators are necessarily to evaluate the erosion rate (Frielinghaus and Bork, 1996).

**MATERIALS AND METHODS**

Different slope catenas under long-term agricultural land use were explored and compared respectively at similar slope positions. The main investigation areas are near Dlusko (catchment of the river Ina/Poland) and near Burg-Stargard (catchment of the Tollense/Mecklenburg/Germany). The results were examined at further catenas in the catchment of river Kittendorfer Peene (Mecklenburg/Germany) as well as in the region Uckermark (Brandenburg/Germany). So all important types of catenas (classification Schmidt, 1986; Frielinghaus and Schmidt, 1991) were included in the investigations, which authorize for the generalization of representative statements for soil change by erosion.

To determine the degree of the change by agrarian use, the investigations were expanded near Dlusko and near Burg-Stargard on catenas, which have remained under forest use. In the investigation areas the climatic conditions are comparable. Presently the annual precipitation varies between 500 to 600 mm and the medium temperature is 7,9°C. The distance between the profiles under forest and agricultural use that are compared equals 200m and 800 m. They are 200 m and 800 m of each other removes. While the forest catenas are found under more than 100 years old beech forests, the field catenas were managed with field crops and grassland for the last 250 years.

The following investigations were accomplished:
- measurement of the slopes gradients; profile description based on the german soil classification KA 4 (Workgroup Soil, 1994); pore volumes, water capacity, dry density (HARTGE/HORN, 1989); particle size analysis (KÖHN and CASSAGRANDE); total carbon content (WÖSTHOFF); calcium carbonate content (SCHEIBLER); total nitrogen content (KJELDAHL); total P, Fe and Al in aqua regia (DIN 38405 and 38406)

**RESULTS AND DISCUSSION**

The four catenas under investigation developed in comparable sediments: horizon sequences, the clay content and the particle size distribution as well as the calcium-, aluminum-, iron- and phosphorus capacities are nearlyidentic in the C horizons of the profiles under forest and under arable land use (Frielinghaus and Schmidt, 1993). The content of clay and fine silt (particles < 0,0063 mm) in the initial substrata vary between 13 and 22 %, the carbon content in calcium carbonate between 0,8 and 1,6 %, the aluminum content between 1,2 and 2,2 %, the iron content between 1,3 and 1,5 % and the phosphorus content around 0,03 %.

The soil development proceeded up to the forest clearing before approx. 250 years. Lessivations under the influence of infiltrated water and the following chemical weathering determined soil formation. A comparison of the balance of the processes of the soil formation and the soil erosion process illustrates the differences (Bork, 1989) (figure 1). That means, that under the present condition's quantity and quality of fertile soil material losses can not compensated by new soil formation.
Figure 1: Intensities of soil formation and soil erosion depending on land use
Abbildung 1: Nutzungsabhängige Intensität der Bodenbildung und Bodenerosion
Figure 2: Soil processes on slopes with forest (a) and agriculture (b) land use
Abbildung 2: Bodenprozesse an Hängen mit Wald- (a) und Ackernutzung (b)
If this process would not have been interrupted, we would find today at the forest catenas and at the agriculturally used catenas a comparable profile characteristics. The constant soil loss has led to a profile shortening, the soil forming process by weathering was interrupted. The analyses do not show such a result. The human initiated action changed the direction of the soil processes at the arable used slopes. Lateral directed soil transport caused a strong denudation, which occurs today too. (figure 2).
All forest profiles unaffected from erosion are typical Haplic Luvisols with well-formed clay impoverished horizon A1 and clay accumulation horizon Bt of the parent material horizon C (Frielinghaus et al., 1993)(figure 3).

Figure 3: Comparison of eroded and non eroded soil profiles at slopes
Abbildung 3: Vergleich erodierter und nicht erodierter Bodenprofile an Hängen
This profile is characterized by the particle size composition, the acidification of the upper horizons and the aluminum, irons and phosphorus total content.
The arable lands' profiles near B.-Stargard and near Dlusko do not show this full sequence of soil horizons. The A1 - horizon has been removed, that means the soil loss exceeds 45 cm (profile 5, Dlusko). Often the loss totals 75 cm, so that the Bt horizon is removed completely too. Then the present soil type is a Calcaric Arenosol or Regosol (profile 6, B.-Stargard).
The field profiles in concave slope areas show an colluvial layer of 45 to 125 cm. The soil morphology differs considerably from it of the forest soils in comparable slope position.
The reconstruction of the landscape makes it possible to recognize the changes of soils due to human activities in the last 500 years (Schmidt, 1991) (Figure 4).
There are more eroded soil forms like Regosols and Gleyic Luvisols in colluvial deposits than in former times. The original Calcic Luvisols exists today only in eroded form or changed to Regosols.

**Figure 4: Soil cover changes of pleistocene lowland (moraine) by agrarian land use**

Abbildung 4: Veränderung der Bodendecke im Jungmoränengebiet durch Landnutzung

a: before cultivation
   vor der Kultivierung
b: recent soil cover with agrarian land use
   gegenwärtige Bodendecke mit agrarischer Landnutzung
c: human-induced soil degradation process
   anthropogen initiierte Bodendegradierungsprozesse

The physical characteristics between the original, not eroded profiles (forest) and the arable field profiles differ significantly.

The differences of the changed eroded profiles are typically for the arable land of North-East Germany. Therefore, it was possible to validate the results with the data basis PRODAT. With a catena type classification a method was developed to estimate the parts of eroded and accumulated soils in mesoscale units of the regions (figure 5).

In the measured soil data basis (MMK, scale 1:25,000) there are associated soil units. It is possible to combine this classification with the MMK-units.
CONCLUSIONS

The water erosion, initiated by human activity and land use intensification, led to changed soil processes and a strong soil profile shortening at convex and the deposition of colluvial material at concave slope areas. Soil formation in arable land did and does not compensate the rates of soil erosion at all. The degree of the changes can be determined by the comparison of eroded profiles with forest soil profiles (permanent forest) with equal genesis and morphology in the landscape. Profile description, chemical and physical parameters are indicators for the degradation.

The general differentiation between the denudation and accumulation areas are typical for many eroded slopes in North-East Germany. The quantities depend on the parent material, the soil hydrology and the inclination. It is possible to use the catena approach for the determination of degradation and erosion that caused heterogeneity in large areas. By those means the results can be transferred from a single catena to landscapes. Mesoscale soil data are the base for the regionalization.

REFERENCES


Keywords : soil change, erosion, moraine regions, Deutschland, Poland
Mots clés : changement du sol, érosion, région morainique, Allemagne, Pologne
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<th>CTIII</th>
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<th>CTVI</th>
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<td>flat catena of the middle till low sandy ground moraine with not hydromorphic soils</td>
<td>steep catena of the loamy ground moraine with not hydromorphic soils</td>
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<td>Orthic Luvisol/Glossisol</td>
<td>Calcic Luvisol/Eutric Luvisol in colluvial deposits</td>
<td>Gleyic Luvisol-Slope Gley</td>
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*A = flowoff position  
* T = transi position  
* Z = afflux position 

![Diagram](image)

Figure 5: Types of catena for transformation the results from single slope to landscapes

Abbildung 5: Catenatypen für Transformation der Ergebnisse von Einzelhängen in die Landschaft