# Biological indicators of topsoil formation – a case study from forest sites in Estonia

*Ulfert Graefe [1], Raimo Kõlli [2], Gerhard Milbert [3], Gabriele Broll [4]*

*[1]Institute for Applied Soil Biology, Hamburg, Germany, [2]Estonian University of Life Sciences, Dep. of Soil Science and Agrochemistry, Tartu, Estonia, [3]Geological Service North Rhine-Westphalia, Krefeld, Germany, [4]University of Osnabrück, Institute of Geography, Germany*

## Introduction

Topsoils are formed to a large extent by the activity of soil organisms. The biological configuration of soils therefore can help to distinguish between different topsoil types. Throwing light on this relation was an issue of the international conference “Humus forms and biologically active compounds as indicators of pedodiversity”, held in Tartu, Estonia (27–28 August 2012). During the scientific excursion of the conference we had the opportunity to take soil samples at the visited sites. Here we present data from the biological analysis of the sampled soil and discuss the results on the background of current classification approaches.

## Material and methods

Three sites were studied, named after the neighbouring villages Koorvere, Kaagvere and Reola. Site **Koorvere** (Fig. 1) in Põlva county (58.0652°N, 26.5834°E) is a 138 years old pine forest on typical podzol (WRB 2014: Albic Carbic Podzol (Arenic). Site **Kaagvere** (Fig. 2) in Tartu county (58.2028°N, 26.5423°E) is a 118 years old mixed pine-spruce forest on loamy sand above sandy loam (WRB: Dystric Albic Glossic Fragic Retisol (Abruptic, Endoloamic, Humic). Site **Reola** in Tartu county (58.1610°N, 26.4510°E) is an about 135 years old spruce forest on drained fen soil (WRB: Eutric Rheic Drainic Sapric Histosol (Fluvic). More detailed site characteristics are given by Kõlli et al. (2015).

**Fig. 1** Topsoil profile at Koorvere

**Fig. 2** Topsoil profile at Kaagvere

Microannelids (comprising mainly enchytraeids) were used as indicator group for the biological structure of the topsoil/humus form complex. Measured parameters were species composition, abundance and vertical distribution of the community. Soil sampling was done with a split soil corer (diameter 5 cm) to a depth of 15-20 cm in three replications (at Reola only two). The soil column was devided into subsamples of 5 cm depth intervals starting at the top of the organic layer. Microannelid extraction from soil samples was performed according to ISO 23611-3 (2007). Knowledge-based indicator values of species are given following Graefe & Schmelz (1999).

## Results

The main results are presented graphically and tabularly in Fig. 3 and Table 1. It comes out that

- the total abundance and species number of microannelids is increasing in the sequence Koorvere, Kaagvere, Reola, reflecting the increase in soil pH (Table 2). This corresponds to the decrease in the relative abundance of indicators of strong acidity and an increase of indicators of slight acidity in the same order.
- The vertical distributions of microannelids exhibit similar patterns and provide evidence that the hotspot of biological activity is occurring at the top of the humus profiles. Downwards the decrease of activity is proportional to the decrease in organic matter (Table 2).
- Indicators of moist conditions are visible only at Reola.

## Discussion

The biological features of the three sites are quite in line with their positioning on the matrix of the Estonian humus cover types (Fig. 4). However, the German approach comes to a slightly different sorting. The profile at Koorvere is classified as Moder (not Rohhumus/Mor), mainly due to the loose (not compact) structure of the Oh horizon. The profile at Kaagvere is classified as Mull (not Moder) due to the lack of an Oh horizon. This is confirmed by the presence of endogeic earthworms at the site, indicating bioturbation in the A horizon. The profile at Reola is also classified as Mull (peat is considered a substrate in the German system), which is supported by the high abundance of microannelids, mainly indicators of slight acidity being at the same time indicators of Mull (Graefe & Schmelz 1999).

It appears that the traditional partition of humus forms in Mull, Moder, Mor is differently handled by the national classification systems and may lead to misunderstandings in an international context. In order to avoid this, additional qualifiers could be used on the model of WRB as proposed by Graefe et al. (2012) and following the guideline: "Classifications ought to be easy and simple, with a limited number of classes at the highestmost level, so that they can be easily remembered and address to main environments and characteristics. Then there is an infinity of descriptors to describe and accomodate every situation" (Edoardo Costantini, personal communication, May 4, 2015). With this in mind we propose for the studied topsoil profiles the WRB-adapted designations in Table 3 (Laxic from Latin *laxus*, loose means loose Oh horizon).

**Table 3** Designation of humus forms on the studied sites according to the Estonian, the German and a WRB-adapted classification system

| Classification system | Koorvere | Kaagvere | Reola |
|---|---|---|---|
| Estonian | mov - fresh mor | mdv - fresh moder | tue - eutrophic peat |
| German | Typischer Moder | F-Mull | Feuchtmull |
| WRB-adapted | Dystric Moder (Laxic, Podzolic) | Dystric Mull (Arenic, Endoloamic) | Histic Mull (Aerohydric, Eutric) |

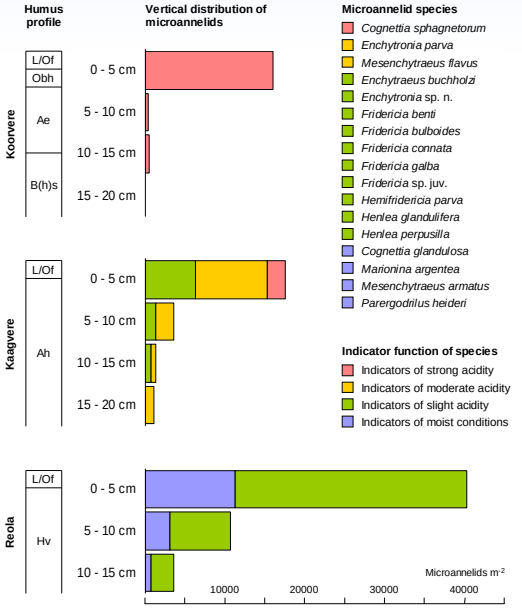


**Fig. 3** Morphological humus profiles compared to the biological humus activity profiles as expressed by the vertical distribution of microannelids at the investigated sites. Colours correspond to different indicator functions of species.

**Table 1** Results of microannelid extraction from topsoil samples

| | Koorvere | Kaagvere | Reola |
|---|---|---|---|
| Total of extracted animals | 100 | 138 | 214 |
| Total abundance (individuals m$^{-2}$) | 16977 | 23428 | 54495 |
| Standard deviation | 9827 | 2836 | 12244 |
| Coefficient of variation | 58% | 12% | 22% |
| Number of species | 1 | 7 | 12 |
| Indicators of strong acidity | 100% | 9% | 0% |
| Indicators of moderate acidity | 0% | 55% | 0% |
| Indicators of slight acidity | 0% | 36% | 72% |
| Indicators of moist conditions | 0% | 0% | 28% |

**Table 2** Soil characteristics of the study sites (from Kõlli et al. 2015)

| Site | Horizon | Depth | pH (KCl) | $N_t$ g kg$^{-1}$ | $C_{org}$ g kg$^{-1}$ |
|---|---|---|---|---|---|
| Koorvere | Of/Oh | 1-4 cm | 3.1 | 12.3 | 432.4 |
| | Ae | 6-12 cm | 3.0 | 0.3 | 13.2 |
| | Bs | 25-40 cm | 4.2 | 0.3 | 7.6 |
| Kaagvere | L/Of | 0-2 cm | 4.0 | 6.8 | 196.6 |
| | Ah | 2-5 cm | 4.2 | 3.0 | 86.4 |
| | Ah | 5-15 cm | 4.4 | 1.3 | 9.0 |
| | Ah | 15-25 cm | 4.0 | 0.5 | 13.2 |
| Reola | Hv | 2-10 cm | 5.0 | 22.6 | 431.8 |
| | Hv | 10-20 cm | 6.3 | 27.4 | 365.2 |

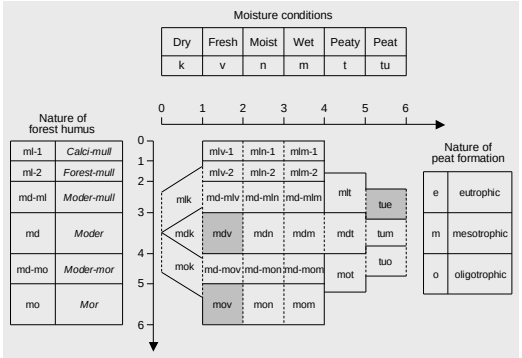


**Fig. 4** Matrix of the Estonian approach to classify humus cover types. Shaded designations apply to the studied sites (from Kõlli & Tamm 2013)

## References

Graefe U, Schmelz RM (1999) Indicator values, strategy types and life forms of terrestrial Enchytraeidae and other microannelids. Newsl Enchytraeidae 6, 59-67

Graefe U, Baritz R, Broll G, Kolb E, Milbert G, Wachendorf C (2012) Adapting humus form classification to WRB principles. EUROSOIL 2012, Book of Abstracts, p. 954

IUSS Working Group WRB (2014) World Reference Base for Soil Resources 2014. International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome

Kõlli R, Tamm I (2013) Humus cover and its fabric depending on pedoecological conditions and land use: an Estonian approach to classification of humus forms. Estonian Journal of Ecology 62 (1), 6-23

Kõlli R, Graefe U, Tamm I (2015) Abundance and species richness of microannelids in humus cover of Estonian forest soils. Agraarteadus - Journal of Agricultural Science 26 (1), 24-29

Jahrestagung der DBG, München, 5.-10.9.2015