1.17 BI01A Enchytraeid diversity

Key issue: Decline in biodiversity
DPSIR classification: Impact

Main information: Measuring this indicator will provide information on the species diversity of enchytraeids. This indicator is to be measured if earthworms are not available in the soils. Together with other biodiversity indicators and complementary information (e.g. land use, humus form, climate) it will provide information on the biological state of the soil and on changes in soil biodiversity.

1.17.1 Example

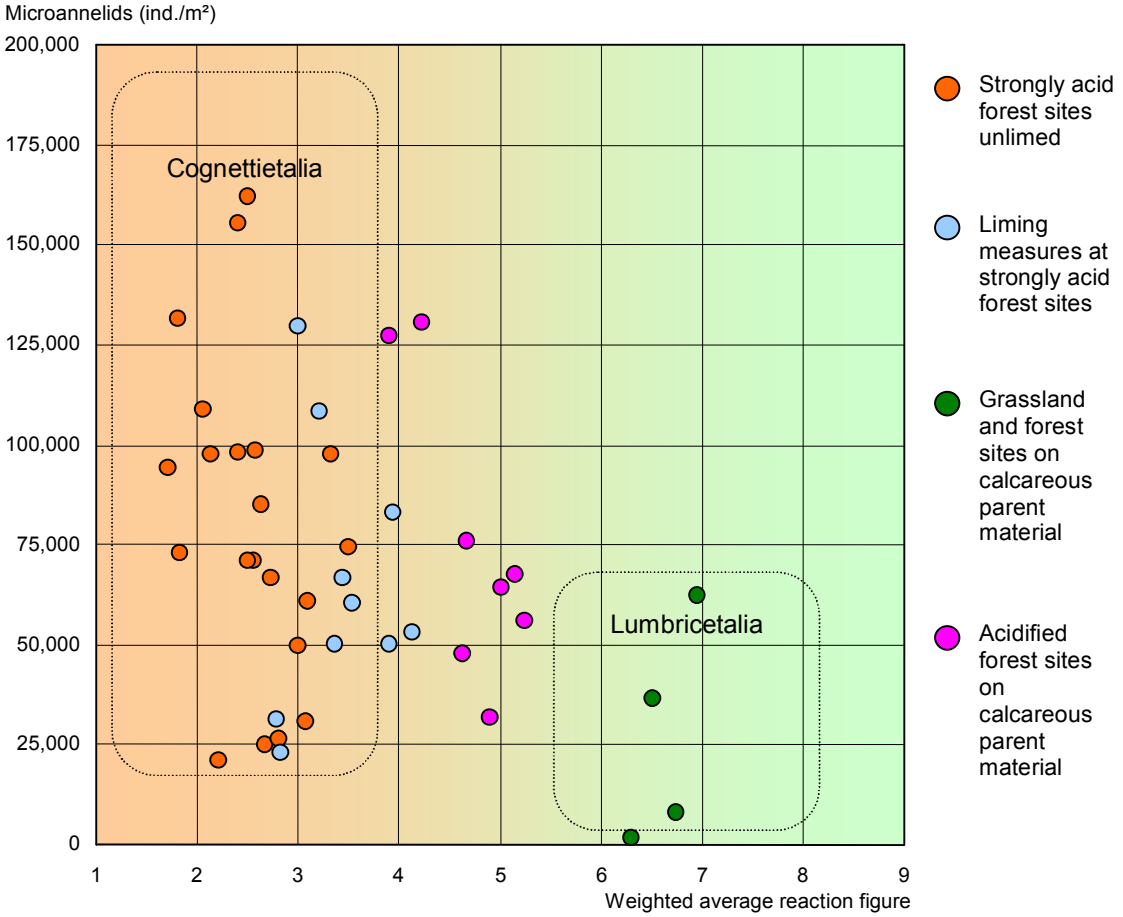

Figure 1.17.1 Biological condition of soils at permanent soil monitoring sites in North Rhine-Westphalia - Diagram with two biological indices: the total abundance of enchytraeids and the weighted average reaction figure of the annelid community

The species are classified with respect to their occurrence along the gradient of soil pH into indicator value groups figured from 1 (indicator of extreme acidity) to 9 (indicator of basic reaction). The average reaction figure is the calculated mean of indicator values of all species within a given community. The weighted average reaction figure is the mean of indicator values multiplied by a factor 1 to 5 for the abundance class of the species. (Beylich and Graefe, 2002; Beylich *et al.*, 1995; Graefe, 1997, 1998; Graefe *et al.*, 1998, 2001, 2002; Graefe and Schmelz, 1999; Graefe and Beylich, 2003, 2006).

There are two distinct groups corresponding to different soil community types. Lumbricetalia are dominated by anecic and endogeic earthworms. Cognettietalia are dominated by enchytraeids. Owing to the absence of soil mixing earthworms soil life in Cognettietalia is largely restricted to the humus layer. In terms of humus forms Cognettietalia corresponds to Moder/Mor and Lumbricetalia to Mull. Species diversity is increasing from Mor to Mull. Liming has shifted the species composition from indicators of strongly acid condition in the direction to indicators of moderately acid condition, but has not resulted in switching to another community type. High abundances of enchytraeids in Mor/Moder indicate high biological activity through the eutrophying effect of high nitrogen deposition.

1.17.1.1 Significance

This indicator will provide information on the diversity of enchytraeids. Together with other indicators for biodiversity and other information (e.g. land use, soil type, climate) it will provide information on the decline of biodiversity.

1.17.1.2 Policy context

The importance of soil biodiversity is acknowledged in international treaties (UN-CBD, UNFCCC, UNCCD), by international organisations (OECD, FAO, UNEP, CGIAR) and by national governments. The UN treaties are implemented through national policies, strategies and action programmes, in which the role and protection of (soil) biodiversity is addressed. However, the scope of attention to this issue in each country depends on awareness by decision makers, human capacities and knowledge, financial resources and priorities. Soil biodiversity needs to be protected because of its intrinsic value, and its ecological functions in the soil. Moreover, through support for appropriate land use systems and management practices, soil biological functions can be enhanced with multiple benefits in terms of increased productivity, increased efficiency of resource use and hence reduced costs of external inputs, increased sustainability and reduced erosion and pollution.

This indicator is measured in the context of the biological classification of soils including soil quality assessment (Beylich *et al.*, 1995; Jänsch and Rombke, 2003), terrestrial bioindication and long-term monitoring (Graefe and Schmelz, 1999) as well as for the evaluation of the effects of chemicals on soil animals (Römbke *et al.,* 2002). Right now, most studies are performed in the context of scientific research but enchytraeids are increasingly used in governmental programs (e.g. in the Netherlands, Germany or Austria).

1.17.1.3 Scientific background

Enchytraeids are small soil-inhabiting worms (few mm to several cm in length) belonging to the family Enchytraeidae, order Oligochaeta, class Clitellata, phylum Annelida. In acidic soils (e.g. in coniferous forests) they can replace earthworms as ecosystem engineers. Their influence on soil functions like litter decomposition, soil pore structure or nutrient cycling, is well known (Graefe, 1997, 1998, 1999, 2004; Römbke, 1991). Due to their often very high number (and population biomass) they are also important in many terrestrial food webs (Didden 1993; Graefe and Beylich, 2006).

1.17.1.4 Assessment of results

Enchytraeids are extracted from soils samples with the standardized method ISO 23611-3 (2006) and identified in the laboratory. The name and number of species are determined. These results can be used to calculate either diversity indexes or to compare the respective data set with a reference data set, for example by using multivariate statistics.

1.17.2 Meta data

1.17.2.1 Technical information

i) **Data sources:** There are several data sets from monitoring systems in Austria (A) (Bauer, 2000, 2003) Germany (D) (Graefe *et al.*, 1998; Barth *et al.*, 2000; Graefe, 2005) and the

Netherlands (NL) (Rutgers *et al.*, 2005). Other data sets come from transect or field studies. All the available data can be used to define baseline/threshold values across EU.

ii) **Description of data:** The raw data usually consist of the names of the species with their respective numbers. Then this information is converted into diversity indices.

iii) **Geographical coverage:** D: Schleswig Holstein, Hamburg, Nordrhein-Westfalen, Hessen, Mecklenburg-Vorpommern (partly), Brandenburg (partly). A: Land Salzburg. NL.

iv) **Spatial resolution:** A, D and NL monitoring network is stratified according to land use.

v) **Temporal coverage:** Enchytraeid sampling at German soil monitoring sites started in 1992, at Austrian sites in 1996. NL network started biological sampling in 1997.

vi) **Methodology and frequency of data collection:** In D samples are taken in intervals of 5 (Nordrhein-Westfalen) to 10 years (Hamburg), in Salzburg 3 to 6 years, in NL every 6 years. In D and A 10 replicates are collected at each sampling occasion. Soil cores are divided in 4 vertical subsamples and extracted by wet funnel method (ISO 23611-3, 2006).

vii) **Methodology of indicator calculation:** The species are classified with respect to their occurrence along the gradients of soil pH, soil moisture, and salinity, as well as to their reproductive strategy, stress tolerance, and their occurrence in the continuum of humus horizons and humus forms. Multiple species information is aggregated to one value per site and inventory by calculating average indicator values and life-form ratios.

viii) **Availability of baselines and thresholds:** Baselines and thresholds according to soil parameters as pH are published in numerous papers (Healy, 1980, Didden, 1993; Graefe, 1993, 2005; Graefe *et al.*, 2001, 2002, Beylich and Graefe, 2002, Graefe and Beylich, 2003; Jänsch and Römbke, 2003; Jänsch *et al.*, 2005)..

1.17.2.2 Quality information

i) **Strength and weakness***:* Up to now data for all EU are not available. Nevertheless several datasets already exist and may be available. The quality of data in these data sets is different as the sampling was generally performed with different methods. This situation will change as for new measurements an ISO method is now published.

ii) **Data comparability**:
Comparability over time: overtime data are comparable if samples are taken at the same period (e.g. sampling in spring or in autumn). Variations may occur if land use changes or if climatic conditions before sampling are strongly different from the previous sampling.
Comparability over space: as the repartition of soil organisms depends on soil characteristics their variability will be considered by the sampling strategy.

1.17.3 Further work required

The following work is required to make the use of this indicator simpler:

Develop new datasets by using an harmonized approach on different locations across EU integrating different climates, soil types, land uses and agricultural practices.

Datasets from various countries (in particular Germany and the Netherlands) have to be compiled in order to define threshold values and baselines.

Research is progressing to develop software and/or technical guides allowing an easy identification step. Furthermore identification of soil species with DNA extracts is also a matter of research and will maybe produce DNA arrays within 10 years.

1.17.4 References

Barth, N., Brandtner, W., Cordsen, E., Dann, T., Emmerich, K.-H., Feldhaus, D., Kleefisch, B., Schilling, B., Utermann, J. (2000): Boden-Dauerbeobachtung – Einrichtung und Betrieb von Boden-Dauerbeobachtungsflächen. In: Rosenkranz, D., Bachmann, G., König, W., Einsele, G. (eds.): Bodenschutz. Kennziffer 9152, Erich Schmidt Verlag, Berlin, 127 p.

Bauer, R. (2000): Biologische Bewertung von Böden: Erfassung der Regenwürmer und Kleinringelwürmer (Annelida; Oligochaeta: Lumbricidae und Enchytraeidae) auf den Dauerbeobachtungsflächen im Bundesland Salzburg. Mitt. Österr. Bodenkundl. Ges 59: 39-41.

Bauer, R. (2003): Characterization of the decomposer community in Austrian pasture and arable field soils with respect to earthworms and potworms (Annelida: Lumbricidae and Enchytraeidae). Newsletter on Enchytraeidae 8: 41-50.

Beylich, A., Graefe, U. (2002): Annelid coenoses of wetlands representing different decomposer communities. In: Broll, G., Merbach, W., Pfeiffer, E.-M. (eds.): Wetlands in Central Europe. Soil organisms, soil ecological processes and trace gas emissions. Springer, Berlin, pp. 1-10.

Beylich, A., Fründ, H.-C., Graefe, U. (1995): Environmental monitoring of ecosystems and bioindication by means of decomposer communities. Newsletter on Enchytraeidae 4: 25-34.

Didden, W. A. M. (1993): Ecology of terrestrial Enchytraeidae. Pedobiologia 37: 2-29.

Graefe, U. (1993): Die Gliederung von Zersetzergesellschaften für die standortsökologische Ansprache. Mitt. Dtsch. Bodenk. Ges. 69: 95-98.

Graefe, U. (1997): Bodenorganismen als Indikatoren des biologischen Bodenzustands. Mitt. Dtsch. Bodenk. Ges. 85: 687-690.

Graefe, U. (1998): Annelidenzönosen nasser Böden und ihre Einordnung in Zersetzergesellschaften. Mitt. Dtsch. Bodenk. Ges. 88: 109-112.

Graefe, U. (1999): Die Empfindlichkeit von Bodenbiozönosen gegenüber Änderungen der Bodennutzung. Mitt. Dtsch. Bodenk. Ges. 91: 609-612.

Graefe, U. (2004): Das vertikale Verteilungsmuster der Kleinringelwurmzönose als Indikator der Prozessdynamik im Humusprofil. Mitt. Dtsch. Bodenk. Ges. 103: 27-28.

Graefe, U. (2005): Makroökologische Muster der Bodenbiozönose. Mitt. Dtsch. Bodenk. Ges. 107: 195-196.

Graefe, U., Beylich, A. (2003): Critical values of soil acidification for annelid species and the decomposer community. Newsletter on Enchytraeidae 8: 51-55.

Graefe, U., Beylich, A. (2006): Humus forms as tool for upscaling soil biodiversity data to landscape level? Mitt. Dtsch. Bodenk. Ges. 108: 6-7.

Graefe, U., Schmelz, R. M. (1999): Indicator values, strategy types and life forms of terrestrial Enchytraeidae and other microannelids. Newsletter on Enchytraeidae 6: 59-67.

Graefe, U., Elsner, D.-C., Necker, U. (1998): Monitoring auf Boden-Dauerbeobachtungsfächen: Bodenzoologische Parameter zur Kennzeichnung des biologischen Bodenzustandes. Mitt. Dtsch. Bodenk. Ges. 87: 343-346.

Graefe, U., Gehrmann, J., Stempelmann, I. (2001): Bodenzoologisches Monitoring auf EU-Level II-Dauerbeobachtungsflächen in Nordrhein-Westfalen. Mitt. Dtsch. Bodenk. Ges. 96: 331-332.

Graefe, U., Elsner, D.-C., Gehrmann, J., Stempelmann, I. (2002): Schwellenwerte der Bodenversauerung für die Bodenbiozönose. Mitt. Dtsch. Bodenk. Ges. 98: 39-40.

Healy, B. (1980): Distribution of terrestrial Enchytraeidae in Ireland. Pedobiologia 20: 159-175.

Jänsch, S. and Römbke, J. (2003): Ökologische Charakteriserung ausgewählter Enchytraeenarten hinsichtlich relevanter Standorteigenschaften (speziell Bodenparameter): UWSF – Zeit. Umweltchem. & Schadstoff-Forschung 15: 95-105.

Jänsch, S., Römbke, J., Didden, W. (2005): The use of enchytraeids in ecological soil classification and assessment concepts. Ecotoxicol. Environ. Saf. 62: 266-277.

Rutgers, M. *et al.* (2005): Soil ecosystem profiles - sustainable land-use with references for a healthy soil. Report 607604007, RIVM, Bilthoven (In Dutch, with English summary)

Römbke, J. (1991): Estimates of the Enchytraeidae (Oligochaeta, Annelida) contribution to energy flow in the soil system of an acid beech wood forest. Biology and fertility of Soils 11: 255-260.

Römbke, J., Notenboom, J. & Posthuma, L. (2002): The effects of zinc on enchytraeids. The Budel case study. Natura Jutlandica Occasional Papers No. 2: 54-67.

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