Organic carbon in topsoil from arable land and grazing land of Europe

Vibeke Ernstsen[A], Domenico Cicchella[B], Alecos Demetriades[C], Benedetto De Vivo[D], Enrico Dinelli[E], Frants von Platen[A], Clemens Reimann[F], Timo Tarvainen[G] and the EuroGeoSurveys Geochemistry Expert Group

[A]Geological Survey of Denmark and Greenland (GEUS), Copenhagen, Denmark, Email ve@geus.dk
[B]University of Sannio, Benevento, Italy, Email cidom@unisannio.it
[C]Institute of Geology and Mineral Exploration, Acharnae, Hellas, Email ademetriades@igme.gr
[D]Università di Napoli Federico II, Napoli, Italy, Email bdevivo@unina.it
[E]University of Bologna, Bologna, Italy, Email dinelli@geomin.unibo.it
[F] Geological Survey of Norway (NGU), Trondheim, Norway, Email Clemens.reimann@ngu.no
[G]Geological Survey of Finland, Espoo, Finland, Email Timo.Tarvainen@gtk.fi

Abstract
Knowledge about soil quality at a European scale is urgently required for e.g., the new European Chemicals Regulation, the pending EU Soil Protection Directive and, the assessment of soil as a repository of organic carbon in a changing climate. A unique data collection on total organic matter (TOC) has been established by the Geological surveys in 33 European countries, covering an area of more than 5 million km ^{2}. The sampling density of each arable land (0-20 cm) and grazing land (0-10 cm) is of 1 site per 2500 km^2. The sampling was carried out according to a jointly agreed field protocol. All samples were prepared and analysed in just one laboratory. All samples were sampled during 2008 and early 2009. For both arable land and grazing land the results show a tendency to higher contents of TOC in the northern countries, Ireland and United Kingdom than other countries, even though some local differences are present for most countries. The concentrations of TOC vary between 0.4 and 46 % w/w for arable land and between 0.4 and 49 % w/w for the grazing land. Managing soil organic matter are important for e.g., the ecosystem servicing including soil, air and water quality, fewer pollutants, productivity, and mitigation of climate change.

Key Words
Soils, total organic carbon, TOC, arable land, grazing land, IS 10694.

Introduction

The organic fraction of soils often accounts for a small but variable proportion of the total soil mass but nevertheless the organic fraction can exert a profound influence on e.g., soil properties, ecosystem functioning, and the magnitude of various ecosystem processes.

The organic matter may influence the physical properties (colour, water retention, and stabilization of structure), the chemical properties (CEC, buffering capacity, pH, chelation of metals and interactions with xenobiotics) and biological properties (reservoir of metabolic energy, source of macronutrients, ecosystem resilience, stimulation and inhibition of enzyme activities) (Sumner 2000; Van-Camp *et al.* 2004). The need for accurate information on the organic matter content in soils at European, National or Regional level has been increasing steadily over the past few years (Van-Camp *et al.* 2004). Knowledge about soil quality at European scale is urgently required for e.g., the new European Chemicals Regulation, the pending EU Soil Protection Directive, assessments of soil as a repository of organic carbon in a changing climate, soil degradation and desertification.

The content of TOC in one site per 2500 km^2 of arable land and grazing land has been measured for soil samples collected during 2008 and early 2009. Local differences in the contents of soil organic matter are not reflected in the study but the sampling density brings about valuable information (a snapshot) about the prevailing status of soil organic matter in topsoils within 33 European countries.

Methods

Field sampling method and analysis
All soil samples were sampled following a jointly agreed field protocol (EuroGeoSurveys Geochemistry Working Group 2008). For each 2500 km^2 one sample were collected from arable land and grazing land. Five subsamples were collected from each corner and the centre of a 10 x 10 m square and composited to provide one large sample (2-2.5 kg) which was directly placed into a Rilsan® bag. All soil samples were air

dried and sieved < 2mm prior to analysis at the same preparatory laboratory. Organic carbon was analysed as described by ISO 10694 Soil quality - Determination of organic and total carbon after dry combustion (elementary analysis) (1995). The concentration of TOC in the topsoil was expressed as a percentage of soil weight (TOC % w/w, i.e. g C/100g soil)

Results

The contents of TOC in 2197 samples from below arable land (Figure 1) vary between 0.4 and 46 %. The highest concentrations of TOC were measured in samples from Finland, Ireland and Norway (46 %) but also in other countries (e.g., in Sweden, United Kingdom, Germany) distinctively high concentrations were measured. The median value for arable land is 1.7 % TOC.

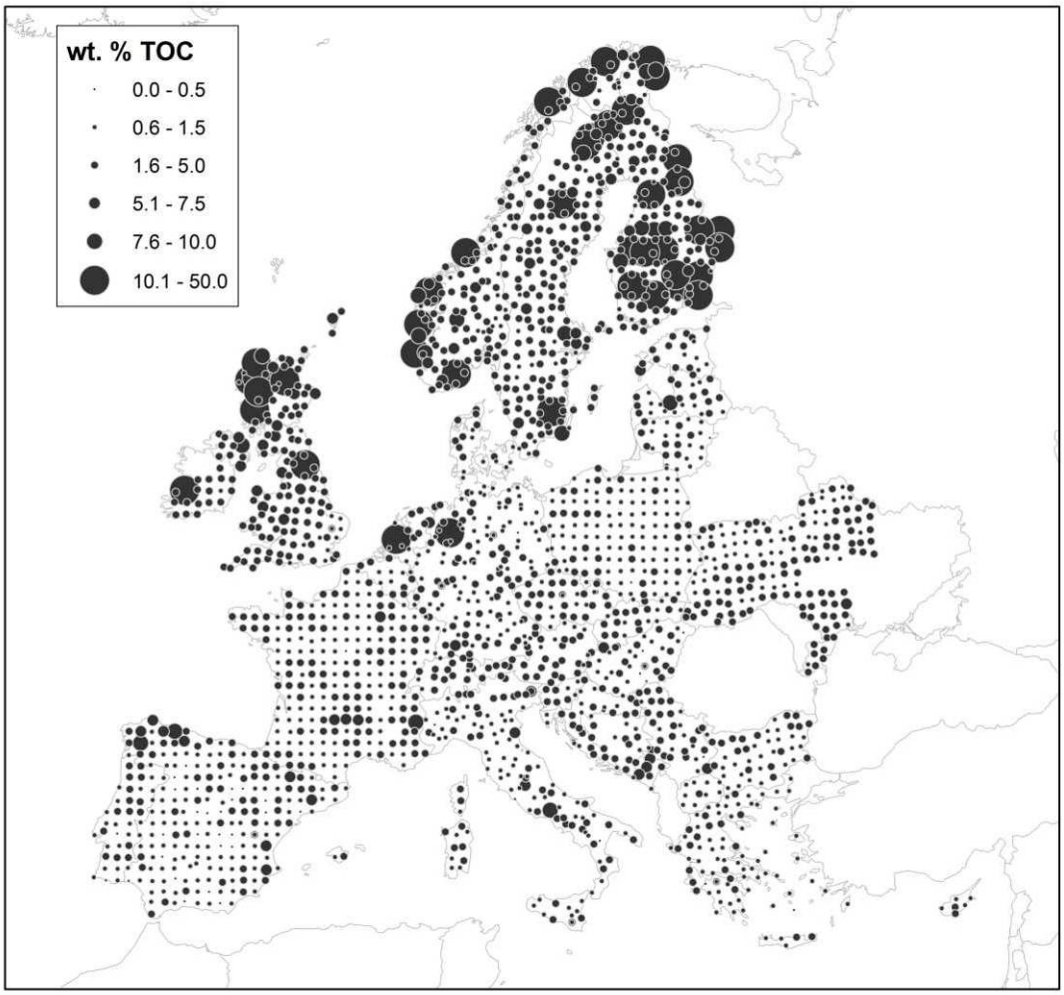

Figure 1. The spatial distribution of total organic carbon (TOC) in the upper twenty centimetres below arable land at 2197 sites – on average 1 site per 2.500 km^2.

The contents of TOC in 2113 soil samples from below grazing land (Figure 2) vary between 0.4 and 49 %. The highest concentrations of TOC were measured in samples from Sweden, United Kingdom, Norway, and Finland (44-49 %). The median value for grazing land is 2.7 % TOC.

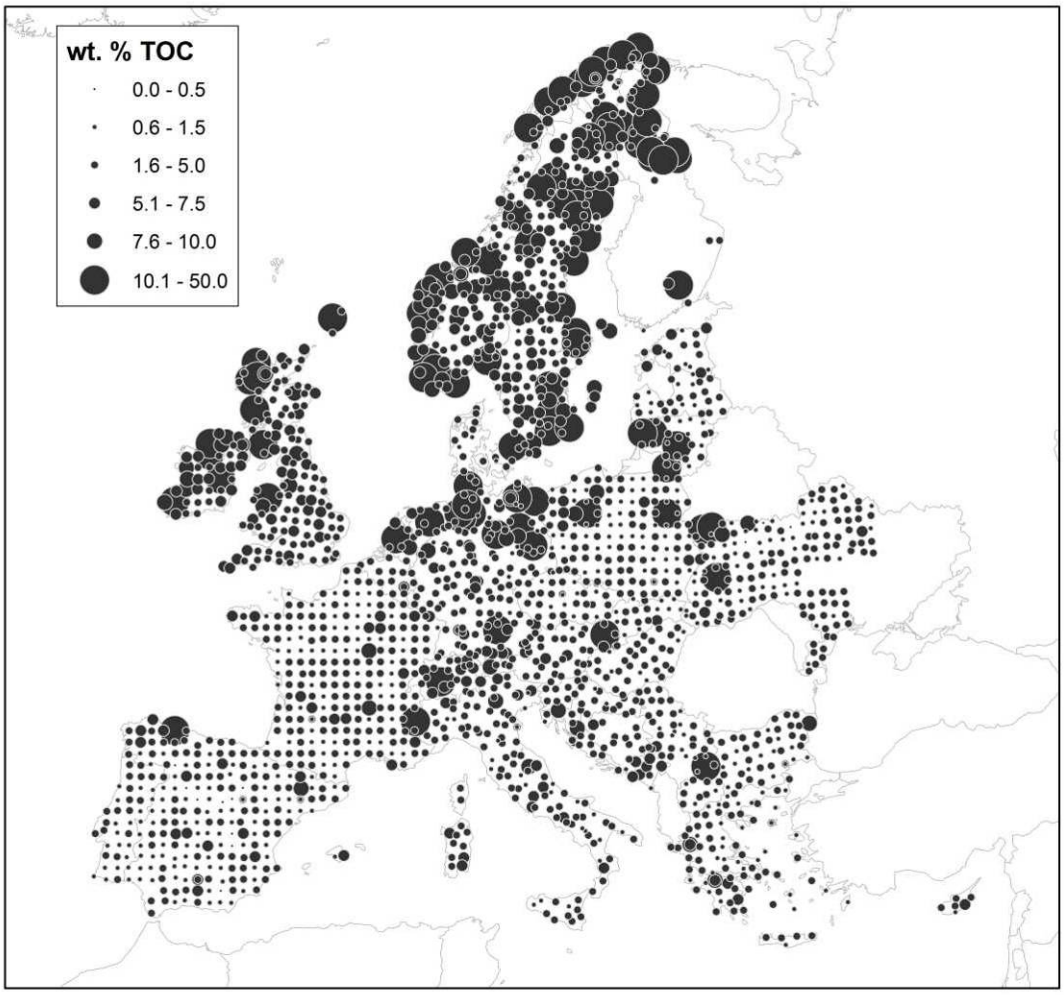

Figure 2. The spatial distribution of organic carbon (TOC) in the upper ten centimetres below grazing land at 2113 sites – on average one site per 2.500 km^2.

Conclusion

The content and distribution of TOC demonstrates considerable differences within Europe governed by differences in natural factors e.g., temperature, moisture, altitude, topography, soil parent material and human-induced factors e.g., land use and the nature of farming systems. The distribution of soil organic matter indicates large and important regional differences for the ecosystem services.

References

Baldock JA, Nelson PN (2000) Soil organic matter. In 'Handbook of Soil Sciences'. (Ed. ME Sumner) pp. B25-B84. (CRC press: Boca Raton, London, New York, Washington, D.C.).

EuroGeoSurveys Geochemistry Working Group (2008) EuroGeoSurveys Geochemical mapping of agricultural and grazing land soil of Europe (GEMAS) – Field manual. Geological Survey of Norway, Trondheim, Norway, report 2008.038

European Commission (2008) Climate change can soil make a difference? (Conference Soil and Climate Change, Brussels, Belgium, 12th June 2008) (http://ec.europa.eu/environment/soil/pdf/report_conference.pdf

Van-Camp L, Bujarrabal B, Gentile A-R, Jones RJA, Montanarella L, Olazabal C, Selvaradjou S-K (2004) Volume III – Organic matter and biodiversity. Reports of the Technical Working Groups established under the Thematic Strategy for Soil Protection. EUR 21319 EN/3, 872 pp. Office for Official Publications of the European Communities, Luxembourg