Final report

Priority programme 1090

Soils as a source and sink for CO_2 – mechanisms and regulation of organic matter stabilization in soils

Schwerpunktprogramm 1090

Böden als Quelle und Senke für CO_2 –
Mechanismen und Regulation der Stabilisierung organischer Substanz in Böden

Table of contents page

Attachments

Summary

Soil organic matter (SOM) affects all soil functions and it is a central element in the global carbon (C) cycle. Approximately 81% of the terrestrial C that is active in the carbon cycle, is stored in soils as compared to only 19% stored in the vegetation. The turnover of carbon during biomass formation (primary production) and decomposition leads to the release or binding of the greenhouse gas CO_2. Consequently, any change in the size and the turnover rate of soil C pools may potentially alter the atmospheric CO_2 concentration and the global climate. The Kyoto Protocol on climate change in 1992 and explicitly the Intergovernmental Panel on Climate Change (IPCC, 2007) demand fundamental understanding of processes involved in C stabilization in soils. The objective of the priority programme 1090 "Soils as a source and sink for CO_2 – mechanisms and regulation of organic matter stabilization in soils", established in 2000, was to elucidate these stabilization mechanisms of SOM and to delineate a quantitative understanding of the potential of temperate soils to stabilize OC over long periods (i.e., decades to centuries). Thereby the fundamental knowledge necessary to manage the C budget in soils should be provided. All experimental, analytical and modelling work concentrated on specifically selected study sites under forest and agricultural use.

Combining work on the structural composition of SOM with work on SOM turnover (two approaches that have been studied very often independently) allowed to develop a mechanistic concept of SOM stabilization. This concept is based on a differentiation between the mineralisation of plant litter and the stabilization processes within the soil itself. Our results clearly demonstrate that:

(1) Selective preservation of recalcitrant compounds is only relevant for the active pool (<10 years) and is of particular importance in horizons with large C contents like in topsoil A horizons. Thus, recalcitrance alone can not explain long term stabilization and is not the major driving force of passive C pool formation. This implies a reconsideration of the basic concepts underlying actual compartment and cohort models.

(2) Stabilization by organo-mineral interactions operates at long-term scales and dominates during late decomposition phases and in sub-soils. Pedogenetic processes of mineral formation control the strength of bonding and the amount of SOM sorbed.

(3) Spatial inaccessibility of SOM for organisms is caused by hydrophobic surfaces and the specialization of microorganisms on microhabitats and substrates, as well as by transport processes and gradients. Hydrophobicity of surfaces is of particular importance for the stabilization in the passive pool in acid forest soils and horizons with large contents of charcoal.

(4) A new conceptual model was developed and evaluated that incorporates processes for pedogenesis linked to stabilization mechanisms and SOM pools with different turnover times.

A major step forward was achieved in understanding mechanisms of SOM stabilization, quantification of stabilization rates of SOM, and manipulation of the OC budget in soils. We conclude that in soils and soil horizons with differing texture and mineralogy, various stabilization mechanisms are operative, with differing importance. Consequently the stabilization potentials of soils are site and horizon specific. Key stabilization mechanisms are highly affected by pedogenesis (e.g. weathering of clay minerals, formation of iron oxides and hydroxides), soils history and site management.

Within the framework of the priority programme 1090 there are also a number of methodological developments, including the development and improvement of available operational fractionation methods to describe functional SOM pools. A final outcome of the programme is the improvement in the parameterization of predictive C turnover models and the development of a new type of modelling approach.

The results are published in about 200 individual papers; about 50 % are published in the five most high-ranking journals of the field (soil science). The coordinative project group published state-of-the-art knowledge on SOM stabilization mechanisms and on SOM fractionation concepts and pools. The international conference: „Mechanisms and Regulation of Organic Matter Stabilization in Soils“, held in October 2003, initiated a series of subsequent international soil organic matter conferences. The integrated results from the PP as well as a comprehensive set of data for the PP 1090 agricultural and forest soils are published in 8 synthesis papers in a special issue of Journal of Plant Nutrition and Soil Science.

Introduction

The amount of organic matter (SOM) stored in soils represents one of the largest reservoirs of organic C on the global scale. More than twice as much carbon (C) is held in soils as in vegetation or the atmosphere, and changes in the soil carbon content and turnover can have a large effect on the global carbon budget. Therefore, SOM plays a key role in the global carbon cycle and thus in the generation and regulation of carbon dioxide (CO_2), the most important climatic gas. There is a lack of expertise especially for the quantitative understanding of the relationships between formation and decomposition of stable SOM. This causes great uncertainty when simulation models of carbon turnover are used to calculate the development of C pools in soils under changing environmental conditions and different land use management. At the moment an unambiguous prognosis about the development of the different C pools in soils under changing environmental conditions and land use management is not possible. The subject has gained public interest since the Kyoto Protocol on climate change in 1992 which demands for fundamental understanding of mechanisms of SOM stabilization and their regulating factors. As pointed out by the Intergovernmental Panel on Climate Change, such knowledge is indispensable for the establishment of a sustainable management of the carbon budget maintaining or even improving at the same time major soil functions (IPCC, 2007). Fundamental information on the quantitative balance between formation and decomposition of stable soil organic matter is necessary to specifically manage the long-term storage of organic matter in soils (Fig. 1).

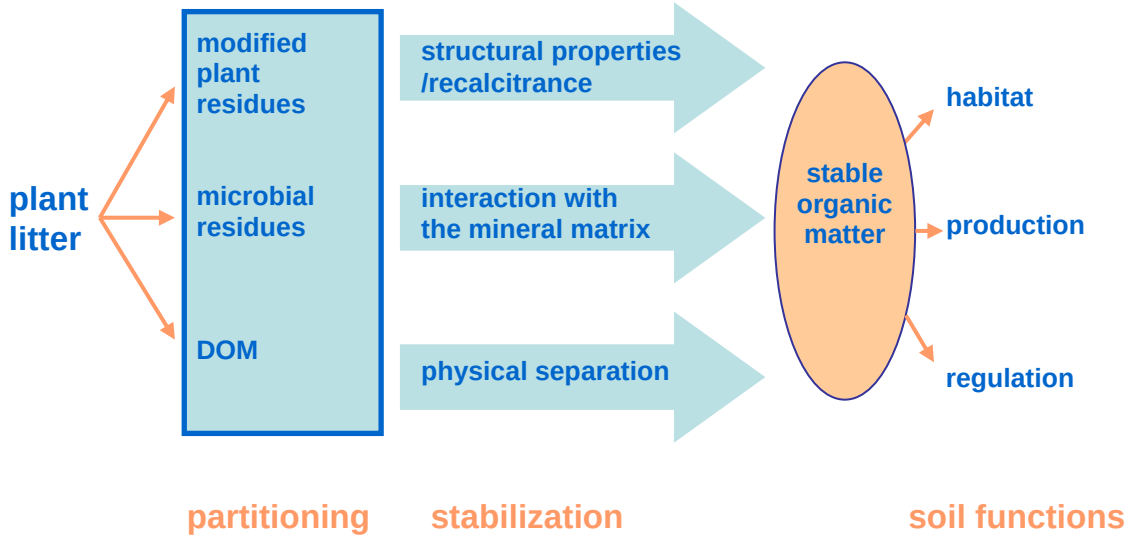

Fig. 1: Effect of SOM partitioning and stabilization on soil functions (DOM = dissolved organic matter)

Concept of the priority programme 1090

The priority programme 1090 of the German Research Foundation (Deutsche Forschungsgemeinschaft DFG): “Soils as a source and sink for CO_2 – mechanisms and regulation of organic matter stabilization in soils” started in 2000 with the main goal to achieve the basic understanding on the potential of temperate soils to stabilize C over long periods, *i.e.* decades to centuries. Although model conceptions about the stabilization processes of organic substance in soils existed, a quantitative understanding and prediction of the development of various C pools in soil under diverse conditions was not possible. The lack of expertise for the quantitative understanding of the relationships between formation and decomposition of stable SOM causes great uncertainty in simulation models of carbon turnover to calculate the development of C pools in soils under changing environmental conditions and different land use management.

The priority programme research was based on four hypotheses:

(1) Organic carbon (C) is stabilized in soils by the selective preservation of recalcitrant molecules.

(2) Organic C is stabilized by organo-mineral interactions and by complexation with metal ions.

(3) Organic C is stabilized through spatial inaccessibility for decomposer organisms.

(4) The interactions of stabilization mechanisms determine the role of soils as CO_2 sink and can be optimized by a sustainable SOM management.

Because most turnover processes in soil are very slow, well-documented long-term field experiments and the associated sample archives proofed valuable sources of information for these investigations. Terrestrial soils of the temperate zone under agricultural as well as forest use were used, as the forest and agricultural sites differ distinctly in the dynamics of litter input, cultivation and in the soil chemical and biological conditions. The field studies of all groups took place at these sites. We combined information from these long-term soil organic matter field experiments with short-term laboratory experiments. All experimental, analytical and modeling work thus concentrated on well-documented agricultural and forest sites of the temperate zone:

Long-term experimental site under agricultural use:

- Halle 'Ewiger Roggenanbau' (since 1878)
- Bad Lauchstädt 'Statistischer Düngungsversuch' (since 1902)
- Rotthalmünster 'Höhere Landbauschule'

Forest sites

- Steigerwald 'Steinkreuz' (beech and oak)
- Fichtelgebirge 'Waldstein' (spruce)

Details of the investigated sites are found in Kögel-Knabner et al. (2008) (attachment 3).

Approach to these sites and coordination of sampling was provided by W. Merbach (Halle), H. Flessa (Göttingen) and E. Matzner (BayCEER, Bayreuth).

The achievements of this programme were only possible through the integration of different disciplines (chemistry, physics, and biology of soils). Major progress has been achieved in the methods to describe structure and turnover of SOM, ranging from the isolation and molecular characterisation of specific organic matter components to the determination of carbon turnover with modern field isotopic approaches. Sophisticated analytical methods were applied for describing OM structure (*e.g.* ^{13}C and ^{15}N NMR, pyrolysis, X-ray spectrometry, SEM-EDX, Fourier-Transform Infrared Analysis) and for quantifying pool sizes and turnover rates of SOM *in situ* (^{14}C dating, ^{13}C and ^{15}N natural abundances, compound-specific isotope data). These tools were combined in the different projects of the priority programme in order to develop a quantitative understanding of the relationships between formation and decomposition of stable organic matter. A specific innovation in this priority programme was that qualitative information about the mechanistic process understanding must be combined with quantitative data on the turnover rates.

The research questions were followed in 28 individual project groups and one integrative project (see attachment 1). The individual projects in particular can be assigned to the following topics:

1) Stabilization due to chemical recalcitrance

- low molecular and macromolecular precursors (e.g. lignin) for the formation of stable SOM
- relevance of root litter for the sequestration of organic matter in the subsoil
- properties and decomposition of dissolved organic matter (DOM)
- influence of micro-organisms on the synthesis and decomposition of SOM
- isolation and characterization of stable C fractions

2) Stabilization by interaction with the mineral phase

- stabilization by sorption processes
- stabilization by complex formation with metals
- stabilization in meso- and micropores
- formation of stable clay-organic matter associates

3) Stabilization by physical separation

- influence of soil fauna and microfauna on the stabilization in microhabitats /aggregates
- aggregation of soil and physical stabilization

4) Turnover in various C pools and modelling of management effects

- storage capacity of soils for various C fractions
- turnover times of various pools and individual components of SOM
- identification of zoological control parameters
- improvement of SOM turnover models

Major research achievements of the priority programme 1090

The conceptual understanding of stabilization mechanisms and the problems of relating SOM fractions to functional SOM pools as required for modelling is given in the two reviews originating from the integrative project of the priority programme (attachment 2):

v. Lützow M, Kögel-Knabner I, Ekschmitt K, Matzner E, Guggenberger G, Marschner B, Flessa H (2006) Stabilization of organic matter in temperate soils: Mechanisms and their relevance under different soil conditions – a review. European Journal of Soil Science 57, 426-445.

v. Lützow M, Kögel-Knabner I, Ekschmitt K, Flessa H, Guggenberger G, Matzner E, Marschner B (2007) SOM fractionation methods: Relevance to functional pools and to stabilization mechanisms. Soil Biology & Biochemistry 39, 2183-2207.

Our major research achievements are presented in 8 synthesis papers that are to be published in a special issue ‚An integrative approach of organic matter stabilization in temperate soils: linking chemistry, physics and biology' in the *Journal of Plant Nutrition and Soil Science*, Volume 171 (1), 2008.

Editorial: Kögel-Knabner I, Ekschmitt K, Flessa H, Guggenberger G, Matzner E, Marschner B and v. Lützow M, An integrative approach of organic matter stabilization in temperate soils: linking chemistry, physics and biology.

Bachman J, Guggenberger G, Baumgartl T, Ellerbrock R, Fischer WR, Goebel M-O, Horn R, Jasinska E, Kaiser K, Scale-dependent physical protection of soil organic matter: Sorption mechanisms, wettability and aggregate stability.

Ekschmitt K, Kandeler E, Poll C, Brune A, Buscot F, Friedrich M, Gleixner G, Hartmann A, Kästner M, Kopinke F-D, Scheu S, Wolters V, Soil carbon preservation through biological constraints of decomposer activity.

Flessa H, Amelung W, Helfrich M, Wiesenberg GLB, Gleixner G, Brodowski S, Rethemeyer J, Kramer C, Grootes P-M, Storage and stability of organic matter in a Luvisol and Phaeozem with continuous cropping: A synthesis from the priority programme SPP 1090.

Kalbitz K, Kaiser K, Contribution of dissolved organic matter to carbon storage in forest soils.

Kögel-Knabner I, Guggenberger G, Kleber M, Kandeler E, Kalbitz K, Scheu S, Eusterhues K, Leinweber P, Organo-mineral associations in temperate soils: integrating biology, mineralogy and organic matter chemistry.

Ludwig B, Kuka K, Franko U, v. Lützow M, Comparison of two quantitative soil organic carbon models with a conceptual model using data from two agricultural long term experiments.

Marschner B, Brodowski S, Dreves A, Gleixner G, Grootes P-M, Hamer U, Heim A, Jandl G, Ji R, Kaiser K, Kalbitz K, Kramer C, Leinweber P, Rethemeyer J, Schmidt MWI, Schwark L, Wiesenberg GLB, How relevant is recalcitrance for the stabilization of organic matter in soils?

v. Lützow M, Kögel-Knabner I, Ludwig B, Matzner E, Flessa H, Ekschmitt K, Guggenberger G, Marschner B, Kalbitz K, Stabilization mechanisms of organic matter in four temperate soils: Development and application of a conceptual model.

The pdfs of these manuscripts are enclosed (attachment 3) and provide the detailed results from the priority programme. In the following, these major results are summarized:

Marschner et al. (2008) analyze hypothesis 1. The results clearly demonstrate that the biotic community is able to degrade any OM of natural origin and that we have no indication for the existence of inert OM components. Turnover of potentially recalcitrant compounds (lignin, lipids) was similar or even faster than bulk soil OM. Even fossil C was used by microorganisms and black C from charred plant material proved to be moderately degradable. Long-term stabilization of potentially labile compounds (polysaccharides, proteins) shows the importance of active stabilization mechanisms. From these findings we can conclude, that recalcitrance is only important during early stages of decomposition. Thus, recalcitrance alone can not explain long term stabilization and is not the major driving force of passive C pool formation. We therefore reject hypothesis 1. This implies a reconsideration of the basic concepts underlying most actual compartment and cohort models. The concept of stabilization by selective preservation of recalcitrant compounds (hypothesis 1) is also questioned by Ekschmitt et al. (2008) who attribute constraints on decomposition rates to the biology of the decomposer organisms. They demonstrate that C sources and biota are isolated spatially due to the specialization of organisms on microhabitats and substrates (hypothesis 3). In biologically active microsites decomposition is restricted by transport processes and gradients.

The role of organo-mineral interactions and complexation by metal ions for OM stabilization (hypothesis 2) is discussed in the synthesis papers by Kögel-Knabner et al. (2008) and Kalbitz and Kaiser (2008). The results from the work groups of Kalbitz and Kaiser (2008) demonstrated by means of laboratory incubations that sorption of dissolved organic matter (DOM) to soil minerals and (co)precipitation with Al stabilizes OM in the longer term. *In situ* investigations show that the proportion of the mineral-bound OM and its ^{14}C age generally increase with soil depth. Stabilization by organo-mineral interactions operate at long-term scales and dominate during late decomposition phases and in sub-soils (synthesis paper by Kögel-Knabner et al., 2008). OM in organo-mineral associations of fine fractions and loamy soils has a higher contribution of bacterial polysaccharides whereas mineral-associated OM in acid sandy soils is more aliphatic. In acid subsoils especially microporous oxide phases efficiently stabilize OM by ligand exchange while

more than one bonding mechanism may operate in neutral soils. It became evident that pedogenetic processes of mineral formation control the strength of bonding and the amount of OM sorbed. Surface coverage was found to be discontinuous and specific surface area is not always a good predictor for C stabilization. This could be explained by conceptual models that describe the spatial orientation of organo-mineral interactions under different OC contents or a self-assembly of OM into multilayered structures on mineral surfaces. The chemical composition of organo-mineral associations influences soil physical properties and mineralization processes (Bachmann et al., 2008). Physical barriers due to the wetting resistance and chemical heterogeneity of surfaces, hydrophobic interfaces, and instable wetting fronts cause spatial heterogeneity of soil moisture and spatial inaccessibility for decomposer organisms (hypothesis 3). Hydrophobicity of soil particles was identified as a major factor in aggregate formation and stability supporting the occlusion of OM in nano-scaled clay microstructures that effectively stabilize OM in the long term.

A synthesis of data and an evaluation of the relevance of different stabilization mechanisms in the two agricultural soils is presented by Flessa et al. (2008). Stability of OM increased from free OM to occluded OM and to mineral bound OM. The increase in stability of OM occluded in aggregates with decreasing aggregate size seems to result from the change of biogenic to abiotic aggregation processes and simultaneously from an increase in recalcitrance of the occluded OM. Very high amounts of mineral bound OM on total C stocks with intermediate to passive turnover times demonstrate the essential role of long-term stabilization by organo-mineral interactions in agricultural soils (hypothesis 2). Further fossil C may contribute essentially to the total OC and forms a large stock of passive soil OM.

Based on these results we developed and evaluated a process oriented conceptual model that relates the diverse stabilization mechanisms to active, intermediate, and passive pools and shows the hierarchical structured co-action of the various processes (v. Lützow et al., 2008 and Ludwig et al., 2008). Because the relevance of different stabilization mechanisms within the passive pool varies in dependence on pedogenetic conditions, specific key stabilization mechanisms for different horizons of two forests and two agricultural PP sites were identified (hypothesis 4). Soil management had a strong effect on the contribution of the different stabilization processes to overall SOM stabilization. Cultivation reduces aggregation and in turn increases the contribution of organo-mineral interactions to the stabilization within the intermediate and passive pool.

Only little evidence was found for other SOM stabilization processes as proposed in the literature, such as stabilization by formation of humic polymers, encapsulation of OM in pseudo-macromolecules and intercalation of OM in clay minerals.

Problems remain to quantify the contribution of different stabilization mechanisms, especially within the passive pool, because operational fractions that match the specific stabilization mechanisms are missing. Because most fractionation procedures to describe the passive pool are not homogeneous the consideration of the whole soil profile is important for the interpretation and for the evaluation of such composite fractions.

Changes in the relevance of different stabilizing mechanisms in dependence of soil forming factors must be considered in new soil specific model structures. Major difficulties in the understanding and prediction of SOM dynamics originate from the simultaneous operation of several mechanisms, especially within the passive pool and the fact that most of our current fractionation methods do not yield homogenous or functional OM pools.

Numerous methodological contributions, an improvement in the parameterization of predictive C turnover models, as well as the development of new model approaches are an additional outcome of the work in the PP, summarized in Table 1.

Table 1: Methodological contributions of the DFG priority programme 1090

Methodological contributions	**References** (see list of publications)
Functional identification of decomposer organisms	Egert et al., 2003, 2004; Selesi et al., 2005, 2007; Kramer & Gleixner, 2008; Kindler et al., 2006; Miltner et al., 2004
Molecular approach to evaluate the gene expression of laccases	Luis et al., 2005
Method to quantify black carbon in soils	Brodowski et al., 2005
Quantification and identification of soil lipids	Wiesenberg et al., 2004; Jandl et al., 2002
Identification of molecular lipid markers for C3/C4 plants	Wiesenberg et al., 2004; Wiesenberg & Schwark, 2006
Isotope-selective sensing of soil-respired CO_2	Hörner et al., 2004; Hörner & Löhmannsröben, 2006
Qualitative and quantitative characterization of operational fractions by their pool size, composition and turnover time	Ellerbrock & Kaiser, 2005; Eusterheus et al., 2003, 2005; Helfrich et al. 2007; Flessa et al., 2008; Kaiser & Ellerbrock, 2005; Kaiser & Guggenberger, 2003, 2006, in prep.; Kleber et al., 2005, Ludwig et al., 2003; Mikutta et al., 2005; Miltner et al., 2005, Rethemeyer et al., 2005,; Rumpel et al., 2002; Wiesenberg et al., 2004; v. Lützow et al., 2007.
Improvements in the parameterization of the Roth-C model: predictive modeling	Ludwig et al., 2003, 2005, 2007, 2008
New model approaches	Kuka et al. 2007; Rühlmann et al., 2006
Development of a conceptual model	v. Lützow et al., 2008

Major activities of the priority programme 1090 (2000-2007)

- ❒ Twenty-eight projects were funded and started in summer 2000
- ❒ Four working groups were established
  WG 1: Interaction of organic matter with the mineral matrix (coordinated by G. Guggenberger)
  WG 2: Recalcitrant organic materials and their contribution to stabilized organic matter
  (coordinated by B. Marschner)
  WG 3: Compartments and microhabitats (coordinated by V. Wolters/K. Ekschmitt)
  WG 4: Pools – turnover – modelling (coordinated by H. Flessa)
- ❒ Soil sampling campaigns in 2000 and 2001
  Forest soils: Waldstein, Steinkreuz (coordinated by E. Matzner/ K. Kalbitz, Bayreuth)
  Agricultural soils: Halle, Bad Lauchstädt (coordinated by W. Merbach, Halle)
- ❒ First annual meeting at Hohenkammer, near Munich, 10/2000.
  Establishment of a web-page
  Coordination of analytical techniques/methods, sample types and materials used by different, groups, turnover rates and their measurement. (reported on homepage ‚Methods' or 'Sites': http://www.wzw.tum.de/bk/schwrdt/schwerpt.htm).
  Group reports
- ❒ 2nd annual meeting, Leucorea, Wittenberg. October 2001
  Keynote speakers: M. Gerzabek, Wien, C. Chenu, INRA Versailles, A. Smucker, Michigan State University, P. Smith, University of Aberdeen
- ❒ 3rd annual meeting in Hannover, February 2003 reports of the working groups, poster presentations
  Integrating thematic sessions: conceptual model, establishment of a 'common value' for turnover estimates, inert C-pool

  Reports of the working groups and poster presentations were published on the SPP homepage http://www.wzw.tum.de/bk/schwrdt/schwerpt.htm).
- ❒ Start of the integration project, 03/2003
- ❒ SPP-workshop: modeling the C dynamics of agricultural soils. Halle/Saale, 08/2003 organized by Franko and Kuka (Halle)
- ❒ 4th annual meeting, Hannover, 02/2005

  Reports of the working groups and poster presentations were published on the SPP homepage http://www.wzw.tum.de/bk/schwrdt/schwerpt.htm).
- ❒ Presentation of the SPP in the DFG-magazine ‚forschung' 3-4/2005
  ‚Das Klima aus dem Untergrund'; I. Kögel-Knabner and M. v. Lützow
- ❒ Final colloquium of the SPP 1090 at Schloss Thurnau near Bayreuth, 03/2006

  Invited international experts: Jeff Baldock, Adelaide, Australia; Karl Ritz, Silsoe, UK; Jon Chorover, Tucson, USA; Jérôme Balesdent, Cadarache, France; Margaret Torn, Berkeley, USA

The main research achievements of the SPP and activities (2000-2006) were summarized and can be found on the homepage: http://www.wzw.tum.de/bk/schwrdt/schwerpt.htm

Publication of results and conference activities

Publication of results

The results from the priority programme 1090 are reported in more than 200 publications in international journals with peer review system (attachment 4). About 50 % of these papers are published in the major journals in soil science with impact factor >2 (ISI 2006, maximum impact factor for 'soil science' 2.6). Additionally, more than 20 publications are presently in the review process.

International conferences initiated by priority programme 1090

- SOM1

  International Conference October 2003, Hohenkammer, near Munich (organized by I. Kögel-Knabner) 'Mechanisms and Regulation of Organic Matter Stabilization in Soils'

  Invited speakers: E. Gregorich, Ottawa, Canada; S.T. Petsch, Massachusetts, USA; P.G. Hatcher, Ohio, USA; R.M. Rees, Aberdeen, UK; M. Olsson, Uppsala, Schweden.

  (150 participants)

  Special issue, Geoderma, Volume 128, 2005: ‚Mechanisms and regulation of organic matter stabilization in soils', selected publications of the international conference: Schloss Hohenkammer, near Munich, October 5-8, 2003. Guest-Editors: I. Kögel-Knabner, M. v. Lützow, G. Guggenberger, H. Flessa, B. Marschner, E. Matzner, K. Ekschmitt

  13 papers in total, 10 papers from priority programme members (list of contents see attachment 5)

- SOM2

  Conference on Mechanisms of Soil Organic Matter Stabilization, 10/2005, Monterey, CA, USA (Scientific committee: Phil Sollins, T. Filley, I. Kögel-Knabner)

  4 oral presentations, 13 posters from priority programme

- SOM3

  Third International SOM Conference, 10/2007, Adelaide, Australia (organized by Jan Skjemstad, Jeff Baldock and Evelyn Krull)

  4 oral presentations from priority programme

- SOM4

  to be held in southern France, 10/2010, (organized by soils group in Versailles-Grignon)

Participation in other national and international meetings

- Biannual meeting of the German Soil Science Society, Wien, 09/2001

  Poster session, 24 posters

- GEO2002, Würzburg Oktober 2002, symposium organized by B. Marschner and I. Kögel-Knabner

  21 contributions from priority programme (6 oral presentations, 15 posters)

- ❒ Biannual meeting of the German Soil Science Society, Frankfurt/Oder 09/2003

  20 contributions from priority programme, 2 poster prices (Commission I soil physics, commission VII mineralogy)

- ❒ EUROSOIL Conference, Freiburg 09/2004

  Oral Symposium “Soil organic matter”, convenors I. Kögel-Knabner, Germany, A. Piccolo, Italy

  13 contributions from priority programme (9 oral presentations, 4 posters)

- ❒ Biannual meeting of the German Soil Science Society in Marburg, 09/2005

  about 15 SPP contributions

- ❒ European Geosciences Union, Vienna, 2. - 7. April 2006

  Identification and characterization of the stable C pool(s) in soils (SSS24)
  Convenors: I. Kögel-Knabner, Germany and M. Gerzabek, Austria

- ❒ Symposium at the World Congress of the Soil Science Society, 06/2006, Philadelphia, USA

  Oral Symposium Commission 2.2 Soil Chemistry: Soil organic matter stabilization and C sequestration. Convenors: A. Piccolo, Italy, I. Kögel-Knabner, Germany, A. Smucker, USA

- ❒ ‘International Symposium on Organic Matter Dynamics in Agro-Ecosystems’ 07/2007, Poitiers, France.

  6 contributions from priority programme (4 oral presentations, 2 poster contributions)

- ❒ Biannual meeting of the German Soil Science Society in Dresden, 09/2007
  Symposium ‘Interactions of chemical, biological and physical processes for soil organic matter stabilization’; convenor: I. Kögel-Knabner

  16 oral presentations and 4 poster contributions

Qualifications

The qualifications obtained within the framework of the priority programme are summarized in attachment 6. A detailed list of the individual projects is also provided in attachment 6.

References

Kögel-Knabner, I., Guggenberger, G., Kleber, M., Kandeler, E., Kalbitz, K., Scheu, S., Eusterhues, K. and Leinweber, P., 2008. Organo-mineral associations in temperate soils: integrating biology, mineralogy and organic matter chemistry. Journal of Plant Nutrition and Soil Science, 171: in press.

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