Abstracts of the workshop

Regulation of Soil Organic Matter and Nutrient Turnover in Agriculture

held on the 12th and 13th of November 2009 in Witzenhausen, Germany

The workshop was partly granted by the Deutsche Forschungsgemeinschaft (GRK 1397)
Information about the Research Training Group 1397

The research Training Group 1397 “Regulation of Soil Organic Matter and Nutrient Turnover in Organic Agriculture”, funded by the Deutsche Forschungsgemeinschaft, is a joined interdisciplinary research project of the Universities of Kassel and of Göttingen. The aim is to prepare doctoral researchers for the complexities of the job market in science and simultaneously to encourage early scientific independence. This workshop has been organised by the graduate students. More information can be found at:

http://www.uni-kassel.de/fb11/dec/research-training-group-1397_en.html

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Faculty of Ecological Agricultural Sciences
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Graduate students: Husam Al-Asfoor, Anja Bergstermann, Stefanie Heinze, Felix Heitkamp, Sandra Herrmann, Anna Jacobs, Nadine Jäger, Daphne I. Jost, Nils Rottmann, Anja Sänger, Konrad Siegfried, Mohamed Al-Rawahi

The contributions are not peer-reviewed. The authors are responsible for the content of their contributions.

Please cite contributions as e.g.:
Background of the workshop

The regulation of the budget of soil organic matter (SOM) and nutrients by management is a central focus in agriculture, especially in organic agriculture. The budgets of SOM and nutrients determine soil fertility, i.e. the long-term productivity of soils. However, the underlying processes of soil fertility in organic agriculture are not well understood. During the workshop, the results of the first cohort of the Research Training Group 1397 and of other scientists on the possibilities to regulate SOM and nutrient budgets by soil management, crop rotation and by feeding strategies via manure quality are presented and discussed.

Keynote Speakers

Prof. Dr. Georg Guggenberger, Institute of Soil Science, Hannover, Germany
Dr. Nicolas Brüggemann, Institute for Meteorology and Climate Research, Garmisch-Partenkirchen, Germany
Dr. Egbert Lantinga, Biological Farming systems, Wageningen, the Netherlands

Invited Speakers

Univ.-Prof. DI Dr. Martin H. Gerzabek, Institute of Soil Research, Vienna, Austria
Prof. Dr. Friedhelm Taube, Institute of Crop Science and Plant Breeding, Kiel, Germany
Dr. Søren O. Petersen, Department of Agroecology and Environment, Tjele, Denmark
Dr. Jan Dijkstra, Institute of Animal Sciences, Wageningen, the Netherlands
# Time schedule for the workshop

**Regulation of soil organic matter and nutrient turnover in agriculture**

on the 12th and 13th of November 2009 in Witzenhausen, Germany

**Thursday, 12th of November 2008**

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<th>Time</th>
<th>Session</th>
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<td>From 9:00</td>
<td>Registration</td>
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<tr>
<td>12:30-12:50</td>
<td>Welcome by the speaker of the Research Training Group</td>
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<td></td>
<td>Prof. Dr. B. Ludwig</td>
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<tr>
<td>12:50-13:20</td>
<td>Keynote speaker session I</td>
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<tr>
<td></td>
<td>Prof. Dr. G. Guggenberger</td>
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<td></td>
<td>Factors of destabilisation of soil organic matter</td>
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<tr>
<td>13:20-13:50</td>
<td>Keynote speaker session II</td>
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<td></td>
<td>Dr. N. Brüggemann</td>
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<td></td>
<td>Exchange of climate relevant gases in agricultural ecosystems vulnerable to land use and climate change</td>
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<tr>
<td>13:50-14:20</td>
<td>Keynote speaker session III</td>
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<tr>
<td></td>
<td>Dr. E. Lantinga</td>
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<td>Cow diet composition and fertilizer value of excreta</td>
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<td>From 14:20</td>
<td>Postersession</td>
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<tr>
<td>15:30-15:50</td>
<td>Wachendorf, C; Heyn, N &amp; Jörgensen, R G:</td>
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<td></td>
<td>Landuse conversion effects on soil respiration and microbial biomass: from arable land to short rotation coppice</td>
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<tr>
<td>15:50-16:10</td>
<td>Demyan, S; Smirnova N; Rasche F; Müller T &amp; Cadisch G:</td>
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<td></td>
<td>Characterization of soil organic matter by mid-infrared spectroscopy/evolved gas analysis</td>
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<td>16:10-16:30</td>
<td>Herrmann, S; Mayer, J; Michel, K &amp; Ludwig, B</td>
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<td></td>
<td>Use of near and mid-infrared spectroscopy for quality parameter assessment of compost</td>
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<tr>
<td>16:30-16:50</td>
<td>Invited talk: Petersen, S O:</td>
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<td></td>
<td>Flow of nutrients and climate relevant gases in experimental rotations on three soil types</td>
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<tr>
<td>From 19:00</td>
<td>Dinner in the tropical greenhouse</td>
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Friday, 13th of November 2008

<table>
<thead>
<tr>
<th>Session</th>
<th>I Soil organic matter turnover</th>
<th>II Flow of nutrients and climate relevant gases</th>
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</thead>
<tbody>
<tr>
<td>9:00-9:20</td>
<td>Helfrich, M; Ludwig, B &amp; Flessa, H: Modelling of subsoil C dynamics using simple models</td>
<td>Sänger, A; Geisseler, D &amp; Ludwig, B: Effects of rainfall pattern on carbon and nitrogen dynamics in soil amended with biogas slurry and composted cattle manure</td>
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<td>9:20-9:40</td>
<td>Brock, C &amp; Leithold, G: Assessment of management impact on humus mass dynamics in agricultural soils with humus balances</td>
<td>Siegfried, K &amp; Bürkert, A: Estimating nutrient and carbon losses on an irrigated sandy soil in Northern Oman</td>
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<tr>
<td>9:40-10:00</td>
<td>Potthast, K; Hamer, U. &amp; Makeschin, F: Impact of litter quality on mineralization processes in managed and abandoned pasture soils in Southern Ecuador</td>
<td>El-Naggar, A; El-Araby, A; de Neergard, A &amp; Jensen, H H: Farm nutrient balances at different patterns of organic farms in Egypt</td>
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<tr>
<td>10:00-10:20</td>
<td>Break</td>
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<td>10:20-10:40</td>
<td>Jacobs, A; Helfrich, M; Dyckmans, J; Rauber, R &amp; Ludwig, B: Aggregate dynamics and carbon storage in different tillage simulations - a microcosm study</td>
<td>Richter, S &amp; Michalzik, B: Effects of increased temperature on carbon and nitrogen fluxes from the organic layer of a beech forest - a mesocosm study</td>
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<td>10:40-11:00</td>
<td>Heinze, S; Rauber, R &amp; Jörgensen, R G: Tillage systems and their impact on microbial C, N, P, and S storage in two long-term experiments on loess-derived Luvisols</td>
<td>Eickenscheidt, N; Brumme, R &amp; Veldkamp, E: Contribution of N deposition to N$_2$O emissions in a temperate beech and spruce forests</td>
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<tr>
<td>11:00-11:20</td>
<td>Wilhelm, B &amp; Hensel, O: Impact of straw quantities and tillage depth on emergence rate and yield of oil radish – results of a three year field experiment in organic agriculture</td>
<td>Wolf, K; Veldkamp, E &amp; Flessa, H: Influence of terrain heterogeneity on trace gases fluxes from tropical montane forest soils</td>
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<td>11:20-11:30</td>
<td>Break</td>
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<tr>
<td>11:30-11:50</td>
<td>Rottmann, N; Jörgensen, R G; Siegfried, K &amp; Bürkert, A: Decomposition of different kinds of litter and the effects of fertilizer and crop under subtropical conditions</td>
<td>Bergstermann, A; Rauber, R &amp; Flessa, H: Effects of conventional and reduced tillage on greenhouse gas fluxes</td>
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<tr>
<td>12:10-12:30</td>
<td>Heitkamp, F; Raupp, J; Jäger, N; Flessa, H &amp; Ludwig, B: Fertiliser type and rate affect partitioning of soil organic matter into pools of different stability</td>
<td>Weymann, D; Well, R; Flessa, H &amp; Meyer, K: Estimating indirect agricultural N$_2$O emission from aquifers using dissolved NO$_3^-$, N$_2$O and N$_2$</td>
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<tr>
<td>12:30-14:00</td>
<td>Lunch</td>
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<tr>
<td>14:00-14:20</td>
<td>Zeichensaal</td>
<td>Böttcher, J; Schäfer, K; Weymann, D; von der Heide, C &amp; Duijnisveld, W H M: Emission of greenhouse gases: Evaluation of measurements at scales from &lt; 1 m$^2$ to 500 m$^2$</td>
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<td>14:20-14:40</td>
<td>Invited talk: Taube, F: Nitrogen fluxes in intensively managed grasslands</td>
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<tr>
<td>14:40-15:00</td>
<td>Invited talk: Gerzabek, M H; Tatzber, M; Lair, G; Rampazzo-Todorovic, G &amp; Zehetner, F: Soil organic matter dynamics in the Danube floodplain: results from a chronosequence study and a $^{14}$C labelling long-term field experiment in Lower Austria</td>
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Contributions to the workshop without published abstracts

- Thursday, 12th of November, 12:50 – 13:20

**Factors of destabilisation of soil organic matter**  
Georg Guggenberger  
Institute of Soil Science, University of Hannover, Germany

- Thursday, 12th of November, 13:50 – 14:20

**Cow diet composition and fertilizer value of excreta**  
Egbert Lantinga  
Biological Farming systems, Wageningen, the Netherlands

- Thursday, 12th of November, Session I: 15:50-16:10

**Characterization of soil organic matter by mid-infrared spectroscopy/evolved gas analysis**  
Demyan, Scott¹, Natalya Smirnova², Frank Rasche¹, Torsten Müller², Georg Cadisch¹  
¹University of Hohenheim, Institute for Plant Production and Agroecology in the Tropics and Subtropics, Garbenstr. 13, 70599 Stuttgart, Germany  
²Institute for Plant Nutrition, Garbenstr. 13, 70599 Stuttgart, Germany

- Thursday, 12th of November, Session II: 15:50-16:10

**The new view on soybean – Effects of cropping systems on C and N rhizodeposition and N balance**  
Jochen Mayer*, Andreas Hammelehle, Paul Mäder, Michael Schloter, Ana Dubois, Astrid Oberson  
*Agroscope Reckenholz-Tänikon Research Station ART, Zürich, Switzerland

- Thursday, 12th of November, Session III: 15:50-16:10

**Using buffalo manure in organic farming: Does diet composition affect dung quality?**  
Husam Al-Asfoor¹, Eva Schlecht¹ and Albert Sundrum²  
¹Department of Animal Husbandry in the Tropics and Subtropics, University of Kassel, Steinstrasse 19, 37213 Witzenhausen, Germany  
²Department of Animal Nutrition and Animal Health, University of Kassel, Nordbahnhofstrasse 1a, 37213 Witzenhausen, Germany

- Friday, 13th of November, Joint session: 14:20-15:00

**Nitrogen fluxes in intensively managed grasslands**  
Friedhelm Taube  
Institute of Crop Science and Plant Breeding, University of Kiel, Hermann-Rodewald-Str. 9, 24118 Kiel, Germany
Exchange of climate relevant gases in agricultural ecosystems vulnerable to land use and climate change

Nicolas Brüggemann

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Ecosystems vulnerable to land use and climate change, such as savannas and steppes, are predominantly located in regions of the Earth characterized by plant growth-limiting amounts of precipitation and nutrients. However, especially in these regions there is an increasing demand for food, fiber and energy production which even increases the pressure on these ecosystems in terms of land use intensification or land use change. In the future, innovative land management concepts have to be developed for these regions in order to secure productivity of agricultural ecosystems, to relief pressure from natural ecosystems and to minimize negative environmental impacts, such as nutrient losses and increased greenhouse gas emissions.

Here I show data from Burkina Faso and Inner Mongolia on biosphere-atmosphere exchange of C and N trace gases and soil C and N transformations, focusing on the role of land use/land management in nutrient fluxes and trace gas exchange. In Inner Mongolia, nutrient—especially nitrogen—dislocation with sheep feces from the grasslands to sheepfolds is one of the major impacts of the dominant land use, i.e. grazing, in this ecosystem, leading to hotspots of C and N trace gas emission (CH$_4$, NH$_3$, NO, N$_2$O) and nitrate leaching. On the other hand, increasing grazing intensity leads to a decrease in freeze–thaw-related N$_2$O fluxes from the grassland, which can make up the majority of the annual N$_2$O emission budget in this steppe ecosystem. In Burkina Faso, the highest N$_2$O and CH$_4$ fluxes were observed for natural savanna in the rainy season, whereas agricultural land converted from natural savanna showed lower N$_2$O fluxes and even CH$_4$ uptake on average. Termite mounds played a substantial role in N$_2$O and CH$_4$ fluxes in the natural savanna, but did not so in the crop fields due to permanent removal of the termite mounds by the farmers.
Landuse conversion effects on soil respiration and microbial biomass: from arable land to short rotation coppice

Christine Wachendorf*, Nicole Heyn and Rainer Georg Joergensen

University of Kassel, Department of Soil Biology and Plant Nutrition, Nordbahnhofstr. 1a, 37213 Witzenhausen, Germany

With the increase of bioenergy crops, questions arise about the turnover and sequestration of soil organic matter under this landuse with a high export of plant biomass. Factors influencing the SOM turnover in fast growing tree plantations are the omission of soil tillage and fertilization, changing input of aboveground and belowground litter as well as changes in soil water and temperature.

Aim of the investigation was to follow initial changes of different pools of soil organic matter after establishment of short rotation coppice. Therefore soil under willow, poplar and arable land were sampled from the same site, located near Witzenhausen, Germany. The arable soil was cultivated in 2008 and 2009 with barley. Cuttings of poplar (clon Max1) and willow (clon Tordis) were planted in April 2008. First soil sampling was done in October 2008 when poplars and willows already reached a height of 2 to 3 m. Soil was sampled at two depths, 0-5 and 5-10 cm. Soil respiration in the field was measured from October 2009 till August 2009 monthly, with exception of the winter period between November and March when the soil was too wet or frozen.

Soil microbial biomass C and N, were significantly higher under short rotation coppice than arable land. Soil and basal respiration as well as metabolic quotient were significantly influenced by soil depths. There was a significant interaction of microbial biomass C between plants and depths. In the upper soil layer microbial biomass C was lower under barley than in the lower layer, whereas it decreased with depths under short rotation coppice. The metabolic quotient was always higher at the first depth, but it decreased stronger with depths under barley than short rotation coppice. Soil respiration was lower under barley before harvest, which was probably mainly due to a much higher root biomass under short rotation coppice.

Results showed that shortly after establishment of poplar and willow soil microbial biomass increased. Furthermore differences in respiration rates between the upper and lower soil layer showed, that even in the ploughed soil layer under barley, depths dependent differences occur.

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Use of near and mid-infrared spectroscopy for quality parameter assessment of compost

Sandra Herrmann¹*, Jochen Mayer², Kerstin Michel¹ and Bernard Ludwig¹

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²Agroscope Reckenholz-Tänikon Research Station ART, Reckenholzstr. 191, 8046 Zurich, Switzerland

Screening tests are basic procedures commonly used to assess compost quality. Important parameters for quality assessment are the germination capacity and the suppression of plant pathogens which have to be measured by time-consuming laboratory methods. The objective was to test whether visible (Vis) and near-infrared spectroscopy (NIRS) or middle infrared (MIR) spectroscopy is more useful to analyze parameters important for compost quality. Ninety-seven compost samples from Switzerland were analyzed by conventional methods, by Vis-NIRS and by MIRS. The contents of total C (C₉₀), total N (N₉₀), NO₃-N, NH₄-N, NO₃-N/NH₄-N ratio, mineralizable N after 56 days (N₉₅₆), total P (P₉₀), K, Ca and salt, the C/N ratio, pH and microbiological characteristics (hydrolysis of fluorescein diacetate (FDA-hydrolysis), as indicator of total enzyme activity, acetate and cellulase activity) were determined. Furthermore, plant tolerance and the suppression of pathogens were tested using germination tests with salad, cress, ryegrass and bean or a Rhizoctonia solani and a Pythium ultimum bioassay. The samples were scanned in the range of 400-2500 nm (visible light and NIRS) using a Foss NIRSystems spectrometer 6500 and in the range of 2500 – 10000 nm (MIRS, Tensor 27, Bruker, Germany). Mathematical treatments were carried out using Win ISI v 1.63 and Opus Quant 2 to interpret the NIRS and MIRS measurements, respectively. The whole spectrum was used to develop cross-validation equations for all constituents. The prediction accuracy was evaluated for both techniques as excellent for C₉₀ based on the modelling efficiency (EF-values ≥ 0.9) and the coefficients of determination (r² ≥0.9). In contrast the Ca was only evaluated excellent by MIRS method. Approximate quantitative predictions using NIR spectroscopy were possible for the contents of K, Ca and salt, pH, cellulase, both cress variants and salad, and for the contents of P₉₀, K, C/N ratio, NO₃-N/NH₄-N ratio acetate and salad using MIR spectroscopy. Unsuccessful predictions as indicated by EF-values lower than 0.6 and r² values below 0.7 were obtained for NO₃-N, NH₄-N, Cmic, N₉₅₆, FDA-hydrolysis, ryegrass, bean and the suppression tests. Overall the results of the present study indicate that Vis-NIRS and MIRS have the potential to be used for quality assessment of composts and to replace time-consuming methods such as germination tests using salad and cress in the case of NIRS and the nitrate-N, ammonium-N and acetate using the MIRS technique.
Hidden fluxes of organic matter - the importance of canopy-derived particulate organic matter (POM) in forest ecosystems

Beate Michalzik* and Anne le Mellec

1 Friedrich-Schiller University Jena, Institute of Geography, Unit of Soil Science, Germany
2 Biodiversity and Climate Research Centre (BiK-F), Frankfurt/Main, Germany

The canopy is the second largest source for organic matter in forests. In contrast to dissolved organic matter (DOM), throughfall fluxes of particulate OM (0.45µm < POM < 500 µm) have not been taken into account for routine sampling and element budgeting. To date, it is largely unknown to what extent the input of POM may affect soil processes or be altered by climate change and corresponding biotic feedback processes such as pronounced herbivore insect pests. Over the course of 2.5 years we followed the concentrations and fluxes of DOM and POM along different ecosystem compartments at the Level-II-monitoring B1 and F1 (mature beech and spruce) sites in the Solling area, Germany. In fortnightly intervals, we took solution samples from bulk and throughfall precipitation, from forest floor layers and from the Ah and Bv horizon.

In addition to annual throughfall fluxes of DOC amounting to 99 kg C ha\(^{-1}\) at the spruce and 34 kg C ha\(^{-1}\) at the beech site, 15% (+16 kg C ha\(^{-1}\) a\(^{-1}\), spruce) and 40% (+14 kg C ha\(^{-1}\) a\(^{-1}\), beech) more organic carbon was transported as POC from the canopy to the ground. For particulate bound nitrogen (PON) corresponding values were 11% (+3 kg N ha\(^{-1}\), spruce) and 23% (3.5 kg N ha\(^{-1}\), beech). In the forest floor layers at both sites the additional contribution of POC was 13 to 18% and the one of PON 6 to 15%, with decreasing proportions of < 5% in the mineral soil horizons.

Including particular organic matter fluxes in element budgeting approaches might contribute to fill budgeting gabs in terrestrial C and N cycling.
Differences in soil quality between organic and conventional cropping systems at Foulum, Denmark

Ngonidzashe Chirinda¹,²*, Jørgen E. Olesen¹, John R. Porter², Per Schjønning¹ and Søren O. Petersen¹

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²Faculty of Life Sciences, University of Copenhagen, Hoejbjækegaard Alle 9, 2630 Taastrup, Denmark

Management strategies can affect both soil properties and crop productivity of agroecosystems. Previous studies on field soils managed for either organic or conventional farming have shown differences in soil quality indicators such as soil organic carbon, microbial biomass and total mineralizable nitrogen, albeit results have been inconsistent. Maintaining soil fertility remains a challenge for organic crop producers. Our objective was to assess the variability in selected properties of a sandy loam soil under organic and conventional management regimes, which differed in the type of fertilizer applied. In addition, we considered catch crop induced changes in organically managed systems. First, we hypothesized that organic cropping systems fertilized with animal manure will stimulate soil quality attributes compared with conventional systems amended with inorganic fertilizers. Our second hypothesis was that inclusion of catch crops in organic systems will improve nutrient retention and crop productivity. In September 2007, April 2008 and September 2008 soils from a long-term experiment in Denmark, initiated in 1996, were sampled from plots of a loamy soil (~10% clay) that had either winter wheat or spring barley during the 2007/2008 growing season. The soils were characterized for multiple attributes: total organic carbon, total nitrogen, microbial biomass nitrogen, total mineralizable nitrogen and levels of potential ammonium oxidation and denitrifying enzyme activity. In April 2008, prior to fertilization, soil cores were collected at two depths (0–5 cm and 5–10 cm) in plots under winter wheat. Water retention characteristics of each soil core were determined and used for modeling soil gas diffusivity. Grain yields were measured at harvest maturity. The differences in management strategy caused variations in carbon inputs. However, soil organic carbon levels were similar across systems. At field capacity, the model-predicted gas diffusivity at 0–5 cm depth was 1.7 times higher in the organic than the conventional system (P=0.01). There was evidence of consistently higher soil microbial activity in organic compared to conventional treatments, although the differences were not always statistically significant. For soils under spring barley, the recent catch crop led to high microbial activity in April 2008. Despite some inconsistencies, under organic management regimes the inclusion of catch crops increased total mineralizable nitrogen and potential ammonium oxidation. Higher gas diffusivity in organically managed systems probably contributed to increase soil aeration and, consequently, aerobic microbial activity compared to conventional systems. Winter wheat grain yields were at least 51% higher in the conventional compared with the organic cropping systems. With spring barley grain yields in organic systems increased to levels similar to that observed in the conventional system through the inclusion of catch crops.
Impact of nutritional strategies on the composition of cattle manure

Jan Dijkstra

Animal Nutrition Group, Wageningen University, PO Box 338, 6700 AH Wageningen, Netherlands

In many agricultural systems, manure slurry, consisting of a mixture of faeces and urine, is used as fertilizer. Changes in nutrition management of cattle affect the composition of manure. For example, a reduction of the dietary protein content usually results in a more than proportional reduction of the urinary N excretion. This may affect volatilization losses as well as the fertilizing value of slurry. Net mineralization of N in the soil generally decreases with increasing C:N ratio of the slurry. Diet digestibility is among the most important factors that determine the C:N ratio of slurry. Since diet composition affects nutrient flow into the hindgut of cattle, diet composition is likely to affect the hindgut and faecal microbial community as well. For a full, integrated evaluation of the effects of nutritional strategies on nutrient utilization and losses at the farm level, reliable estimates of excreta production and composition are essential. In this contribution, the effects of diet composition on manure composition (amount and type of N and OM) will be evaluated.

The present contribution is largely based on an experiment in which diets with 2 levels of crude protein (CP; c. 110 and 190 g/kg DM) and 2 levels of net energy (NE; c. 5.4 and 6.7 MJ/kg DM) were fed to cattle in a tie-stall. Faeces were quantitatively sampled and chemical composition of faeces and slurry determined. With an increase in CP and NE content, the faecal C:N and C:N$_{org}$ ratios decreased significantly. Faecal bacterial biomass concentration was highest in high NE, high CP diets. Bacterial diversity in faeces was similar for all faeces, but different protein levels induced changes in bacterial community structure. In the slurry, the C:N ratio (range 5.1 – 11.4) decreased upon an increase in dietary CP content or NE content. In a field experiment to evaluate utilization of N from the slurries applied to grassland on a sandy soil, there was a negative relationship between the C:N ratio of the slurries and the first-year N availability. Thus diet composition has a major impact on manure composition and consequently nutrient losses. A mechanistic model of rumen fermentation and intestinal digestion was used to predict OM, C and N output in various faecal and urinary components as a function of intake and diet composition, in order to obtain improved quantitative understanding. Feeding grass silage obtained with low N fertilization levels or mature grass silage increased manure C:N ratio compared with silage from high fertilised grass or from young, leafy grass. Replacing grass silage with maize silage also increased manure C:N ratio. Since the model accounts for major interactions between different types of nutrients and the interaction with microbial activity, its use significantly improves prediction of digestion (hence excretion of nutrients in manure) compared with current static feed evaluation systems. This knowledge contributes to development of nutritional strategies that reduce N losses during manure storage, and improve utilization of N from manure N applied to soil.

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Establishing methods for the determination of microbial biomass in cattle dung

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²Department of Animal Nutrition and Animal Health  
³Department of Animal Husbandry in the Tropics and Subtropics  
University of Kassel, Nordbahnhofstraße 1a, 37213 Witzenhausen, Germany

In organic agriculture the preservation and improvement of soil fertility is a fundamental aim. Biological soil activity due to microorganisms is known to control soil organic matter content and is therefore an indicator for soil quality. In this regard, the availability of nutrients for microbial and plant growth plays a crucial role.

Within an interdisciplinary research program comprising soil biology, environmental chemistry and animal nutrition this project focuses on microorganisms in cattle dung. The purpose is to examine the impact of feeding on manure quality. Concerning the impact of ruminant feeding on the carbon to nitrogen ratio and the microbial activity in dung, so far, no extensive studies exist.

In order to determine microbial biomass in cattle dung, different methods are being tested, compared and modified. On the one hand, the generally established CFE method (Brookes et al. 1985) to quantify microbial carbon and nitrogen is being used. On the other hand, ATP as an indicator for living cells is detected with luminescence. Concerning this matter, two extracting methods with different extracting agents (DMSO, TCA) are compared.

This study emphasizes on interactions between different utilisation options related to cattle feeding with a strong focus on the improvement of soil fertility. Furthermore, basics for the development of optimisation strategies are to be designed with regard to an efficient use of resources and a reduction of animal caused environmental impacts.

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Flow of nutrients and climate relevant gases in experimental rotations on three soil types

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Within organic farming there is a continued effort to close nutrient cycles in order to improve nutrient use efficiency for crop production while also minimizing environmental impacts. In Denmark a long-term crop rotation experiment on three soil types, i.e., Jyndevad (4.5% clay, 2.0% C), Foulum (8.8% clay, 3.8% C) and Flakkebjerg (15.5% clay, 1.7% C), provides a platform for studies of agronomic and environmental aspects of organic farming. Selected results from investigations at these sites are presented.

In 2007 and 2008 one study determined soil microbial biomass N and mineralizable N on all three locations during the growing season in four selected rotations, three organic and one conventional; the rotations differed in manure strategy (livestock slurry, grass-clover green manure, or mineral N) and use of catch crops. The objective was to evaluate the potential importance of labile soil N for crop N supply and environmental losses. Consistent effects of crop rotation were observed across the three sites, but soils differed in the ability to store N (and C) in these labile pools.

The greenhouse gas balance of organic farming systems has become an important indicator of sustainability. Nitrous oxide emissions were monitored in winter wheat of the four rotations between October 2007 and September 2008 at Foulum and Flakkebjerg. A second monitoring program of N₂O emissions was conducted between March 2008 and May 2009 in a selected rotation; here grass-clover co-digestion is considered as a strategy to improve N use efficiency and reduce N₂O emissions. Both studies indicate that N inputs rather than cropping system or soil management control the extent of N₂O emissions. Our limited ability to control N₂O emissions may be due to the fact that N₂O emissions result from complex interactions between C/N transformations and soil properties.

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Modelling of subsoil C dynamics using simple models

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Soil C dynamics below the plough layer have been little studied, despite a suspected large C stabilization potential of subsurface horizons. The objective of this study was to test two simple models (model A: single compartment for C\textsubscript{3}- and for C\textsubscript{4}-derived C; model B: division of C\textsubscript{3}- and C\textsubscript{4}-derived C into active and passive compartments) in their ability to simulate the C dynamics in subsoil horizons of a Haplic Phaeozem after conversion from C\textsubscript{3}- (rye) to C\textsubscript{4}-cropping (maize). The models were calibrated on an unfertilized maize soil and then validated on a maize soil with NPK-fertilization. Both models simulated well C\textsubscript{3}- and C\textsubscript{4}-C dynamics in the investigated soil depths (20–40 cm and 40–60 cm). In all cases, the model efficiency was $> 0$, which indicated that the simulated values described the trend in the measured data better than the mean of the observations. The decomposition rate constants were comparable to those of other agricultural sites in the temperate zone. However, model B yielded a very low decomposition rate constant for passive C\textsubscript{4}-C in 40–60 cm – possibly due to the low amount of data (5 sampling dates in 39 years) and high measurement uncertainties due to a rather low incorporation of C\textsubscript{4}-derived C in this soil depth during the investigated time span. More sophisticated models require detailed data on SOC pools and turnover rates in subsoils which are generally not yet available for most experimental plots.

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Assessment of management impact on humus mass dynamics in agricultural soils with humus balances

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Humus balances are intended to serve as tools for the assessment of humus reproduction in agricultural systems, that means of management impact on humus stocks in soils. It has to be noted that they refer to management impact only and are not intended to allow for the analysis of humus mass dynamics, the latter being the result of the combined impact of both management, environmental site conditions, and land-use history. For example, one defined agricultural system with a defined humus balance saldo will have a different impact on humus dynamics if established on a former pasture or a site with a history of intense arable crop production. In the example, humus reproduction in the established farming system is the same with both starting conditions, but humus dynamics are not.

However, humus reproduction is affected by site x management interactions. Thus, site conditions may not be neglected in humus balance algorithms. The intended talk will address the issue, to what extend interactions between management and environmental site conditions need to be considered in humus balance algorithms and how this may be realizied. In this context, the approach used in the Model-based Humus Balance HUMOD (Brock et al. 2008) will be presented and critically discussed.

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Impact of litter quality on mineralization processes in managed and abandoned pasture soils in Southern Ecuador

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Southern Ecuador currently undergoes deforestation at one of the highest rates in South America. Over the past several decades, vast areas of forest have been converted into cattle pastures by slash and burn practice. Frequently these pasture sites are invaded by bracken fern, when bracken becomes dominant pasture productivity decreases and the sites are abandoned. The land use change from productive pastures towards abandoned pasture sites is accompanied by altered litter inputs to soil. To investigate the impact of invasive bracken on mineralization processes, soil samples (0-5 cm) were taken from an active pasture with Setaria sphacelata as predominant grass and from an abandoned pasture overgrown by bracken. Grass (C_4 plant) and bracken (C_3 plant) litter, differing in C:N ratio (33 and 77, respectively) and lignin content (Klason-lignin: 18% and 45%, respectively), were incubated in soils of their corresponding sites for 28 days at 22°C. Unamended microcosms containing only the respective soil or litter were taken as controls. During incubation the amount of CO_2 and its $\delta^{13}$C-signature were determined at different time intervals. Thus, the C-source (litter versus soil organic matter) mineralized preferentially by the microorganisms was identified. Additionally, the soil microbial community structure (PLFA-analysis) as well as the concentrations of KCl-extractable C and N were monitored.

In soils amended with grass litter the mineralization of soil organic matter was retarded (negative priming effect) and also a preferential utilization of easily available organic substances derived from the grass litter was evident. Compared to the other treatments, the pasture soil amended with grass litter showed an opposite shift in the microbial community structure towards a lower relative abundance of fungi. After addition of bracken litter to the abandoned pasture soil a positive priming effect seemed to be supported by an N limitation at the end of incubation. This was accompanied by an increase in the ratio of Gram-positive to Gram-negative bacterial PLFA marker. The differences in litter quality between grass and bracken are important triggers of changes in soil biogeochemical and soil microbial properties after land use conversion.
Effects of rainfall pattern on carbon and nitrogen dynamics in soil amended with biogas slurry and composted cattle manure

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Soil moisture affects the degradation of organic fertilizers in soils considerably, but little is known about the importance of the rainfall pattern on the turnover of carbon (C) and nitrogen (N). Thus the aim of our study was to determine the effects of different rainfall patterns on C and N dynamics in soil amended with biogas slurry (BS) or composted cattle manure (CM). Undisturbed soil cores without (control) or with BS or CM, which were incorporated at a rate of 100 kg N ha$^{-1}$, were incubated for 140 days at 13.5 °C. Irrigation treatments were (i) continuous irrigation (3 mm day$^{-1}$), (ii) partial drying and stronger irrigation (no irrigation for 3 weeks, one week with 13.5 mm day$^{-1}$), and (iii) periodic heavy rainfall (24 mm day$^{-1}$ every 3 weeks for 1 day and 2 mm day$^{-1}$ for the other days). The average irrigation was 3 mm day$^{-1}$ in each treatment. Cumulative emissions of carbon dioxide (CO$_2$) and nitrous oxide (N$_2$O) from soils amended with BS were 92.8 g CO$_2$-C m$^{-2}$ and 162.4 mg N$_2$O-N m$^{-2}$, respectively, whereas emissions from soils amended with CM were 87.8 g CO$_2$-C m$^{-2}$ and only 38.9 mg N$_2$O-N m$^{-2}$. While both organic fertilizers significantly increased CO$_2$ production compared to the control, N$_2$O emissions were only significantly increased in the BS-amended soil. The rainfall pattern affected the temporal production of CO$_2$ and N$_2$O, but not the cumulative emissions. Cumulative nitrate (NO$_3^-$) leaching was highest in the BS-amended soils (9.2 g NO$_3^-$-N m$^{-2}$) followed by the CM-amended soil (6.1 g NO$_3^-$-N m$^{-2}$) and lowest in the control (4.7 g NO$_3^-$-N m$^{-2}$). Nitrate leaching was also independent of the rainfall pattern. Our study shows that rainfall pattern does not affect CO$_2$ and N$_2$O emissions and NO$_3^-$ leaching markedly providing that the soil does not completely dry out.

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Estimating nutrient and carbon losses on an irrigated sandy soil in Northern Oman

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Little is known about gaseous and leaching losses of carbon (C) and nitrogen (N) in irrigated agriculture of the hyperarid Arabian Peninsula. Therefore, gaseous emissions of \(\text{NH}_3\), \(\text{N}_2\text{O}\), \(\text{CO}_2\) and \(\text{CH}_4\) were measured on an experimental field near Sohar (Oman) with an INNOVA photo-acoustic infrared multi-gas monitor connected to a custom made cuvette (closed chamber system). Conducted on an irrigated sandy soil with four replications the experiment comprised two manure types (characterised by a C/N ratio of 24 with high fibre content and a C/N ratio of 15 with low fibre content) and a control treatment with equivalent levels of mineral nitrogen (N), phosphorus (P) and potassium (K). These three fertility treatments were factorially combined with a crop rotation at two levels comprising cauliflower (\textit{Brassica oleracea}) and carrot (\textit{Daucus carota} subsp. \textit{sativus}) each preceded by a crop of radish (\textit{Raphanus sativus}). Experimental leaching losses were calculated using the solute concentrations of N, P and K in leachate samples and the cumulative amount of leached solutes determined by ion exchange resin cartridges. Seepage was estimated with the software Hydrus 1d using estimates of crop-specific evapotranspiration.

Gaseous N emissions averaged 21 kg N ha\(^{-1}\) (60% NH\(_3\)-N, 40% N\(_2\)O-N) for a cropping period of 120 days, with little variations between treatments. During the same period C emissions were 5 t C ha\(^{-1}\) (99% CO\(_2\)-C, 1% CH\(_4\)-C) on plots treated with organic manures. Plots treated with mineral fertiliser had a mean emission rate of 3 tons C ha\(^{-1}\). Repeated measurement analysis of the gas emission data revealed significant effects of crop rotation and manure treatment for NH\(_3\)-N and CH\(_4\)-C. Crop rotation had a significant effect on emissions of CO\(_2\)-C and N\(_2\)O-N. Cumulative leaching averaged 5 kg N ha\(^{-1}\) for plots treated with organic manure of low C/N, 28 kg N ha\(^{-1}\) for plots treated with organic manure of high C/N and 15 kg N ha\(^{-1}\) for the control treatment.
The agricultural area managed by organic farming systems in Egypt is rapidly increasing. However, few studies evaluated the effect of different soil fertility management strategies on soil fertility and farm nutrient balances. Since Egyptian agricultural soils lies in the arid to semi-arid region and in general characterized by low organic matter content. It is hypothesized that the incorporation of animal manure and compost is a determining factor for balancing the nutrient export. In this study nutrient budgets were determined in four farms including twelve different crops. The organically managed farms were different in soil types, farm size and organic fertilization strategy. Frequently collected soil samples were analyzed for total and soluble N-P-K. Inputs represented by the applied organic fertilizers and outputs (Nutrient removal by crop) were also analyzed for total N-P-K content. The preliminary results show that in addition to soil fertility management procedures the soil type and the grown crops play a major role in farm nutrient balance.
Aggregate dynamics and carbon storage in different tillage simulations – a microcosm study

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The use of minimum tillage (MT) systems is broadly discussed due to its ability to increase the occurrence of stable macroaggregates and of organic matter (OM) in arable soils. However, the underlying processes are described contradictorily. We simulated conventional tillage (CT) and MT systems by incubation of soil <250 µm from long-term CT and MT fields with maize straw (13C natural abundance, 15N enriched) for 28 days at 15°C. The depth of residue incorporation was varied analogous to field conditions: For CT simulations, residues were incorporated among the entire profile of the microcosm (15 cm). For MT simulations, the same amount of maize straw was incorporated into the top third of the profile. For both tillage simulations, the dynamics of macroaggregate formation, the storage of maize-derived C and N within new-built macroaggregates, the CO2-evolution, and the contribution of maize-C to CO2 were investigated. The formation of macroaggregates in the top third of the microcosms occurred immediately after the start of incubation and varied widely between tillage simulations: After 8 days of incubation, 40% and 10% of the soil were recovered as macroaggregates in MT and in CT simulations, respectively. Simultaneously, the contribution of macroaggregate-C to the total C was highest in MT simulations. After 28 days of incubation, the relative proportion of added maize-C stored within macroaggregates in the top third of the microcosm did not differ between both tillage simulations (CT: 17%; MT: 18%). C-mineralization showed slight differences between tillage simulations: Cumulative CO2-evolution was higher from MT simulations while the relative proportion of maize-C mineralized did not differ (CT: 47%; MT: 45%). Overall, our results showed that long-term application of MT and the depth of residue incorporation has no effects on the potential mineralization of recently added residues. Further, the formation of macroaggregates is strongly affected by the amount of OM incorporated by tillage.
Tillage systems and their impact on soil microbial biomass C, N, P, and S storage in two long-term experiments on loess-derived Luvisols

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The impact of two different long-term tillage management systems (moldboard plough and rotary harrow) on microbial biomass indices was analyzed on two Haplic Luvisols (Garte Süd and Hohes Feld) near Göttingen, Lower Saxony. The present study was conducted to investigate the responds of soil organic C, microbial biomass (C, N, P, and S), activity (basal CO₂ production), and fungal colonization (ergosterol) on mouldboard plowing and rotary harrow tillage practice which threaded the soil till 25 cm and 8 cm depth, respectively. Rotary harrow management led to increased stocks (5%) of soil organic carbon and had no impact on the stocks of total N, P, S, and the extractable P and S. The microbial biomass C stocks were increased (14%) by rotary harrow treatment which was mainly caused by the accumulation of organic material in the upper soil layer. The higher microbial biomass in the soil surface compensated the strong decrease with depth and increasing distance to the organic matter accumulation. Microbial biomass N and P followed microbial biomass C with 19%, and 28% higher stocks, respectively due to rotary harrow management. The microbial biomass C/N ratio with a mean of 6.2 and the C/P ratios with a mean of 26, the microbial biomass S and the basalrespiration did not differ between the tillage treatments. The qCO₂ was indicated by a strong increase with depth which was more pronounced with rotary harrow management and led to 17% higher mean ratios referenced to the first 30 cm soil volume. Ergosterol showed significant higher stocks in the soil managed by plough. The increased presence of saprotrophic fungi with mouldboard plough was indicated by significant higher ratios of ergosterol to microbial biomass C and a lower microbial biomass C/S ratio. Our results showed that rotary harrow tillage promoted the storage of soil organic C and microbial biomass indices and reduced fungal colonization in comparison to mouldboard plough management.

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Impact of straw quantities and tillage depth on emergence rate and yield of oil radish – results of a three year field experiment in organic agriculture

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Since the beginning of organic agriculture the deep tillage with the plough has been under discussion. Organic farmers tried to avoid the plough as often as possible and even new machines have been constructed by some sophisticated farmers. Nevertheless the plough is still the main tillage equipment in organic agriculture. Less yields, compacted soils and, first of all, the weed control are the main reasons why conservation tillage is so far not recommended in organic agriculture. However organic farmers are looking for the opportunity to integrate conservation tillage in their system. The tillage before intercrops after harvest of cereals might be an easy and uncomplicated start for interested farmers, with a less risk potential for them.

The field trial was integrated in the crop rotation of the farm “Staatsdomäne Frankenhausen”. The farm is managed and certified since 1998 according to organic standards. It is a two factorial field experiment in a randomized split block with four replicates. For each plot six measuring points have been geo-referenced using a GPS unit (Leica GPS system 500), to recover the points for the measurements after the tillage and the sowing. All measurements, concerning residue cover, emergence rate and yield have been taken place at the measuring points.

The results show the negative effects of thick mulch layers on the emergence rate of the followed crop. But at the same time it is evident, that the modern machinery for conservation tillage has improved the incorporation of crop residues. In case of straw quantities up to 6 t/ha, a shallow tillage (7cm) is enough to guarantee a satisfactory emergence rate of the oil radish and without any significant differences in the dry matter of the oil radish shoots.
Effects of increased temperature on carbon and nitrogen fluxes from the organic layer of a beech forest – a mesocosm study

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Climate warming due to an human-induced increase of greenhouse gases is projected to enhance the Earth’s surface temperature by 1.8 to 5.8°C over the 100 yr (IPCC 2007). In terrestrial ecosystems, change in the surface temperature will likely affect ecosystem driving variables such as soil moisture and soil temperature which in turn govern a variety of ecosystem processes e.g. nutrient cycling. Consequently, to understand how future climate warming might affect terrestrial ecosystem functions soil warming experiments are required.

In a mesocosm study under semi-natural field conditions (conducted on the roof top of the Geographical Institute in Göttingen) undisturbed soil cores (beech organic layer + Ah-horizon) were subjected to different temperature conditions. Using thin heating mats the inner mesocosm air temperature was elevated by about 3°C compared to the reference air temperature outside (n= 5 replicates). A control treatment (n=5) without any warming was established as well. All soil cores were irrigated two to three times per week with collected bulk precipitation applying intensities derived from average rainfall amounts from 2002 to 2007. Weekly soil solution was analyzed for DOC, dN, nitrate, electric conductivity and pH, while CO₂, N₂O and CH₄ was determined in the gaseous phase two to three times per week. A 41-day pre-experimental phase without warming was carried out to establish comparable experimental conditions among the soil cores.

Over the course of 102 days during the experimental warming period the 3°C increase of the air temperature caused an increment in soil temperature by 0.8°C in average, but this result was not statistically significant. Also in the gaseous phase there were no statistically significant differences between the warmed and control treatment, although the nitrous oxide emissions were reduced in the heated mesocosms 12.1%. The nitrate output with soil solution of the heated treatment increased by 13.9% compared to the control, though exhibiting no statistical significance. Only the solution pH was significantly diminished by experimental warming (p=0.026). This might point to a higher mineralization rate due to warming and might also explain the accompanied higher nitrate losses.

In summary, elevated air temperature by about 3°C exhibited no statistically significant effects on soil temperature and for most of the analyzed parameters except for the pH-value.

In this context, further questions need to be addressed tackling i) the determination of threshold temperatures in the range of the projected air temperature increase by 1.8 to 5.8°C at which significant effects on the C and N cycling occur. ii) The conduction of further field and long-term studies to test for soil moisture effects combined with elevated temperatures on nitrification, denitrification and degradation rates and iii) the investigation of the effects of water deficiency in summer time particularly with regard to denitrification processes and nitrous oxide emissions.
Contribution of N deposition to N₂O emissions in a temperate beech and spruce forests

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Anthropogenic N deposition may change the N status of forest soils from N limited to N saturated leading to an increase in available soil N. Thus, forest ecosystems may significantly contribute to nitrous oxide (N₂O) emissions that can cause environmental damage. Understanding the impact of N deposition on N₂O emissions in temperate forest ecosystems still remains a major challenge. The objective of our study was to examine the contribution of atmospheric N deposition to N₂O emissions in temperate forests exposed to chronic high N deposition. Investigations were conducted in a Norway spruce forest (Picea abies) and in a beech forest (Fagus sylvatica) in the Solling, Germany. A short-term as well as a one-yearlasting experiment were carried out. A ¹⁵N ammoniumnitrate-solution was added during the experiment in order to label the N deposition. Nitrous oxide fluxes as well as ¹⁵N isotope abundances in N₂O and mineral soil N were measured using the closed chamber method and ¹⁵N isotope tracing techniques. Emissions of N₂O were significantly higher in the beech forest (1.77 ± 0.85 kg N ha⁻¹ yr⁻¹) as compared to the spruce forest (0.32 ± 0.13 kg N ha⁻¹ yr⁻¹) (P < 0.05). The emission factor was 0.1% of the deposited N in the spruce forest and 0.6% in the beech forest. Our study revealed that 7–11% of the N₂O emissions were derived from N deposition and that deposited nitrate was immediately involved in the production of N₂O via denitrification. However, the type of deposited N species (NO₃⁻-N, NH₄⁺-N) had no effect on the emitted N₂O at least after 24 hours and N₂O was mainly emitted during the first 3 weeks after N deposition.
Influence of terrain heterogeneity on trace gases fluxes from tropical montane forest soils
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Tropical montane regions reveal great spatial heterogeneity in terrain and soil properties which is reflected amongst others in the high diversity of vegetation. Using chamber techniques, we measured trace gas fluxes of N₂O, NO and CH₄ at different landscape positions along an altitudinal gradient (1000 m, 2000 m and 3000 m elevation). We selected six replicated plots at three landscape positions (upslope, midslope and downslope). At all altitudes annual N₂O and NO emissions were very low. They ranged from 0.13 kg N ha⁻¹ yr⁻¹ at 1000 m, to 0.04 kg N ha⁻¹ yr⁻¹ at 3000 m for N₂O and from 0.02 kg N ha⁻¹ yr⁻¹ at 1000 m, to even lower values at 2000 and 3000 m for NO. Methane uptake rates at 1000 m were about four times higher than at 3000 m and almost doubled the rates at 2000 m. Gas fluxes of the three landscape positions also clearly deviated. N₂O emissions from soils of downslope sites more than doubled the fluxes of the upslope sites at 2000 m. At 3000 m annual means of N₂O fluxes were negative for upslope sites, while mid and upslope soils emitted N₂O. We will explain the observed differences with the major processes that control trace gas fluxes: soil nutrient status, soil water budget and the organic layer as gas diffusion barrier.
Decomposition of different kinds of litter and the effects of fertilizer and crop under subtropical conditions

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The experiment was focused by the effect of litter quality, fertilizer and crop for turnover of litter under subtropical conditions. In especially for carbon, nitrogen and other relevant nutrients (S, Ca, K, Mg, P, Mn, Fe). Four different kinds of litter with different quality (alfalfa, maize, canola, wheat) were carried out in Litterbags (5 × 10 cm; 1000 µm mesh wide; poly adenine) under two cropping systems (carrots and cauliflower). The experimental plots were treated with two sorts of fertilizer (mineral and organic). Both fertilizers showed different chemical compositions whereas the amounts of nutrients differ only in C/N ratio and fibre content but not in the total amount of nitrogen, phosphorus, sulphur and potassium. 192 Litterbags were burrowed in 0 - 5 cm depth at a private farm near Sohar in Oman with a mean temperature of 30°C and a mean precipitation lower than 100 mm. The experiment started with the watering period in November 2007 for three month. At the end of the experiment the decomposition was significant effected by litter quality. For mineral fertilizer the decomposition was 10 % higher than for organic fertilizer generally. However, the samples were analysed further for hemicellulose, cellulose, lignin, amino sugar and Nutrients. The soil was characterised as Irragric Cambisol with sand as major component and a organic C content lower than 0,6 %)
Long-term sensitivity of soil organic C and N stocks to the use of manure in the frame of organic and conventional farming practices

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Organic fertilisers have been used throughout the agricultural history but, during the last decades, in many cases, mineral fertilisers have replaced or largely minimised the use of manure. Organic farming practices enhance internal nutrient cycling by increasing or maintaining soil organic matter stocks. The moderate application of stabilised (composted) organic fertilisers is probably the main strategy used by the organic farmers to promote soil organic matter and soil fertility. Conventional farmers also apply organic fertilisers such as manures or slurries. However, they often use fresh (not composted) manures and slurries combined with mineral fertilisers. Our aim was to study the sensitivity of soil organic C and N stocks to the fertilisation practices used by the extensive organic and conventional farmers of central Catalonia.

We selected 13 extensive organic farmers growing cereals and grassy crops in central Catalonia. In each farm we selected a cereal field organically managed for at least 10 years. Next or nearby each field we selected another field conventionally managed. In each of the 30 selected fields we collected soil samples in 4 areas. In each area we extracted three soil cores with a volumetric auger form 0-30 cm that were divided into three layers (0-10, 10-20 and 20-30 cm) and bulked to one sample per layer and area.

Organic C and total N and potentially mineralisable N (NPM) were analysed in all soils. At the same time, all farmers were interviewed in order to define its fertilisation practices. Based on the interviews we calculated the mean annual organic C and N inputs in the studied fields.

Organic farmers applied composted manures ranging from 0 to 1100 kg C ha-1 yr-1 with C/N ratio ranging from 10 to 20. In contrast, conventional farmers applied fresh manures combined with slurries and/or mineral fertilisers ranging from 200 to 1900 kg C ha-1 yr-1 with a C/N ratio lower than 10. Despite the application of low amounts of manure organically managed soils showed higher C and N content in terms of soil mass than conventionally managed soils. C content in terms of land surface was also higher in organic soils. Moreover, organic C and N stocks in organically managed soils were sensitive to the inputs of organic C in manures while in conventionally managed they were not. Stabilised N in composted manures enhanced C sequestration while readily available N of synthetic fertilisers or slurries mixed with fresh manures did not. In organically managed soils organic N stocks were more stable than in conventional soils. However, N mineralisation in organic soils was sensitive to the rate of application of the organic fertilisers. The use of manures appeared to be a key factor for C sequestration and for the availability of N in organic crops. This trend was not observed in conventional soils.

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Fertiliser type and rate affect partitioning of soil organic matter into pools of different stability

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Regulation of the budget of soil organic matter (SOM) and nutrients is a central focus in organic agriculture. A crucial element of organic agriculture is the dependence on organic fertilisers. Type and rate of fertilisers influence the level of SOM markedly, but the effect on partitioning of C into pools of different stability is still open to question. In the present studies six treatments of the fertilisation trial in Darmstadt, Germany (founded: 1980) were considered: straw incorporation plus application of mineral fertilizer (MSI) and application of farmyard manure (FYM) at high (150 kg N ha⁻¹ year⁻¹), medium (100 kg N ha⁻¹ year⁻¹) and low (50 kg N ha⁻¹ year⁻¹) rates.

Soil samples (0-25 cm) were incubated (266 days, 10 °C, and 50% water filled pore space). Cumulative C mineralization (1.1–1.8 t ha⁻¹ 266 days⁻¹) increased significantly (p ≤ 0.05) with the rate but was independent of the type of fertilizer. Fitting an exponential model to the mineralization data indicated that the rate-dependent labile pool (7–13% of C₉ₒᵣ₉ or 1.8 3.2 t ha⁻¹) was a short term effect (turnover time: 460 days). Combining this biological and a chemical fractionation with disodium peroxodisulfate (Na₂S₂O₈) revealed that the size of the mineral protected and recalcitrant C pool (7-9 t ha⁻¹ or 30-40% of C₉ₒᵣ₉) was independent of treatments. The amount of residual C, which was neither labile nor resistant to the oxidative treatment, was higher in the FYM (15-18t ha⁻¹, 60% of C₉ₒᵣ₉) than in the MSI treatments (12-14 t ha⁻¹, 50-60% of C₉ₒᵣ₉) and marginally affected by the rate. The results of this experiment indicate that C sequestration in the medium term was regulated by the type, while C availability from SOM was affected by the rate of fertilizers.

In a field study, soil samples (0-25 cm) from FYM and MSI treatments were taken five times in the span of one year. The cultivated crop (May to September) was Amaranthus hybridus L., a C₄-plant. Emissions of CO₂ were measured from plants, soil and crop residues, using the δ¹³C natural abundance approach. Measurement of light fraction C (LFC, ρ≤2.0 g cm⁻³) indicated a depletion of labile substrate for soil respiration, but did not match it quantitatively. The amount of amaranth-derived C incorporated into the microbial biomass tended (p = 0.12) to be higher at high fertiliser rates but were unaffected by fertiliser types. The results of this field-experiment showed, that the microorganisms in high fertilised soils were more active in decomposing amaranth residues or incorporated amaranth derived C more effective than microorganisms in low fertilised soils.

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Effects of conventional and reduced tillage on GHG fluxes

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The most important biological greenhouse gases (GHG) are carbon dioxide, methane and nitrous oxide. Agricultural activities contribute to approximately 20% to the global anthropogenic greenhouse gas emissions. Cultivated soils have been identified as one of the main GHG sources within the agricultural sector whereas arable soils usually act as a sink for methane. It is generally accepted that reduced tillage have beneficial effects on soil fertility compared to conventional tillage, e.g. decreasing erosion, increasing aggregation and stabilising of soil organic matter. Reduced tillage practices furthermore may lead to increased carbon sequestration in soils and a lower demand of diesel. However, this benefit may be at least partly offset by increased emissions of nitrous oxide or decreased consumption of methane due to higher soil compaction. Production, consumption and transport of GHG gases in soils are strongly influenced by the changes in soil structural quality and in water content associated with tillage and compaction. The complex interactions between soil properties, climatic factors and agricultural practice are highly altered by an intensive use of cultivation practices. The dynamics and the amounts of GHG fluxes of arable soils are therefore governed by management strategies. There is non consensus in the literature about GHG fluxes in dependence of different tillage systems.

The aim of this study was to examine the influence of tillage systems (conventional vs. reduced tillage) on greenhouse gas fluxes within two long-term experimental sites in Germany. Therefore the annual nitrous oxide emissions and the methane uptake were quantified. Furthermore the seasonal variation of the flux rates were investigated and soil and climatic factors which control the temporal variability of the flux rates were determined.
Net-exchange rates of N\textsubscript{2}O and CO\textsubscript{2} from three different long-term fertilization experiments – a laboratory study

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Increased soil organic carbon stocks may contribute to the reduction of atmospheric CO\textsubscript{2} and improve soil quality. Little is known about the feedback on the trace gas N\textsubscript{2}O. An incubation experiment was conducted with soil samples from three different long-term fertilization experiments. Two of them (Spröda, Methau) were fertilized praxis-oriented with 150 kg N ha\textsuperscript{-1} yr\textsuperscript{-1} whereas the soil from the third experiment (Bad Lauchstädt) was fertilized with manure in excess (1000 dt manure ha\textsuperscript{-1} yr\textsuperscript{-1}) compared to a no fertilizer treatment. These experiments were based on the carbon accumulation by organic fertilization in contrast to mineral/zero fertilization. The incubation experiment included a control period, used for the determination of the background emission, a fertilizer application of manure or mineral fertilizer and a simulated heavy rain event (water saturation up to almost 100% WHC).

Long-term effects of fertilizer history on N\textsubscript{2}O were only found in the background emissions where treatments with higher C\textsubscript{org} content emitted more N\textsubscript{2}O. After the application of fertilizer and the heavy rain event no long-term effects were found since the effects of the short-term events were much more pronounced. However, the soil with excess fertilization showed an unexpected pattern with low N\textsubscript{2}O emissions during the whole incubation. In contrast, the soil without any fertilization emitted up to five times more N\textsubscript{2}O because of its soil structure. Less abundance of macroaggregates led to a deteriorated aeration and diffusion in the soil.
Estimating indirect agricultural N₂O emission from aquifers using dissolved NO₃⁻, N₂O and N₂

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In nitrate-contaminated aquifers containing reduced compounds like organic carbon or sulfides, denitrification is an intense process and the production of the major greenhouse gas nitrous oxide (N₂O) might contribute to N₂O emissions to the atmosphere. In the present study, we investigated six aquifers in order to characterize the dynamics of N₂O during denitrification progress and to assess the risk for indirect emissions of this major greenhouse gas.

Spatial distribution of NO₃⁻ and N₂ produced by denitrification in groundwater (excess N₂) reflects the NO₃⁻ input (NO₃⁻t₀ or initial NO₃⁻ concentration) as well as cumulative denitrification during aquifer passage. Reaction progress (RP) at a given location, i.e. the relative consumption by denitrification of the NO₃⁻ that had been leached to the aquifers, characterizes the stage of the denitrification process. RP can be derived from the ratio between accumulated gaseous denitrification products and initial NO₃⁻ concentrations.

In the presented study, we measured the spatial distribution of NO₃⁻, N₂O, and excess N₂ in pleistocene sandy aquifers of Northern Germany. This was done to identify heterogeneity of denitrification dynamics and N₂O emission potential. During groundwater flow paths we found a general pattern with very low N₂O concentrations at the end of the reaction progress (RP close to 1) but relatively high N₂O concentrations at RP between 0.1 and 0.6. Thus, this pattern might help to improve the prediction of indirect N₂O emissions. Mean emission factors basing on the ratio of N₂O concentrations and initial NO₃⁻ concentrations ranged between 0.0002 and 0.0022, indicating an overestimation of potential indirect N₂O emission by the IPCC default value that currently stands at 0.0025 for the groundwater component.

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Emission of greenhouse gases: Evaluation of measurements at scales from < 1 m² to 500 m²

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It is well known that emissions of greenhouse gases from soil into atmosphere are spatially highly variable, especially when measured at small scales (m² or less). Therefore, reliable area representative emission values are often hard to obtain. To overcome these problems we measured N₂O emissions from sandy soils at a scale of 300 or 500 m², respectively, using a static closed chamber method. Our closed chamber was a tent of 100 m × 3 m or 100 m × 5 m, respectively, and a height of about 0.5 m. After closing the tent gas concentration increase was measured over 10 h by an open-path Fourier Transform Infrared (FTIR) spectrometer. The air inside the tent wasn’t vented. The emission was calculated as flux density from the early (about first 60 to 120 min) linear part of the concentration increase. However, the closed chamber method is often criticized because increasing gas concentrations in the head space may affect emission rates.

To evaluate the reliability of our large scale N₂O emission measurements (closed tent method) we simulated gas fluxes in the soil/tent system and the soil/atmosphere system as well, using a numerical diffusion model. Furthermore, a number of comparison measurements for different gases were made using small scale static closed chambers, and a commercial dynamic closed chamber system.

In our contribution we will present results of our emission measurements and the model simulations. We will focus on (i) are emission measurements with static closed chambers (or closed tent) in principle biased, and (ii) are chamber measurements at different scales and with different modes of operation comparable?
Soil organic matter dynamics in the Danube floodplain: results from a chronosequence study and a $^{14}$C labeling long-term field experiment in Lower Austria

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Recently, we established a chronological framework for fluvial deposits along a soil sequence at the Danube River near Vienna, Austria, using optically stimulated luminescence (OSL) dating. We identified fluvial deposits from different time periods ranging from the early last millennium BC to the 18th century AD. We bridged the gap from the 18th century AD to the present with fallout $^{137}$Cs dating, and developed a chronofunction model relating Fe oxide crystallinity ($\text{Fe}_o/\text{Fe}_d$) to deposition age along the soil sequence. This model allows for age estimation of soil layers using routinely measured pedological characteristics ($\text{Fe}_o/\text{Fe}_d$). We examined specifically the build-up of soil organic matter, the weathering of apatite phosphate and the retention of pollutants related to soil development. We found rapid C accumulation during the initial 100 years of soil formation, with rates exceeding those in northern peatlands by an order of magnitude. We showed that floodplain land use strongly affects soil C sequestration and pool allocation, and found that the distribution of different C pools reaches a steady state within a few decades of soil development. Our results demonstrate that continually rejuvenated soils on riverine floodplains are strong C sinks, but also show that intensive cultivation severely compromises their high C sequestration potential.

Soil organic matter (SOM) dynamics was investigated in a typical Chernozem developed from floodplain sediments close to the oldest site in our chronosequence. The long-term field experiment established 1967 there allowed to investigate the mineralization and stabilization of $^{14}$C-labeled wheat straw and farmyard manure under different cropping systems (crop rotation, monoculture and bare fallow). The different organic amendments and cropping systems resulted in considerably different distributions and half-lives of three modeled SOM pool compartments. Significantly lower amounts of residual $^{14}$C-labeled material were found in the bulk soils of the bare fallow systems compared to farmyard-manured crop rotation and monoculture, indicating enhanced organic matter stabilization in the latter cropping systems. In 2004, remaining $^{14}$C-labeled amendments (in % of original application in 1967) in bulk soils were 8.7 ± 0.3 for crop rotation, 8.6 ± 0.4 for monoculture, 7.5 ± 0.7 for bare fallow (all farmyard-manured) and 5.0 ± 0.6 for straw-manured bare fallow.

The data of the long-term field-experiment were used to calibrate the Roth-C-26.3-model for the Pannonian climatic region. Decomposition rate constants were modified regarding the possible climatic influence on carbon sequestration in soil C pools. The main change was in the decomposition rate constant for HUM (humified) soil C pool, which is now fitted for different plots from 0.005 to 0.01 y$^{-1}$ instead of 0.02 y$^{-1}$. These changes resulted in higher HUM pool of the calibrated model because of the longer turnover period of 100-200 years instead of 50 years. Our specific research question was the long-term effect of residue removal on SOM levels under different crop management, under different soil conditions and climatic regimes. Modeling results of the removal of crop residues showed that it can entail a long-term decline of SOM.
Poster session

Thursday, 12th of November

14:20 to 15:30
Nutrient balances of Nitrogen, Phosphorus, and Potassium compared to their nutrient stocks in different farming systems of the Ecuadorian Andes

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Dresden University of Technology, Institute for soil science and site ecology

Sustainable land use in three different land use systems of the southern Ecuadorian Andes are being investigated with the objective of a participatory problem solution with local farmers. Producing sufficient food supplies and enhancing sustainable land use at the same time is a serious conflict in developing countries where vast areas of soils are already degraded or suffer from nutrient deficits. As a result of declining harvest yields, farmers are forced to establish new areas under cultivation which they usually do by burning of natural forests. Therefore the approach aims to find alternatives for a large scale sustainable land use of already existing areas under cultivation. We put our focus on calculating nutrient balances for Nitrogen, Phosphorus, and Potassium in different farming systems by modelling with NUTMON (Nutrient Monitoring) to make statements on the subject of sustainable land use. Results are used to identify problem areas within the farms and to contribute to the improvement of the nutrient balance by installing adapted technologies or management measures.

Representative soil samples were taken in each farm with a soil auger to a depth of 30 cm of the mineral soil. We then calculated the nutrient stocks of Nitrogen, Phosphorus, and Potassium to put them into a relation to the nutrient balance and hence estimate the sustainability of the land use.

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Quality and quantity of litter as key components for labile SOC pool formation and microbial community composition

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Decomposition of litter can be seen as a key process for the flow of energy and nutrients in terrestrial ecosystems and may be affected sensitively by changing management practices. Litter quality and quantity plays a major role in soil organic matter (SOM) turnover in intensively managed as well as in natural or semi-natural ecosystems. Information is needed on the impact of organic matter (OM) quality on the structure, functional characteristics and dynamics of soil microbial communities and factors that regulate these soil processes.

Here we demonstrate the suitability of a hot-water extractable carbon pool ($C_{HWE}$) as an indicator for estimating the supply of soils with decomposable SOM. This pool is considered to be a sensitive indicator of SOM quality, being relatively labile in nature and can likely reflect management changes in soil-plant systems. We show how quality of shoot and root litter in extensively managed grasslands influence labile SOC pools. Furthermore, we applied this method modified on plant residues as a qualitative indicator for the stability of litter against microbial attack. For validation the above and belowground plant material was decomposed in a lab-respiration experiment for a period of 30 days. Functional and structural soil microbial community characteristics were described by extracting soil enzyme activities and PLFAs.

Plant diversity and plant functional composition increased root biomass production reflected in a significant higher $C_{HWE}$ in semi-natural meadows. The quantity of OM input to the soil enhanced the formation of a labile C pool. From the respiration experiment we could show that the aboveground biomass has about 30 % higher C turnover than belowground litter. From this, root litter of semi-natural ecosystems tend to be even more recalcitrant. Additionally, semi-natural plots with more recalcitrant roots show a pronounced fungal dominated microbial community playing an important role in regulating soil C storage.
Impact of grazers and grassland diversity on nitrogen oxide emissions

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Concentrations of the climate-relevant trace gases nitrous oxide (N₂O) and nitric oxide (NO) have continued to rise since the beginning of the industrial era. Deposited urine and animal droppings are a major source of soil nitrogen oxide emissions. This study aims at investigating if the kind of livestock (cattle or sheep) and grassland diversity have an influence on nitrogen oxide emissions. A field experiment was carried out over two grazing periods to quantify soil N₂O and NO emissions from species-rich grassland and adjacent sites where plant diversity had been decreased by use of herbicides. The sites were grazed by either Simmental cattle or German Blackheaded Mutton and Leine sheep. The experiment was set up in 2006 as a block design with rotational grazing from May to September in three replicates on mesotrophic hill grassland in the Solling uplands (Lower Saxony). The dominating soil type is a Pelosol on Buntsandstein. N₂O and NO emissions were measured directly before and shortly after livestock were on the plots. We used closed chambers for N₂O and NO measurements. Gas samples were analyzed using a GC and chemiluminescence detector. Additionally, we measured air and soil temperature, air pressure, soil moisture and soil extractable mineral N. The results show that sheep grazing compared to cattle grazing is followed by higher N₂O emissions. Grassland diversity turns out to be subordinate to the impact of grazers on nitrogen oxide emissions.

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Simultaneous measurement of S, macronutrients, and heavy metals in the soil microbial biomass with CHCl₃ fumigation and NH₄NO₃ extraction

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The study was carried out to investigate whether 1 M NH₄NO₃ extraction is a useful alternative to 10 mM CaCl₂ extraction for estimating soil microbial biomass S and whether the data of CHCl₃-labile NH₄NO₃ extractable macronutrients and heavy metals are useful and in agreement with the available data on element concentrations in soil microorganisms. Microbial biomass C was followed by microbial biomass S after CaCl₂ extraction with an average C/S ratio of 82, and by microbial biomass S after NH₄NO₃ extraction with an average C/S ratio of 57. The mean contribution of CHCl₃-labile metals in relation to the NH₄NO₃-extractable fraction from non-fumigated soils ranged from 0.1 to 112% in the order potassium < magnesium < cadmium < sodium < zinc + nickel < manganese < copper. The mean contribution of CHCl₃-labile metals in relation to the microbial biomass C ranged from 0.03 to 22‰ in the order cadmium < nickel < zinc < manganese < magnesium < copper < sodium < potassium. These relative contributions varied within the different metals from a 4-fold (Na⁺) to a more than 200-fold range (Cu²⁺). Significant positive correlations with microbial biomass C were observed for CHCl₃-labile zinc, sodium and especially potassium. The concentration of all elements except copper in relation to microbial biomass C were in the range known from the limited literature on fungi grown on heavy metal contaminated soils.

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Impact of fertilization strategies on the carbon and nitrogen dynamics
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Little is known about the long-term impact of fertilizer type and rate on carbon (C) and nitrogen (N) content in soil fractions. The aim of present study was to examine the effects of 28 years of different fertilization practices on C and N contents of whole soil in different soil fractions. The experiment comprised of four treatments, namely the application of farmyard manure (FYM) and the application of mineral fertilizer along with straw incorporation (MSI), each at high (FYM$_H$, MSI$_H$: 140-150 kg N ha$^{-1}$ year$^{-1}$) and low (FYM$_L$, MSI$_L$: 50-60 kg N ha$^{-1}$ year$^{-1}$) rates. Soil samples were taken from the surface (0-10 cm) and subsurface (10-25 cm) layers. Microbial biomass C ($C_{mic}$) and N were obtained by the chloroform fumigation extraction method. Compared to soils receiving continuous application of mineral fertilizer plus straw, FYM treated soils had significantly ($p < 0.05$) higher organic carbon ($C_{org}$) and total nitrogen contents ($N_t$). After the fertilizer type, application rate was the second most important factor, affecting C and N contents in soil. FYM$_H$ treated soils had higher C contents in all soil fractions compared to the other treatments. The rate of fertilizer significantly affected microbial biomass carbon ($C_{mic}$) and nitrogen ($N_{mic}$) contents. The interaction of fertilizer type, rate and soil depth significantly affected C content in the light fraction (LFC) of soil. LFC content was highest in FYM$_H$ treated soils. In the subsurface soil, LFC was higher and more closely related ($R^2=0.71$) to the $C_{mic}$ content. The reason for the increased LFC and $C_{mic}$ content down the soil profile may either be due to an accumulation of straw at the lower depth through ploughing or due to differences in soil moisture and temperature.
Quantification of non-stable soil organic C and N in sands for priority programs in groundwater protection areas (\textit{N}_{\text{fair-Concept}})

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Remarkably high levels of soil organic matter (SOM) in sandy arable soils of Northwest Germany and adjacent regions were only partly explicable by non-equilibrated OC stocks due to changes in land use, e.g. from grassland to arable land (Springob et al. 2001). The other reason was a podzolization-enhancing climate combined with specific conditions of historical land-use as heathland, plaggen fertilization and high groundwater (Springob & Kirchmann, 2002). Such conditions generated much ‘non-texture’ stabilised SOM with very low specific mineralisation rates and wide bulk soil C to N ratios. (Schachtschabel, 1953, Springob & Kirchmann, 2003). That material is really stable and here is denoted as \textit{OC}_{\text{relic}} (and \textit{ON}_{\text{relic}}) Quantification of \textit{OC}_{\text{relic}} is useful for an adequate modelling of soil carbon dynamics in the global change discussion, and it is essential for estimating the risk of nitrate leaching from net decay of SOM in drinking water catchments.

We quantified \textit{OC}_{\text{relic}} and \textit{ON}_{\text{relic}} by a C/N-based calculation procedure (easily >50% of total OM), and we subtracted \textit{N}_{\text{relic}} from total N to obtain a kind of standardised total N pool (\textit{N}_{\text{stand}}). \textit{N}_{\text{stand}} than is compared with its regional equilibrium levels in Ap horizons. If there is much more \textit{N}_{\text{stand}} than should be at a place, than there is a high risk of net N release and leaching of Nitrate. As “much more“ we consider a surplus of > 4000 kg N/ha 30 cm.

We derived five distinctive risk classes based on \textit{ON}_{\text{stand}} which are already in use in the permission process of grassland conversion (\textit{N}_{\text{fair-Concept}}), and also in mapping the risk of excess N mineralisation from OM to define priority areas for groundwater protection measures.


