International Union of Soil Sciences

Global Soil C Conference

3-6 June 2013

Program & Abstracts

International Union of Soil Sciences

College of
Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN–MADISON

DEPARTMENT OF
Soil Science
UNIVERSITY OF WISCONSIN–MADISON

International Union of Soil Sciences

Global Soil C Conference
3-6 June 2013

Program

Monday Program 3
Abstracts 10

Tuesday Program 5
Abstracts 43

Wednesday Program 8
Abstracts 77

List of Participants 102

MONDAY 3rd June

Division 1 – Soil Carbon in Space and Time

Opening and Keynote

8.30-9.00	**Hartemink, A.E., B. Lowery & J. Yang** Welcome
9.00-9.45	**McBratney, A., B. Minasny, U. Stockmann & D. Field** – The knowns and unknowns of soil (organic) carbon and its sequestration
9.45-10.15	Coffee Break

Soil Morphology *(Chair Alex McBratney)*

10.15-10.30	**Poch, R.M. & I. Virto** – SOM: We know what, how much… but where?
10.30-10.35	**Attoe, E.E., M.A. Kekong & A.U. Akpanidiok** – Studies on the relationship between organic matter and exchangeable aluminum in representative soils of Cross River State, Nigeria
10.35-10.40	**Chendev, Y.G., L.L. Novykh, T.J. Sauer, A.N. Petin & E.A. Zazdravnykh** – Evolution of carbon storage and morphometric properties of afforested soils in the Central Russian Upland and U.S. Great Plains

Soil C and Soil Genesis

10.40-10.55	**Monger, C.** – Soils as generators and sinks of inorganic carbon in geologic time
10.55-11.00	**Konen, M.** – Quantification of soil carbon stocks in the field – some pedogeomorphic issues from the midwestern United States
11.00-11.05	**Libohova, Z., D.E. Stott, P.R. Owens & H.E. Winzeler** – Soil carbon stability in glaciated landscapes of northern Indiana
11.05-11.10	**Muhawish, N.M. & R.K. Al-Kafaje** – Soil organic carbon and phosphorus status after combined of PR and organic materials in a gypsiferous soil
11.10-11.15	**Inubushi, K.** – Soil microbial biomass in Andosol for C storage index and buried paleosol
11.15-11.20	**Szalai, Z., K. Kiss, G. Jakab, R. Balás, P. Sipos, N. Zboray & T. Németh** – DOC-iron relations under fluctuating redox conditions in Gleysol-Phaeozem and Histosol-Phaeozem toposequences
11.20-11.25	**Micheli, E., J. Hempel, V. Lang & P. Owens** – Organic carbon as major differentiation criteria in soil classification systems
11.25-12.15	Discussion
12.15-13.15	Lunch

Soil C Geography *(Chair Karl Stahr)*

13.15-13.30	**Minasny, B., A.B. McBratney & B.P. Malone** – Digital mapping of soil carbon
13.30-13.35	**Hempel, J., A.B. McBratney, D. Arrouays, N. McKenzie, A.E. Hartemink, M. Grundy, M. Greve, S.Y. Hong & G. Lelyk** – GlobalSoilMap and global carbon predictions
13.35-13.40	**Ogeh, J.** – Organic carbon stock in topsoil of a forest land in Nigeria
13.40-13.45	**Srinivasarao, Ch., B. Venkateswarlu, Y. Sudha Rani, A.K. Singh, K.D. Kokate, & S. Dixit** – Carbon balance with climate resilient technology interventions in 100 vulnerable districts of India
13.45-13.50	**Stott, D., C.A. Cambardella & D.L. Karlen** – Assessment of soil carbon content across several U.S. cropland watersheds
13.50-13.55	**Bockheim, J.G. & N.W. Haus** – Distribution of organic carbon in Antarctic soils
13.55-14.15	Discussion

Soil C Monitoring *(Chair Martin Gerzabek)*

14.15-14.30	**Arrouays, D., B.P. Marchant, N.P.A. Saby, P.H. Bellamy, M.P. Martin, R.M. Lark, J. Meersmans, T.G. Orton, D. Allard, B.P. Louis, C.C. Jolivet & M. Kibblewhite** – On soil carbon monitoring networks
14.30-14.35	**Takata, Y., A. Leon & H. Obara** – Monitoring of soil carbon stock and soil management in Japanese agricultural land
14.35-14.40	**Bortolon, E.S.O., J. Mielniczuk, C. Gustavo Tornquist, L. Leandro Bortolon & F. Lopes** – Carbon balance at regional scale estimated with Century model in southern Brazil
14.40-14.45	**Cihacek, L., M. Ulmer & E. Kraft** – Soil carbon changes over two decades in the northern Great Plains of the U. S.
14.45-14.50	**de Lamo, X., S. Adu-Bredu, I. Ali-Babiker, B.O. Antwi, H. Barro, A. Bassolé, B. Geneste, F. Jeremie, W. Kadewa, K. Kokou, A.D. Kokutse, D. Mkwambisi, J. Mutemi, J. Mworia, F. Opijah, R.M. Poch, R. Sagoe, L. Saint-André, B. Salih, S. Sawadogo & M.T. Sebastià** – Modelling soil organic carbon stocks in Sub-Saharan Africa
14.50-14.55	**Husnjak, S., A. Bensa, H. Mesić & D. Jungić** – Soil organic carbon content in Croatian agricultural regions topsoil
15.00-15.05	**Ivanov, A. & V. Stolbovoy** – The carbon balance of soils in the Northern Eurasia
15.05-15.10	**Pallasser, R., B. Minasny & A.B. McBratney** – A novel method for measurement of carbon on whole soil cores
15.10-15.15	**Wills, S., T. Loecke, C. Sequira, G. Teachman, S. Grunwald & L. West** – Overview of the U.S. Rapid Carbon Assessment Project
15.15-15.35	Discussion
15.35-16.05	Tea break

Soil C and Pedometrics *(Chair Erika Micheli)*

16.05-16.20	**Bliss, N.B., S.W. Waltman & L.T. West** – Distribution of soil carbon in the conterminous United States and implications for sampling strategies
16.20-16.25	**de Brogniez, D., C. Ballabio, B. van Wesemael, R. Jones, A. Stevens & L. Montanarella** – Spatial distribution of topsoil organic carbon in Europe
16.25-16.30	**Loecke, T., S. Wills, C. Sequeira & L.T. West** – Uncertainty propagation of the RaCA soil carbon stock data
16.30-16.35	**Mesic, M., M. Birkás, Z. Zgorelec, I. Kisic, I. Sestak, A. Jurisic & S. Husnjak** – Carbon variability in some Hungarian and Croatian Soils
16.35-16.40	**Santacruz, A., Y. Rubiano & C. Melo** – Evolutionary optimization of spatial sampling networks designed for the monitoring of soil organic carbon
16.40-16.45	**Zhu, A.X., J. Liu & S. Zhang** – Mapping soil carbon using legacy samples with uncertainty
16.45-16.50	**Viscarra Rossel, R.A.** – Proximal soil sensing of soil carbon stores for more certain accounting
16.50-17.30	Discussion

TUESDSDAY 4th June

Division 2 – Soil Carbon Properties and Processes

Keynote *(Chair Roger Swift)*

8.30-9.15	**Sparks, D.L. & C. Chen** – Shedding light on carbon-mineral complexation in the soil environment: impacts on C sequestration and cycling

Soil C Chemistry

9.15-9.30	**Gerzabek, M., A.J.A. Aquino, D. Tunega, G. Haberhauer, H. Pasalic, H. Lischka, C. Oostenbrink & G. Schaumann** – Humic substances (HS) models – water and cations bridges
9.30-9.35	**Akinsete, S. & S. Nortcliff** – Storage of total and labile soil carbon fractions under different land-use types: a laboratory incubation study
9.35-9.40	**Askari, M.S., S. O'Rourke & N.M. Holden** – A comparison of the prediction accuracy for soil organic carbon measured by point and imaging spectroscopy
9.40-9.45	**Brown, D., R.S. Bricklemyer, S.M. Clegg, J.B. Reeves & D.B. Smith** – Rapid, multi-sensor, laboratory soil characterization for carbon and related soil properties
9.45-9.50	**Forouzangohar, M., J.A. Baldock, R.J. Smernik, B. Hawke & L.T. Bennett** – Mid-infrared spectra to predict the NMR spectra of soil organic carbon: a two-dimensional correlation spectroscopy approach
9.50-9.55	**Kiss, K., G. Jakab, N. Zboray, B. Madarász, R. Balázs, T. Németh & Z. Szalai** – Characterization of soil organic substances present in different Hungarian soils by UV-Vis spectrophotometry
9.55-10.00	**Oufqir, S., P. Bloom, B. Toner & P. Hatcher** – Extracted humic acid does not represent the composition of clay bound soil organic matter
10.00-10.20	Discussion
10.20-10.50	Coffee break

Soil C Physics *(Chair Bill Bland)*

10.50-11.05	**Fernández-Ugalde, O., P. Barré, I. Virto, C. Chenu & G. Bardoux** – Stabilization of soil organic carbon by clay minerals: does clay mineralogy determine the turnover rate of clay-associated carbon?
11.05-11.10	**Ajayi, A.E. & R. Horn** – Modification of soil's hydro-physical functions by Black Carbon
11.10-11.15	**Atanassova, I., S. Doerr & G.L. Mills** – Hot water soluble organic compounds related to hydrophobicity in sandy soils
11.15-11.20	**Lange, S., A. Suzanne & M. Francois** – Physico-chemical properties of biochar
11.20-11.25	**Yost, J., C. Palmer & L. Egerton-Warburton** – Just the prairie sink: the role of soil aggregates in sequestering carbon in restored temperate grasslands
11.25-12.00	Discussion
12.00-13.00	Lunch

Soil C Biology *(Chair Mary Beth Kirkham)*

13.00-13.15	**Stepniewski, W. & Z. Stepniewska** – The role of microbes for carbon sequestration in anthropogenic soils, waste deposits, and lakes
13.15-13.20	**Butterly, C., R. Armstrong, D. Chen & C. Tang** – Elevated CO_2 and rhizosphere C priming affect the decomposition of crop residues
13.20-13.25	**Comeau, L.-P., R. Lemke, J.D. Knight & A. Bedard-Haughn** – Root and shoot carbon input from four prairie crop sequences using repeat ^{13}C pulse labeling technique

13.25-13.30 **Dare, M. O., J.A. Soremekun, F.O. Inana & O.S. Adenuga** – Microbial biomass carbon and nitrogen in irrigated soil under different maize cropping systems

13.30-13.35 **Levinson, W., K. Schreiner, K. Fournillier, N. Blair & L. Egerton-Warburton** – Contribution of fungal macromolecules to soil carbon sequestration

13.35-13.40 **Liu, C., H. Tong & F. Li** – Microbial and chemical enhancement of pentachlorophenol transformation in paddy soil supplemented with biochar

13.40-13.45 **Sugihara, S., S. Funakawa, H. Shinjo, A. Kadono, Y. Takata, K. Sawada, K. Ikazaki, K. Fujii & T. Kosaki** – *In situ* short-term dynamics of CO_2 flux and microbial biomass after simulated rainfall in dry croplands

13.45-13.50 **Huang, Y., D.J. Lowe, G.J. Churchman, N.J. Rawlence, L. Schipper & A. Cooper** – DNA adsorption on allophane and the interactions between DNA, organic matter, and allophane in Andisols in New Zealand

13.50-14.10 Discussion

Soil C Mineralogy *(Chair Diane Stott)*

14.10-14.25 **Churchman, J., A. Noble, G. Bailey & D. Chittleborough** – Clay addition and redistribution to enhance carbon sequestration in soils

14.25-14.30 **O'Rourke, S. M., J.N. Turner & N.M. Holden** – Determination of small scale spatial carbon concentration in an intact soil profile by X-ray fluorescence scanning

14.30-14.35 **Watanabe, T., S. Urayama, S. Sugihara, A. Nakao, S. Funakawa, T. Kosaki & S. Araki** – Preservation of organic carbon in humid tropical soils by active Al and Fe

14.35-14.40 **Nguyen, M., B. Hockaday & B. Lau** – Probing temperature-dependent organo-mineral interactions with molecular spectroscopy and quartz crystal microgravimetry

14.40-14.45 **Sulman, B., E. Shevliakova, S. Malyshev & S. Pacala** – Simulating priming effects, measurable carbon pools, and climate change sensitivity of soil carbon in an earth system model

14.45-14.50 **Wang, X., L.H. Cammeraat, K. Kalbitz & P. Romeijn** – Soil redistribution and dynamics of organic carbon: an experimental approach

14.50-14.55 **Zboray, N., T. Németh, R. Balázs, K. Kiss, A. Bidló & Z. Szalai** – Comparison of quantitative SOM measuring methods and investigation of their dependence on soil properties

14.55-15.00 **Jones, E. & B. Singh** – The role of organo-mineral interactions in stabilising carbon in contrasting soils under natural vegetation

15.00-15.20 Discussion

15.20-15.50 Tea break

Division 3 – Soil Use and C Management

Soil C and Soil and Water Conservation *(Chair Rainer Horn)*

15.50-16.05 **Bonilla, C.A., P.A. Pastén, G.E. Pizarro, V.I. González, A.B. Carkovic & R.A. Céspedes** – Forest fires and water erosion effects on soil organic matter in the Serrano River Basin (Chilean Patagonia)

16.05-16.10 **Jakab, G., K. Kiss, Z. Szalai & N. Zboray** – Erosion derived humus redistribution on arable field

16.10-16.15 **Miesel, J., R.K. Kolka, P.A. Townsend & W.C. Hockaday** – Fire severity effects on soil organic matter in northern Minnesota, USA

16.15-16.20 **Shrestha, H.R., L. Bennett, C. Weston & T. Baker** – On measuring the effects of prescribed fire on forest floor litter and soil carbon stocks in a mixed eucalypt forest in south-eastern Australia

16.20-16.25 **Cui, J., M. Sadegh Askari & N.M. Holden** – Relating soil carbon and structure to land use management

16.25-17.25 Discussion

WEDNESDAY 5th June

Division 3 – Soil Use and C Management

Keynote *(Chair Jock Churchman)*

8.30-9.15 **Lal, R.** – Soil carbon management and climate change

Soil C and Soil Fertility

9.15-9.30 **Ashworth, A., F. Allen, J.P. Wight, D.D. Tyler & A. Saxton** – Long-term soil organic carbon changes as affected by crop rotation and bio-covers in no-till crop systems
9.30-9.35 **Anda, M.** – Preservation of organic matter and the use of rice husk to increase soil organic C in heavy clay soils dominated by kaolinite and sesquioxides
9.35-9.40 **Ebigwai, J.K., E.A. Edu & I.A. Okon** – Evaluation of carbon sequestration within Phytoliths of some dry farming crops in Calabar, Nigeria
9.40-9.45 **Funakawa, S., K. Fujii, C. Hayakawa, K. Sawada, T. Watanabe & T. Kosaki** – Could soil acidity enhance sequestration of organic carbon in soils?
9.45-9.50 **Hatano, R., M. Shimizu, T. Arita, Y. Kouda, A. Mori, S. Matsuura, M. Niimi, M. Mano, R. Hirata, T. Jin, A. Limin, O. Kawamura, M. Hojito & A. Miyata** – Farmyard manure application mitigates greenhouse gases emissions from managed grasslands in Japan
9.50-9.55 **Sainju, U.** – Residue and soil carbon storage affected by tillage, cropping sequence, and nitrogen fertilization
9.55-10.20 Discussion
10.20-10.50 Coffee break

Soil C and Plant Nutrition *(Chair David Brown)*

10.50-11.05 **Mordhorst, A., S. Peth & R. Horn** – Impact of mechanical loading on static and dynamic CO_2 effluxes of arable Luvisols under different soil management
11.05-11.10 **Sanford, G., J.L. Posner, R.D. Jackson, C.J. Kucharik, J.L. Hedtcke & T. Lin** – Soil carbon lost from Mollisols of the North Central U.S.A. with 20 years of agricultural best management practices
11.10-11.15 **Shirato, Y. & Y. Yagasaki** –Estimating carbon sequestration potential of cropland management in Japanese arable soils with the Rothamsted carbon model
11.15-11.20 **Spokas, K.** – Biochar: potential role in soil carbon sequestration
11.20-11.25 **Stewart, C.E., R.F. Follett, E.G. Pruessner, G.E. Varvel, K.P. Vogel & R.B. Mitchell** – Nitrogen and harvest effects on switchgrass and maize contributions to deep soil C after 9 years
11.25-11.30 **Tóth, Z. & A. Dunai** - Soil organic carbon content – effect of tillage and fertilization in long-term field trials
11.30-11.35 **Xie, Z., G. Cadisch, T. Hasegawa, G. Liu, C. Chen, H. Sun, Q. Bei, H. Tang, J. Liu, Y. Xu, Q. Zeng & J. Zhu** – Soil organic carbon stocks, changes and CO_2 mitigation potential by alteration of residue amendment pattern in China
11.35-12.00 Discussion
12.00-13.00 Lunch

Division 4 – The Role of Soil C in Sustaining Society and the Environment

Soil C and the Environment *(Chair Rattan Lal)*

13.00-13.15	**Hartill, J., K. Hergoualc'h, L. Verchot & J. Smith** – Methane emissions following land use change on tropical peat in Jambi, Indonesia
13.15-13.20	**Ojima, D., M. Jahn, D. LeZaks & S. Collier** – Leveraging data, information and knowledge on soil carbon toward decision making for improving sustainability outcomes
13.20-13.25	**Adewopo, J., M.I. Silveira & S. Gerber** – Long-term soil C dynamics under three subtropical grassland management systems
13.25-13.30	**Waring, C., A. McBratney & B. Whelan** – Is percent ancient carbon a useful indicator of soil health?
13.30-13.35	**Comeau, L.-P., K. Hergoualc'h, L. Verchot, J. Smith & J. Hartill** – Soil CO_2 emission and soil organic matter characteristics associated with land-use change in tropical peatlands of Sumatra, Indonesia
13.35-14.05	Discussion

Soil C and Land Use Change *(Chair Markus Anda)*

14.05-14.20	**Novita, N., K. Hergoualc'h & J.B. Kauffman** – Soil carbon dioxide flux associated with land use change in the tropical peatland of Tanjung Puting National Park, Indonesia
14.20-14.25	**Kosaki, T. & S. Funakawa** – Dynamics of soil carbon, nutrients and microbial activity under shifting cultivation systems: clues about indigenous wisdom in the humid tropics
14.25-14.30	**Allaire, S.E., S. Lange, B. Baril, A. Vanasse, J. Mackay & D. Smith** – CO_2 dynamic in biochar amended sandy loam for switchgrass production
14.30-14.35	**Mayes, M., E. Marin-Spiotta, L. Szymanski, M. Ozdogan, M. Akif Erdogan & M. Clayton** – Land use and parent material effects on soil carbon stocks and spatial variability in the Konya Basin, Turkey
14.35-14.40	**Melling, L., K.J. Goh, A. Chaddy & R. Hatano** – Soil CO_2 fluxes from different ages of oil palm in tropical peatland of Sarawak, Malaysia
14.40-14.45	**Cihacek, L., K. Olson, M. Al-Kaisi, F. Arriaga, H. Blanco, J. Jifon, S. Kumar, R. Lal, B. Lowery, R. Miles, D. Presley, M. Ruark, T. Schumacher, D. Stott & K. Thelen,** – History of the NC-1178 Regional Research Committee
14.45-15.15	Discussion
15.15-15.45	Tea break

Summary

15.45-16.00	**Stahr, K.** – Division 1, Key Issues and Priorities
16.00-16.15	**Gerzabek, M.** – Division 2, Key Issues and Priorities
16.15-16.30	**Horn, R.** – Division 3, Key Issues and Priorities
16.30-16.45	**Lal, R.** – Division 4, Key Issues and Priorities

Closing

16.45-17.20	General Discussion
17.20-17.35	**Hartemink, A.E., K. McSweeney & J. Yang** Closing remarks

The knowns and unknowns of soil (organic) carbon and its sequestration

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Australia
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Abstract

Soil contains approximately 2.3 Tt of organic carbon globally, and about as much carbonate carbon, and is the largest terrestrial pool of organic carbon. Small changes in the soil organic carbon stock could result in significant impacts on the atmospheric carbon concentration. The fluxes of soil organic carbon vary in response to a host of potential environmental and anthropogenic driving factors. Scientists world-wide are contemplating questions such as: 'What is the average net change in soil organic carbon due to environmental conditions or management practices?', 'How can soil organic carbon sequestration be enhanced to achieve some mitigation of atmospheric carbon dioxide?' and 'Will this secure soil quality?'. These questions are far reaching, because maintaining and improving the world's soil resource is imperative to providing sufficient food and fibre to a growing population. Additional challenges are expected through climate change and its potential to impact food supply. There seem to be two conflicting views of soil carbon stabilisation: a chemical one and a biologico-physical one. These two views suggest different potentials for soil carbon sequestration. While most of the focus has been on organic carbon, warming and drying climates may lead to precipitation of secondary carbonates, while acidification associated with increased organic C sequestration may require neutralisation by lime reducing the net sequestration.

Notes

SOM: We know what, how much… but where?

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Abstract

Most research about soil organic matter (SOM) has dealt with its composition, fractionation, stability degree or turnover time, through analyses that imply the complete or partial destruction of the soil structure. More recently, different soil fractionation techniques on aggregates have produced much information about the relationships between SOM, minerals and soil structure. Nevertheless, there is still a gap between these 'lab-produced' aggregates or organo-mineral associations and the real structure in the field, since these techniques disregard the actual porosity pattern of soils, which is ultimately determining the variability of the microsite conditions where SOM is found. Classical micromorphology is the only technique producing true-scale images of porosity of undisturbed soils. Nevertheless, the study of SOM through light microscopy has the limitation of its isotropic nature, which results in it giving information about the size and shape of SOM particles, but not on their composition. Fluorescence microscopy, SEM and microanalyses applied to undisturbed samples are also very useful, although the results do not fully provide information about the distribution of SOM types. TOF-SIMS, nano-SIMS or XANES through synchrothron facilities can give information about the location of SOM functional groups in relation to soil structure. Therefore they are very promising in order to associate specific microsites and SOM with different degrees of activity or stability. We believe that the combination and development of these techniques would finally lead to a final objective: the location of SOM types along the continuum of observation from the landscape to the soil microsite.

Notes

Studies on the relationship between organic matter and exchangeable aluminum in representative soils of Cross River State, Nigeria

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Abstract

Fifty-two soil samples from cultivated and uncultivated land of Cross River State in Nigeria were analyzed for their contents of organic matter and exchangeable aluminum. The results indicated that organic matter ranged from 0.28 to 2.21 percent and 0.62 to 3.93 percent in the cultivated and uncultivated soils respectively. Mean values of 1.39 and 0.97 were obtained in the cultivated surface and subsurface soils while uncultivated surface and subsurface soils gave mean values of 1.87 and 1.29 respectively. The soil pH (H_20) -0.56*, 0.82** (cultivated surface and uncultivated subsurface soils), organic matter 0.66* (uncultivated subsoil), clay 0.86** (uncultivated surface soils).

Notes

Evolution of carbon storage and morphometric properties of afforested soils in the Central Russian Upland and U.S. Great Plains

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[2] USDA-ARS, National Laboratory for Agriculture and the Environment, Ames, Iowa, USA
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Abstract

Tree windbreaks represent an attractive multiple-benefit land use through their ability to mitigate climate change by modifying the local microclimate to improve crop growth and by sequestering carbon in the soil and tree biomass. The objective of this project was to use detailed soil profile descriptions and spatially-distributed soil sampling to determine the soil C sequestration potential of tree planting across climatic gradients at three sites in the Central Russian Uplands and the U.S. Great Plains. The three Russian sample locations, Streletskaya, Yamskaya, and Kamennaya spanned a gradient of mean annual temperature of 5.3°C and precipitation of 580 mm for Streletskaya to 5.8°C and 480 mm at Kamennaya. The three U.S. locations, Reynolds, ND; Huron, SD; and Norfolk, NE; had ranges of annual temperature of 3.9°C and precipitation of 450 mm for Reynolds to 9.2°C and 690 mm at Norfolk. The hydrothermal coefficient (HTC) of Selyaninov (1928) was used as a climate index for the sites. The HTC is calculated as $K=10R / \sum t$, where R is the precipitation for period within the year with temperature > 10°C and $\sum t$ is the sum of the mean daily temperatures for the same period. HTC values are 1.0, 1.1, and 1.23 for the Kamennaya, Yamskaya, and Streletskaya sites and 1.24, 1.31, and 1.48 for the Huron, Reynolds, and Norfolk sites. A lower HTC indicates relatively more warm and dry conditions. Tree windbreaks at the Russian sites ranged in age from 50 to 58 years and were within fields that had been cultivated over 140 years when sampled in 2012. Windbreak age ranged from 20 to 70 years and age of cultivation from 22 to ~110 years for the U.S. sites. At each site, soil pits were prepared within the windbreak, the adjacent crop fields, and a nearby undisturbed grassland. Profile descriptions were completed to a depth of ~1.5 m for all locations except Huron, which had shallow groundwater. Horizons were delineated at 10 locations on three pit walls, depth to carbonates determined via effervescence, and soil samples collected for laboratory analyses. Windbreak soils had consistently thicker humus-enriched A or A + AB horizons when compared to the crop fields. The thickness of A or A + AB horizons in the windbreak soils were most often comparable to the undisturbed grassland soils. A linear relationship was detected between the difference in A + AB thickness of soils beneath windbreaks and undisturbed grasslands and the HTC. These results indicate that windbreaks with more cool and moist climate conditions are more favorable for humus accumulation in the surface soil layers. The relationship between humus accumulation and climate factors enables the estimation of soil carbon stocks in existing windbreaks and the prediction of potential carbon sequestration in future plantings.

Notes

Soils as generators and sinks of inorganic carbon in geologic time

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Abstract

Soil development is a continuum in geologic time. That is, the surfaces of Earth's land masses would have been exposed to gains, losses, transformations, and translocations as paleo-continents drifted and collided regardless of the composition of the early atmosphere or the presence of early life. In the Precambrian, diffusion of CO_2 into soils would theoretically have been occurring before cyanobacteria colonized land. However, the advent of photosynthesis and microbial respiration on the otherwise barren terrain must have been a perturbation to the CO_2 flux in soil, as well as a stimulant to chemical weathering resulting from organic acids and the microbial harvesting of cations from minerals. In the Silurian, a similar but more profound perturbation would have occurred when vascular land plants colonized land. Thus by the early Paleozoic, soils were substantial generators of bicarbonate to groundwater and streams in humid regions. In arid and semiarid regions, however, soils are "non-flushing" and therefore bicarbonate accumulated in soil profiles, like today, as pedogenic carbonate, provided free calcium or magnesium was available. Experimental and micromorphology evidence reveals that roots and microorganisms facilitate the formation of pedogenic carbonate, which can therefore be considered as an ecologically induced biomineral. One major question dealing with soil inorganic carbon of current importance, a question that can be addressed by an IUSS network, is the following. Given the importance of a shrinking Cryosphere to the global carbon cycle, how would an expanding Aridosphere impact the global carbon cycle?

Notes

Quantification of soil carbon stocks in the field – some pedogeomorphic issues from the midwestern United States

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Abstract

Soil spatial variability in low relief glacial landscapes is often overlooked, poorly documented, casually explained as random, and rarely communicated. Modern soil spatial variability is the cumulative result of a complex interaction between geologic, biologic, hydrologic, anthropogenic, and pedologic processes acting over time. A great deal of modern soil spatial variation in the United States Corn Belt is systematic and can be explained through an integrated understanding of glacial and eolian sedimentation systems and post-glacial landscape evolution. The processes involved and the resulting variability occur across multiple scales on the landscape. An understanding of pedologic variability can aid in the applied aspects of soil resource decision making scenarios and aid in understanding soil carbon (SOC) stocks. The purpose of this presentation will be twofold. Initially the presentation will discuss the complex integration of glacial and post-glacial processes across the mid-continent and to highlight quantitative examples leading to a systematic understanding of modern soil-landscape relationships. Beyond the issue of soil variability in the field, reporting SOC stocks is also problematic due to the multiple ways SOC stocks are reported. The second portion of the presentation will compare and contrast current SOC reporting protocols and encourage a movement towards a pedologic reason for determining the depth and reporting method for SOC stocks. Examples from Iowa, Illinois, and Ohio landscapes with < 2 meters modern relief will be the focus of the presentation. The cumulative contribution of glacial depositional systems, sediment facies relationships, periglacial processes, Holocene hillslope erosion-sedimentation, bioturbation, and post-settlement agricultural practices on modern soil spatial variability and ultimately on SOC stocks will be discussed. Scientists monitoring SOC stocks in the field should be very aware of in-field variability associated with past agricultural practices and pedogeomorphic landscape evolution. In addition, a standardized methodology for reporting SOC stocks based on pedologic principles should be adopted.

Notes

Soil carbon stability in glaciated landscapes of northern Indiana

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Abstract

The concerns about climate change have increased interest in understanding differences in soil carbon pools and availability. The objective of this study was to assess the spatial distribution and stability of soil carbon (SC) as controlled by slope position, in glaciated northern Indiana. We collected 210 soil samples from the 0-25 cm surface layer along 10-point transects following the soil catena. Total SC was determined by dry combustion and C pools by incubation. The spatial distribution of total SC followed patterns related to soil wetness. Overall, the depression areas and the poorly- and very poorly-drained soils stored between 50 and 141 Mg C ha^{-1} or between 50 to 68 % more SC when compared to the drier areas. After 28 days of incubation (C_{min}), depressions and poorly- and very poorly-drained soils released 1.2 Mg C ha^{-1}, which was significantly more than the drier areas at 0.8 Mg ha^{-1}. All areas released about 0.6 and 1.1 Mg C ha^{-1} between day 28 to 60 (C_{act}) and 60 to 90 (C_{slw}), respectively, however, relative to total SOC size, the drier areas evolved about 8.5% C as CO_2 compared to 5.0% in the wetter areas. The mean daily rate of C-CO_2 evolved decreased exponentially during the first 28 days from 1.5 to 0.2 µg g^{-1} h^{-1}. Soils with high and relatively less decomposed organic matter represented by Haplosaprist great group had the highest amount of total SC, 141 Mg C ha^{-1}, compared to Endo- and Argiaquolls great groups with 60 Mg C ha^{-1}. The difference indicates the potential of Endo- and Argiaquolls, to store C if converted to C accruing management practices. The management of these targeted areas can potentially increase the soil C stock in arable lands. This information will be useful to those modeling soil C stock for global change calculations and to land managers developing systems that will sequester soil carbon.

Notes

Soil organic carbon and phosphorus status after combined of PR and organic materials in a gypsiferous soil[1]

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Abstract

Gypsiferous soils in Iraq are suffering from low fertility due to low levels of organic matter and limited availability of nutrients especially phosphorus (P). Therefore, two experiments were conducted to study the impact of combination of low cost phosphate rock (PR) and organic materials (OM) on soil organic carbon (SOC) and P status. The first experiment was an incubation experiment which was conducted to determine level of organic carbon (OC) required for the second experiment, this experiment was consisted of two factors the first was level of OC (as sheep manure) applied at nine levels viz: 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, and 0.60 % of soil weight, the second factor was level of PR (0, 20, 40, and 60 mg P kg^{-1} soil). The second experiment was a greenhouse pot experiment with two factors, the first was P source [triple super phosphate (TSP), PR, PR+ Peat, and PR+ Manure), the percent of OC in the OM was 0.6 %, the second factor was P level (0, 30, 60, and 90 mg P kg^{-1} soil). Wheat (Triticum aestivum) was grown in the second experiment. Results from incubation experiment showed that increasing OC application increased available P (Avail. P) and water soluble P (WSP) as expressed by power and exponential models, respectively. Available P was also increased linearly by increasing P level in soil (incubation experiment). Results of pot experiment revealed that the fourth treatment (PR+manure) was significantly superior over other treatments in increasing root weight, organic P (OP), and Avail. P, while the third treatment (PR+Peat) was significantly superior over other treatments in increasing SOC.

Notes

Soil microbial biomass in Andosol for C storage index and buried paleosol

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Abstract

Andosol is important soil in Japan, covering about half of arable upland, with huge amount of soil carbon stock. Microbial biomass is pool of nutrients and motor for soil C turnover. Soil microbial biomass C (SMC) in surface Andosol in Japan was measured and correlation to total soil C (TC) was compared with those for non-Andosol. Significant linear correlation was found for both groups; however the slope for the correlation (SMC/TC) was significantly lower for Andosol than for non-Andosol. This indicates that SMC is relatively lower in the same TC level. Subsurface Andosol in buried paleosol had higher SMC than upper soil layer than buried paleosol, indicating that cumulated soil C may be substrate for microorganisms even after thousand years of eruption and surface horizon formation. These finding indicate unique features of microbial biomass and C turnover in Andosol.

Notes

DOC-iron relations under fluctuating redox conditions in Gleysol-Phaeozem and Histosol-Phaeozem toposequences

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Abstract

Present study focuses on the spatial pattern, seasonal dynamics and interrelationships between redox conditions (EH), dissolved organic carbon (DOC) and dissolved iron (DI) in headwater wetlands. Altogether eight profiles were studied along two toposequences. These toposequences are located in Völgység region and in Danube-Tisa Interfluve (Hungary, Central Europe). Each profile represents core parts and boundaries of vegetation induced patches (ecotopes). Seasonal and diurnal dynamics of porewater temperature, pH, EH, have been recorded and porewater have been sampled in each profiles. DOC and DI were measured by C/N elementar analyser and fl-AAS. Spatial pattern results significant differences in studied environmental factors even within small area. Higher EH measured generally in nettle (U. dioica) covered Phaeozems, while the most reductive conditions prevailed in vegetation boundaries: sedge (C. riparia) – reed (Ph. communis). These boundaries were characterized by mollic Gleysol and gleyic Phaeozem. Temporal variability of redox conditions partly depended on the physiological activity of plants and the saturation of the wetland soils too. The seasonal fluctuation in redox potential is only determined by vegetation: the EH values decreased from March to August. In EH values we also observed strong diurnal dynamics. As similar as EH, DOC also showed diurnal and seasonal fluctuations. The decreasing EH always caused increasing DOC content, the correlation coefficient was strong between them (Spearman's rho -0.840). DOC values in the boundaries were 3-4 times higher than in core part of the ecotopes. Reductive conditions increase solubility of iron as the EH range of the Fe reduction process (Fe3+ to Fe2+) is between +200 and -100 mV. In our field-scale measurements four redox ranges have been identified where solubility of iron is increased (+320 to +270, +80 to +70, +30 to +20 and -160 mV). These ranges not definitely appeared in all studied spatial units, it seems that they were specific to the local vegetation. The increasing DOC content led to increasing amount of dissolved iron (Spearman's rho 0.988) when EH was higher than +100 mV. Under +100 mV the concentrations of DOC remained constant, while dissolved iron content increased further, so in this range there is a direct correlation between the amount of dissolved iron and the redox conditions (-0.897). Our results suggest that the increased iron solubility under slightly reductive conditions (upper +100 mV) is generated by organic complexation of iron.

Notes

Organic carbon as major differentiation criteria in soil classification systems

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Abstract

Organic carbon is one of the major differentiation criteria in internationally used (such as Soil Taxonomy and the World reference base for soil resources) and most national soil classification systems. Several soil units on the highest level of systems, surface and subsurface horizons, modifiers and qualifiers are defined on the basis of the presence and amount of organic carbon and/or the depth and thickness of organic carbon rich soil layers. The paper is discussing and evaluating the current definitions based on simple statistical and mathematical approaches applied on the US NASIS and the ISRIC WISE data sets. Conclusions on the consistency and the differentiation functions of the organic carbon related criteria, as well as visions and approaches for a future global classification system will be presented.

Notes

Digital mapping of soil carbon

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Abstract

The reliable assessment of soil carbon stocks is of key importance for soil conservation and in mitigation strategies for increased atmospheric carbon. This paper will review and discuss the recent advances in digital mapping of soil C. The challenge to map carbon is demonstrated with the large variation of soil C concentration at a field, continental, and global scale. The general activities in digital soil mapping involve: collection of a database of soil carbon observations over the area of interest; compilation of relevant covariates (soil forming factors) for the area; calibration or training of a spatial prediction function based on the observed dataset; interpolation and /or- extrapolation of the prediction function over the whole area; and finally validation using existing or independent datasets. We discuss several relevant aspects in digital mapping: carbon concentration and carbon density, source of data, sampling density and resolution, depth of investigation, map validation, map uncertainty, and environmental covariates. We demonstrate harmonization of soil depths using the equal-area spline and the use of a material coordinate system to take into consideration the varying bulk density due to management practices. Soil C mapping has evolved from 2-D mapping of soil C stock at a particular depth ranges to a semi 3-D soil map allowing estimation of continuous soil C distribution with depth.

Notes

GlobalSoilMap and global carbon predictions

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Abstract

The GlobalSoilMap project is representative of a global consortium of scientific institutions involved in soil survey and soil science. The GlobalSoilMap group was formed as an outgrowth of the International Union of Soil Sciences Working Group for Digital Soil Mapping with the purpose of providing consistently produced soil property information at 100m resolution across the world to aid in solving some of the key environment and societal issues including food security, global climate change land degradation and carbon sequestration. Data would be produced using mostly the storehouse of existing legacy soils data along with geographic information and a range of coavariates. A range of modeling techniques is used dependent on the complexity of the soil survey information. There are key soil properties that would be most useful to the modeling community and other users: organic carbon (g/kg), texture (sand %, silt%, clay% and coarse fragments %), pH, depth to bedrock or restrictive layer. Predictions are made at specified depths with uncertainty values assigned to each prediction. An innovative splining technique will be employed to provide a continuous prediction of soil property values throughout the depth of each profile. Maps have been produced at the country level in the Australia, Canada, Denmark, Nigeria, South Korea and the US and many other parts of the world.

Notes

Organic carbon stock in topsoil of a forest land in Nigeria

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Abstract

In this study, soil samples were taken from the O/A horizon of undisturbed Oil palm (*Elaeis gueinensis*), Teak (*Tectonia grandis*), and Dikka nut (*Irvingia gabonensis*) plantations of about 18 to 20 years old. The samples were analysed for pH, exchangeable acidity, organic carbon, organic matter, particle size. Results of the soil analysis showed Teak plantation had significantly higher organic matter concentration than the Oil palm and Dikka nut plantations. The result suggests that the teak plantation had high soil fertility plots than other land uses and the virgin forest. Soil organic carbon were similar for the Oil palm and Teak land use types but were both higher than the organic carbon value in the Dikka nut plantation (O/A horizons). This result suggests that Teak plantations may be advantageous for increasing soil fertility but, with respect to restoration of the soil nutrient parameters studied and subsequently contribute positively to plant growth.

Notes

Carbon balance with climate resilient technology interventions in 100 vulnerable districts of India

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Abstract

Global warming potential (GWP) is used to compare the effectiveness of each GHG to trap heat in the atmosphere relative to some standard gas, by convention CO2. EX-ante Carbon-balance Tool (EX-ACT), developed by FAO provides ex-ante measurements of the impact of agriculture (and forestry) development projects on GHG emissions and C sequestration. Under National Initiative on Climate Resilient Agriculture (NICRA) project, various climate resilient farm technologies (Soil, water, nutrient, crop, livestock, forestry etc) are being demonstrated during last one and half years in 100 villages in climatically vulnerable districts. Out of this, carbon balance was studied with EX-ACT model for 4 villages in Nalgonda and Khammam districts in Andhra Pradesh. Interventions in Nandyalagudem (Nalgonda) showed that the project activities represent a sink of 3854 t CO2 e (tons CO2 equivalents). The project is able to sequester 5712 t CO2 e while emitting 1857 t CO2 e so that the net effect of project activities created a sink of 3854 t CO2 e. In Boringthanda village, a net balance of 2410 t CO2 e, corresponding to a mitigation potential of 12.5 t CO2 e. In Nacharam village of Khammam district, the project is being implemented in 1272.9 ha area and have a potential to sink of 6176 t CO2 e during 20 years. The modules of inputs, livestock and non-forest land use changes showed sources of 6908 t CO2 e.

Notes

Assessment of soil carbon content across several U.S. cropland watersheds

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Abstract

The cropland Conservation Effects Assessment Project (CEAP) was initiated to provide a scientific basis for assessing effectiveness of conservation practices on water and soil quality. In 2006, sampling was initiated within a number of USDA-ARS experimental watersheds to measure and assess management impacts on near-surface (0 to 5 cm) soil quality indicators. In this paper we focus on soil organic carbon (SOC) content from over 3,400 samples, because of its influence on several other soil quality indicators. The sampling schemes for each of the 17 locations were designed to address individual objectives. For instance, in the St. Joseph River Watershed in northeastern Indiana, the question was how pothole topography and management were impacting soil quality. We used the Soil Management Assessment Framework (SMAF) to score the measured data so that climate and inherent soil factors would be taken into account. The SOC-SMAF scoring algorithms, which are modified based on soil classification, texture and climate, use a more-is-better model reflecting the amount of SOC associated with good productivity and minimal environmental impact. Cropping systems within the St. Joseph Watershed included corn (*Zea mays*)-soybean [*Glycine max*. (L.) merr.], corn-soybean plus wheat (*Triticum aestivum*) and/or oat (*Avena sativa*) in the rotation, alfalfa (*Medicago sativa*), and crop reserve program (CRP) land. Where possible both tilled and non-tilled systems were evaluated for each cropping system, with samples taken along slope transects that reflected watershed topography. Interactions among many factors including soil type, climate, and management practices such as tillage and crop rotation influenced SOC content at each sampling site. Measured SOC contents ranged from 3.0 to 21.7 g kg^{-1} and SMAF-SOC scores ranged from 0.09 to 1.00, where 1.00 represents optimum levels of SOC based on soil taxonomic classification and climate. The mean SMAF-SOC scores were 0.43, 0.51, and 0.43 for summit, mid-slope, and toe-slope positions. Analysis by current crop showed SMAF-SOC scores of 0.57, 0.52, 0.44, 0.41, and 0.72 for corn, soybean, wheat, alfalfa, and CRP, respectively. This assessment and those planned for the other watersheds are expected to show that SOC evaluations need to be soil- and site-specific because many factors, including environmental influences and inherent soil characteristics, influence this important soil quality indicator.

Notes

Distribution of organic carbon in Antarctic soils

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Abstract

Antarctica can be divided into nine ice-free regions. Only 0.35% of the continent is ice-free, amounting to 49,000 km^2. However, because of a dramatically warming climate, the ice-free area of Antarctica is increasing; and there is evidence that the soils may be acting as a sink rather than a source for atmospheric carbon dioxide. Profile quantities of soil organic carbon (SOC) are greatest along the Antarctic Peninsula, intermediate in East Antarctica, and lowest in the Transantarctic Mountains (TAMs). Sea-birds and nesting birds constitute the dominant factor influencing SOC levels in Antarctic soils. There is a positive correlation between C density and number of months where the mean annual air temperature is above 0°C. In the McMurdo Dry Valleys, profile quantities of SOC are related to proximity to water sources. From chronosequence studies, the amounts of SOC in the TAMs peak in about 2 ka yr and declines thereafter.

Notes

On soil carbon monitoring networks

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Abstract

Numerous scientific challenges arise when designing an soil monitoring network (SMN), especially when assessing large areas and soil carbon content and stocks that are driven by numerous controlling factors of various origins and scales. Different broad approaches to the establishment of SMNs are reviewed. National frameworks for soil monitoring exist in numerous countries and especially in most member states of the European Union. However, while some countries have achieved uniformity in methodology and coverage, this is far from common even among national systems. In addition to achieving harmonization, there are many generic issues that must be addressed by scientists when establishing and operating SMNs, including the requirement for these to be effective for different soil-systems. Of particular importance is the requirement for SMNs to detect change in soil C over relevant spatial and temporal scales with adequate precision and statistical power. We present several examples addressing this scientific issue and summarize the main findings of previous reviews on this topic. It is essential to establish an adequate sampling protocol that can be applied rigorously at each sampling location and time. We make some recommendations regarding the within-site sampling of soil. Different statistical methods should be associated with the different types of sampling design. At the global scale the question of sampling and testing method harmonization remains a very difficult issue. The establishment of benchmark sites devoted to harmonization and inter-calibration is advocated as a technical solution. We present a case study in France addressing crucial scientific issues such as how many calibration sites are necessary and how to locate them.

Notes

Monitoring of soil carbon stock and soil management in Japanese agricultural land

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Abstract

A better understanding of spatial and temporal variation of soil organic carbon stock and the related factors in agricultural land is crucial for promoting climate-smart agriculture. A national soil carbon monitoring project (approximately 3300 sites) has been launched since 2008 in Japan in order to monitor annual variation of soil carbon and its association with agricultural management at national scale. This paper summarized the latest soil carbon stock and agricultural management, using data between 2008 and 2011. Soil carbon stocks in surface soils showed that carbon stocks varied depending on soil types. Average soil carbon stock was the highest in Peat soils (Histosols, 220 Mg ha^{-1}), followed by Andosols (Andosols, 100-130 Mg ha^{-1}), Lowland soils (Fluvisols, 55-70 Mg ha^{-1}), and Brown Forest soils (Cambisols, 66 Mg ha^{-1}). It was even lower in Red and Yellow soils (Acrisols, 40-55 Mg ha^{-1}) and was the lowest in Sand-dune Regosols (Arenosols, 25 Mg ha^{-1}). The amount of agricultural land in Japan totaled 4.6 million ha, and it contained 383 Tg of soil carbon within 30 cm depth. Agricultural management, such as organic amendment (OA) application and crop residue management, differed depending on land uses, but there was a small annual variation. The average OA application rate was the largest in greenhouse and the lowest in paddy field in the four years of the survey. On the other hand, crop residue incorporation and surface application were the most common management practices in paddy field, while it was removed in greenhouse.

Notes

Carbon balance at regional scale estimated with Century model in southern Brazil

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Abstract

The conversion of native ecosystems in agricultural use has been identified as a major factor responsible for greenhouse gases emissions, especially CO_2, into the atmosphere, contributing to global climate change. In tropical regions, such as Brazil, changes in land use and soil management directly affect the soil organic matter dynamics, reducing nearly to 50% of the carbon (C) stocks even in the first years of cultivation. Modeling of soil organic C (SOC) dynamics associated with geographic information systems (GIS) can be useful to estimates C emissions and sequestration as a function of the changes in the land use and soil management. Thus, in order to estimate the balance of CO_2 emissions and sequestration at the regional scale based on estimates of the Century model and GIS, we selected Santana district, in Ijuí, RS (28° 20'27"S and 53° 53'27"W; elevation of 220-400 m), in southern Brazil, covering a total area of 10,669 ha. In the Santana district occur Oxisols (6,359 ha, 60%), Inceptisols (1,833 ha, 17%), Chernosols (1,468 ha, 14%), and Entisols (1,009 ha, 9%). We identified in the Santana District, four homogeneous areas [Area 1 (51.1 ha), Area 2 (142.0 ha), Area 3 (77.1 ha), and Area 4 (102.2 ha)] based on cropping systems, soil tillage systems, and presence of remained native vegetation; however, these areas were converted into agriculture at different times. Within these areas soil samples were taken at 0-20 cm soil depth in native forests and croplands located under Oxisols with a maximum slope of 8%, due these soils are the most intensively cultivated and fairly representative of regional agriculture. Soil samples were analyzed to soil texture, soil bulk density and soil carbon concentration. The Century model was calibrated and validated based on the sampled areas and their estimates were generalized to the entire area of Santana district. Therefore, we define different simulation units (SU) that are similar zones in soil type, landscape elements (hilltops, slope, and depositional areas) and time of agricultural use (1901, 1957, 1965, 1976, and 1988). For delimiting the SU, we used GIS techniques performed in ArcGIS 9.x. Century model was used to estimates the CO_2 emissions to the atmosphere due the burning of the native forest remaining material, and also the balance of both C and CO_2 as a function of soil management after the beginning of agriculture. The agricultural land use reduced SOC stocks from 550.9 x 103 to 276.8 x 103 Mg of SOC between 1900 (original condition) and 1986 (end of most intensive tillage), which represented emission of 2,277.5 x 103 Mg of CO_2 to the atmosphere. However, when conservation tillage was adopted since 1987 we observed recovery of the soil C content. It was estimated for 2007 compared to 1986, the recovery of SOC stock in 60.9 x 103 Mg (still 38.7% below the original). In same period, if not considered burning the forest, we observed positive CO_2 balance with CO_2 sequestration about 276.5 x 103 Mg of CO_2. These results shows the CO_2 potential emission to the atmosphere by the forests removal and burning, as well as the potential of soil C sequestration by the adoption of soil conservation tillage systems. Moreover, it was observed that the Century model adequately estimated the evolution of SOC stocks and CO_2 balance due to the use, land use changes, and soil management. Century model can be an important tool to study the impact of agriculture on both SOC stocks and global climate changes.

Notes

Soil carbon changes over two decades in the northern Great Plains of the U.S.

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Our early work in the northern Great Plains of the U. S. involved sampling 28 paired cropland-undisturbed grassland sites across Major Land Resource Area (MLRA) 54 of southwestern North Dakota in the early 1990s. The paired sites included sampling long-term cropland areas with undisturbed grassland areas located within 100 meters of each other on similar soils. At the initial sampling, the cropland sites had previously been predominantly managed in a crop-fallow culture. During the intervening years, crop-fallow has evolved into continuous cropping with no-till management with no-till management. Nine of the previously sampled sites representing three soil series were re-sampled in 2010 to evaluate the soil C changes occurring over nearly two decades time. Changes in both soil organic C and inorganic C will be discussed.

Notes

Modelling soil organic carbon stocks in Sub-Saharan Africa

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Abstract

Over 70 percent of Sub-Saharan Africa is rural and heavily dependent on natural resources from their immediate environment. Sub-Saharan Africa is also the region with the world's highest rate of soil degradation (46 percent of the continent). Depletion of soil organic carbon (SOC) has been identified as a major process in soil degradation, to the extent that SOC content has been equated to soil quality. SOC plays a vital role in soil fertility and biodiversity conservation as well as in soil water-holding capacity and the prevention of erosion and desertification. Due to the large size and long residence time of organic carbon in the soil, SOC has received much attention in recent years for its role in mitigating the effects of raising atmospheric CO_2 and associated climate change. A deep understanding of the relative importance of the different regional, landscape and local factors affecting SOC stocks is therefore crucial for an optimum management of African soil resources and the goods and services that they provide. In the framework of the EU funded ClimAfrica project, a stratified random survey is being coordinated in 9 study areas distributed across a spanning climate gradient and encompassing a wide range of representative African ecosystems in order to build a database including drivers at regional (climate, bedrock), landscape (topography) and local (management, socio-economy) scales. Empirical modeling techniques will be applied to assess the relative importance of these factors on productivity, SOC and biodiversity variables. The models will allow the assessment of the consequences of potential climate and land use changes on African ecosystems and human well-being. We discuss the importance of common databases of field measurements in the investigation of ecological processes related to biogeochemical cycles, the assessment of SOC stocks and dynamics, and the projection of possible ecosystem responses in front of environmental changes. Prospective analyses of the first sets of results will be presented and discussed.

Notes

Soil organic carbon content in Croatian agricultural regions topsoil

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Abstract

This paper presents the state of soil organic carbon (SOC) content in soils of agricultural regions and subregions of Croatia, and differences caused by climate, geomorphology, soil conditions, and land use. For research, Northwestern (NP) and the Eastern Pannonian (EP), Mountain (M), then North (NA) with South Adriatic (SA) subregions was selected. Data source for determining SOC was humus content in the surface layer of soil profiles collected during the production Croatian soil map in scale 1:50.000. Among the examined subregions, an important difference of agroecological factors is determined. Decreasing trend in rainfall M>NP>NA>SA>EP, and air temperatures SA>NA>EP>NP>M is defined. NP and EP subregion marks lowland relief flat to almost flat terrain, NA lowland and hilly-mountainous relief, M mountainous relief and SA hilly and mountainous relief. In the area of NP and EP subregions, dominating parent material is alluvial deposits, at NA limestones, dolomites and flysch, and at M and SA limestones and dolomites. Average SOC content in the studied agricultural subregions varies from low (1-2%) in arable soils, to moderate (2-4%) in soils that are under grassland or forest. General downward trend in SOC caused by different environmental conditions to individual sub-regions is as follows: M>SA>NP>EP>NA. Determined minimum values of SOC in arable soils of all subregions studied indicate inherent rapid reduction process of organic matter in intensive agricultural production, and the need to undertake measures for the protection of such soils.

Notes

The carbon balance of soils in the Northern Eurasia

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Abstract

The Northern Eurasia is a huge area covering different climates, vegetation zones and soils. The territory is rarely populated and is poorly known for scientific community. As a result the area is insufficiently introduced in the global C cycle. The study closes this gap and illustrates available spatially distributed data characterizing the magnitudes and distributions of terrestrial C reservoirs and fluxes, their historical and present-day dynamics. The C reservoirs include soil (organic and inorganic C) by standard layers, above and below ground vegetation. Agriculture and forestry initiated the loss of about 5 PgC which is about 20% of initial C content in soils. The C fluxes cover all fluxes in and out of vegetation and soil, such as net primary production, litterfall, consumption and disturbances of vegetation, humus mineralization, humification, leaching, river transport, etc. Based on the GIS techniques principle C balances have been computed e.g., vegetation, soils, ecosystems (vegetation – soil associations), net ecosystem production, net biome production, contribution of the Northern Eurasia to the Atmosphere. Based on the abovementioned results the best C management practices minimizing the risks of unappreciated climate change are drawn for different regions of the territory.

Notes

A novel method for measurement of carbon on whole soil cores

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Abstract

To evaluate soil carbon stocks over broad landscapes there is a general lack of confidence because current information is based on point analyses of a highly variable quantity which may also not comparable between data sets. Dry combustion is the most reliable and trusted method of determining soil C but like all methods has been severely challenged by the required scale. Several alternative methods for measuring soil carbon stocks have been promoted in recent years as a way of dealing with the current soil-C data crisis but all these techniques such as spectroscopy are very dependent on standardising by dry combustion.

A new robust approach has been developed where the contents of whole soil cores have been analysed by dry combustion to yield unambiguous and reliable C data for full depth intervals. The demonstration system has a current configuration which is based on extracting all C from a 50 cm length soil plugs. The method relies on direct quantitative detection and minimising any interference from water which can be considerable in clay soils. Apart from pre-drying to remove excess moisture, the flow-on benefits have been vastly reduced time and associated costs in soil processing. The greatest advantage is that this methodology captures the natural variability in all dimensions and can directly produce results on a volumetric (kg/m^2) or gravimetric (g/kg) basis making it readily amenable to any protocol such as proposed under IPCC without the need to worry about bulk density. Determinations on cores have been reproduced within 0.1% C (mass basis) which is the level of sensitivity required so that any uncertainty in measurement can be kept below any real spatial and temporal changes. The technique, which can be deployed on cores set out over a grid (sampling design), facilitates fast and cost effective determination of soil C stocks to support mapping and modelling.

Notes

Overview of the U.S. Rapid Carbon Assessment Project

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Abstract

The Rapid C Assessment was undertaken to ascertain the soil carbon stocks across the conterminous US at one point in time. Sample locations were chosen randomly from the NRI (National Resource Inventory) sampling framework and cover all areas in the continental US with SSURGO certified soil maps as of Dec 2010. The project was regionalized into 17 areas for logistical reasons. Within each region, soils were grouped by official soil series description taxonomic class and properties. Sites were selected by soil groups and land use/cover as indicated by NRI or NLCD (USGS National Land Cover Dataset) class so that more extensive soils groups and land use/covers received more points and less extensive fewer points (with a minimum of 5 sites). Each region had 375 – 400 sites resulting in approximately 6,400 sites. At each site, basic information about land use, vegetation and management were collected as appropriate and available. Samples were collected from 5 pedons per site to a depth of 1m, at 0 – 5cm and by genetic soil horizon. A volumetric sample was collected for horizons above 50 cm to determine bulk density. For horizons below 50cm, or when a volumetric sample could not be obtained, bulk density was modeled from morphological information. All samples were air dried and crushed to <2mm. A visible near-infrared (VNIR) spectrophotometer was used to scan each sample. Partial least square regression of the scan was used to predict organic and inorganic carbon concentrations for all samples. A subset of pedons (~3%) was sent to the NRCS Kellogg Soil Survey Laboratory in Lincoln, NE for carbon analysis (combustion and calcimeter). A Bayesian statistical approach was used to incorporate error into model predictions for each sample. Carbon concentration and stocks were summarized by surface horizon and depth increments for pedons, sites, soil groups, and land use/groups. Average C contents for soil group – land use combinations were mapped by linking the values to a raster of SSURGO (Jan 2012) that includes map unit components and NLCD classification. Future work will map carbon across landscapes using environmental covariates and produce probabilities of C concentrations and stocks across multiple land use and management scenarios.

Notes

Distribution of soil carbon in the conterminous United States and implications for sampling strategies

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Abstract

The Soil Survey Geographic (SSURGO) database provides detailed soil mapping for most of the conterminous United States (CONUS). These data have been used to formulate estimates of soil carbon stocks, and have been useful for many types of environmental models, including hydrologic models and ecological models for studies of greenhouse gas exchange. The data were compiled by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) from 1:24,000-scale or 1:12,000-scale maps developed through the National Cooperative Soil Survey. The total soil organic carbon stock in CONUS to one meter depth is estimated as 51 Pg C and for the total profile as 73 Pg C, as estimated from SSURGO with data gaps filled from the 1:250,000-scale General Soil Map of the United States. In this presentation, we explore the non-linear distribution of soil carbon on the landscape and with depth in the soil, and the implications for sampling strategies that result from the observed soil carbon variability.

Notes

Spatial distribution of topsoil organic carbon in Europe

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Abstract

Soil organic matter (SOM) is essential for soil quality. It protects soils from degradation and increases water availability by forming stable aggregates, it enhances fertility by making nutrients available for plants and provides a suitable living environment for soil macro- and micro-fauna. In addition, the potential to augment the pool of SOM is seen as a way to mitigate climate change by increasing the sequestration of carbon dioxide (CO_2) or by reducing its emission. Therefore, improving the monitoring, reporting and verification of soil organic carbon (SOC) is an urgent matter to address. Mapping SOC content allows establishing a baseline which can be used to improve SOC management. In the present study, the measured organic carbon content of 20,000 soil samples collected throughout Europe was used to produce a map of soil organic carbon content. In 2009, the LUCAS-soil (Land Use/Cover Area frame statistical Survey) survey was implemented in 23 Member States of the European Union. About 20,000 soil samples were collected following the same sampling methodology and analysed in a unique laboratory for basic soil physico-chemical properties, among which organic carbon content. LUCAS-soil is the first harmonized survey conducted at continental scale in Europe. In order to map SOC content using the LUCAS data, a digital soil mapping by regression approach was followed. The latter consists in fitting a statistical regression model between measured SOC and the value of the independent variables (covariates) representing the environmental factors influencing its dynamics in the soil. The predictions at unsampled locations are then made by applying the fitted model on the covariates. A linear regression model was fitted with the ordinary least squares (OLS) technique. The significant covariates selected by the model optimisation are the followings: CORINE land cover, elevation and slope (SRTM derived), accumulated annual average temperature and the precipitation over potential evapotranspiration ratio (derived from WorldClim global climate database), geology, net primary productivity (MODIS land-product), texture classes (derived from the LUCAS database). A backward/forward stepwise feature selection was performed to identify the most significant covariates. The overall model-fitting performance (adjusted-R^2) is of 0.368. A k-fold cross-validation (50 iterations with a 0.2/0.8 validation/fitting ratio) was performed and gave an R^2 of 0.367. The normalized root mean squared error equals 15%. The regression residuals were then interpolated using simple kriging and added to the map obtained from regression following a regression kriging procedure. The map produced is the most up-to-date outline of SOC distribution in Europe.

Notes

Uncertainty propagation of the RaCA soil carbon stock data

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Abstract

Understanding the uncertainty around mean soil properties is necessary for environmental risk assessment, ecosystem service monitoring programs (e.g., carbon sequestration and exchange), incorporation into earth system models, and determination of efficient sampling designs. Yet, uncertainty is rarely reported due to insufficient sampling effort or a lack of tractable error propagation methods. The Rapid C Assessment (RaCA) was undertaken to ascertain the soil carbon stocks and uncertainty of those stocks across the conterminous US at one point in time. The RaCA project's replicated random sampling across a clustered-nested design (17 regions, 12 to 20 soil groups within regions, seven land use types within groups, multiple sites within land use types, and five pedons from each site for more than 32000 pedons) allows for assessment of soil C stock uncertainty at a spatial scale never before attempted. With this design the uncertainty can be attributed to a combination of analytical measurement errors, land use effects, and spatial heterogeneity. Propagation of this uncertainty is being assessed with Monte Carlo simulation and analytical methods (e.g., moment methods). The exact nature of the Monte Carlo simulations allows for complete and straightforward uncertainty propagation, but it is computationally expensive and complicates partitioning of uncertainty components. In contrast, analytical methods allow for assessment of nested uncertainty, yet require distributional assumptions that may not be desirable. A comparison of uncertainty propagation methods will be presented using the RaCA soil C stock dataset.

Notes

Carbon variability in some Hungarian and Croatian Soils

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Abstract

Within Bilateral Project between Hungarian and Croatian scientists “Impact of tillage and fertilization on probable climate threats in Hungary and Croatia, soil vulnerability and protection” carbon storage were determined in different soil types in agroecological conditions of Pannonian plain and in Mediterranean region. Total carbon content and CN ratio in different natural (grasslands, meadows, forests) and agro ecosystems (vineyards, gardens and crop fields) were determined. Soil samples were taken during the spring and summer 2010 at different locations. Sampling depths varied from 0-3 cm, 3-10 cm, 0-30 cm, 30-60 cm and 60-90 cm depending on the location, region, soil type and type of ecosystem. At 16 different locations, 6 in Pannonian plain and 10 in Mediterranean region following results are recorded: CN ratio varied from 11 up to 39 determined in Mediterranean vineyard on Cambisol calcaric; carbon content observed in this study varied from 3.3 g C/kg measured in Szentgal at agricultural crop field on Eutric Cambisol in deeper layers (< 60 cm) up to 107.2 g C/kg measured at Mediterranean grassland in surface layer (0-3 cm).

Notes

Evolutionary optimization of spatial sampling networks designed for the monitoring of soil organic carbon

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Abstract

Soil organic carbon is one of the most important pools in the global carbon cycle. Periodical monitoring of this variable has been requested by the scientific community because of its relevance in the global climate change. However, the sample size needed for a reliable estimation through geostatistical methods has leaded to a problem of designing sample networks that minimize the variability while accounting for the budget, situation that becomes an optimization problem. In this research, a mathematical technique known as genetic algorithms was used for designing spatial networks for second-phase sampling of soil organic carbon in CORPOICA's La Libertad Research Center, in order to find a sampling design that optimally reduced the kriging standard error. In the spatial variability analysis of the edaphic variable studied, a satisfactory semivariogram modeling was done through the selection of spherical models. The selected model showed a strong spatial dependency and range values associated to the expected behavior of the variable and to the information collected during field work. According to the results of the design of spatial sampling networks, random schemes obtained through optimization with the method of simultaneous points were more efficient than regular schemes, under La Libertad's biophysical conditions. Besides, it was found that the sequential point method produces suboptimal solutions and it becomes less efficient than the method of simultaneous points when the sampling size is increased. Genetic algorithms optimization method proved to be appropriate to find optimal sites for sampling, although it is a time-consuming technique that requires high computing power and processing speed.

Notes

Mapping soil carbon using legacy samples with uncertainty

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Abstract

This paper presents a new approach to map soil carbon using legacy soil samples and to quantify the uncertainty associated with the use of these samples. This approach assumes that each sample has some representation in the environmental feature space (individual representativeness). This representation can be used to map soil carbon. Based on the assumption that the more similar the environmental conditions the more similar the soil carbon content, the approach employs the Case-Based Reasoning (CBR) concept to predict soil carbon for areas whose environmental conditions are similar to these of the samples. The uncertainty associated with each prediction is computed based on this similarity between the environmental conditions at the sample sites and these at the location of prediction and is then used as a proxy to the quality of the prediction. A case study located in XuanCheng of AnHui Province in China, has demonstrated that this approach was an effective and accurate way to predict soil carbon of the surface layer. It was also shown in this case study that the uncertainty is positively related to the prediction residuals and the uncertainty map can be used to not only show the spatial variation of accuracy but also locations for additional samples to effectively improve the accuracy of the predicted map.

Notes

Proximal soil sensing of soil carbon stores for more certain accounting

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Abstract

Soil organic carbon is an important property that helps to define the qualities and functions of soil. For instance, it increases the cation capacity of soil, increases water-holding capacity, and improves soil structure. The ability of soil to sequester carbon is of increasing interest as a potential way to mitigate greenhouse gases in the atmosphere. The measurement of soil organic carbon content and composition (i.e. the measurable organic carbon fractions: particulate, humic and resistant carbon) can be improved using proximal soil sensors. The aim of this presentation is twofold. First, I will review some of the technologies that can be used, which include charge-coupled devices, vis–NIR, mid-IR and laser induced breakdown (LIBS) spectroscopy, and inelastic neutron scattering. Second, I will report results of research to develop a multi-sensor system to measure soil organic carbon, bulk density and carbon fractions. Results will show that the multi-sensor system can be used to derive accurate estimates of soil carbon content, carbon stores and composition, which might then be used for baselining and with appropriate designs also monitoring.

Notes

Shedding light on carbon-mineral complexation in the soil environment: impacts on C sequestration and cycling

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Abstract

Organic matter (OM)-mineral complexation plays a critical role in soil carbon (C) stabilization. However, direct investigations of organo-mineral associations have been hampered by a lack of methods that can simultaneously characterize soil organic matter and soil minerals. We have applied scanning transmission X-ray microscopy (STXM), combined with near edge X-ray absorption fine structure (NEXAFS) spectroscopy at the C1s, Ca 2p, Fe 2p, Al 1s and Si 1s edges to investigate C distribution and speciation and its associations with Ca, Fe, Al and Si species in soils within the Christina River Basin Critical Zone Observatory (CRB-CZO). Results showed a strong role of Ca in C-mineral association. Fe oxide coatings were more important than aluminosilicates in promoting C-mineral associations. The major C forms associated with soil minerals were aromatic C, carboxylic-C and polysaccharides. Ferrihydrite contributed significantly to organic matter complexation. OM-ferrihydrite complexes can be formed by either adsorption or coprecipitation. We examined these interactions by preparing OM-ferrihydrite complexes at varying C:Fe ratios (0.05-5.36) using dissolved organic matter extracts from a forest litter layer. We monitored C retention capacity, chemical fractionation of OM by UV-Vis spectroscopy, changes in specific surface area (SSA), micro- and mesopore volumes of the OM-ferrihydrite complexes by N2 adsorption and desorption, and desorbability of the adsorbed and coprecipitated OM associated with adsorption and coprecipitation processes. These studies were combined with NEXAFS and Fourier transform infrared (FTIR) spectroscopy to compare the mechanisms of OM-ferrihydrite complex formation. The STXM-NEXAFS technique was employed to study the spatial distribution, macromolecular structure, and chemical composition of the adsorbed and coprecipitated OM at the nanometer-scale. Our study demonstrated that coprecipitation could result in higher C retention and increased C stability than adsorption in the natural environment.

Notes

Humic substances (HS) models – water and cations bridges

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Abstract

The molecular basis for many of HS properties and processes is a topic of intensive research. Besides advanced analytical methods, molecular modeling offers the opportunity to investigate various features of HS. We investigated the wetting process of model nanopore segments (trimers of polyacrylic acid) in humic substances as function of the distance. At shorter distances between the two trimer chains an outer solvation was most stable. However, with increasing distance between two trimeric segments the water molecules penetrated into the formed free space, connecting the two chains by means of a hydrogen-bonded network, which had a significant stabilization effect. The model strongly supports the hypothesized bridging function of water molecules in humic substances. Another setting comprised four undecanoid fatty acids served as models for spatially fixed aliphatic chains in HSs terminated by a polar (carboxyl) group. The rigidity of the oligomer chains is significantly enhanced as soon as the water cluster is large enough to comprise all four carboxyl groups. The interactions of Al^{3+}, Ca^{2+} and Na^{+} with carboxylate and carboxyl groups and the concomitant proton transfer reactions induced by these interactions were investigated and described. The strongest effect on the local environment was observed for Al^{3+} cation. The calculations reflect the amphoteric character of the hydrated Al^{3+} complex showing in most cases its acidic character via proton transfer from the water molecules of the hydration shell to the carboxylate group, but in some cases also deprotonation of the carboxyl group. In addition, dry aluminum cation acts as a strong Lewis acid and initiates electron transfer from the carboxylate groups to the cation also at larger intermolecular distances. In addition condensed phase models of humic substances were developed and diffusion of ions was investigated.

Notes

Storage of total and labile soil carbon fractions under different land-use types: a laboratory incubation study

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Abstract

Land use changes on soil carbon (C) storage is of increasing concern in the context of greenhouse gas (GHG) emissions mitigation. Furthermore, small changes in the amounts of soil C may substantially effect atmospheric concentrations. We studied the effect of different land uses (woodland, grassland and arable land) in two depths of a temperate silt-rich soil on the storage of total organic C (TOC), readily oxidizable C (ROC), hot water-extractable C (HWC), and cold water-extractable C (CWC) fractions in bulk soil (< 2 mm) and macroaggregates fractionated into small (1 - 2 mm), medium (2 - 4 mm) and large (5 - 8 mm) classes. A 120-day incubation was conducted to measure depletion of all C fractions. The highest C concentrations were associated with the macroaggregate-size classes but preferentially stored within the 1 - 2 mm aggregates across the land uses. TOC and ROC concentrations depletion ranged from 1 – 14% across the land uses throughout the incubation period. However, the concentrations of labile fractions (HWC; CWC) declined significantly during the incubation by 40 – 59% and 3 – 35% for surface and sub-surface soil depths respectively, indicating that C fluxes are largely controlled by the highly bio-reactive labile fractions. Consequently, labile C is a promising measure for detecting changes in TOC following land use change. Woodland contained 3 – 4 times more TOC than grassland and arable land soils. Cultivation reduced C storage of this soil by > 70%. Consequently, land use change has a significant impact on C storage.

Notes

A comparison of the prediction accuracy for soil organic carbon measured by point and imaging spectroscopy

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Abstract

Point spectroscopy and more recently hyperspectral imaging have been applied to soil carbon analysis, offering potentially cost and time effective analytical methods, although as yet not quite market-ready. One question that arises is what is the best technology type to use for developing soil carbon (C) prediction by near infrared (NIR) measurement? The current study was designed to compare the accuracy of a number of spectrometers (two point vs. two image instruments) to predict soil organic C (SOC). The objectives were: (a) to evaluate the capability of each spectrometer for the prediction of soil organic carbon; (b) to assess the suitability of pre-processing spectral transformation methods; and (c) to compare the best C prediction models for the available spectral datasets. The study was conducted in four steps using 375 soil samples; it included evaluation the prediction accuracy for each instrument, assessment of the optimum pre-processing transformation techniques, investigation of the impact of wavelength range and resolution of spectra on prediction models and the effects of spectral type on the inherent difference in the accuracy of calibration models. In general, the SOC calibration models produced by point spectroscopy were more accurate than by imaging systems, bust most interesting was the similarity in accuracy between the two systems when a common NIR range was tested. For example the validated SOC models had a R^2 of 0.84 and 0.80 and RMSE of 3.02 and 2.74, respectively. The impact of pre-processing methods on the accuracy of prediction models depended on the kind of spectrometers, and normalization spectral transformation methods considerably increased the accuracy of model calculated by hyperspectral imaging systems. Soil organic carbon was predicted accurately with appropriate processing with all systems, a slightly more accurate model was achieved with point spectroscopy spectra (R^2 of 0.89 and RMSE of 2.3) compared to hyperspectral imaging spectra (R^2 of 0.87 and RMSE of 2.47) while point spectroscopy required more sample preparation time, imaging spectroscopy required more pre-processing to achieve a reliable model.

Notes

Rapid, multi-sensor, laboratory soil characterization for carbon and related soil properties

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Abstract

There is growing interest in multi-sensor field characterization of soils for carbon (C) and related soil properties. However, studies consistently show better results for laboratory-based soil spectroscopy analyses. In this paper, we explore the possibility of combining multiple proximal soil sensing techniques in the laboratory to determine soil organic carbon (SOC), inorganic carbon (IC), and mineralogy. We obtained previously characterized soil samples from the US Geological Survey (USGS) Geochemical Landscapes Project (n = 415 for total C, SOC, IC, n = 387 for quantitative mineralogy.) These samples were extracted from A and C horizons at 159 sites along east-west and north-south North American continental transects. Milled samples were pressed into pucks and interrogated using Visible and Near-Infrared (VisNIR) diffuse reflectance, Mid-Infrared (MIR) diffuse reflectance, and Laser-Induced Breakdown Spectroscopy (LIBS). Using Partial Least Squares (PLS-2) regression and site-out cross-validation, we found that combining these sensors yielded better predictions than any individual sensor for total C, SOC and IC (combined RPD = 1.8, 2.4, and 1.9, respectively.) The improvement was particularly notable for IC, with an improvement from RPD = 1.6-1.8 with individual sensors to 2.4 combined. Work is ongoing to compare different chemometric modeling techniques for prediction of soil C and mineralogy. We see potential for multi-sensor, reagent-free analysis to become a standard procedure for soil characterization in the laboratory. With the interrogation of thousands of samples, accurate regional chemometric models could be developed for relatively complete soil characterization, from soil carbon (quantity and quality) to mineralogy and trace elements. This would allow for far more samples to be characterized, more rapidly and inexpensively, than is possible using traditional laboratory techniques. These analyses could in turn be used to more intensively calibrate field-based multi-sensor approaches.

Notes

Mid-infrared spectra to predict the NMR spectra of soil organic carbon: a two-dimensional correlation spectroscopy approach

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Abstract

Nuclear magnetic resonance (NMR) spectroscopy can provide reliable assessment of the chemical composition of soil organic carbon (SOC), but is very expensive, time-consuming and has significant environmental health and safety considerations. Mid-infrared (MIR) spectroscopy is an attractive alternative because it is a high-throughput, cost-effective and easy-to-use technique that has the capacity to estimate SOC content in large number of samples. However, current MIR analysis does not adequately capture subtle but important differences in SOC content and, in particular, in SOC chemistry. In our previous study, a two-dimensional correlation spectroscopy approach was employed to directly correlate MIR and NMR spectra of SOC. Strong and distinct correlations were found between MIR spectral features and those of C-13 NMR spectra, and thus, the potential of MIR spectra to predict the NMR spectra of SOC was demonstrated. This study is aiming at developing a novel modelling tool for predicting NMR spectra of SOC based on the more readily sampled MIR spectra. This new IR spectroscopy tool can be used for characterizing the chemistry of SOC more accurately and, perhaps, for monitoring its changes more sensitively. This will greatly assist in understanding SOC changes with land-use practices and climate, and support accurate carbon accounting in emerging carbon markets.

Notes

Characterization of soil organic substances present in different Hungarian soils by UV-Vis spectrophotometry

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Abstract

Our aims were to investigate organic characteristics of soils, because this work was part of a project focusing on relationship between solute mineral components and organic matter quality also. The study was performed by UV-Vis spectrophotometry on four Hungarian soil types which are Calcic Mollic Gleysol (called CMG), Calcic Phaeozem (CP), Rendzic Leptosol (RL) and Leptic Cambisol (LC). UV-Vis spectrometry methods are widely used to characterize soil organic matter, especially humic substances from different extracts of soils. When applying spectrophotometrical techniques several problems occur. In the UV-Vis region of the spectrum broad absorption bands are observed and this smoothness means that different components are presented in the samples. The dissolution of humic substances are governed by their molecular size (or weight) and acidity, and are influenced by some external conditions. The decrease in pH and increase of dissolved electrolyte concentration support coagulation against dissolution, therefore it is necessary to adjust pH and salt concentration typical for the soils. The spectra are influenced by cromophore groups of humic substances, ions dissolving out from the soil (e.g., Fe^{3+} from LC) and also by the presence of solid particles. According to these our experimental conditions were the followings: (i) 0,05 mol/L solution (e.g., $NaHCO_3$, etc.) to extract humic substances. It was favourable to use buffer solutions (e.g., phosphate BS) as they provide stable conditions. (ii) Scanning spectra of the extract between 800 and 200 nm in a quartz cuvette. For the characterization of humic substances we used the following methods: The E4/E6 ratio of the absorbance at 465 nm to the absorbance at 665 nm is mainly governed by size and aggregation state of the molecules. In this case the visible spectrum is measured in $NaHCO_3$ solution (pH 8.0). Ratios lower than 5 are characteristic of humic acids (CMG), while fulvic acids have higher ratios (CP, LC). Using phosphate BS (pH 7.4) the E4/E6 ratio increased (because the pH decreased and phosphate ions extruded mineral components from organomineral complexes). It was showed that in the soil solution humic substances with lower molecular size become more abundant while decreasing the pH. The proportion of Specific UV Absorbance value (on 254 nm) and C-content correlates to the quantity of aromatic groups. The so-called E2/E3 (the ratio of the absorbance at 250 nm relative to 365 nm) is also an applied metric for studying the aromatic characteristic of humic substances. The lower ratio of the RL and LC soils means higher aromaticity. The SUVA and E2/E3 ratio data were in good agreement. According to a Hungarian method called Hargitai the absorbance of the solution extracted by 1% NaF divided by that extracted with 0,5% NaOH at different wavelengths provides qualitative information of humic acids. The humic substances are bound to clay and carbonate minerals through Ca^{2+} and Al^{3+} ions. NaF can abrupt these strong complexes. NaOH splits these organomineral complexes by alkaline hydrolysis. The NaF dissolved well-decomposed humic fractions (CP, CMG, RL) with higher molecular size while raw humic materials were better dissolved by NaOH (LC). The results do not show correlation between E4/E6, Hargitai and UV methods as these techniques analyse different properties of the soil humic substances.

Notes

Extracted humic acid does not represent the composition of clay bound soil organic matter

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Abstract

Humic-clay composites (HCC) are recognized to be important geocolloids because of their influence on sequestration of carbon in soil. Clays are thought to protect high molecular weight (MW) components of humic substances (HS) to the detriment of low MW components. However, current experimental evidence is inconclusive. Our objectives were to discern the composition of the soil organic matter bound to soil clays and compare with extracted humic acid (HA) using ^{13}C CP-MAS, DP-MAS NMR, and FTIR, and evaluate the effect of exchangeable Ca, Sr, and Ba. The HCC and HA were obtained from a prairie soil (Mollisol) formed on Des Moines Lobe glacial till used in corn and soybean production in southwestern Minnesota, and dominated by interstratified smectite-illite clay. The HCC was separated by dispersion and sedimentation in water, while HA was extracted by NaOH using standard methods. The samples were exchanged with Ca, Sr or Ba prior to spectroscopic measurements. The CP-NMR spectra showed that interstratified smectite-illite minerals in the HCC are preferentially associated with polysaccharides, fatty acids, and polypeptides with only a minor aromatic component in contrast to the HA which has a large aromatic peak consistent with a major fraction of phenolic components. However, a DP-MAS spectrum of HCC shows that it contains a wide component of black carbon. The FTIR results for HA were consistent with typical soil HA with carboxylate, hydroxyl, and phenolic groups, and shifts in the carboxyl band expected for changes in exchangeable cations, but the clay bands dominated the HCC spectra. We conclude that clay minerals associate with peptides, lipids, and polysaccharides favoring the protection of these normally readily biodegradable fractions relative to the lignin derived components that represent a large fraction of the extractable HA.

Notes

Stabilization of soil organic carbon by clay minerals: does clay mineralogy determine the turnover rate of clay-associated carbon?

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Abstract

Mineral-associated soil organic matter (SOM) is known to be more stabilized than non-complexed SOM. This is particularly true for SOM associated to finely divided phyllosilicates. However, soils contain different phyllosilicates with different surface properties and the relative abilities of such different clay minerals to stabilize C are debated. The aim of this study is to compare the turnover time of organic C associated to different clay phases in a temperate soil. We used a chronosequence of C_3/C_4 vegetation established in a silt loam Luvisol ("Les Closeaux" experiment, Versailles, France). We sampled the control plots under wheat and the 19-year maize plots at two depths (0-25- and 45-60-cm). After complete dispersion of samples, we separated "primary" organo-mineral associations of sizes 2-20 µm, 0.2-2 µm, 0.05-0.2 µm, and <0.05 µm. Clay mineralogy was analyzed in each size-fractions and organic C and C isotopic composition will be analyzed in the coming weeks. Particle-size fractionation allowed separating fractions with contrasted phyllosilicate mineralogy. In the 2-20-µm fraction, illite and kaolinite were the dominant clay minerals. Interstratified and smectite minerals containing swelling phases were preferentially accumulated in the 0.2-2, 0.05-0.2, and <0.05-µm fractions; the two finest fractions containing nearly exclusively smectite and interstratified illite/smectite. The mineralogical trends in the different fractions were the same in surface and at depth. We indeed separated fractions with contrasted clay mineralogy. The incoming results on C content and C isotopic composition will therefore allow discussing the influence of clay mineralogy on SOM dynamics.

Notes

Modification of soil's hydro-physical functions by Black Carbon

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Abstract

The potential benefits of Black Carbon (a generic term used to describe highly condensed material generated from the incomplete combustion of fossil fuels and organic matter) as soil conditioner, for carbon sequestration, enhanced agronomic productivity and mitigation of greenhouse gas emission had been extensively discussed in literature. Biochar (BC) is reported to enhance the binding of important nutritive cations and enhance nutrient availability to plant. It is similarly credited with improvement of water holding capacity and aggregate stability in soils. However, there are very few investigations which inform about quantitative data also concerning specific mechanisms which can also be used to explain such improved conditions. In our study, we investigated the effect of biochar application on pore size distribution, pore functioning like hydraulic and air permeability, the effect of repeated wetting and drying on structure formation and changes in pore rigidity and also included the determination of pretreatment dependent hydrophorbicity and the rheological properties. We prepared mixtures of sandy and silty soil material from 2 soils at a given bulk density of 1.45g/cm³ with 2, 5, and 10% of biochar. Measurement of water retention at 0, -6, -15, -30, -50, -500, and -1500kPa, saturated hydraulic conductivities, air capacity and other parameters will be used to characterize the modification of the hydraulic functions due to BC addition. Our result will provide a critical data for the understanding of the specific role of BC in water and solute transport in unsaturated BC-stained soil, thereby elucidating the importance of BC in much reported "agricultural productivity" and "climate change adaptation". The data will also be useful in the parameterizations of the hydraulic models aimed at studying soil functions in a changing climate.

Notes

Hot water soluble organic compounds related to hydrophobicity in sandy soils

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Abstract

As a labile pool of soil organic carbon, hot water soluble carbon (HWSC) is a sensitive indicator of ecosystem changes caused by natural and anthropogenic disturbances. HWSC contains binding agents influencing soil aggregate stability, which is mainly controlled by soil water repellency (SWR) levels. It is widely accepted that water repellency in soils is associated with the formation of hydrophobic layers of organic compounds on soil particle surfaces and/or the presence of interstitial particulate organic matter. These compounds possess aliphatic, isoprenoid or aromatic nature. Here we characterize the organic compounds composition associated with hot water extracts (HWE) from accelerated solvent extraction (ASE) for water repellent soils (Australian eucalypt forest soils and a UK South Wales dune sand) differing in water repellency levels. Hot water extraction eliminated water repellency (WDPT < 5s) in the three soils. Soil water extracts were lyophilized at (-50°C) and subjected to fractionation in DCM, DCM/iso-propanol and methanol. Fractionated extracts were measured by GC/MS. Dominant compounds extracted from soils were benzoic acid and its hydroxy- and methoxy- derivatives, short chain dicarboxylic acids, saccharides (mono- and di-), glycosides, short chain dicarboxylic acids (C4, C8 and C9), short chain fatty acids (C8-C18), short chain alkanols and esters of oleic, stearic and palmitic acids. The hot water solubilizes aromatics and sugars which coordinate through multidentate ligands to the mineral and organic soil components. The rupture of these bonds liberates hydrophobic esters of lauric, palmitic and stearic acids. The high abundance of extracted saccharides points to the critical role of these compounds in disaggregating soil particles and revealing hydrophilic positions. Our results indicate that extraction of hydrophobic compounds is not necessarily a prerequisite for soil water repellency elimination.

Notes

Physico-chemical properties of biochar

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Abstract

Biochar is a porous media containing up to 90 % of carbon obtained from biomass pyrolysis. Since its carbon is usually stable over a long time period, it is view as a good option for carbon sequestration in soil. In addition, it may improve physico-chemical soil properties. However, its impacts on soil depend upon its own initial properties that vary according to its production method and initial biomass. The objective of this study is to characterize physico-chemical properties of diverse biochars in order to improve transportation and storage, and help in selecting appropriate biochar as soil amendment according to different agricultural practices. Properties of biochars such as water retention, carbon content, density, granule size distribution, resistance to abrasion and many other parameters will be compared between biochars made by different producers and discussed accordingly to their potential uses in agriculture.

Notes

Just the prairie sink: the role of soil aggregates in sequestering carbon in restored temperate grasslands

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Abstract

Temperate grasslands, with their network of deep roots and rich soil belowground, act as carbon sinks, and play an important role in the carbon cycle. Carbon stabilization by soil aggregates has been proposed as a principal mechanism for long-term soil organic C sequestration in these systems. Soil disturbances and cultivation in grasslands reduces soil C content and changes the abundance, distribution, and stability of soil aggregates. A key question is therefore whether soil aggregate C can be reinvigorated when former agricultural fields are restored to grasslands. In this study, we examined the impact of different grassland restoration practices and time of restoration on carbon sequestration in soil microaggregates and macroaggregates over time. Soils were collected from 15 grasslands that differed in management practice and length of restoration. Samples were subsequently separated into four different aggregate sizes by wet sieving, and then dried, ground, and analyzed for C content with an elemental analyzer. Preliminary results suggest that prolonged land management resulted in a C content of macroaggregates (>250μm) over 20% greater than that of microaggregates (<250μm), which indicates an aggregate hierarchy in the later stages of restoration management. Carbon-depleted aggregates were detected in early restoration sites. Increasing time of restoration produced an increase in macro- and microaggregate-associated C. Our findings support the importance of both aggregate classes as C-stabilization sites in restored grasslands, and also provide support for long-term restoration and management practices in these ecosystems.

Notes

The role of microbes for carbon sequestration in anthropogenic soils, waste deposits, and lakes

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Abstract

The paper presents and discusses the role of microorganisms for sequestration of carbon in three different media such as anthropogenic soils, waste deposits and lakes. In case of anthropogenic soils the main factors under consideration are soil physical, mineralogical, chemical properties and climate conditions. Carbon sequestration in lakes is discussed mainly in the context of eutrification and climate. The role of microbes for carbon sequestration in municipal waste deposits is discussed in relation to waste chemical composition, climate conditions, waste deposit construction and in particular to its isolation from the environment with top and bottom liners.

Notes

Elevated CO_2 and rhizosphere C priming affect the decomposition of crop residues

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Abstract

Soil carbon (C) has gained renewed attention in recent years due to global climate change. Atmospheric carbon dioxide (CO_2) concentrations in Australia are expected to increase from 370 ppm to 550 ppm by the year 2050. This could have significant implications for soil C via changes in the amount and quality of soil C inputs (plant growth; biomass partitioning; C:N) and changes in C mineralisation, affecting the overall soil C balance. In a column experiment conducted at the soil free-air carbon dioxide enrichment (SoilFACE) facility we observed increased growth of wheat and field pea under elevated CO_2 with a greater response for shoots than for roots. Furthermore, the C:N of wheat biomass increased irrespective of soil N status. Increased plant productivity under elevated CO_2 is consistent with other studies and is attributed to the direct stimulation of photosynthesis and to increased water-use efficiency due to reduced evapotranspiration. Using repeated pulse-labelling with 13 CO_2 we observed greater ^{13}C enrichment of plant roots, rhizosphere and bulk soil under elevated CO_2.This indicated a greater contribution to soil C under elevated CO_2 than ambient CO_2 concentration. In the current paper these processes are investigated further. In particular, the effect of increased root growth and rhizosphere C flow under e CO_2 on the decomposition of added crop residues and the interaction with residue quality (C:N ratio) is investigated in two glasshouse experiments using dual-labelled (13C/15N) crop residues. In the first experiment wheat (C:N 60) and field pea (C:N 20) residues were mixed at 0.5% w/w into the top 0-10 cm of soil columns containing a Xerosol. Soil columns were planted with wheat (cv. Yitpi) and plants were grown for 8 weeks under ambient (390 ppm) or elevated (700 ppm) CO_2 concentrations and two N levels. Residue decomposition was assessed each week by trapping CO_2 produced within each core. C and N pools in the soil-plant system were quantified. The second experiment used the same soil and CO_2 concentrations but included two plant species growing on a wider range of buried residues. It consisted of three rhizospheres; wheat + fertilizer N, wheat no fertilizer N and field pea no fertilizer N, and four residue treatments; wheat low N (C:N 115.4), wheat high N (C:N 30.5), field pea low N (C:N 20.5) and field pea high N (C:N 19.4). Cores were destructively sampled after 9 weeks and C and N in soil and plant samples were assessed. Data generated from these experiments will further our understanding of the effects of elevated CO_2 concentration on C and N cycling in soil-plant systems.

Notes

Root and shoot carbon input from four prairie crop sequences using repeat ^{13}C pulse labeling technique

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Abstract

This work quantified the fate of soil C captured during a single growing season of four simple cropping sequences in the Canadian prairies and evaluated the fate of those original residues in the soil after a second growing season planted with wheat. The studied cropping sequences were: continuous wheat, pea-wheat and canola-wheat from Scott, Saskatchewan [Dark Brown Chernozem soil (DBCz)] and continuous wheat and lentil-wheat from Swift Current, Saskatchewan [Brown Chernozem soil (BCz)]. To track the progress of C into different soil organic matter (SOM) pools, plants were grown in intact soil cores collected from the two sites and pulse labeled weekly with ^{13}C-CO_2 in airtight chambers. Root C and shoot C in the soil were studied separately to evaluate the effect of both on SOM dynamics. The remaining shoot-derived C was from enriched-shoot residues returned to soil cores with non-enriched root. For BCz lentil, BCz wheat, DBCz canola, DBCz pea and DBCz wheat root-derived C estimates at the end of the first growing season were 838, 572, 512, 397 and 418 mg of C per kg soil respectively. At the end of the 2nd growing season, the remaining root-derived C for the same crops was 347, 225, 242, 232 and 122 mg of C per kg soil respectively. At the end of the 2nd growing season, the remaining shoot-derived C for the same crops was 364, 241, 265, 222 and 178 mg of C per kg soil, respectively. Overall, even though legume crops produced less aboveground biomass than canola and wheat, they generated similar amounts of SOC.

Notes

Microbial biomass carbon and nitrogen in irrigated soil under different maize cropping systems

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Abstract

Soil microbial biomass carbon (C) and nitrogen (N) under different maize cropping systems were evaluated at Kampe Irrigation Project farmlands in Southern Guinea savanna region of Nigeria. In a 40-hectare land, irrigated plots that have been cultivated for minimum of three years with sole maize, maize/okra, and maize/cowpea intercrops, maize/okra relay cropping and a five year fallow were sampled and analysed for organic C, microbial biomass C and N. Experimental design was randomized complete block design with six replicates. Microbial biomass C and organic C were significantly lower ($P<0.05$) in sole maize, maize/okra intercrop and maize/okra relay plots compared to maize/cowpea intercrop and fallow plots.

Microbial biomass C in maize/cowpea plot (246 mg/ka) was about 100% higher than that of sole maize (122 mg/kg) and maize/okra relay cropping (127 mg/kg). The microbial biomass N in maize/okra intercrop (62 mg/kg) and maize/ cowpea intercrop (60 mg/kg) was significantly ($P<0.05$) higher than other plots. The microbial biomass C:N ratio in sole maize, maize/cowpea intercrop and maize/okra relay was significantly ($P<005$) higher than other treatments. Intercropping cowpea with maize can increase nutrient cycling through soil microbial biomass and thereby improve soil quality.

Notes

Contribution of fungal macromolecules to soil carbon sequestration

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Abstract

Fungal products have long been implicated as important contributors to soil C-sequestration. However, there is surprisingly little information on hyphal biochemistry and the patterns of decomposition. Literature suggests that fungal decomposition and turnover may range from several days to months. We examined the temporal sequence of decomposition in *Fusarium avenaceum*, a widespread soil fungus. Mesh envelopes filled with fungal cell wall tissue were buried in soil and then exhumed at regular intervals over a 36-day period. Residual tissues in each envelope were analyzed for their mass and tissue composition by FTIR and thermochemolysis GCMS with tetramethylammonium hydroxide (TMAH). The temporal sequence of decomposition showed a 74% reduction of fungal tissue in the first five days of incubation. There was no significant loss in residual biomass for the remaining 36 days. Organic chemical analyses showed distinct changes in fungal tissue, with the most significant changes occurring in the first 5 days. Specific changes were seen in the amide I, carbohydrate C-O stretch, and ester carbonyl regions of the FTIR spectra. Amide I absorbance shifted from 1650cm^{-1} to 1630cm^{-1} indicating a change in relative concentration of various amide groups. Two prominent carbohydrate C-O stretches (1035-1075cm^{-1}) initially existed but upon degradation, the 1075cm^{-1} absorbance was reduced to a shoulder on the former. The loss of ester carbonyl absorbance (1745cm^{-1}) indicated a loss of ester-bound lipids. TMAH-GCMS analysis showed loss of a specific, but as yet unidentified, carbohydrate. We are presently investigating the method of stabilization of the fungal residue.

Notes

Microbial and chemical enhancement of pentachlorophenol transformation in paddy soil supplemented with biochar

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Abstract

The effects of biochar on soil microbial community structure, function, and system redox potential during the dechlorination of polychlorinated compounds remain unclear. In this study, we investigated how biochar added to paddy soil affected pentachlorophenol (PCP) transformation and microbial communities in anoxic conditions. PCP adsorption and transformation and HCl-extractable Fe(II) generation were significantly enhanced in soils amended with biochar. The increased bioelectrochemical power produced in this system suggests that the extracellular electron transfer was increased. The microbial community diversity (ACE and Chao1) had a positive exponential correlation with biochar dosages in the soil, which indicated that higher microbial diversity in the soil enhanced the PCP transformation rate. In addition, quantitative real-time PCR showed that biochar acted as a growth stimulant for iron-reducing and dechlorinating bacteria, which promoted PCP biotransformation. Consequently, enhanced PCP transformation in biochar-supplemented soil led to enhanced PCP adsorption, Fe(III) reduction, and extracellular electron transfer and biostimulation of iron-reducing and dechlorinating bacteria. This finding provides insight on the effects of biochar on soil microbial community structure and function during PCP biochemical transformation.

Notes

In situ short-term dynamics of CO_2 flux and microbial biomass after simulated rainfall in dry croplands

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Abstract

The wetting-drying cycles of soil primarily drive carbon (C) dynamics in dry croplands, where rainfall events are largely sporadic throughout the year. We evaluated the *in situ* short-term (hourly) dynamics of soil CO_2 efflux and microbial biomass, to show the significance of one rainfall event on the soil C stock under various ecosystems. The experiments were conducted on six dry croplands as follows; (1) tropical clayey at Tanzania (TZc) and Thailand (THc), (2) tropical sandy at Niger (NGs) and Thailand (THs), and (3) temperate clayey at Kazakhstan (KZc) and Hungary (HGc). Hourly measurements of soil CO_2 efflux, *in situ* microbial biomass (MB) and *in situ* microbial activity (qCO_2) were conducted after the application of a simulated rainfall (W plot). We also evaluated the potentially mineralizable C (PMC). The rewetting of a dry soil led to a C flush and increased qCO_2, which finished 24–120 h later because of rapid soil drying at all sites. Only NG site, there is no clear C flush and microbial fluctuation, possibly because there is no C substrate due to removal of crop residue. The cumulative soil CO_2 efflux due to rainfall treatment for first 100 h was effectively greater in the THs-W plot (1.7 g C m^{-2}) than the other W plots (0.8, 1.4, 0.0, 1.3, 0.3 g C m^{-2} in the TZc, THc, NGs, KZc and HGc, respectively). As a result, the ratio of the above value to total C, and to PMC is 1.9, 0.09, 0.1, 0.0, 0.07, and 0.02 % (to TC), and is 31.7, 4.9, 8.1, 0.0, 1.7 and 1.3 % (to PMC) in THs, TZc, THs, NGs, KZc and HGc, respectively. These results suggest that the significance of one rainfall event must be larger in the tropics, especially in sandy soil where had received much crop residues.

Notes

DNA adsorption on allophane and the interactions between DNA, organic matter, and allophane in Andisols in New Zealand

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Abstract

Allophane comprises tiny (3.5-5 nm), Al-rich spherules with extremely large surface areas up to 1500 m^2g^{-1} that form strong associations with organic matter (OM) and tend to form nanoaggregates up to ~100 nm in size. Allophanic soils (Andisols) contain large concentration of sequestered organic carbon, but the reasons why and how allophane can hold so much carbon remain unclear. To help reconstruct past environments, some studies have extracted ancient DNA from sediments and soils, but how well DNA is preserved and protected in soils for millennia is unknown. Our initial experiments on Andisols showed that natural clay (mainly allophane) containing high carbon adsorbed less added DNA than clays with low carbon, which implied adsorptive sites were saturated by OM. The structures of OM in the natural clays were shown by synchrotron radiation to comprise quinonic, aromatic, aliphatic, and carboxylic carbon. Using the synchrotron, we found that added DNA was bound to natural clay through the phosphate group. To understand the mechanisms of DNA adsorption on OM-rich allophane and OM-free clay, we synthesized pure allophane and will use a humic acid spike to investigate how OM (as humic acid) influences DNA adsorption on allophane. We aim to use synchrotron radiation to examine the bonds between allophane, humic acid, and DNA. We further plan to synthesize allophane nanoaggregates of various sizes to test our hypothesis that DNA and OM are also sequestered through physical protection within interstices of allophane nanoaggregates as well as by chemical adsorption on active sites of allophane spherules.

Notes

Clay addition and redistribution to enhance carbon sequestration in soils

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Abstract

Organic carbon is very often associated with clays in soils. The capacity of soils for organic carbon generally increases as the content of clays (phyllosilicates and/or oxides) increases. In southern and western Australia, farmers have been adding clays to soils with sand-textured surface horizons for >50 years to overcome non-wetting. More recently, they have been redistributing clays from B horizons into A horizons through delving and/or spading. We posit the notion that the addition or redistribution of clay into sandy soils enhances their capacity to sequester organic carbon. Our studies of both the loss and addition of clays in soils have helped to clarify a mechanism for the positive influence of clays on carbon sequestration. Electron microscopy showed that extensive microaggregation involving clays with organic matter characterized a virgin site in a southern Australian Alfisol. However, conventional cultivation for up to ~120 years led to marked decreases in the contents of both organic matter and clay, and fewer and smaller microaggregates. Contrasting this, addition of various forms of clay led to greatly increased crop yields in sandy soils in both northern Thailand and northern Australia. In a delved southern Australian Alfisol, the appearance of plant roots within clay clods redistributed from the clay-rich B horizon corroborates work on the virgin Alfisol leading to our conviction that organic matter becomes protected within a clay matrix from predation by microbes. The resulting microaggregation simultaneously enhances water retention, plant productivity and carbon sequestration.

Notes

Determination of small scale spatial carbon concentration in an intact soil profile by X-ray fluorescence scanning

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Abstract

The issue of soil carbon (C) security needs to be addressed before soil C sequestration programmes can be advanced and deployed with confidence to ensure forecast increases in national soil C stocks are long-term. This paper proposes a methodology to map C concentrations in an intact soil profile by adapting X-ray fluorescence (XRF) scanning for soils. The objective is to understand the role of small scale spatial organisation of soil C with respect to the long-term security of the abiotic C store. XRF scanning is employed as a semi-quantitative tool in sedimentology for paleoclimate reconstruction in marine and lacustrine environments. Data are collected at a maximum spatial resolution of 200 µm for up to 1.8 m of core. Integration of 3 instrumental components, (i) an optical camera system, (ii) an x-ray source and filtering and (iii) an x-ray line camera, can acquire an RGB colour image, x-radiographic image and elemental profiles (Croudace et al., 2006) for the soil core. The three file types can be realigned for analysis of soil profile colour, structure and composition. Elements from aluminum to uranium are quantified, but direct measurement of C (atomic mass of 12) is not possible. A number of proxies have been used to infer organic carbon in sediment, such as bromide (Ziegler et al., 2008) and the ratio between coherent and incoherent scattering (Guyard et al., 2006). In the current study a soil (Cambisol) core was characterised by XRF scanning. The XRF core scanner was calibrated for quantitative analysis with samples of similar soil composition determined by XRF spectrometry for a range of elements. Macro samples were incrementally collected for each 1 cm length and analysed for organic C by dry combustion. Initially, Spearman's rank correlation coefficient was used to quantify the association of C to a range of elements, and combinations of elements in the soil profile, wherein variations in an element, or ratio of elements, has the potential to be used as a pedotransfer function for the determination of soil organic C.

Notes

Preservation of organic carbon in humid tropical soils by active Al and Fe

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Abstract

The objective of present study is to reveal a fraction that is most closely related to OC stabilization in tropical soils. The soils were collected from broad area of tropical regions of Thailand, Indonesia, Tanzania and Cameroon, and temperate region of Japan. Most soils from Thailand and Indonesia formed in mountainous area due to the orogenesis of the regions, while most soils from Tanzania and Cameroon formed on stable shield. The soils were collected from a subsurface horizon in each site to prevent fresh organic matter included that does not associate with clay or iron and aluminum oxides. Clay fraction, iron oxides, and active aluminum and iron were determined by the pipette method, dithionite-citrate extraction (Fed) and acid oxalate extraction (Alo and Feo). To classify the soil samples based on weathering intensities hierarchical cluster analysis was conducted using weathering indices, i.e. the total reserve in bases (TRB), the relative content of crystalline iron oxides, and the activity ratio of iron oxides. Correlation and single regression analyses were conducted using OC, clay, Fed, Alo and Feo. The soils were clustered into 3 groups, 1) low TRB and high crystallinity iron oxides, 2) high TRB and high crystallinity of iron oxides, and 3) high TRB and low crystallinity of iron oxides, which is considered to be weathered in this order. 1st group is mainly composed by soils from Tanzania, Cameroon and non-volcanic area of Indonesia, 2nd group is those from Thailand and volcanic area of Indonesia and 3rd is those from Japan. In each group correlation coefficient between OC and Alo + Feo were higher than those between OC and Fed or clay. The correlation coefficient between OC and Feo in the first group was lower than Alo. Single regression analysis indicated that Alo + Feo explained approx. 60 – 70 % of OC variance. For the most weathered group Feo did not explain the OC variance while Alo explains approx 80 %. Amount of Feo and Feo/Alo ratio of the most weathered group were significantly lower than the other groups, indicating that iron is more crystallized and has lower activity. Based on the findings above, we conclude that 1) Alo and Feo are important components for investigation of OC stabilization in humid tropical soils as well as humid temperate soils, 2) quantitative relationship between OC and Alo + Feo were similar in the order despite the weathering intensity of the soils including temperate Japanese soils, and 3) in the highly weathered soils the amount of Feo is smaller than Alo due to the iron crystallization and thus Alo has greater effect on OC stabilization.

Notes

Probing temperature-dependent organo-mineral interactions with molecular spectroscopy and quartz crystal microgravimetry

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Abstract

The global-scale cycling of carbon and mechanisms of carbon storage are important in climate change issues. It is uncertain as to whether climate change will turn soil into a carbon source or change its ability to serve as a sink. Minerals are rarely found in a "clean" crystalline state, but rather bound to natural organic matter (NOM). In fact, 50 – 75% of all NOM in soils and sediments, form organo-mineral complexes at the mineral surfaces. These organo-mineral associations can protect NOM from decomposition for timescales of centuries to millennia and serve as a mechanism by which carbon is stored in soils. The stability of organo-mineral complexes—defined as the degree of resistance to decomposition—could affect carbon storage as temperatures increase. The mechanisms of carbon stabilization need to be studied extensively to predict how reservoirs respond to changes in temperature. This study utilizes spectroscopy and surface-sensitive techniques to investigate the kinetics and chemical changes in organo-mineral complexation caused by climate-relevant temperature changes. Aluminum oxide (Al_2O_3) and iron oxide (Fe_2O_3) were chosen as the representative soil mineral substrates. Fulvic and humic acids purchased from the International Humic Substance Society were used. With nuclear magnetic resonance spectroscopy (^{1}H NMR), we determined the identity of the interacting functional groups as well as the nature of the interactions (i.e., covalent vs. non-covalent) between NOM and Fe_2O_3. Standard one-dimensional ^{1}H NMR spectra were acquired without sample spinning by applying a 90o ^{1}H excitation pulse and a water signal saturation pulse. Chemical shift values were externally referenced to trimethylsilane. Spin-lattice relaxation times were measured using a standard inversion-recovery pulse program and a recycle delay of 20s, without the use of water suppression. Our initial results suggest that aromatic (phenolic) components of the NOM preferentially interact with Fe_2O_3. With quartz crystal microgravimetry (QCM), we quantified the extent and kinetics of adsorption between NOM and Al_2O_3. QCM resolves mass differences in real-time and at high-resolution (1 ng/cm^2) using the piezoelectric property of quartz. A working suspension of NOM passed through a flow module (with programmable temperature setting) that contains the Al_2O_3-coated QCM sensor and changes in resonance frequency (Δf) were monitored as NOM deposit onto the substrate. Preliminary QCM results suggest that NOM adsorption onto Al_2O_3 follows Langmuir kinetics. At 25ºC and 40ºC, similar adsorption extents (162 ng/cm^2 and 155 ng/cm^2) were observed, suggesting that NOM sorption capacity may be independent of temperature. In contrast, the NOM adsorption rate doubled (from 15 to 30 ng/cm^2/min) as temperature increases from 25ºC to 40ºC. Desorption analyses are currently underway to test the hypothesis that warming will result in an overall reduction of the extent of organo-mineral binding due to greater desorption than adsorption. The results of this study will help to 1) predict how soils dominated by aluminum- and iron- rich clays will respond to increasing temperature and 2) either challenge or fortify existing climate change models.

Notes

Simulating priming effects, measurable carbon pools, and climate change sensitivity of soil carbon in an earth system model

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Abstract

The current generation of coupled climate-carbon cycle earth system models (ESMs) uses very simple representations of soil carbon, typically simulating two or three noninteracting soil carbon reservoirs with different first-order decomposition rates. This conceptualization ignores important features of soil carbon dynamics, including microbial activity, priming, physical protection through the formation of microaggregates, and chemical protection in organo-mineral complexes. Because physically and chemically protected pools may have different sensitivities to changes in temperature and moisture, these omissions likely reduce the accuracy of simulated soil carbon sensitivity to climate change. Furthermore, the soil carbon reservoirs simulated in these simple models are defined by turnover rates rather than mechanistic features and do not correspond to measurable soil carbon pools, making validation and interpretation of results difficult. We have developed a new soil carbon model for use in the Geophysical Fluid Dynamics Laboratory (GFDL) land model (LM3), a component of the GFDL ESM. Soil carbon decomposition in the new model is driven by a dynamic microbial biomass, which allows the model to simulate priming effects. The model also includes a representation of carbon sequestration in microbially inaccessible protected pools. We compare model predictions to observations at Harvard Forest, Massachusetts, USA, and discuss the implications of the new model structure for simulations of terrestrial carbon cycle responses to climate change. The model successfully simulates contemporary carbon pool sizes and heterotrophic respiration rates, and will allow us to investigate the effects of soil mineralogy, afforestation, and microbial community changes on soil carbon storage and stability in a warming world.

Notes

Soil redistribution and dynamics of organic carbon: an experimental approach

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Abstract

Water erosion affects the redistribution of soil organic carbon (SOC) in many ways. However much remains unclear in the complex processes that take place during erosion, transport and deposition with regard the interaction between SOC and the soil. The main objective of this study was to determine the complete carbon (C) budget of a loess soil affected by water erosion in an experimental setting. In a unique 3-replicated rainfall-simulation experiment we quantified fluxes of sediment, SOC, dissolved organic carbon (DOC) and CO_2. The experiment took 120 days in which four representative rainstorms were generated. For the solid phase we characterized carbon pools of the eroding, transported and deposited material using density fractionation and by determining C enrichment (ERc) in the sediments. The gas phase (CO_2 emissions) was measured semi-continuously over the whole experimental period. The water phase was studied with respect to DOC in both overland flow and through flow. Significantly higher ERc of the sediments exported were measured, ranging between 1.3 and 4.0. In the sediments the C contents of the free light fraction and mineral-associated OC were both significantly higher than those of control soils. Material transported over the surface did not show a significant change in loss of C and particulate OC flux was about 10 times more important than the DOC fluxes. Mineralization of C as shown by the emission of CO_2 was slightly lower at the erosion site and was clearly higher on the deposition site in comparison to the control soil. The role of CO_2 in the carbon budget of this experiment was found to be most important as it counted for 98% of total C loss. The C fluxes found in this experiment also showed that they are in the same magnitude as found under reported natural conditions which shows that laboratory studies are useful to zoom in on the complex processes of C dynamics during erosion, transport and deposition.

Notes

Comparison of quantitative SOM measuring methods and investigation of their dependence on soil properties

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Abstract

There are several methods for the quantitative analysis of soil organic carbon (SOC) and soil organic matter (SOM). They differ significantly in the chemicals and instruments used because none of them is perfect. Results depend on physical and chemical composition of the soil; disturbing effects often cause an increase in SOC/SOM content measured. Calculations between SOC and SOM values are also problematic because carbon content of humic substances varies in a wide range. We used the most common (Loss-on-Ignition, dry combustion with automatic C/N elemental analyzer, Tyurin's titrimetrical, Walkley-Black) and other potential (termogravimetry with a Hungarian development called derivatograph, photometrical) methods for quantification of SOC/SOM content. Our objective was to measure these methods' dependence from the soil's physical-chemical composition e.g. mineral characteristics (clay and chloride content, presence of carbonates and valence changing metals – Fe and Mn) and identification of disturbing effects. Samples included Gleyic, Albic and Haplic Luvisols and a Technic Umbrisol and were taken from the vicinity of Sopron, Hungary. A total of 23 Luvisols and Umbrisol samples were collected from each horizon of pedons and C horizon. We investigated linear correlation coefficients between results gained from each method. Correlation coefficients between the sets of results varied between 0,93 and 0,99. Although all six methods have shown strong correlation (R^2>0,90) with each other, there are remarkable differences mostly in samples with low SOM content. Error of the loss-on-ignition method in samples with low SOM content was extremely high and showed strong correlation (R^2=0,83) with clay content. The main reason of this phenomenon can be tracked with termogravimetry. It shows that dehydration of clay minerals between 100 and 200°C is the responsible process. However we haven't found any correlation between clay content and results from wet oxidation methods (Tyurin's titrimetric, photometrical and Walkley-Black methods). There is weak correlation between results of the loss-on-ignition method and the hygroscopic value. Iron(II) content can also influence results especially in wet oxidation techniques therefore it is interesting to study its connection with SOM quantity. We use X-ray Diffraction for the quantification of total iron content and for the characterization of clay minerals (potential Fe(II) sources in air dried soil prepared for laboratory analysis) in the samples. For SOM quality measurement we use the E4/E6 ratio. Humic substances with higher grade of polymerization tend to oxidize less efficiently than smaller and less polymerized ones. Dependence of SOM content measurements from SOM quality will be investigated.

Notes

The role of organo-mineral interactions in stabilising carbon in contrasting soils under natural vegetation

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Abstract

Many factors influencing the stability and longevity of organic matter in soils remain elusive presenting difficulties in modelling organic matter turnover dynamics. Soil minerals are hypothesized to stabilize organic matter by reducing their microbial decomposition potential following adsorption to the mineral surface. However, there is limited direct evidence for the protection of organic by interaction with soil minerals in different soil types. We used a sequential density fractionation procedure to isolate <1.6, 1.6-1.8, 1.8-2.0, 2.0-2.2, 2.2-2.6 and >2.6 g cm^{-3} density fractions of soils of contrasting clay mineralogies: Calciustert (smectite dominant), Natrustalf (kaolinite dominant), Rhodudox (sesquioxide dominant) and Rhodustalf (illite dominant). With increasing fraction density total C was found to decrease as mineral content increased. Conversely the C:N ratio was found to decrease with increasing fraction density suggesting increased microbial processing. The proportion of total C in each fraction varied greatly between soils with the Natrustalf yielding 44.2% C in the <1.6 g cm^{-3} particulate organic matter fraction and only a combined 14.8% of total C in the 2.0-2.2 and 2.2-2.6 g cm^{-3} fractions. In contrast, the Rhodustalf yielded 19.7% of total C in the <1.6 g cm^{-3} fraction and a combined 44.6% of total C in the 2.0-2.2 and 2.2-2.6 g cm^{-3} fractions indicating a larger proportion of C was associated with minerals in this soil. X-ray photoelectron spectroscopy and DRIFTS were used to investigate the C and N functional groups of density fractions, uncovering enrichment of organic functional groups in association with certain minerals. Sesquioxide dominated fractions in the Rhodudox were found to be overrepresented in oxidised C environments indicating the presence of mono-/bidendate ligand exchange with surface hydroxyl groups of the sesquioxides. In comparison, a smectite dominant fraction, 2.0-2.2 g cm^{-3}, in the Calciustert was enriched with protonated amide forms that have the potential to directly associate with the delocalised charge across the surface of permanent charge minerals. The observed enrichment of functional groups on adsorption to mineral surfaces suggests preferential protection of these organic species from microbial decomposition.

Notes

Forest fires and water erosion effects on soil organic matter in the Serrano River Basin (Chilean Patagonia)

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Abstract

Many physical, chemical, and biological soil properties can be affected by forest fires. In particular, fire can cause partial or complete combustion of soil organic matter (SOM), and the burning of vegetation make the soil more susceptible to removal by water erosion. In recent years, forest fires and water erosion have become a major threat to the soils in the Chilean Patagonia. An example of this is the Serrano River basin, where more than 36,000 ha, mainly native forest, have been burned in the last four decades. Therefore, a study was conducted to evaluate the effects of forest fires and water erosion on SOM in the Serrano River basin. A total of 23 sites were sampled, with two replicates at each site. Sites were selected considering soil type and burned/not burned areas. Four major soil types were found (Distric Cambisols, Eutric Cambisols, Lithosols and Luvic Phaeozems), and three main forest fires were identified (in year 1985, 2005, and 2011). Soils were sampled at two depths (0.2 and 0.4 m), and the samples were analyzed and compared based on texture, organic matter content, cation exchange capacity (CIC), and total N, P, and K. Estimates of soil erosion rates were obtained by using the Water Erosion Prediction Project (WEPP) model and actual soil and weather data (30-year period of record, 1982-2011). Vegetation type and growth parameters were fitted in the model to reproduce the sites conditions. The analysis showed no statistically significant difference in the SOM content between burned and not burned sites, and the same situation was observed when analyzing the CIC and nutrients. However, burned sites showed a statistically significant higher erosion rates as a result of the bare soil and the precipitation following fires. Thus, this paper discusses these processes and the effects under the soil and climate conditions in Patagonia.

Notes

Erosion derived humus redistribution on arable field

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Abstract

Soil erosion is one of the most important redistributing factors on arable fields. The detachment and delivery of soil particles hardly depend on certain parameters as size, aggregate stability, bulk density etc. The colloids, as the smallest size particles, are believed to move easily while the sand fraction is much more stable. Accordingly both mineral and organic colloids are overrepresented in runoff and soil loss that causes selective erosion. The theoretical enrichment of humus and the clay fraction in soil loss was studied in two Hungarian pilot areas on Cambisols. For the plot scale investigations a rainfall simulator was applied to describe selective erosion. In catena scale soil samples were taken along some hill slopes from the eroded spots to the accumulated parts. In each sampling point the whole solum was investigated to find differences in humus compound and volume.

In plot scale selective erosion takes place as redistribution within the plot with crust formation. Thin sections and XRD measurements demonstrate the horizontal structure of the particles on the surface, covered by humus and clay colloids. Particle size distribution of soil loss changes with time during the precipitation. At catena scale there are ambiguities between the test sites. On the deposited part of site one the humus content decreases gradually with depth, however, the layers have similar humus quality (E4/E6 ratio). On site two the topsoil has the lower humus content while the E4/E6 ratio varies in the horizons. The differences could be the result of tillage intensity and time, but there is no definite evidence of selective sedimentation at this scale. To clarify the relationship between plot and catena scale selective erosion further investigations are needed.

Notes

Fire severity effects on soil organic matter in northern Minnesota, USA

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Abstract

Wildfire may cause major losses of forest soil organic matter and consequently limit soil nutrient availability and forest regeneration, although the characteristics of post-fire organic matter are also likely to influence these processes. Fire is a key ecological process in the Laurentian mixed forests of the Great Lakes region, USA, and recent patterns of prolonged regional drought suggest that the ecological effects of these fires may become increasingly severe. The 2011 Pagami Creek wildfire in northern Minnesota was a historical fire event and resulted in a range of fire severity levels determined via remote sensing and field measurements. To evaluate the effects of fire severity on forest soil organic matter, we quantified total soil carbon (C) and nitrogen (N) content using elemental analysis, and black (pyrogenic) C content using nuclear magnetic resonance (NMR) spectroscopy in areas classified as low to high fire severity. Forest floor C content decreased with fire severity, and there were no differences in forest floor N content among severity classes. Similarly, there were no differences in total C or N content for mineral soil at 0-10 cm or 10-20 cm depths. All fire severity levels decreased C:N ratio relative to unburned reference areas for the forest floor and 0-10 cm mineral soil; however, there were no differences in C:N among severity levels. Results on pyrogenic C content will be presented. Our results indicate that fire effects on soil C and N content are limited primarily to the organic soil layers, and that effects on mineral soil are minimal. Understanding the environmental effects of forest fire as a function of fire severity is critical for developing appropriate policies and practices for minimizing detrimental effects and managing fire-prone forests for long-term resilience.

Notes

On measuring the effects of prescribed fire on forest floor litter and soil carbon stocks in a mixed eucalypt forest in south-eastern Australia

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Abstract

Low-intensity prescribed (planned) fire is being increasingly used to reduce the risk of wildfire in south-eastern Australia. The effects of fire on soil organic matter and nutrient cycling processes have been variously studied, but usually only in pseudo-replicated comparisons or from sampling immediately before and after burning. There are few long-term longitudinal studies of the effects of fire in eucalypt forests. Regardless, measurement / monitoring of long-term effects, including accurate quantification of changes in forest floor carbon stocks, is difficult because for example of high spatial variability and subjective differences in distinguishing litter from soil, both potentially affected by fire regime. In addition, changes / refinement in laboratory analytical equipment and methodologies over decades can exacerbate the difficulty of comparisons. In this study we specifically deal with the problem of subjective distinction of litter and soil (avoiding loss / double-counting) using an integrated sampling and sample processing approach. That is, soil was sampled volumetrically and precisely by depth (0-2, 2-5, 5-10, 10-20, 20-30 cm) beneath litter quadrat (0.1 m^2) sampling positions, and both litter and soil were processed into <2 mm and >2 mm size classes for analysis. The study area is in a mixed eucalypt forest, about 100 km north-west of Melbourne, Australia. Replicated (N = 5) low intensity fire treatments were applied since 1985 in either spring (S) or autumn (A) and at approximately 3 year (S3 and A3) or 10 year (S10 and A10) intervals to long-unburnt forest. Litter and soil were sampled in 2012, after 26 years of burning treatments. There was no effect of burning treatments on soil bulk density. Only frequency of burning affected litter plus soil carbon stocks: S10 (106 Mg ha^{-1}), A10 (104), S3 (95), A3 (95), relative to the unburnt control (C, 106). On average, the organic matter content (estimated as loss on ignition at 550^{o}C) of the samples was: litter >2 mm (790 g kg^{-1}), litter <2 mm (490) and soil 0-2 cm depth (120). Considering soil plus litter <2 mm as ‘soil’, the treatment effects on soil carbon stock to 30 cm depth (Mg ha^{-1}) were: S10 (93), A10 (95), S3 (85), A3 (84) and C (92). While in both accounts the maximum difference was about 10 Mg ha^{-1}, it was evident that the burning treatments differentially affected both the amount and distribution of carbon in litter (as sampled) size fractions, and thus sampling approaches that are not integrated may lead to significant errors in and/or mis-interpretation of treatment effects.

Notes

Relating soil carbon and structure to land use management

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Abstract

Sustainable soil management is critical to the Irish economy because livestock products raised from grass contributed €24 billion in 2011. Mismanagement results in a vicious circle of soil quality deterioration and reduced productivity. This study accessed soil carbon content near the soil surface (0-10cm) over a range of land use management from 20 tillage and 20 grassland farms in Ireland. Visual Evaluation of Soil Structure (VESS) was used to score (Sq) each field. The average Sq score was Sq 2.15 on arable lands and 2.24 on grasslands, with no significant difference. However, within grassland management, an increase of Sq (decrease in soil structural quality) with increased management intensity was found (R^2=0.7). The soil carbon content ranged from 15 to 46 g kg^{-1} soil under arable management and from 37.5 to 103.8 g kg^{-1} soil on grassland indicating a greater capacity of carbon sequestration on grassland. There was no correlation between soil carbon and Sq values under arable management, but a negative correlation was found between Sq and soil carbon (R^2=-0.59, $p<0.01$) under grassland indicating that soil structural quality decline was associated with reduced soil carbon. The results indicated that Irish soil management was largely sustainable in term of soil structure and carbon under both arable and grassland management, but if management intensity increased, many farms would become unsustainable from a soil quality perspective.

Notes

Soil carbon management and climate change

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Abstract

Among global issues of the 21st century are: enrichment of atmospheric concentration of greenhouse gases (GHGs) and the attendant climate change, increase in food production needed to meet the demands of growing and affluent population, and aggravated risks of soil and environmental degradation. Thus, enhancing the magnitude and mean residence time (MRT) of soil carbon (C) pool is integral to any strategy of addressing these and other related global issues. The promise of soil C sequestration is based on the magnitude of net biome productivity (NBP) of ~3Pg C/yr, and the hypothesis that some NBP can be retained in the soil to offset emissions and also enhance the resilience of soil and agroecosystems to climate change. Complementary to soil organic C (SOC) is the soil inorganic C (SIC) pool, together estimated at ~ 4000Pg to 3-m, play a major role in the global C cycle (GCC). The soil C sink capacity has been enhanced by depletion of the antecedent SOC pool in degraded soils. Despite the large potential of 0.5-1 Mg C/ha/yr, there are numerous uncertainties: 1) increased emissions of GHGs with increase in the atmospheric concentration of CO_2, 2) change in the rate of C uptake by soils of the tropics by climate change, 3) impact of chemical weathering of silicate rocks in altering terrestrial sinks, 4) unknown fate of C transported by erosional processes, 5) a possible positive feedback from the melting of permafrost, 6) decrease in capacity of terrestrial sinks because of soil degradation, and 7) the effects of wild/managed fires on soot, charcoal and NBP. These uncertainties interact with mechanisms of SOC stabilization and those which enhance its MRT. These mechanisms include: physical protection through deep placement and formation of stable aggregates, interaction between SOC and clay minerals, landscape position, and humification leading to formation of recalcitrant fractions. There is a vast potential of SOC sequestration through adoption of recommended practices on croplands (e.g., conservation agriculture, cover cropping, integrated nutrient management) grazing lands (e.g., controlled grazing, better forage/tree species, soil and water conservation), forest lands (e.g., afforestation, stand management, species selection), wetland/peatland restoration, and restoration of degraded soils. Comparatively low rate of SIC sequestration as pedogenic carbonates exist in vast arid and semi-arid lands, and in agroecosystems irrigated with good quality water. However, there are also challenges of credible measurements of small changes in soil C in a relatively large pool, and of scaling up the data from profile to watershed and regional scale. There are numerous co-effects of soil C sequestration including improvements in soil quality, increase in agronomic productivity, enhancement of biodiversity, reduction in non-point source pollution etc. Payments to land managers for ecosystem services and trading of C credits may enhance adoption of recommended technologies especially by resource-poor farmers, and small landholders in the tropics. Researchable priorities include understanding of trends and variability in principal determinants of SOC pools and its residence time, assessing the impact of C-climate feedbacks and understanding coupled cycling of C with other elements (N, P, S) and H2O. Soil C sequestration is a cost-effective, win-win option, and a bridge to the future until low-C or no-C fuel sources take effect.

Notes

Long-term soil organic carbon changes as affected by crop rotation and bio-covers in no-till crop systems

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Abstract

One negative-feedback for climate-warming gases in agriculture is soil organic carbon (SOC) sequestration. However, the rate of no-tillage SOC storage is not well known due to biogeochemical and production variation. Therefore our objective was to compare long-term SOC flux at two no-till field sites in Tennessee (Spring Hill and Milan) on a Maury silt loam and Loring soil series, respectively, in a split-block design with four replications. The whole-block was cropping sequences of corn (*Zea mays*), soybeans (*Glycine max*), and cotton (*Gossypium hirsutum*) with split-block bio-cover treatments of: winter wheat (*Triticum aestivum*), hairy vetch (*Vicia villosa*), poultry litter, and a fallow control. The SOC was calculated at soil surfaces (0-5 cm) during yr-1, 2, 4, and 8. During the first 3 years, small annual losses in carbon over all treatments occurred at Spring Hill and Milan (1.06 and 1.40 Mg ha^{-1}, respectively). During this time, cotton sequences lost more surface SOC than other treatments at Milan ($P \leq 0.05$). However, by yr-4, SOC began to recover. By yr-8, poultry litter bio-cover gained more surface SOC compared to fallow at Milan, whereas no trends among bio-covers were observed at Spring Hill. Sequences with high frequencies of corn generally gained significantly greater surface SOC than treatments with high cotton and soybean frequencies at Milan. Across all sequences and bio-covers, by yr-8 SOC at the 0-5 cm depth increased to 1.5 and 1.6% at Spring Hill and Milan, respectively from pre-experimental levels of 1.3% at both locations.

Notes

Preservation of organic matter and the use of rice husk to increase soil organic C in heavy clay soils dominated by kaolinite and sesquioxides

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Abstract

Soil organic matter of three Oxisols referred to as Segamat, Sungai Mas and Kuantan soils was compared under natural conditions. Preservation of soil organic matter was determined by measuring metal organic C association and soil pores and specific surface areas (SSA) before and after soil organic matter removals. These three soils contained high clay content (73% to 82%) and their mineralogical composition was dominated by kaolinite and sesquioxides (goethite, hematite and gibbsite). Morphological features showed different colors, i.e., dark reddish brown for Sungai Mas, dark brown for Kuantan and red for Segamat. The Kuantan soil has much higher organic C (3.4%) than Sungai Mas and Segamat soils (~1.3-1.4%). Under natural conditions (SOM was not removed by hydrogen peroxide), the soil pores were dominated by mesopores (2-50 nm). Partitioning the mesopores into various sizes showed that the cumulative small mesopore (2-20 nm) volume was considerably higher for Kuantan (63%–73%) than the Sungai Mas or Segamat (25%–35%) soils. This is caused by the lower crystallinity (broad peaks of minerals observed by X-ray diffraction, XRD) and smaller size of minerals (as observed by scanning electron microscopy) in the former. The values of SSA were compatible with those of the soil pores where the magnitude of SSA with and without SOM was 1.6 to 1.9 and 2.0 to 2.2 times higher, respectively, in Kuantan than in Sungai Mas or Segamat soils. Stabilization of SOM in Kuantan soil occurred through physical protection in the mesopores and cation bridging, as revealed by the increase in mesopore volume (from 58% to 92%) after SOM removal and the high Fe_p and Al_p contents (extracted by sodium pyrophosphate), respectively. The less crystalline and smaller clay size particles present in the heavy clay Oxisols have a positive impact on soil carbon sequestration and stabilization. An attempt to increase soil organic C and its longer residual time in Oxisols was performed by applying rice husk compost (RHC), a material relatively resistant microorganism decomposition, to Segamat soil having red color and low organic C. Experiments were performed under different environments (laboratory, greenhouse, and field) for 15 to 24 months. Results showed that RHC significantly increased the organic C of the Oxisol and changes in its chemistry occurred after 24 months under laboratory conditions and 12 months under greenhouse and field conditions. Solid-state cross polarization magic angle spinning (CP/MAS) ^{13}C nuclear magnetic resonance (NMR) showed C types derived from RHC were dominated by cellulose, with specific characteristics of well-ordered structure (very sharp and well resolved peaks at O-alkyl and di-O-alkyl C regions), indicating stabilization of organic C. The RHC decomposition was faster in the order of field > greenhouse > laboratory conditions as revealed by the high values of decomposition indices of hydrophobicity/hydrophilicity ratio, alkyl/O-alkyl C ratio, and aromaticity; and the high magnitude of normalized cumulative C loss for conditions with a high decomposition rate. The cumulative C loss was 71 to 80% (depending on the application rates) in the field, 71 to 74% in the greenhouse, and 48 to 62% in the laboratory after 12 months. Under all conditions, the remaining RHC-derived C was still significantly higher than the control treatment at the end of the experiments, implying that RHC can be used to increase organic matter with longer residence time in soils. This is most suitable for tropical areas to overcome the rapid decomposition of soil organic matter.

Notes

Evaluation of carbon sequestration within Phytoliths of some dry farming crops in Calabar, Nigeria

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Abstract

Phytoliths are microscopic silica bodies of varying sizes and shapes that precipitate in or between cells of living plant tissues. Organic carbon in living cells can be occluded in Phytoliths during growth. It has long been documented that the occluded carbon within the Phytoliths is an important long term terrestrial carbon reservoir that has a major role in the global cycle. *Manihot esculentus* (Euphorbiaceae), *Zea mays* (Poaceae), *Cucumis melo* (Curcubitaceae), *Annona comosus* (Bromiliaceae) and *Xylopia aethiopica* (Annonaceae) are typical dry farming crops in calabar, Nigeria. The study of carbon conservation within Phytoliths in these crops could provide insights into anthropogenic influences on the carbon cycle. In this study we analyzed the carbon contents in the Phytoliths of *Manihot esculentus* (euphorbiaceae), *Zea mays* (poaceae), *Cucumis melo* (cucurbitaceae), *Annona comosus* (Bromiliaceae) and *Xylopia aethiopica* (Zingiberaceae). The result indicated that *Manihot esculentus* contained 0.011%±0.052%, *Zea mays* 0.0148%±0.082%, *Cucumis melo* 0.0145%± 0.087%, *Annona comosus* 0.0152%±0.076% and *Xylopia aethiopica* 0.0128±0.066%. These carbon fractions could probably be one of the best candidates for the missing carbon sink when compared to the mean annual productions of these crops in Nigeria and elsewhere over the years.

Notes

Could soil acidity enhance sequestration of organic carbon in soils?

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Abstract

A field experiment performed to analyze the SOM dynamics under shifting cultivation in northern Thailand revealed that the decomposition rate constant (k) of SOM decreased during middle stage of fallow because of increasing acidity in this stage. According to an extensive survey on SOM decomposition, involving a laboratory incubation experiment, the values of k for strongly acidic soils with pH below 5 (mainly Udepts and Udults in Japan and Kalimantan in Indonesia) are much lower than those for Eurasian steppe soils (mainly Mollisols; approximately neutral pH). As a result, the amount of potentially mineralizable C (C0) in the Kalimantan soils or light-fraction C in the Japanese soils drastically increased. Thus, the strong soil acidity can enhance the accumulation of mineralizable organic materials in surface soils by decreasing the soil microbial activities for SOM decomposition. Field measurements of C flux in various forest soil ecosystems showed that the internal leaching of dissolved organic carbon (DOC) from litter layers or surface soils increased under low pH conditions (i.e., pH around 4), presumably because of the predominant fungal activity. Most of the mobilized DOC was accumulated again in the subsoils. Such DOC flux sometimes accounted for greater than 10% of the annual CO2 emission from the soil surface. It was typically observed in acidic soils under a udic soil moisture regime, i.e., Humods in Japan and Udults in Kalimantan in our study, indicating that the downward movement of DOC in acid soils increases the tendency of the subsoils to accumulate SOM as organo-mineral complexes, especially in a north-temperate forest. For a more detailed investigation of these processes, different approaches were applied at field and laboratory scales. It is suggested that the predominant lignin peroxidase activity in the litter (FH) layers accelerates the release of high concentrations of DOC into the underlying soil horizons of strongly acidic soils. The decomposition rate of cellulose, which is the more readily decomposable fraction of plant litter, was considerably suppressed in strongly acidic soils, as was expected on the basis of the lower activity of cellulase in acidic conditions. As soil pH decrease, soil microbial biomass determined by substrate-induced respiration method decreases while respiration quotient increases. The ratio of chloroform labile C to substrate-induced respiration increased markedly in strongly acidic soils, indicating formation of a large pool of relatively inactive microbial biomass in acid soils. Hence, high soil acidity can enhance the storage level of organic materials in soils in the forms of: 1) readily mineralizable organic materials in the surface soils, 2) organo-mineral complexes in subsoils, formed as a result of accelerated leaching of DOC from the O horizon and 3) inactive microbial biomass pool, typically under low-substrate conditions.

Notes

Farmyard manure application mitigates greenhouse gases emissions from managed grasslands in Japan

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Abstract

Applying manure leads to reduce chemical N fertilizer and to sequester carbon (C) in soils. This study quantified the effect of manure application on the CO_2, CH_4 and N_2O emission at five managed grasslands in four climatic regions in Japan. Net ecosystem exchange (NEE) by eddy covariance method, CH_4 and N_2O emissions by chamber method were measured at manure (M) and chemical N fertilizer (F) plots from 2005 to 2010. Manure application rate was determined based on the potassium demand of grasses. CO_2 emission was estimated as NEE–manure+harvest. Global warming potential (GWP) was calculated using conversion factors of 1 for CO_2, 25 for CH_4 and 298 for N_2O. CO_2 emission in F and M plots was -0.2±2.1 and -3.2±2.4 Mg C ha^{-1} yr^{-1}, respectively, indicating that M plot gained more C than F plot. NEE showed more CO_2 uptake in F plot (-4.4±2.2 Mg C ha^{-1} yr^{-1}) than in M plot (-3.8±2.5 Mg C ha^{-1} yr^{-1}). Harvests in F and M plots (4.3±0.9 and 4.2±0.9 Mg C ha^{-1} yr^{-1}, respectively) induced C shortage, but manure C application (2.1±0.3 to 7.1±1.3 Mg C ha^{-1} yr^{-1}) recovered the shortage. CH_4 was slightly taken up in both F and M plots (-0.03±1.2 and -0.1±0.5 kg C ha^{-1} yr^{-1}, respectively), while significant N_2O emission was found in F and M plots (4.2±3.6 and 4.9±3.7 kg N ha^{-1} yr^{-1}, respectively). Although N_2O emission was higher in M plot than F plot for first three years, it was reversed after fourth year. Major component of GWP was CO_2 emission, and the difference of GWP between F and M plots was significantly correlated with manure C application rate. At least 2 Mg C ha^{-1} yr^{-1} of manure C application mitigates global warming in terms of soil C sequestration without suppression of yield compared to conventional cultivation using chemical fertilizer in Japanese managed grasslands.

Notes

Residue and soil carbon storage affected by tillage, cropping sequence, and nitrogen fertilization

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Abstract

Information is needed on the effects of management practices on soil C storage under dryland cropping systems for obtaining C credit. The effects of tillage, cropping sequence, and N fertilization were evaluated on dryland crop and surface residue C and soil organic C (SOC) content at the 0-120 cm depth in a Williams loam from 2006 to 2011 in eastern Montana, USA. Treatments were no-till continuous malt barley (NTCB), no-till malt barley-pea (NTB-P), no-till malt barley-fallow (NTB-F), and conventional till malt barley-fallow (CTB-F), each with 0, 40, 80, and 120 kg N ha^{-1}. Annualized grain and biomass (stems + leaves) yields and C contents were greater in NTB-P and NTCB than in CTB-F and NTB-F in all years, except in 2008, and increased with increased N rates. Soil surface residue amount and C content were greater in NTCB or NTB-P than in CTB-F or NTB-F in 2007, 2009, 2010, and 2011, and also increased with increased N rates. The SOC at 0-5 and 5-10 cm was greater with 40 than with 0 kg N ha^{-1} in NTB-P, but at 30-60 cm was greater with 120 than with 0 kg N ha^{-1} in CTB-F, NTB-F, and NTB-P. The SOC at multiple depths varied among years. Tillage had no effect on crop and surface residue C and SOC. Greater amount of crop residue C returned to the soil probably increased surface residue and soil C storage at surface layers in NTB-P with 40 kg N ha^{-1}.

Notes

Impact of mechanical loading on static and dynamic CO_2 effluxes of arable Luvisols under different soil management

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Abstract

Mechanical disturbance of soil structure is commonly related to altered physical changes in pore systems, which control CO_2 effluxes e.g. by changes in gas transport properties and in microbial activity. Soil compaction mostly led to reduced CO_2 fluxes. In contrast, structured soils can also release physically entrapped CO_2 or protected carbon sources inside of aggregates, whose accessibility will be altered due to aggregate breakdown by disruptive forces. How far the management of arable soils affected structure- and compaction-related CO_2-releases was investigated by incubation experiments and CO_2 gas analysis in the laboratory under hydraulic equilibrated conditions. CO_2-efflux was analyzed before, during and after mechanical loading using the alkali trap method and gas flow compaction device (GaFloCoD) on intact soil cores (236 – 470 cm^3) from a Danish loamy sand (conservation and conventional tillage systems) and German clayey silt (different pre-crop systems) from the topsoil (10 – 20 cm) and subsoil (35 – 45 cm). Mechanical stability was reflected by the pre-compression stress value, changes in pore systems were described by air conductivity and characteristic porosity values. While CO_2-releases varied highly during the compaction process for different stress magnitudes, soil depths and management systems, basal respiration rates were generally reduced after mechanical loading by almost half of the initial rates. The influence of management-specific physical properties on CO_2 efflux were most pronounced in topsoil layers prior mechanical loading and diminished after compaction indicating considerable changes in microbial activities. Microbial activity was inhibited under less favorable conditions directly after compaction (<1 day), but increased when the soil was re-equilibrated to field capacity suggesting that organic carbon became more accessible, microbial communities changed and/or were redistributed due to soil structural changes related to mechanical and hydraulic stresses. In future, special focus should be given on a clear distinction between physical and microbiological effects controlling CO_2 fluxes in structured soils.

Notes

Soil carbon lost from Mollisols of the North Central U.S.A. with 20 years of agricultural best management practices

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Abstract

Soil organic carbon (SOC) is highly sensitive to agricultural land management, so there is a great deal of interest in managing cultivated soils to sequester atmospheric CO_2. In this study we evaluated the influence of six cropping systems on SOC at the Wisconsin Integrated Cropping System Trial (WICST) over a 20-year period. Analysis of SOC on either a concentration or mass per volume of soil basis indicated a significant decline across all of the systems at WICST. While the rotationally grazed pasture system sequestered carbon (C) in the surface 15 cm these gains were offset by losses at depth. Both no-till (NT) practices and inclusion of perennial crops reduced SOC loss, but neither resulted in C sequestration in the soil profile. Results from this study demonstrate the importance of (i) comparing current and initial soil samples when evaluating SOC sequestration and (ii) evaluating SOC changes throughout the soil profile. The losses of SOC at depths below the plow layer point to either a lack of C input from roots, increased oxidative loss at these depths or both.

Notes

Estimating carbon sequestration potential of cropland management in Japanese arable soils with the Rothamsted carbon model

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Abstract

We constructed a simulation system which linked the Rothamsted carbon (RothC) model with spatial data such as weather, soils, land use, and activity data (the amount of C input to soils by crop residue or manure) including several different management scenarios in future; a BAU (business as usual) scenario and several "Carbon sequestration scenarios" which increase C input to soils. At first step, the RothC model was validated using long-term experimental data. The model needed to be modified for Andosols and paddy soils concerning unique mechanisms of soil carbon dynamics of these soils while the model adequately simulated changes in the soil carbon content with time in non-volcanic ash upland soils. After the validation and modification of the model at plot scale, we estimated the carbon sequestration potential by organic matter application at country scale by applying the model at 100 m spatial resolution from 1970 to 2030. The total soil organic carbon (SOC) in Japanese agricultural lands tended to decrease over time in most combinations of soil types and land uses. The inter-annual variation of annual SOC changes was large. The net-net accounting of the amount of annual changes in SOC, following Kyoto protocol, by taking the average of 1988 to 1992 as base year and 2013 to 2020 as commitment period, resulted in net sink of CO_2 with magnitude of 2 to 5 $MtCO_2$-equilibriu m/year, under different management scenarios in future, various methods of estimating activity data and different climate change scenarios.

Notes

Biochar: potential role in soil carbon sequestration

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Abstract

Biochar (a form of black carbon) has been recently heralded as an amendment to revitalize worn-out/weathered soils, increase soil C sequestration, enhance agronomic productivity, and enter into future carbon trading markets. Soil application has been the assumed target for biochar. Biochar has been shown to occasionally cause immense benefits to both crop yields and soil fertility when added to degraded/weathered soils, but simultaneously has a documented history of negative to negligible agronomic impacts. Past research, as far back as the 1800's, has demonstrated that biochar has variable properties, which spans the full spectrum of black carbon residuals. Thus, suggesting that biochar is not a panacea for all soils. The mechanisms behind these biochar impacts are complex with multiple potential hypotheses. This presentation will summarize on-going research into the potential role of sorbed organics on biochar in the mitigation potential for N_2O emissions and the role of biochar in improving water quality through reduced nitrate and agrochemical leaching. With population expansion and the finite area of tillable ground, improving nonproductive soils with biochar could be a vital key to future global food production, food security, and energy supplies.

Notes

Nitrogen and harvest effects on switchgrass and maize contributions to deep soil C after 9 years

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Abstract

Switchgrass (*Panicum virgatum* L.) is a perennial, cellulosic biofuel feedstock capable of growing under a wide variety of climatic conditions on land marginally suited to cultivated crops. Despite greater switchgrass root production compared to maize, researchers observed similar soil C sequestration rates after 9 years in a non-irrigated study evaluating N fertilizer and harvest management treatments on switchgrass (harvested at Aug. and Oct.) and no-till maize (with and without stover removal) (Follett et al. 2012). To quantify the form of switchgrass (Cave-in-Rock) and maize-derived organic C we sampled these plots to a depth of 150 cm in 2007 and fractioned the soils into labile (POM) or stable (silt+clay) soil fractions, and natural abundance ^{13}C. We then assessed plant biomarkers through the profile using cupric oxide extraction and pyrolysis-GC/MS. Through the entire 0-150 cm profile, switchgrass had greater root biomass and a greater root C:N ratio than maize. Both the POM and silt+clay fractions in the 0-30 cm depth incorporated the higher switchgrass C:N ratio, suggesting that root-derived contribution to SOM under switchgrass may derive directly from lignin rather than root exudates. Lignin biomarkers under maize were more decomposed than under switchgrass, reflecting greater root turnover. These results illustrate complex, plant-specific interactions of nitrogen fertilization and harvest timing on root biomass and soil fraction C.

Notes

Soil organic carbon content – effect of tillage and fertilization in long-term field trials

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Abstract

Long-term field experiments have a high scientific value while they help for the better understanding of many relations in the soil-plant system, and across the reliable results originated from them can give advices to stable interventions (which) are aimed to the sustenance of soil fertility. At the Georgikon Faculty of University of Pannonia, (Keszthely, Hungary) there are many long-term field experiments, in which several different soil physical and chemical parameters are examined. In this paper, the results of Soil Organic Carbon (SOC) content examinations from two different types of them were presented. One of the experiments is the part of the International Experiment for Investigation the Effect of Organic and Inorganic Fertilizers (IOSDV), which was set up in 1983 in Keszthely. The bifactorial experiment has a maize-winter wheat-winter barley rotation, and a split-plot design with 3 replications. The main factor is organic fertilizer application with three different organic matter supply (inorganic fertilizers only without residue incorporation, complementary farmyard manuring in every 3rd year, and complementary residue and green manure application). The other factor is mineral fertilization with increasing rate of N fertilizers. The other experiment is directed to the investigation of different tillage systems. This experiment was set up in 1972, and has a winter wheat-maize rotation. The design of the experiment is split-plot with four replications. The main factor is the tillage system (conventional winter ploughing, shallow winter disking and minimum tillage), the other factor is mineral fertilization with increasing rate of N application as by the other experiment. The soil type of the experiments is Eutric Cambisol (WRB). The measurements were carried out on soil samples originated in the maize sections of both experiments. The soil sampling was made in autumn 2011, in case of the IOSDV-experiment from the cultivated layer, in case of the different tillage investigation experiment from 0-10 and 10-30 cm layers. In the light of bulk density values, total organic carbon content (C pool) of the examined soil layers was calculated. The statistical significance of the experimental treatments were analysed by analysis of variance (SPSS ANOVA). According to the results of IOSDV-experiment, organic fertilizers influenced Soil Organic Carbon (SOC) content of soil in significant degree. Increasing rates of N fertilization did not have significant effect on the examined parameters. In the tillage system-investigation, the conventional tillage system (deep winter ploughing) resulted in the lowest, while minimum tillage system (shallow disking immediately before sowing) resulted in the highest SOC both in the 0-10 and 10-30 cm soil layers. The differences in SOC values between the different layers were much smaller in case of conventional tillage, while in case of minimum and shallow disk tillage systems were ten times larger. N fertilization resulted in higher SOC values in the 0-30 cm layer.

Notes

Soil organic carbon stocks, changes and CO_2 mitigation potential by alteration of residue amendment pattern in China

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Abstract

Proper estimation of the national soil organic carbon (SOC) stocks, changes and CO_2 mitigation potential are critical to adopt proper measures to protect SOC pools and to make strategies for the greenhouse gases (GHGs) mitigation. The data of SOC, bulk density from the Second State Soil Survey of China conducted in the early 1980s, and farmland CH_4 and N_2O emission induced by residue amendment were used to estimate the SOC pools, their changes during 1980-2000 and farmland GHGs mitigation potential in China. Soils were divided into paddy, upland, forest, grassland and waste land soils according to their usages. The SOC stocks are 89.61 Pg in China's 870.94 Mha terrestrial areas covered by 2473 soil series. The annual accumulation rates in farmland and forest soils are 24.6 Tg and 9.7 Tg from 1980-2000, respectively. More carbon of amended organic matter (OM) was retained in paddy soil than in upland soil, but OM amendment in paddy soil led to large CH_4-C emissions, 9.95% and 19.17% of organic carbon input under intermittent and continuous flood conditions, respectively. By alteration of OM amendment on rice season to off-rice upland crop season, CH_4-C emissions could be cut by 3.5 Tg yr^{-1}, accounting for 63% of current CH_4-C emissions (5.5Tg). By increasing OM amendment percentage from 30% to 50%, and by alteration of OM amendment on rice season to off-rice upland crop season, the equivalent CO_2-C mitigation potential in farmland of China would be 49.2 Tg yr^{-1}.

Notes

Methane emissions following land use change on tropical peat in Jambi, Indonesia

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Abstract
Tropical Peatlands have the capacity to be efficient carbon (C) sequestering ecosystems when left undisturbed. A balance of permanent waterlogged conditions with high biomass productivity increases long term C storage potential. With hydrogeology being a key factor in these vulnerable ecosystems it is important to understand how land use change (LUC) affects fluxes of C containing gases. The effect of land clearance, soil compaction, and drainage on tropical peatlands was studied in a peat swamp forest, degraded forest and an oil palm plantation in Jambi, Sumatra. Monthly gas fluxes were taken across 3 sites for duration of 18 months. Methane forms a source annually on all sites, with the peat swamp forest having the highest emissions, suggesting a shift to oxidation on land use change which forms a pathway for C release as carbon dioxide in the managed sites.

Notes

Leveraging data, information and knowledge on soil carbon toward decision making for improving sustainability outcomes

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Abstract

Socio-ecological systems have traditionally been managed to meet immediate needs, often without any awareness of longer-term dynamics of the system. This is especially evident within agricultural systems typically managed for “fast” system variables, such as maximizing crop production. New research has illustrated that “slow” variables of socio-ecological systems help to determine the core structure of these systems, and that by tailoring management to these elements, more sustainable long-term outcomes are more likely. Managing for slow variables such as soil carbon on landscapes will require access to data, information and knowledge about soil resources in such a way that is useful to those who make management decisions. This paper reviews the current state of soil carbon knowledge resources, and complementary information on management techniques and systems used to maintain the integrity or remediate soil carbon stocks. Characterizing the state of this information is a crucial step in opening the conduit of knowledge to managers and decision-makers so that the consequences of individual decisions on this important resource can be reflected. Abroader community to work toward leveraging our vast knowledge of soil carbon is needed in the context of decision-making within agricultural systems.

Notes

Long-term soil C dynamics under three subtropical grassland management systems

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Abstract

This research was conducted on established (>20 years) experimental sites in Florida to quantify the long-term impacts of 3 management systems (intensively managed improved pasture – Improved-P, Pine-Bahia silvopasture – Silvo-P, and native rangelands – Native-R) on total soil organic carbon (TC), total nitrogen (TN), total C:N ratio (C:N), and root carbon (RC). Based on a comparative-mensurative experimental design, a total of 450 sample soil cores were collected from six collocated ~6ha fields (2 replicate field per management system) across 3 soil depth increments (0 to 10, 10 to 20, and 20 to 30cm), and analyzed for TC, TN, and C:N. To quantify the contribution of root biomass, a total of 270 larger soil cores were collected across all fields and analyzed for root C content. At 0-10cm soil depth, all sites sequestered comparable TC (P=0.110), but TN, C:N, and RC differed across the sites. At 10-20cm, Native-R showed significantly lower TC (9Mg ha^{-1}, P=0.005) relative to Improved-P (16Mg ha^{-1}) and Silvo-P (16 Mg ha^{-1}), TN was highest in Silvo-P (0.99Mg ha^{-1}, P=0.022), C:N was similar across sites, and RC was highest in Silvo-P (14Mg ha^{-1}, P<0.0001) . At 20-30cm, Native-R contained lower TC (7Mg ha^{-1}, P=0.022) relative to Silvo-P (13Mg ha^{-1}), but comparable to Improved-P (11Mg ha^{-1}), with similar observation for TN, C:N, and RC. Across all depths (0-30cm), TC, TN, C:N, and RC were similar in Improved-P and Silvo-P sites. The outcomes of this study have important implications for management and policy decisions in relative to soil C sequestration in subtropical grasslands.

Notes

Is percent ancient carbon a useful indicator of soil health?

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Abstract

There are many different indicators of soil health each with specific meaning to soil scientists. However, that meaning or interpretation is often lost for the general public and policy makers. Important messages from the soil science community regarding soil security need to be supported by evidence that is broadly comprehensible to register general recognition of a significant issue that requires action. The concentration of Soil Organic Carbon (SOC) has previously been suggested as an indicator of soil health. To be useful as an indicator SOC must be considered in context, with soil type, climatic region, local rainfall, slope, and land use history influencing measured values of SOC. The concept of Percent Ancient Carbon (PAC) implicitly incorporates the context variables. PAC may be defined as a simple percentage comparing a modern measured soil carbon value against a hypothetical ancient soil carbon value. Ancient approximates with prior to human settlement. Ancient soil carbon may be estimated by measuring soil carbon under comparable undisturbed natural endemic vegetation nearby or estimated by modelling. Reference maps of ancient carbon produced by existing models may be generated and refined over time through scientific discourse testing model assumptions. The task of comparing modern measured soil carbon to a reference value of ancient carbon is simple, open to all to produce PAC maps at all scales and for a variety of purposes. This approach removes the skilled application of model parameters from the end users of PAC maps, limiting the scope for model miss-application. Farmers may find PAC maps useful managing their farms at the paddock scale, whilst PAC maps may highlight the cumulative impact of industrial agriculture to soil scientists and agronomists at the regional or national scale. PAC maps would support policy decisions to help implement sustainable agriculture.

Notes

Soil CO_2 emission and soil organic matter characteristics associated with land-use change in tropical peatlands of Sumatra, Indonesia

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Abstract

Tropical peatlands store about 50 Gt carbon (C) and are being increasingly degraded and deforested. If land use (LU) change on intact peatlands continues at the current rate, all the undisturbed peat swamp forests will have vanished by 2030. Disturbances such as deforestation and drainage can reverse the process of peat accumulation and release a substantial amount of carbon dioxide (CO_2) into the atmosphere. The aims of this study were to 1) compare soil CO_2 fluxes on an intact peat swamp forest (PF), a transitional logged drained forest (DegF) and an oil palm plantation (OP) located on the same alluvial peat plain, and 2) evaluate the characteristics of the peat under the same 3 LU. Carbon dioxide measurements were made monthly from January 2012 to May 2013. Simultaneous with CO_2 flux measurements, environmental variables were measured. Soil profiles were sampled in each LU and the amount of roots, logs, and fine soil was determined. Subsequently the fine soil was physically fractionated. For the PF, the DegF and the OP the CO_2 fluxes were 16.0 ±1.2, 18.5 ±0.7 and 28.4 ±1.2 Mg C-CO_2 ha^{-1} y^{-1} respectively (Jan-Sep 2012). For the same LU, the amount of logs in the soil (top 1 m) were 4.9 ±0.4, 2.7 ±0.5, and 3.1 ±0.5 kg m^{-2} respectively. For the same LU, the % of soil heavy fraction were 14.3 ±10, 54.5 ±46, and OP 65.9 ±18 respectively.

Notes

Soil carbon dioxide flux associated with land use change in the tropical peatland of Tanjung Puting National Park, Indonesia

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Abstract

Measuring soil Carbon Dioxide (CO_2) flux from intact forests and oil palm plantations is highly important due to rapid development of oil palm plantations on tropical peatland, especially Indonesia. Conversion of tropical peat swamp forest results high levels of carbon gas emission to the atmosphere through loss of biomass, peat oxidation, drainage, compaction and land preparation activity. Meanwhile, in small numbers of studies on soil respiration from tropical peatland, only a few studies have compared them in forest and oil palm plantation ecosystems. The specific objectives of this on-going research are: (1) Quantify soil respiration under the forest and oil palm ecosystems as an effect of forest conversion (2) Determine the underlying environmental factors that are related to soil CO_2 flux, (3) Examine seasonal variation (wet and dry season) in soil respiration in both ecosystems. Soil CO_2 flux is currently being measured monthly over one year at Tanjung Puting National Park, Indonesia, using a closed-chamber technique. We selected 3 replicate plots from a primary forest ecosystem containing differing peat depths. Plots are at least 3km apart. At the oil plantations, 3 plots with palms at 3 different ages (1, 2 and 4.5 years) located adjacent to the park. Soil CO_2 flux is recorded using a portable soil respiration system (EGM-4 by PP System). In each forest plot we installed 6 chambers in hummocks and 6 chambers in hollows. In the oil palm plantation plots, 6 chambers were located close to palms and 6 halfway between them. Three months (October to December 2012) preliminary results show that soil CO_2 flux ranged from 209.74 to 445.05 $mgCm^{-2}h^{-1}$ from the forests and 176.95 to 220.03 $mgCm^{-2}h^{-1}$ from the oil palm plantations. In addition, environmental variables including soil moisture, water table depth, soil temperature at 5 cm, water filled pore space (WFPS) and rainfall are monitored as possible controlling factors of CO_2 flux. As a complimentary data to quantify the nutrient cycled to forest ecosystem, we determine rate of litterfall in range from 4.23 $kgha^{-1}m^{-1}$ to11.26 $kgha^{-1}m^{-1}$.

Notes

Dynamics of soil carbon, nutrients and microbial activity under shifting cultivation systems: clues about indigenous wisdom in the humid tropics

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Abstract

Although shifting cultivation is sometimes claimed as a cause of soil degradation, it is still practiced for staple food production in many of the developing countries, particularly in the tropics. It is well known that the main profit of slash-and-burn is the supply of bases, P and N and that of fallowing is the recharge of SOC and nutrients. The fallowing stage, however, has been given limited information, and thus it is hardly to answer the question: How long is fallowing necessary to sustainably maintain soil productivity? The objectives of this study are 1) to understand the mechanism of restoration of soil productivity during fallowing stage with reference to the dynamics of soil carbon, nutrients and microbial activity and 2) to answer the above question, "how long", under the shifting cultivation systems in northern Thailand. The study site was characterized with steep slope of 20°, monsoon climate (annual precipitation of 1,222 mm and mean annual temperature of 20.2°C), and was occupied mainly by Ustic Haplohumults. Study plots were established for different stages of shifting cultivation system (upland rice cropping, 1yr-, 2yr-, 4yr-, 6yr-fallowing, and natural forest) in order to monitor soil respiration, litter fall, biomass production, nutrient contents in soil solutions collected at 15 and 45 cm depths from the soil surface, soil moisture and temperature and microbial activity in the field condition. Carbon input was estimated from biomass production and litter and its output was calculated from hourly soil respiration using Arrhenius-type model with soil temperature and moisture. The amount of SOM stock, including litter layer, in the soil profile ranged from 37.3 to 66.7 Mg C ha^{-1}. Compared with the total stock, annual output of soil carbon under fallowing stage is small (2.15 to 3.35 Mg C ha^{-1} yr^{-1}), as is that of upland rice cropping stage (6.34 Mg C ha^{-1} yr^{-1}). Annual budget of SOM ranged from -5.03 to 1.75 Mg C ha^{-1} yr^{-1} in cropping stage and natural forest, respectively. Cumulative budget increased from -5.03 in cropping stage to nearly zero or slightly positive after 6yr-fallowing. Nitrogen leaching as nitrate was suppressed and much less in the fallowing stage and natural forest (1-8 kg N ha^{-1} yr^{-1}) than cropping stage (11 to 26 kg N ha^{-1} yr^{-1}). It was due to higher nitrogen accumulation (50 to 250 mg N kg^{-1}) of microbial biomass as well as lower metabolic quotient, $q\mathrm{CO}_2$, of microorganisms in the fallowing stage and natural forest (0.5 to 3.2 mg C Bc^{-1} h^{-1}) than in cropping stage (0 to 60 mg N kg^{-1}, 1 to 6 mg C Bc^{-1} h^{-1}). Based on the findings above, it was concluded that 1) soil productivity is restored in the fallowing stage of 6 to 7 years by not only the addition of C and nutrients but also the suppression of N loss through leaching by the succession of the soil microbial community from rapid consumers of resources to stable and slow utilizers, resulting in an increase in the amount of N storage in the microbial biomass and a decrease in the rate of SOM decomposition, and thus, 2) shifting cultivation system can be seen to be well adapted to soil-ecological conditions and sustainable in northern Thailand provided the traditional style of fallowing for about 10 years is maintained.

Notes

CO_2 dynamic in biochar amended sandy loam for switchgrass production

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Abstract

On one hand, standard intensive plant production emit overall large amount of greenhouse gases (GHG) in part due to mineral fertilizer application and fabrication and losses of soil carbon. On the other hand, biomass production for energy is needed to partly replace fossil fuel consumption. The biomass production should therefore requires as less fossil energy and emit as little GHG as possible. A sandy loam was seeded with switchgrass (*Panicum virgatum* L.) in a split-plot experimental design. Biochar was implanted as the main plots at a rate of 10 t ha^{-1} while N treatments (Calcium ammonium nitrate: 50 kg N ha^{-1}, N-fixing rhizobacteria applied on seeds and no fertilization) were distributed as sub-plots. All plots were instrumented for monitoring soil CO_2 concentrations, soil water content, temperature, and CO_2 emissions during two growing seasons (2010-2011). Other soil properties were also measured. CO_2 dynamic (concentration and emissions) will be discussed along with biochar amendment, N treatments and plant properties.

Notes

Land use and parent material effects on soil carbon stocks and spatial variability in the Konya Basin, Turkey

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Abstract

The spatial variability of soil carbon stocks and their responses to long-term land use effects across different soil types are poorly known in semi-arid and arid ecosystems. Landscape-scale (10s-100s km^2) data can improve understanding of state factor controls and land use effects on soil carbon stocks, enable more accurate modeling of soil carbon dynamics that reflects heterogeneities in environmental conditions, and improve decision-making about land use practices for soil conservation. Employing a state factor approach, we studied effects of soil parent materials and land use types on total and organic soil carbon (TC and SOC) and total nitrogen (TN) in the Konya Basin, Turkey. Complex geology and 8,000-year legacy of land use make this region an ideal natural laboratory for studying land use effects on different geologic substrates. We used Landsat satellite analyses of land cover and geographic information systems (GIS) stratify our study design and aid selection of field sites. We collected a total of 560 samples from 35 sites, and compared effects of three land uses (agriculture, range and orchard cultivation) across soils of three different parent materials (clay-loam alluvial, sandy-loam volcanic and lacustrine marl soils), at two depths (0-12, 12-15 cm). Additionally, we studied land use and soil parent material effects on spatial variability of soil properties across groups of field sites to determine minimum detectable differences in soil carbon between field sites. Preliminary analyses show that SOC and TN depended strongly on soil parent materials and sampling depth, and land use effects differed across soil types. Alluvial soils (0-25.0 cm) had significantly higher SOC (19.4 ± 1.32 Mg ha^{-1}) and TN (2.86 ± 1.23 Mg ha^{-1}) than lacustrine (9.72 ± 3.01 Mg ha^{-1} SOC, 1.57 ± 0.69 Mg ha^{-1} TN) and volcanic soils (7.40 ± 1.72 Mg ha^{-1} SOC and 1.02 ± 0.35 Mg ha^{-1} N). Land use affected total SOC on alluvial soils, where range sites had significantly higher SOC (49.2 ± 2.22 Mg ha^{-1}) than agriculture (34.1 ± 3.66 Mg ha^{-1}) and orchard (33.1 ± 2.48 Mg ha^{-1}) sites, but no such land use effects were observed on lacustrine or volcanic soils. Analyses of soil spatial variability are forthcoming. These results demonstrate that the effects of land use on surface soil SOC and TN can strongly differ across soil types in the Konya Basin. An implication for predictive modeling of soil responses to land change is that such models should incorporate parameterization of properties related to parent materials as they vary across landscapes. Our findings on soil carbon spatial variability across site groups can inform recommendations for sample sizes and designs that adequately represent the heterogeneity of soils across space in semi-arid ecosystems.

Notes

Soil CO_2 fluxes from different ages of oil palm in tropical peatland of Sarawak, Malaysia

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Abstract

Conversion of tropical peatland into oil palm plantation in Southeast Asia has been assumed to enhance decomposition process via peat oxidation due to drainage and water management, causing increased emission of soil CO_2. It has also been postulated that this process will increase with time of oil palm cultivation. However, soil CO_2 emission from an oil palm plantation is strongly influenced by management also. Tropical ecosystem is generally characterised by its wet and dry seasons. Hence, to understand the relationship between all of the above dominant factors, soil CO_2 emissions over 28 months from 3 palm ages (1, 5 and 7 years old) in an oil palm plantation in tropical peatland of Sarawak, Malaysia were investigated. Monthly measurements of soil CO_2 fluxes were carried out using a closed-chamber method. The highest mean soil CO_2 flux was recorded in the 7 years old palm (220.80 mg C m^{-2} h^{-1}) followed by 5 years old (196.80 mg C m^{-2} h^{-1}) and 1 year old (182.77 mg C m^{-2} h^{-1}) palm. Pearson correlation showed that water-filled pore space (WFPS) was negatively associated with soil CO_2 fluxes in all three different ages of oil palm. The cumulative soil CO_2 fluxes for 1, 5 and 7 years palm were 3.51, 3.84 and 4.32 kg C $m^{-2}yr^{-1}$ respectively. The increase in soil CO_2 emission with palm age corresponded with higher root biomass of growing palms implying that root respiration was a major component of soil respiration in tropical peatland under an oil palm plantation. It has also been found that soil CO_2 fluxes in the oil palm plantation was not predominantly influenced by water table which had been alluded to by most studies but was more strongly influenced by soil water-filled pore space (WFPS) and root biomass.

Notes

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Abstract

The current North Central NC-1178 Regional Research Committee has been one of the most successful examples of regional research collaboration within the eleven-state North Central Region of the USA with over 30 years of working history. This regional committee has evolved with designations beginning with NC-174 to NC-1017 to its current designation of NC-1178. The success of this committee has been due to a dedicated core of scientists that have actively participated throughout the committee's history. Numerous member joint publications, workshops and scientific presentations throughout its history have highlighted the committee's activities. The history, people, and collaborations of this committee will be highlighted.

Notes

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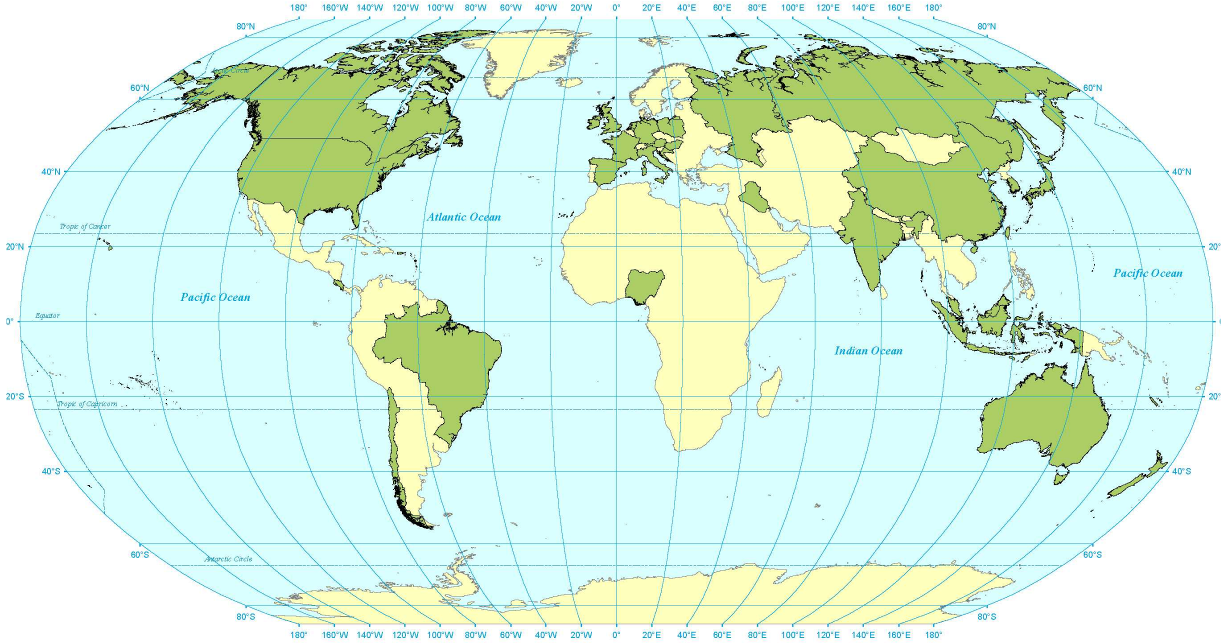

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