China-US Joint Workshop

Biogeochemistry of Carbon and Nitrogen

中美碳氮生物地球化学循环研讨会

Shenyang Agricultural University, China

June 27-28, 2013

Sponsors: National Natural Science Foundation of China (NSFC)

High-End Academic Conference Program of University Key Disciplines of Liaoning Province, China

United States National Science Foundation (NSF)

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Biogeochemistry of Carbon and Nitrogen

June 27-28, 2013, Shenyang, China

Conference Program

Organizers:

Shenyang Agricultural University

Institute of Applied Ecology, Chinese Academy of Sciences, CAS

Institute of Geographic Sciences and Natural Resources Research, CAS

The University of Tennessee

Oak Ridge National Laboratory

Workshop of Biogeochemistry of Carbon and Nitrogen

Introduction

Sequestration of carbon (C) in soil is an issue of great concern for scientists, land-mangers, and law makers. A core scientific question underlying this concern is: how do biological and physical processes convert fresh organic materials into forms that persist in soil over decades to centuries? Most research in this area focuses on catabolism—the physiology of breakdown. However, on longtime-scales, no molecule is so recalcitrant that microbes cannot metabolize it (with the possible exception of black C). Thus, the physiochemical processes controlling microbial access to C may be as important as catabolism in controlling its fate. So too may be what microbes do with the C they acquire. Additionally, the often complex interactions between the C cycle and other biogeochemical cycles, most notably nitrogen (N), provide critical feedbacks to ecosystem function. Though the interactions are complex, identifying the key determining factors and feedbacks controlling the composition and turnover times of soil organic matter pools will improve our estimates of C sequestration and how it will change with the climate. Integrating these fine-scale mechanistic processes requires crossing traditional disciplinary boundaries and approaching research questions using a cross-fertilization of knowledge, skills and abilities.

While these fine-scale mechanistic explanations are useful, we must also find a way to link them to their large-scale manifestations. Some fine-scale dynamics have large-scale impacts and it is important to analyze which of the seare critical to capture in biogeochemical models. This requires modeling approaches which can cross scales and identify the critical dynamics to capture in simple, widely-applicable macro-scale models. As a result, current models often do not incorporate these fine-scale dynamics.

Within the framework of the China-US Joint Research Center for Ecosystem and Environmental Change (JRCEEC), China-US Ecopartnership for Environmental Sustainability, and Joint Research Laboratory of Soil and Water, a collaborative research group mechanism has been suggested effectively advancing research. Group members are expected to work closely and lead novel scientific investigations, publish high-profile journal articles, and exchange research resources and students. One such recently proposed group is the Collaborative Research Group (CRG) on Biogeochemistry and Global Change. As a CRG, we aim to bring together researchers working on fine scale issues in soil physics, chemistry, biology, and how these interact with water availability to control fluxes of greenhouse gases, energy, and nutrients at larger spatiotemporal scales. Current work by group members includes: carbon-nitrogen coupling, DOC-mineral interactions, pore-scale hydrology, modeling soil enzyme activity and soil moisture thresholds for microbial activity and carbon allocation.

Goals and Objectives

The goals for this CRG-based workshop are to:

1) Explore and discuss overlapping and complimentary research interests between U.S. and Chinese participants
2) Identify opportunities for collaborative research projects and exchange of students and scientists between the U.S. and Chinese institutions

Specific objectives are to:

1) Build the professional networks of students and young scientists
2) Identify complimentary sets of knowledge, skills and abilities that can be exploited to stimulate interdisciplinary research collaborations
3) Identify existing, or establish baselines for data collection and analysis that may eventually be used to facilitate data sharing between research groups

Organizers

- Shenyang Agricultural University
- Institute of Applied Ecology, Chinese Academy of Sciences (CAS)
- Institute of Geographic Sciences and Natural Resources Research,CAS
- The University of Tennessee
- Oak Ridge National Laboratory

Organizing Committee

Chair: Dr. Jingkuan Wang, Professor and Dean, Shenyang Agricultural University

Co-chair: Dr. Sean Schaeffer, Assistant Professor, The University of Tennessee
Dr. Wenju Liang, Professor, Institute of Applied Ecology, CAS

Members:
Dr. Mark Radosevich, Professor, The University of Tennessee
Dr. Melanie Mayes, Research Staff Scientist, Oak Ridge National Laboratory
Dr. Aimee Classen, Associate Professor, The University of Tennessee
Dr. Melanie Eldrige, Assistant Professor, The University of Tennessee
Dr. Xinyu Zhang, Assistant Professor, Institute of Geographic Sciences and Natural Resources Research, CAS
Dr. Hongbo He, Professor, Institute of Applied Ecology, CAS
Dr. Jie Zhuang, Professor, The University of Tennessee

Secretaries: Dr. Xiuli Dang, Shenyang Agricultural University
Dr. Jun Yu, Shenyang Institute of Applied Ecology, CAS
Dr. Shuyin Li, Shenyang Agricultural University

Dates

June 27-28, 2013

Venue and Hotel

The conference will be convened in the conference Center of Shenyang Agricultural University. Hotel arranged by the conference is the Shenyang Sunrise International Hotel.

Agenda

	June 26, 2013 (Wednesday)
All day	**Registration**
	June 27, 2013 (Thursday)
9:00-9:20	**Opening Ceremony** Chair: Jingkuan Wang **Opening Remark and Guest Introduction** Jingkuan Wang, Shenyang Agricultural University **Welcome by the President of Shenyang Agricultural University** Yulong Zhang, Shenyang Agricultural University **Introduction of China-US Joint Research Center and Ecopartnership** Jie Zhuang, The University of Tennessee
9:20-12:00	**Plenary Presentation I** Chair: Xudong Zhang
9:20-10:00	**Title: Terrestrial Dark Matter: Unraveling the Ecological Role of Prokaryotic Viruses and Rarely Cultivated Bacteria in Soils** Mark Radosevich, The University of Tennessee
10:00-10:40	**Title: Microbial Decomposition of Organic Matter in Soils During Pulse Events** Sean Scheaffer, The University of Tennessee
10:40-11:20	**Title: Development and Testing the Microbial Enzyme Decomposition (MEND) Model** Melanie Mayes, Oak Ridge National Laboratory
11:20-12:00	**Title: Estrogen- and Androgen-Sensing Bioluminescent Bioreporters Used For Several Studies** Melanie Eldridge, The University of Tennessee
12:00-12:20	**Group Photo in the Front of The University Restaurant on Campus**
12:20-13:30	**Lunch at the University Restaurant on Campus**

13:30-16:55	**Plenary Presentation II** Chair: Sean Scheaffer
13:30-14:00	**Title: Contributions of Soil Biota to Soil Aggregate Stability and C Sequestration** Wenju Liang, Institute of Applied Ecology, CAS
14:00-14:30	**Title: Manipulation of Microbially Derived Components Linking to Soil C and N Cycling--From Laboratory to Field** Xudong Zhang, Institute of Applied Ecology, CAS
14:30-15:00	**Title: Dynamics of Microbial Residues Linking to C and N Cycling in an Arable Rothamsted Soil in Response to Fertilization for 150 Years** Hongbo He, Institute of Applied Ecology, CAS
15:00-15:20	**Tea Break**
15:20-15:50	**Title: Effects of Manure and Mineral Fertilizers on Soil Enzyme Activities and Phosphorus in Paddy Soil of Subtropical China** Xinyu Zhang, Institute of Geographic Science and Natural Resources Research, CAS
15:50-16:10	**Title: Carbon Fluxes From Plants to Soil and Dynamics of Microbial Immobilization Under Plastic Film Mulching and Fertilizer Application With ^{13}C Pulse Labeling** Tingting An and Jingkuan Wang, Shenyang Agricultural University
16:10-16:25	**Title: Effect of Irrigation Methods on Soil Phosphorus Leaching Potential in Greenhouse** Chang Liu, Ph. D student, Shenyang Agricultural University
16:25-16:40	**Title: Influence of Long-term Fertilization on Soil Microbial Biomass, Dehydrogenase Activity, Bacterial and Fungal Community Structure in Brown Soil in Northeast China** Peiyu Luo, Ph.D. student, Shenyang Agricultural University
16:40-16:55	**Title: The Characteristic and Current Situation of Brown Soil Acidification in Liaoning Province of China** Yue Shen, Ph.D. student, Shenyang Agricultural University
16:55-17:50	**Group Discussion on Future Research Collaboration** Chair: Mark Radosevich
15:50-18:00	**Closing Remark** Chairs: Jingkuan Wang and Sean Schaeffer
18:00-20:00	**Dinner**

June 28, 2013 (Friday)

Field trip to Shenyang Station of Agricultural Ecosystem, CAS

Abstracts and Biosketches of Invited Speakers

Terrestrial Dark Matter: Unraveling the Ecological Role of Prokaryotic Viruses and Rarely Cultivated Bacteria in Soils

Mark Radosevich

Department of Biosystems Engineering and Soil Science, University of Tennessee, USA

Prokaryotic life in soil is more abundant and diverse than perhaps any other ecosystem in the biosphere. We are completely dependent on these organisms for the ecosystem services they provide yet the vast majority remains unknown to us because they resist cultivation in the laboratory. We know even less concerning the viruses present in soils and the extent to which viral infection influences biological processes such as carbon and nutrient transformations in terrestrial systems. To address this knowledge gap our research has focused on the distribution and dynamics of viral assemblages in terrestrial ecosystems and gaining insight into the physiology of abundant but rarely cultivated bacteria through the use of *in situ* enrichment as a unique method to enhance cultivation of soil prokaryotes. The overall abundance of viruses in soils we have examined was remarkably stable but highly diverse and unique to land management type. Lysogenic interactions varied seasonally and with land use and the observed values suggest that lysogeny is a more prevalent virus reproductive strategy in soil than in aquatic ecosystems. The results indicate that phage populations are highly diverse and dynamic but the extent to which viral infection of prokaryotes influences biogeochemical transformations remains unclear. *In situ* enrichment with biosep beads enhanced the cultivability of soil bacteria. The physiology and genetics of *Gemmatirosa kalamzooensis*, a member to an abundant but rarely cultivated phylum, and a versatile soil heterotroph will also be presented.

Biosketch of Dr. Mark Radosevich

Mark Radosevich, is professor of soil microbiology in the Department of Biosystems Engineering and Soil Science at the University of Tennessee. He has 20 years experience conducting research involving the fate and transport of organic pollutants in soils. During the past ten years he has addressed fundamental questions regarding the ecological role of terrestrial bacteriophage. Recently he was appointed as a research group leader in the area of Water and the Environment within the University of Tennessee Institute for Agriculture. He is responsible for assembling teams and facilitating interdisciplinary research directed at environmental sustainability in agroecosystems. Other recent research topics include the use of biochars as soil amendments, use of phage and phage-encoded proteins as biocontrol agents, and characterizing the ecological role of the *Gemmatimonedetes*, an abundant but rarely cultivated soil bacterial phylum.

Microbial Decomposition of Organic Matter in Soils during Pulse Events

Sean M. Schaeffer and Jennifer M. DeBruyn

Department of Biosystems Engineering and Soil Science, University of Tennessee, USA

Soils are arguably the most biodiverse habitat on earth, home to an astounding abundance and diversity microbes. Collectively these organisms provide a vast array of ecosystem services that sustain life on Earth. These essential processes include biogeochemical cycling of carbon and nutrients, soil formation and stabilization, production of food and fiber, as well as sequestration and breakdown of contaminants. Of these processes, decomposition of organic matter (OM) is one of the most important functions performed by organisms in terrestrial ecosystems, integral to global carbon and nutrient cycling. Soil decomposers are the critical link between above and below ground carbon and nutrient pools, and therefore a key factor governing the creation and stability of soil organic matter (SOM).

The dynamics of microbial carbon and nutrient cycling processes in soilsare not static, but are heavily influenced by changes in environmental conditions and organic matter inputs. Therefore it is critical that we not just examine these processes under ideal steady state, "background" or "normal" conditions, but also during stressful and pulse events: short moments in time where OM influxes are high and microbial dynamics are drastically altered. Climate change models project an increase in extreme events, therefore an understanding of microbial carbon cycling under rapidly changing conditions is essential. In our work, we seek to clarify dynamics of microbial carbon and nutrient cycling during pulses of inputs, and under environmental stress. While there are many examples of pulse events in nature, our initial focus is on two scenarios, one on the dynamics of environmental stress and pulse utilization in water limited systems (semi-arid and arid soils) and one on resource pulse utilization in a high productivity system (temperate forest soil). While they may seem like disparate scenarios, from a microbial perspective they are, in fact, very similar: these are biogeochemical "hot moments", where a rapid pulse of substrate results in increase in microbial activity and rapid cycling of C and N. The responses of microbes are critical to understanding the ultimate fate of C and N in these situations.

Biosketch of Dr. Sean Schaeffer

Dr. Sean Schaeffer is an Assistant Professor in the Department of Biosystems Engineering and Soil Science at the University of Tennessee, Knoxville. He obtained a B.Sc. from the University of Utah, a M.Sc. from the University of Arizona, and a Ph.D. from the University of Arkansas. Prior to arriving in Tennessee, he was a Postdoctoral Scholar and Project Scientist at the University of California, Santa Barbara. Dr. Schaeffer is a soil biogeochemist with research interests in the coupled cycling of carbon and nitrogen and how they control the long-term stability of soil organic matter. His current research includes NSF-funded projects studying: 1) microbial carbon assimilation and allocation under drought conditions in southern California grasslands, and 2) the effects of seasonal transitions and freezing/thawing on microbial carbon and nitrogen cycling in low and high Arctic ecosystems. His other research interests include: the role of viruses in terrestrial biogeochemical cycles, stability of soil organic carbon fixed by biofuel crops, soil processes in cadaver decomposition islands, and the application of novel stable isotope tracer techniques to study ecosystem processes. Dr. Schaeffer is a member of the Ecological Society of America and the American Geophysical Union.

Development and Testing the Microbial Enzyme Decomposition (MEND) Model

Melanie A. Mayes, Gangsheng Wang, SindhuJagadamma, J. Meg Steinweg, Chris Schadt, and W. Mac Post

Climate Change Science Institute and Environmental Sciences Division

Oak Ridge National Laboratory, USA

Contemporary models of soil organic carbon simulate C dynamics by determining pool sizes and turnover rates *post hoc* from long term agricultural experiments. This standard representation does not explicitly consider microbial activities, and this lack of quantification means that acclimation of the heterotrophic community and associated exo-enzyme activities to climate change and edaphic conditions are ignored. We created a mechanistic microbial model of enzymatic degradation of measureable pools of soil organic C (OC), the Microbial-ENzyme-mediated Decomposition (MEND) model. The pools consist of soil OC as mineral-associated OC (< 53 μm), particulate OC (> 53 μm), dissolved OC and sorbed dissolved OC, and microbial biomass. Particulate OC is separated into major categories of plant matter (cellulose, lignin) that are attacked by different major classes of microbial enzymes. The activities of extracellular enzymes are considered through the Michaelis-Menten equation, and the model is parameterized by steady-state and dynamic analyses using kinetic parameter values and pool estimates gleaned from an extensive literature search. Lab-scale sorption and incubation experiments using four different ^{14}C labeled substrates (glucose, cellulose, lignin monomer, and fatty acid) and a global selection of soils are being used to calibrate the model. Model sensitivity analysis identified microbial growth efficiency, enzyme production rate, and microbial maintenance rate as targets for current experimental endeavors. Microbial growth efficiency is emerging as an important, temperature-sensitive adjustment of microbial physiology. Several publications predict that growth efficiency decreases as temperature increases, which resulted in lower CO_2 fluxes from the MEND model when compared to constant growth efficiency. Current lab experiments involve testing the growth efficiency under a variety of conditions. For future model testing and field-scale verification, we will choose field sites including tropical, temperate, and arctic ecosystems to determine the functional and phylogenetic composition of the microbial community and its contributions to carbon and nutrient cycling. Eventually, we will link MEND into the Community Land Model

(CLM4) and compare performance with the existing model structure. The ultimate outcome is a validated, realistic, globally-relevant mechanistic microbial soil OC model as a robust and mechanistic component of land-surface models in global climate and earth system models.

Biosketch of Dr. Melanie Mayes

Melanie Mayes is Joint Faculty with the University of Tennessee and Oak Ridge National Laboratory, where she is in the Climate Change Science Institute and the Environmental Sciences Division. She conducts interdisciplinary research in carbon and nutrient cycling and in the fate and transport of metals, organics, and other contaminants in soils and rocks. She designs experiments to build better models of natural processes and is interested in diverse research at the intersection of water, minerals, solute chemistry and biological cycling.

Her current research includes developing a mechanistic soil carbon cycling model that includes measureable soil carbon pools, sorption and desorption of dissolved organic carbon, and extracellular enzyme-facilitated decomposition of organic matter. The project also uses neutron reflectometry and molecular dynamics simulation to synergistically derive information on the molecular-level structure of organic carbon stabilized on soil minerals. She is actively involved with contaminant fate and transport in aquifer materials at Departments of Energy and Defense facilities.

Mayes is the 2011 recipient of the University of Tennessee Earth and Planetary Sciences Young Alumna Award, the Stanley I. Auerbach Award for Excellence in Environmental Sciences from the Environmental Sciences Division at Oak Ridge National Lab, and was named an Associate Editor of Excellence by the Soil Science Society of America Journal.

Estrogen- and Androgen-Sensing Bioluminescent Bioreporters Used For Several Studies

Melanie Eldrige
Center for Environmental Biotechnology, University of Tennessee,USA

Increasing public concern over exposure to Endocrine Disrupting Chemicals (EDC) and estrogenic substances (such as bisphenol A) has amplified the need for methods to rapidly monitor endocrine-active substances in the environment. In countries like Brazil that have had major economic expansion, sanitation has not kept pace with growth. Most environmental monitoring programs have focused on microbial contamination, placing less emphasis on chemicals that could be detrimental to public health. While wastewater treatment reduces the concentration of available EDC substances in effluents, wastewater does represent a significant source of estrogen addition to the environment. We have developed a high throughput bioassay to detect substances that mimic human hormones in terms of receptor activation in EDC bioassays. Bioluminescent *Saccharomyces cerevisiae* strains BLYES, BLYAS, and BLYR were used to detect the presence of potential environmental estrogenic, androgenic, or toxic compounds, respectively. These strains contain the bioluminescent *luxCDABE* genes from *Photorhabdusluminescens* and the *frp* gene from *Vibrio harveyi*, which are expressed on two plasmids either under the control of human estrogen response elements (*S. cerevisiae* BLYES), human androgen response elements (*S. cerevisiae* BLYAS), or are constitutively expressed for the detection of toxicity (*S. cerevisiae* BLYR). These bioreporters have been used extensively to measure endocrine disrupting chemicals in groundwater, drinking water, surface water, and wastewater in both the United States and Brazil. Results demonstrate that these bioluminescent bioreporters are superior to chemical analysis at detecting bioavailable estrogenic substances. In addition, high throughput methods have streamlined the bioassay making it suitable for routine monitoring; it has been adopted as part of the State Environmental Agency of São Paulo’s monitoring program and is also being used to monitor all wastewater treatment plant effluents across the state of Tennessee. In Brazilian surface water, values as high as 7.1 ng 17β-estradiol (E2) equivalents per liter have been found in raw surface water and 0.2 ng/L in treated water, while in Tennessee values for surface water are rarely above detection limits and traditional wastewater effluents are typically 6 ng E2 equivalents per liter. These bioassays have also been used to measure estrogenic potential in oil samples from the Deepwater Horizon oil spill, determining that crude oil contains 7,626 ng E2 equivalents per liter and even after weathering, samples contained 447 ng E2 equivalents per liter. Given that low ng of E2/L are able to cause an upregulation of egg yolk protein genes in male zebrafish (a feminization trait), the amount of estrogenic substances entering the environment is significant.

Biosketch of Dr. Melanie Eldridge

Melanie Eldridge is currently a Research Associate in the Center for Environmental Biotechnology at the University of Tennessee. Her research focuses on using bioluminescent bioreporters to detect endocrine disrupting chemicals. She has over 15 years of experience in molecular biology work in the areas of microbial ecology, environmental microbiology, genetic engineering, and bioassay development. Currently she is studying environmental contamination with hormonally –active compounds by using genetically engineered bioluminescent yeast-based bioreporters. In addition, she is a Fulbright Scholar who will be studying metal-nanoparticle effects on native species in Brazil and is a new Assistant Professor of Microbiology at the University of New Haven, Connecticut.

Contributions of Soil Biota to Soil Aggregate Stability and Carbon Sequestration

Wenju Liang[a], Jun Yu[a], Shixiu Zhang[a,b], Qi Li[a], and Xiaoping Zhang[b]

[a]*State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, CAS*

[b]*Northeast Institute of Geography and Agroecology, CAS*

Soil aggregates, which are the basic unit of soil structure, play important roles in the development of sustainable agriculture. The processes of different aggregate size formation accompany with the sequestration of organic carbon, which regulated by soil organisms. In this study, soil microbial and nematode communities were examined within four aggregate fractions: large macroaggregates (>2 mm), macroaggregates (2–1 mm), small macroaggregates (1–0.25 mm) and microaggregates (<0.25 mm) isolated from three tillage systems: no tillage (NT), ridge tillage (RT) and conventional tillage (CT) in Northeast China, aimed to better understand the biological mechanisms of soil aggregation and soil organic carbon (SOC) retention, and to provide some suggestions for the rational agricultural managements.The results showed that conservation tillage systems (NT and RT) can promote the formation of macroaggregates (>2 mm), and enhance the stability of soil aggregation and improve microbial and nematode diversity and activity. The distribution pattern of soil microbial and nematode communities within aggregate fractions did not vary with tillage systems, but regulated by the size of aggregates and the predator-prey relationship. Structural equation modeling revealed that SOC, microbial biomass, and glomalin-related soil protein (GRSP) accounted for 79% of the variation in soil aggregation. Soil microbial biomass and easily extractable glomalin-related protein were important driving factors for aggregate stability in the conservation systems. Our results suggest that conservation tillage systems can conserve more C in biomass through changing the composition of soil microbial and nematode communities, and ultimately increase C stock. However, this potential mechanism was predominantly depending on the size of soil aggregate fractions. Higher abundance of arbuscularmycorrhizal fungi (AMF) could enhance C retention within >1 mm aggregates, while more gram-positive bacteria and plant-parasitic nematodes might increase C accumulation within <1 mm aggregates.

Biosketch of Dr. Wenju Liang

Wenju Liang serves as a Professor at the State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, ChineseAcademy of Sciences, and conducting research relevant to soil biota response to global change. He received the Ph.D. degree from the Institute of Applied Ecology, ChineseAcademy of Sciences in 1995. Dr. Liang was a Postdoctoral Fellow at the Faculty of Life Sciences, Bar-Ilan University, Israel from March 1998 to April 1999, working on soil nematode abundance and diversity in terrestrial ecosystems. Since 1995, he is working at the Institute of Applied Ecology, Chinese Academy of Sciences, where he leads the soil ecology group. His scientific interests currently focus on soil ecology, soil nematode response to global change, effect of soil biota on C sequestration. Dr. Liang is an Adjunct Professor of the University of Chinese Academy of Sciences.

Manipulation of Microbially Derived Components Linking to Soil C and N Cycling —From Laboratory to Field

Xudong Zhang, Huijie Lv, and Hongbo He

State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, CAS

The availability of substrates regulates directly microbial metabolic processes. As a feedback, the turnover of microbially derived components play important roles in manipulating soil carbon (C) and nitrogen (N) cycling. However, how the dynamics of microbial metabolites or residues linked to soil C and N cycling remains unknown. Therefore, a series of laboratory incubations were conducted with soils amended with different amount of ^{15}N-labeled inorganic nitrogen and glucose, and also a field trial was established by applying ^{15}N-labeled fertilizer. The ^{15}N incorporation into microbially derived components (e.g., amino sugars and amino acids) was identified by gas/liquid chromatography/mass spectrometry while the ^{15}N enrichment in other organic N fractions was determined by element analysis-combustion-isotope ratio mass spectrometry (EA-C-IRMS) techniques. Based on the heterogeneity of soil amino sugars, the different dynamics of the ^{15}N enrichment patterns between muramic acid and glucosamine indicated that bacteria reacted faster than fungi to assimilate the labile substrates initially, but fungi can grow on bacterial residues along with substrate consumption and immobilization, leading to a succession in microbial community structure over time. We also found that newly-synthesized microbial components can decompose and be utilized as C and N sources to maintain the equilibrium between supply and demand for C and N. Compared to fungal cell wall residues which mainly contributed to the stabilization of soil organic matter, bacterial cell wall components were readily degraded and play more important role in mediating C or N cycling. In the field experiment, the microbial-mediated interim transformation of soil N fractions was the key process to maintain soil N turnover. The hydrolyzable ammonium N was a temporary pool for rapid fertilizer N retention and simultaneously was apt to release N for crop uptake. In contrast, the amino acids could serve as a transitional pool of available N, hence N in the amino acid fraction can mediate N supply and the depolymerization of SON constituents and controls the proceeding of fertilizer N cycling in the soil-plant system.

Biosketch of Dr. Xudong Zhang

Dr. Xudong Zhang is a Professor at the Institute of Applied Ecology, Chinese Academy of Sciences, Director of the Shenyang National Agroecosystem Research Station, and Vice Director of the State Key Laboratory of Forest & Soil Ecology. He has recently been named Vice President of the Soil Science Society of China. Dr. Zhang received his B.S. degree in Agronomy from Jilin Agricultural University, and M.S. and Ph.D degrees from Shenyang Agricultural University in Soil Science. His research focuses on understanding the microbial control over biogeochemical cycles of carbon and nitrogen in ecosystems, especially regarding their role in maintaining the sustainability of agricultural soils. His research also involves the development of soil and soil tillage and/or management practices which improve soil quality and enhance crop productivity. Dr. Zhang has made significant and important contributions to those researches. His work has been published in high level journals, for instance, Soil Biology & Biochemistry, Soil Science Society of American Journal., European Journal of Soil Science, Talanta, Rapid Communication in Mass Spectrometry, Soil and Tillage Research, etc. Dr. Zhang is currently a member of editorial boards of several academic journals.

Dynamics of Microbial Residues Linking to C and N Cycling in an Arable Rothamsted Soil in Response to Fertilizer Application for 150 years

Hongbo He[a], Xudong Zhang[a], and Philip C. Brookes[b]

[a]*State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, CAS*

[b]*Soil Science Department, Rothamsted Research, Harpenden, Herts, AL5 2JQ, UK*

The concentration and turnover of soil organic matter (SOM) can be manipulated by different management techniques such as cultivation and fertilization. Because SOM cycling is mainly driven by microorganisms, the dynamics of microbial residues such as amino sugars provide a temporally integrated indicator of the effects of different managements on microbial processes which influence the accumulation or depletion of SOM. However, the effects of long term fertilization on the dynamics of amino sugars are currently unknown, especially when linked to soil carbon (C) and nitrogen (N) mineralization and sequestration. At Rothamsted Research, UK, there is an extensive archive of soils from the long-term field experiments, making it uniquely possible to monitor the temporal changes, at a scale of more than 150 years, in amino sugar profiles in soil. We measured four amino sugars (i.e., glucosamine, galactosamine, mannosamine and muramic acid) in selected treatments in the Hoosfield Continuous Barley Experiment at Rothamsted Research. These were 1) farmyard manure, applied from 1852 to 1871 (FYM1), 2) continuous farmyard manure, applied from 1852 to the present (FYM2), and 3) continuous chemical fertilizer, applied from 1852 to the present (NPK). The dynamics of the soil amino sugars were significantly influenced by the different fertilization regimes, spanning more than 150 years, because of the changing SOM status. Soils given NPK fertilizers and 20-year manure contained less total amino sugars than continuous FYM application although more significant fraction of the amino sugars were decomposed in the latter treatment. The accumulation of fungal-derived glucosamine was significantly larger than bacterial muramic acid in the NPK and FYM1 treatments, whereas the long-term input of manure preferentially stimulated the bacterial biomass than that of fungi. This resulted in significant accumulation of bacterial residues relatively, thus a correspondingly lower ratio of glucosamine to muramic acid in the FYM2 treatment. In a specific fertilization regime, the turnover rates of the amino sugars became similar to those of SOM after the rapid formation of the acclimated microbial community and this pattern possibly maintained from decades to more than one hundred years.

However, whenever the supply of C and N changed asynchronously, the soil amino sugar concentrations changed more sensitively than the total SOM. In the case of inorganic N input imposed on the FYM application, the bacterially derived muramic acid was decomposed more rapidly than the fungal counterpart to compensate C demand. In conclusion, on a century scale, the dynamics of microbial residues can well reflect the time-integrated functions and the feedback of soil microorganisms to changing C and nutrient status; hence can be used to interpret the transformation mechanisms and cycling processes of SOM in response to fertilization managements.

Biosketch of Dr. Hongbo He

Dr. Hongbo He is a Professor at the Institute of Applied Ecology, Chinese Academy of Sciences. Dr. He received her B.S. and M.S. degree in Chemistry from Nankai University, and Ph. D degrees from the Institute of Applied Ecology, Chinese Academy of Sciences. Her research interests on understanding the microbial process controlling over biogeochemical cycles of C and N under the scenario of global change, especially regarding microbially derived residues linking to the transformation and sequestration of soil organic C and N. Her Studies also involve the development of the novel techniques, i.e., isotope tracing and the memory effect of microbial residues, which is urgent to explore the dynamics of underlying mechanisms in C and N turnover. Dr. He has published more than 20 papers in high level journals, for instance, Soil Biology & Biochemistry, European Journal of Soil Science, Journal of Soils and Sediments, Talanta, Rapid Communication in Mass Spectrometry, Soil and Tillage Research, etc.

Effects of Manure and Mineral Fertilizers on Soil Enzyme Activities and Phosphorus in Paddy Soil of Subtropical China

Zhang Xinyu[1], Xu lili[1,2,] Sean Schaeffer[3], Mark Radosevich[3,] Wen Xuefa[1], Wang Huimin[1],Wang Qiubing[2], Sun Xiaomin[1]

[1]*Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101;* [2]*College of Land and Environment, Shenyang Agricultural University, Shenyang 110866, China;* [3]*Biosystems Engineering and Soil Science, University of Tennessee, Knoxville, Tennessee, 37996, U.S.A*

Soil enzyme activities are used as sensitive indicators of soil fertility and agro-ecological system function. We hypothesized that organic manure application may increase the C, N and P cycling enzymes by increasing the input of organic matter to the soil, while the activities of the N and P-cycle hydrolase enzymes may increase under low rate of N and P mineral fertilization but decrease with higher rates of N and P mineral fertilization. The hypothesis was tested in the long term fertilizer application experiment of reddish paddy soil in subtropical area of southern China. Four hydrolase enzymes involved in the carbon (β-1,4-glucosidase), nitrogen (β-1,4-N-acetylglucosaminidase; L-Leucine-7-amino-4-methylcoumarin) and phosphorus (acid phosphatase) cycles were studied at 6 treatments (control, organic manure and different rates and ratios of mineral fertilizer). The results showed that (1) organic manure was benefit to the soil acidity, soil available and total phosphorus contents, and improved the acid-phosphatase, βG, NAG and LAP enzyme activities, while the mineral fertilizer could improve the soil acidity and βG and NAG enzyme activities, but may cause the surplus of soil available and total P, inhibit the acid-phosphatase activities. (2) βG activities were positively and significantly correlated with SOC and TN contents. NAG and LAP activities were both positively and significantly correlated with soil SOC, TN contents and βG activity. But NAG activities also had positively and significantly correlation with soil pH, available P and total P contents, available P/TP, and negatively and significantly correlation with SOC/TP and TN/TP. Acid phosphatase activity was negatively and significantly correlated with soil pH value, available and total P contents ($p<0.01$) and the ratio of available P/TP ($p<0.05$), but positively and significantly correlated with SOC/TP, TN/TP, βG

($p<0.05$) and LAP activities ($p<0.01$). Considering the effects of mineral and organic fertilizer on soil phosphatase enzyme activity and soil P contents, we recommended that inorganic fertilizer reduction and combination use of organic manure with inorganic fertilizers should be considered based on the balance between crop demand and soil supply of available P. Because available P and acid phosphatase were sensitive to manure and fertilizer additions, we recommended that they should be tested regularly to monitor P loading. This would enable producers to maintain soil quality and minimize off-site impacts by optimizing rate and ratio of fertilizer applications.

Biosketch of Dr. Xinyu Zhang

Dr. Xinyu Zhang is an assistant Professor at the *Institute of Geographic Sciences and Natural Resources Research*, *Chinese Academy of Sciences*. Dr. Zhang received her B.S.,M.S. and Ph.D degrees from Shenyang Agricultural University in Soil Science. Prior to arriving in IGSNRR, she was a visiting scholar at the University of Exeter, UK and postdoctoral scholar at the Research Center for Eco-environmental Sciences, Chinese Academy of Sciences. She was a visiting scholar at the University of Tennessee. Dr. Zhang is a soil biochemist with research interests in the cycling of carbon, nitrogen and phosphorus. Her current research includes NSF-funded projects studying: 1) microbial mechanism of carbon stability and allocation under nitrogen deposition conditions in subtropical forest ecosystems, and 2) effects of different fertilization practices on soil PLFA and C, N and P cycling enzymes in subtropical agro-ecosystems. She has published 37 papers in peer reviewed journals, such as Geoderma, PLOSONE, Journal of Environmental Sciences, etc.

Carbon Fluxes From Plants to Soil and Dynamics of Microbial Immobilization under Plastic Film Mulching and Fertilizer Application with ^{13}C Pulse Labeling

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Atmosphere CO_2 is photosynthetically fixed by plant and then transformed into the soil. The distribution of photosynthetically fixed carbon in plant- soil- microbial system controls carbon pools fluxes, cycling, and dynamics. The influence of plastic film mulching and fertilizer on carbon fluxes from plants to soil and dynamics of microbial immobilization is essential to understand the belowground carbon cycling and sequestration in agriculture system. In-situ ^{13}C pulse-labeling was used to trace the fate of ^{13}C in a maize- soil- microbial system and assess the effect of different mulching methods (with or without plastic film mulching) and three levels of organic manure fertilizer application (CK: no fertilizer control; M1: medium-level organic manure; and M2: high-level organic manure) on the dynamics of the photosynthetically fixed ^{13}C by maize planted in the long-term Brown Earth Experiment Station in Shenyang, Liaoning Province of China during the maize growth stages (seedling, shooting and teaseling stage).

The largest proportion of ^{13}C allocation into the belowground was 31.51% at the maize shooting stage and the smallest was 11.83% at the maize seedling stage. The amount of ^{13}C in microbial biomass carbon (MBC), 283.16 μg kg^{-1} and 136.67 μg kg^{-1} respectively in rhizosphere and bulk soil, reached the highest at the shooting stage under the organic manure treatment. The highest amount of ^{13}C in MBC was 208.45 μg kg^{-1} in rhizosphere soil and the lowest was 28.76 μg kg^{-1} in bulk soil at the seedling stage under the control treatments. The contribution of ^{13}C in MBC to soil organic carbon remained more than 60% in organic manure treatments at the seedling and shooting stage, while it was with large variation range in control treatments during the whole stages. All the results demonstrate that organic manure application coupled with film mulching facilitates the photosynthetized carbon fixation and enhances microbial immobilization during the whole stages.

Biosketch of Tingting An

Tingting An is a Ph. D student in soil science, supervised by Professor Jingkuan Wang, Shenyang Agricultural University, China. Her major research covers soil fertility, soil biogeochemistry, belowground carbon cycling and carbon and nitrogen isotopes application. Tingting An has participated in the research of two projects funded by Natural Science Foundation of China and one project supported by the Strategic Priority Research Program of the Chinese Academy of Sciences. She has published five referred research papers.

Effect of Irrigation Methods on Soil Phosphorus Leaching Potential in Greenhouse

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Water-saving irrigation methods have been increasingly used for vegetable cultivation in greenhouse. The Change-Point has been proved to be useful tool for predicting potential P release from soils. In this experiment, drip and subsurface irrigation methods were applied, with furrow irrigation method as control in greenhouse in northeastern China. The Change-Points were calculated and the pH, organic matter, active Fe, active Al and available P contents were measured for different irrigation methods under different soil layers (0-80 cm). The results showed that Change-Points were 59.4 mg kg^{-1}, 65.4 mg kg^{-1} and 68.6 mg kg^{-1} for furrow irrigation, subsurface irrigation and drip irrigation, respectively in 0-20 cm. The Olsen-P contents of soils were 106.4 mg kg^{-1}, 117.9 mg kg^{-1} and 122.6mg kg^{-1} for furrow irrigation, subsurface irrigation and drip irrigation, respectively in 0-20 cm. It was found that all Change-Points were higher than Olsen-P contents in topsoil (0-20 cm) indicating that significant P losses by leaching should occur. The values of Change-Points were 60.6 mg kg^{-1}, 66.8 mg kg^{-1} and 70.6 mg kg^{-1} for furrow irrigation, subsurface irrigation and drip irrigation, respectively in 20-40 cm, while the Olsen-P contents of soils were 62.6 mg kg^{-1}, 67.3 mg kg^{-1} and 69.8 mg kg^{-1}, respectively. It was found that there were no significantly differences between Olsen-P contents and Change-Points for 20-40 cm indicating that significant P losses by leaching should not occur. No Change-Points were found under different irrigation methods throughout the depth of 40-80 cm. Statistical analysis showed that the pH, organic matter, active Fe, active Al and available P contents of soil had significantly effect on the Change-Points. The order of P leaching potential for different irrigation methods were furrow irrigation>subsurface irrigation > drip irrigation.

Biosketch of Chang Liu

Chang Liu is a Ph. D student in soil science, supervised by Professor Yulong Zhang, Shenyang Agricultural University, China. She received her Master's Degree in soil science from Shenyang Agricultural University. Her research focuses on soil pollution control and water-saving irrigation of crop production. Her current research includes: (1) soil phosphorus forms under different irrigation practices in greenhouse production; (2) effect of irrigation methods on the leaching potential of soil phosphorus under greenhouse conditions. She has published five referred research papers.

Influence of Long-Term Fertilization on Soil Microbial Biomass, Dehydrogenase Activity, Bacterial and Fungal Community Structure in Brown Soil in Northeast China

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The objectives of this study were to evaluate the effects of mineral fertilizer and organic manure on soil microbial biomass, dehydrogenase activity, bacterial and fungal community structure in a long-term (33 years) field experiment. Except for the N treatment, long-term fertilization greatly increased soil microbial biomass C (SMBC) and dehydrogenase activity. Organic manure had a significantly greater impact on SMBC and dehydrogenase activity, compared with mineral fertilizers. Bacterial and fungal community structure was analyzed by polymerase chain reaction (PCR)-denaturing gradient gel electrophoresis (DGGE). Long-term fertilization significantly increased bacterial and fungal diversity. Organic manure applied with mineral fertilizers had a greater impact on bacterial diversity than mineral fertilizers, and organic manure had a greater impact on fungal diversity compared with mineral fertilizer. Total soil N (TN) and P (TP), soil organic C (SOC) and available P (AP) had a same level of influence on bacteria ribotypes while total soil N, soil organic C and available P had a larger influence than alkali-hydrolyzable N on fungi ribotypes. Our results suggest that long-term P-deficiency fertilization significantly decreased soil microbial biomass, dehydrogenase activity and bacterial diversity but not fungal diversity, compared with P-sufficient fertilization. N-fertilizer and SOC have important influence on bacterial and fungal communities.

Biosketch of Peiyu Luo

Peiyu Luo is a Ph. D student in plant nutrient, supervised by Professor Xiaori Han, Shenyang Agricultural University, China. He received Bachelor of Agronomy from Hunan Agricultural University and received Master of Microbiology from Shenyang Agricultural University. His research focuses on soil fertilizer and soil microbiology.

The Characteristics and Current Situation of Brown Soil Acidification in Liaoning Province of China

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Soil acidification has already been mentioned to the environmental issue as one of the soil degradations. The brown soil is one of the main types of soils in Liaoning province, northeastern China. The pH of it was range from 6.5 to 7 during the second soil census which showed a neutral to slightly acidic reaction. However, the pH of brown soil tended to be a decreasing trend in recent years. The objective of this study was to ascertain the status of brown soil acidification. Therefore, this paper targets nine counties and cities distributes all directions of Liaoning province including the north of Liaoning province (Changtu and the Kaiyuan), the middle of Liaoning (Shenyang), the east (Kuandian and Qingyuan), the south (Wafangdian) and the west (Jinzhou, Fuxin and Huludao) as the sample area. This study took the acid soil area and acid region of second soil census in the year of 1982 as control to contrast the acidification status in the year of 2012. The results were as follows:

Soil pH decreased significantly in the nine sample areas comparing with the second soil census. The area of weak acid (pH range from 5.6 to 6.5) and acidity (pH range from 4.5 to 5.5) were increased and the area of neutral (pH range from 6.6 to 7.0) was decreased. The acid area of Kuandian in the east of Liaoning province increased 28.16% and the weak acid area decreased 6.53% which showed a significantly acidified trend. The range ability was the largest among the nine areas. The soil area of pH below 6.5 in Qingyuan County was higher than Shenyang and Wafangdian. The mean of pH was 6.42 and range from 5.91 to 6.76 of the nine counties and cities in the year of 1982, and the pH was range from 5.45 to 5.94 after 30 years tillage with an average pH decreased to 5.73. The largest reduction area was in the city of Kaiyuan with pH dropped 1.16, and smallest one was in Qingyuan county with the pH dropped 0.46.

The exchangeable acid (EA) tended to be higher in the east and lower in the south and west area of Liaoning province. Significant difference was found of EA between the east and south area. The EA of Kuandian was 5.26 cmol kg^{-1}, which was almost 4.7 times higher than that in the south area. Significant difference of Cation Exchange Capacity (CEC) and base saturations (BS%) were both found in different districts. The CEC decreased as the pH decreased. BS% was more than 70% while the pH was range from 6.6 to 7.0. However, the BS% was less than 60% while the pH was range from 4.6 to 5.5. The base saturation tended to be highest in the north area and lowest in the east area.

Biosketch of Yue Shen

Yue Shen is a Ph. D student in soil science, supervised by Professor Yanli Yi, Shenyang Agricultural University, China. Her major research covers soil fertility and the mechanisms of soil acidification. She has participated in one project funded by the Doctoral Fund of Ministry of Education of China. She has published three referred research papers.