SOCIETA' ITALIANA DI CHIMICA AGRARIA

PhD Summer School

*Soil, plant and biomasses in a changing environment*

16-19 May 2012, Pieve Tesino (TN), Italy

Organizing committee: Stefano Grego (Pres), Stefania Astolfi, Marco Trevisan, Gian Maria Beone, Tanja Mimmo and Stefano Cesco

# International PhD Summer School of Pieve Tesino (TN)

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**16-19 May 2012**

University of Viterbo

University of Bozen-Bolzano

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# Scientific program

**16th May 2012**

afternoon: arrival and registration

**15.00-15.30: Opening ceremony - Stefano Grego** (DAFNE, University of Tuscia, Viterbo, Italy)

afternoon session: ***DYNAMICS OF THE AGRO-FORESTRY SYSTEM IN THE CHANGING ENVIRONMENT***

**Chair: Silvia Rita Stazi** (DIBAF, University of Tuscia, Viterbo, Italy)

**15.30-16.30 Paolo De Angelis** (DIBAF, University of Tuscia, Viterbo, Italy) Climate Changes and terrestrial ecosystems: an overview

**16.30-17.30 Alfredo Di Filippo** (DAFNE, University of Tuscia, Viterbo, Italy) Climate change impacts on temperate forests assessed through tree-ring networks

**17.30-18.30 Team work and discussion*:** *Human activities and effects on agriculture and forestry** *(under supervision of the chair)*

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**17th May 2012**

morning session **RHIZOSPHERE MANAGEMENT AS A TOOL FOR A SUSTAINABLE AGRICULTURE**
**Chair: Nicola Tomasi** (DiSA, University of Udine, Italy)

**8.30- 9.30 Paolo Nannipieri** (DiPSA, University of Florence, Italy) Potential impact of climate changing on biochemical activities of soil

**9.30-10.30 Roberto Pinton** (DiSA, University of Udine, Italy) Rhizodepositions: the way out to the environment

**10.30-11.00** *Break*

**11.00-12.00 Team work and discussion*:** *Rhizosphere: so many achievements and even more challenges** *(under supervision of the chair)*

afternoon session: **FOREST MANAGEMENT UNDER CLIMATE CHANGE**
**Chair: Alfredo Di Filippo** (DAFNE, University of Tuscia, Viterbo, Italy)

**14.30-15.30 Giustino Tonon** (FaST, University of Bozen/Bolzano, Italy) Forest management and soil organic carbon

**15.30-16.30 Claudio Zaccone** (DiSACD, University of Foggia, Italy) Reconstructing paleoenvironmental changes using ombrotrophic bog profiles

**16.30-17.00** *Break*

**17.00-18.00 Poster presentation by PhD students**

**18.00-19.30 Team work and discussion:** *Managing forests to reduce climate change impacts*

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UNIVERSITÀ CATTOLICA del Sacro Cuore

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**18th May 2012**

morning session: **PEDODIVERSITY AND SOIL BIODIVERSITY**

**Chair: Maria Cristina Moscatelli** (DIBAF, University of Tuscia, Viterbo, Italy)

**8.30- 9.30 Anna Benedetti** (CRA-RPS, Rome, Italy) Soil microbial biodiversity in changing environment

**9.30-10.30 Sara Marinari** (DIBAF, University of Tuscia, Viterbo, Italy) Analytical tools to study pedodiversity induced by land use change and management

**10.30-11.00** *Break*

**11.00-12.00 Edoardo Puglisi** (Istituto di Microbiologia, University of Piacenza, Italy) Approaching the puzzle of plant, microbes and organic matter interactions in the rhizosphere

afternoon session: **AGRICULTURAL PRODUCTION AND ECONOMICS**

**Chair: Edoardo Puglisi** (Istituto di Microbiologia, University of Piacenza, Italy)

**14.30-15.30 Stefano Amaducci** (Istituto di Agronomia, genetica e coltivazioni erbacee, University of Piacenza, Italy) Sustainable Crop Productions

**15.30-16.30 Gabriele Dono** (DEAR, University of Tuscia, Viterbo, Italy) Problems of economic impact assessment of climate change

**16.30-17.00** *Break*

**17.00-18.00 Poster presentation by PhD students**

**18.00-19.30 Team work and discussion*: Sustainability of primary productions: the role of agricultural chemists**

***** *(under supervision of the chair)*

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**19th May 2012**

morning session: **CARBON SEQUESTRATION IN SOIL: THE ROLE OF ORGANIC AMENDMENTS**
**Chair: Marco Contin** (DiSA, University of Udine, Italy)

**8.30- 9.30 Giovanni Gigliotti** (DSAA, Univeristy of Perugia, Italy) Composting process, compost application and greenhouse gases emission

**9.30-10.30 Claudio Ciavatta** (DiSTA, University of Bologna, Italy) Organic and organic-based fertilizers: agro-environmental and legislative aspects

**10.30-11.00** *Break*

**11.00-12.00 Giorgio Alberti** (DiSA, University of Udine, Italy) Biochar: what we know and what we do not know (but hopefully we will)

**12.00-13.00 Maria De Nobili** (DiSA, University of Udine, Italy) The complex effects of the addition of agricultural biomasses and biomass energy waste on soil properties and C sequestration

afternoon session: **BIOFUELS AND BIOMASS CONVERSION OPTIONS**
**Chair: Tanja Mimmo** (FaST, University of Bozen/Bolzano, Italy)

**14.30-15.30: Fabrizio Adani** (DiProVe, University of Milano, Italy) Anaerobic Digestion, renewable nutrients and environmental impacts.

**15.30-16.30: Marco Baratieri** (FaST, University of Bozen/Bolzano, Italy) Biomass upgrading into gaseous and liquid fuels: thermo-chemical and biochemical processes

**16.30-17.00** *Break*

**17.00-18.00 Team work and discussion*:** *Biological and physico-chemical approaches to the upgrading of biomass wastes* *(under supervision of the chair)*

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**20th May 2012**

breakfast and departure

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# Poster presentations by PhD students

## 17th May 2012 - 17.00-18.00

**Chair: Tanja Mimmo** (FaST, University of Bozen/Bolzano, Italy)

**Arsenic removal from contaminated waters by low-cost synthetic sorbents (Layered Double Hydroxides)**
SMGG Azam, AG Caporale, A Sommella, M Pigna, MA Rao, A Violante

**Further investigation of the relationship between 137Cs and 210Pbex flux and sediment output from two small experimental catchments in Calabria, southern Italy**
GIOVANNI CALLEGARI, CARMELO LA SPADA, PAOLO PORTO, DESMOND E WALLING

**Relazione tra qualità del suolo e qualità dell'olio di oliva per differenti cultivar di Olea europea L.**
Barbarisi C, Volpe MG, Giordano M and De Marco A.

**Individuazione di zone fitoclimatiche per lo studio delle emissione di gas serra nei vari ambienti naturali italiani basandosi sulla cartografia disponibile.**
Sergio Albertazzi, Giuliano Vitali

## 18th May 2012 - 17.00-18.00

**Chair: Edoardo Puglisi (**Istituto di Microbiologia, University of Piacenza, Italy)

**Effect of organic management on quality and nutritional characteristics of processing tomato**
I Coppola, M González Cáceres, D Agrelli, R Scelza, D Ronga, L Sandei, R Vadalà, S Pirondi, F De Sio, M Zaccardelli, C Amalfitano, P Adamo and M Rao

**Development and application of chemical, physical, and biological parameters to evaluate soil quality**
Laura Guidotti, Gian Maria Beone

**Lignocellulosic supply chains for bioenergy: sustainability in Mediterranean agroecosystems. The case study of Miscanthus.**
NERI RONCUCCI, NICOLETTA NASSI O DI NASSO, SIMONA BOSCO, GIORGIO RAGAGLINI and ENRICO BONARI

**Mobility of heavy metals in soil assessed by column leaching and sequential extraction**
R Balint Nimirciag, E Buratto and F Ajmone-Marsan

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# Abstract of lectures

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**Alfredo Di Filippo**
DAFNE, University of Tuscia, Viterbo, Italy

## Climate change impacts on temperate forests assessed through tree-ring networks

Dendroecological networks allow "historical ecologists" to investigate the effect of environmental factors on growth and reproduction processes of forest ecosystems over years to millennia and from watershed to continental regions. A network of tree-ring site chronologies including six different species sampled at various elevations throughout Italy was used to investigate the spatial organization of tree populations according to climatic factors that control their growth variability. In particular dendroecological records from beech populations sampled at different elevations within two different bioclimatic regions (Alps *vs* Apennines) were used to define beech bioclimatic distribution and for investigating tree response to climate. Climatic signals revealed the separation between the Mediterranean and the Alpine regions, whose spatial boundary was a function of summer drought control on growth. Within each region, elevation regulates climatic responses, as it controls both thermal regime and growing season onset and duration. In both the Alps and the Apennines *Fagus sylvatica* L. populations were arranged along three altitudinal bioclimatic zones: *low-elevation*, *mountain*, and *high-mountain*. Average Basal Area Increment (BAI), a common indicator of tree productivity, showed diverging trends for bioclimatic and altitudinal zones. In addition, over the past few centuries the barycenter of low-elevation and mountain belts has dipped to lower areas during cold phases while it has risen during the recent warming. Such bioclimatic shifts could provide a new approach to the reconstruction of climate, especially temperature.
The analysis of several old-growth beech forests clarified the link between tree longevity, tree growth rates, bioclimate, and disturbance processes. Tree lifespan and growth rates were affected by climate (spring–summer temperature stress) and were inversely related to one another along elevation gradients. The greatest lifespan was observed in old-growth high-mountain populations, and was related not only to slower growth due to a shorter growing season, but also to multidecadal periods of growth suppression during the initial development stages in the understory (i.e. slower growth rates at the youngest cambial ages). Basal area increment of trees with the maximum observed lifespan showed an increasing trend over time. Because growth of old (>300 years) trees has increased in the Alps, while it has recently declined in the Apennines, different bioclimatic regions can have opposite responses to global climatic change. In the next decades, if warming continues, beech lifespan could be reduced in the Alps by faster growth and in the Apennines by drought-induced mortality.

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**Paolo Nannipieri**
*DiPSA, University of Florence, Italy*

## Potential impacts of climate change on biochemical activities of soil

The impact of elevated atmospheric $CO_2$ on biochemical activities in soil is mainly indirect since the $CO_2$ concentration in the pore space of soil, specially where the biological activity is high, is higher than the atmospheric concentration and the increase in atmospheric $CO_2$ stimulates photosynthetic activity of C3 plants, but also rhizodeposition with consequent increases in the activity and growth of rhizosphere microorganisms, because most of soil microorganisms are generally C-limited. However, the enhanced plant growth can create N-limited conditions with possible negative effects on microbial activity of the rhizosphere soil. Other indirect effects caused by greater below-ground C allocations concern the enhancement of soil structure and increased uptake of nutrients and water by plants. Contrasting results on activity, composition and size of soil microbial communities and on the interaction between microorganisms and plants and fauna depend on the different plant-soil systems studied and the different techniques used. Microarray analysis have showed that the abundance of genes codifying enzymes involved in $CO_2$ fixation, N fixation and nirS (codifying enzyme reducing nitrite to NO) under elevated $CO_2$. Xylanase, invertase, alkaline phosphatise and casein hydrolysing activities of the top soil (0-5 cm) were increased elevated $CO_2$ (720 μmol.mol-1) whereas microbial biomass was not affected probably because the increase in rhizodeposition stimulated the synthesis of these enzymes but not microbial growth.
Mycorrhizal infection of plant roots under elevated $CO_2$ concentration is generally stimulated due to increased C allocation to roots but future research should address the central role of mycorrhizae in the context of global change, as they appear to be a keystone in the $CO_2$–related response.

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**Roberto Pinton**
*DiSA, University of Udine, Italy*

## Rhizodepositions: the way out to the environment

Rhizodeposition, made of cell debris, intact border cells, low and high molecular weight exudates, can have a great impact on biological, chemical and physical characteristics of the rhizosphere. The type and amounts of rhizodeposition is dependent on plant and soil biotic factors as well as abiotic (environmental) factors. Release of root exudates may be just necessary to facilitate normal root metabolism or can be the consequence of an altered physiological status.
Root exudation is normally assumed to account for about 3-5% of carbon fixed in photosynthesis; however the rate of exudation can significantly increase under conditions of biotic and abiotic stresses. Evidence has been provided that, at least in some cases, up-regulation of exudation can help alleviating the stress. Response at the level of root exudation has been associated to genotypic differences in nutrient use efficiency of crop plants.
Rhizodeposition can be used as a source of energy by microorganisms proliferating in the rhizosphere; furthermore, roots can release signals compounds, enabling the establishment of beneficial association or symbiosis with microorganisms or allelochemicals to counteract the growth of competing plant species.
Taken together, these observations support the idea that rhizodeposition can favor adaptation of plants to different environments and help them coping with adverse soil condition.
Understanding mechanisms underlying root exudation and clarifying regulatory aspects or this process is crucial to unravel the complexity of plant-soil relationships and envisage their potential role for a better use of natural resources in a changing environment.
An overview of types and function of rhizodeposition as well as methodological aspects of exudates collection will be presented. Mechanisms of release and cause-effect relationships of root exudation will be highlighted, especially with respect to nutrient efficiency and resistance to abiotic stresses. Possible strategies for a sustainable management of the rhizosphere will be also discussed.

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**Giustino Tonon**
*FaST, University of Bozen/Bolzano, Italy*

## The effect of forest management on soil organic carbon

Ecosystems play a fundamental role in regulating the global carbon balance. The 80% of all terrestrial aboveground carbon is stored in the forest ecosystems and the 70% of all the soil organic carbon (SOC) is contained in forest soils (Jobbagy & Jackson 2000). The attention to the capacity of forest soils to store atmospheric $CO_2$ has constantly increased and it is now a global priority to identify, on the base of experimental evidences, the best forest management practices to sequester atmospheric carbon (Lal 2005). A new way of considering forest management is needed to conserve and enhance the carbon stocks in the forests, particularly the stocks carbon in forest soil. The best forest management strategy with universal value doesn't exist. Ecological, historical, socio-economic conditions and traditional forest management are crucial elements in establishment the best forest management option for a given landscape. Nevertheless, some general indications are possible.

Forest thinning of even-aged forest is a recommendable sivicultural practise for its possible positive effect on soil organic carbon and because thinning increases stand stability and therefore offers an important control mechanism for the maintenance of carbon storage in forest ecosystems. Thinnings have to be done for long-term silvicultural goals to improve the quality of the final product, but also to increase NPP and the forest carbon stocks. A deeper analysis should be done on the use of thinning products.

Where ecological and socio-economical conditions are suitable the so called "forestry carbon" should move towards the continuous cover forestry. This is a forest management option with minor impact on soil process and positive long-term effect on soil and forest carbon storage.

The old-growth forests are relevant carbon sinks and their protection cannot be discussed if the conservation of biodiversity and the increment of carbon sink capacity of terrestrial ecosystems will continue to be a crucial priority at global level.

Finally, the elongation of length rotation period of coppices and even-aged forests could be a possible measure to increase forest carbon sequestration, but how much this management approach is realistic has to be assessed at regional scale by a full quantitative carbon analysis of the "wood chain" during the management cycle.

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**Claudio Zaccone**
*DiSACD, University of Foggia, Italy*

## Reconstructing paleoenvironmental changes using ombrotrophic bog profiles

Since the pioneering studies of Rennie (1807), who interpreted stratigraphic changes in Scottish bogs both in terms of natural changes in palaeoclimate and of environmental changes induced by humans, ombrotrophic bogs have been recognized as excellent archives of the past. Due to the particular conditions characterizing these environments, when organic molecules and/or inorganic dusts deposit, they can serve as proxies for reconstructing palaeo-vegetation and -climate and/or human impact at the time of deposition.
Hundreds of studies have been carried out in the last two centuries using ombrotrophic cores; anyway, scientific literature is still rather controversial about the role of bogs as reliable records, as some scientists argued that "climatic, vegetational and human activity-related information" could be affected by decay and humification processes occurring throughout peat profiles.
Coupling chemical and molecular information, detailed age dating, humification parameters, major an trace element analyses, dust particle presence, etc, it is possible to verify the role of the organic matter evolution in preserving or affecting the record of palaeoenvironmental changes occurring during millennia, and thus the reliability of these natural archives.

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**Anna Benedetti**
*CRA-RPS, Rome, Italy*

## Soil microbial biodiversity in changing environment

Micro-organisms form the basis of most ecosystems on which agriculture and food production depend. Put simply, agriculture and food production would not exist without this "hidden" but critically important biodiversity.
Micro-organisms play essential roles that we can separate into five interlinked functional domains: soil inhabitants, plant and rhizosphere inhabitants, plant pathogens, biological control agents and food production micro-organisms. The focal point of this important role played by micro-organisms in the regulation of life on the earth is the unrivalled diversity of micro-organism genetic resources for food and agriculture, and the correspondingly huge variety of functions they confer to agriculture.
Many beneficial micro-organisms are linked with plants in the soil, where they induce resistance or perform biological control functions. Free-living soil-borne micro-organisms contribute to the formation and structure of soil, the storage of nutrients and carbon sequestration. Those acting in association with crop plants further regulate soil fertility and the accessibility of nutrients. Soil micro-organisms are also responsible for bioremediation of polluted sites by restoring soil fertility. Once food is produced, micro-organisms are relied upon for its conservation and transformation.
Climate change will act as an additional driver of change in agricultural systems as environmental conditions are altered drastically. As a consequence of the vital functions that micro-organism genetic resources for food and agriculture confer, they can be considered as pivotal to sustainable agriculture when challenged by such drivers of change. Because plants' performance is directly linked to interactions with micro-organisms, future strategies to counteract negative effects of climate change will need to involve more than simply deploying crop plants in environments to which they are well adapted.
Micro-organism genetic resources for agriculture can be used to produce energy directly, facilitate adaptation to climate change and mitigate climate change. Novel biological control agents can be used to limit the harmful impact of pathogens and pests, obviating the need for energy-expensive pesticides. Other micro-organisms could also be used to improve the efficiency of intensified agriculture, such as those that store carbon in the soil, and hence prevent the emission of greenhouse gases. The fertility of the soil for any particular cropping system could be enhanced naturally, either by creating conducive conditions for the proliferation of beneficial micro-organisms or by introducing them directly into targeted environments. Soil-regulating micro-organisms can be used to manage soil health and ecosystem resilience. Micro-organisms also have an important role in the protection and transformation of agricultural produce, post-harvest.

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**Sara Marinari**
*DIBAF, University of Tuscia, Viterbo, Italy*

# Analytical tools to study pedodiversity induced by land use change and management

Land use changes, especially resulting from the rapid urbanization process, have often had a great impact on pedodiversity. Pedodiversity is a measure of soil variation as well as a function of soil formation and development or evolution. This is also mentioned by Odeh (1998) defining the term pedodiversity as: "variability of soils in a specific area or region, as determined by its constitution, types, attributes and the conditions under which the various types were formed" (2006). Pedodiversity is introduced to pedology to analyze soil spatial patterns, soil geography, and test the pedogenetic theories. Thus, pedodiversity is not only concerned with analysis of the pedotaxa abundance in a given area or region, but it should tackle also with the pedological structures, spatial pedotaxa and soilscapes. Further comparisons with diversity patterns detected in related disciplines (earth sciences, biodiversity, etc.) show surprising similarities with the pedological ones, opening new possibilities to detect regularities between different natural objects.
In fact, the increasing extinction of species and functions caused by the land use and environmental changes has attracted biodiversity analyses for preserving the diversity and stopping species extinction. The loss of soil types may therefore represent loss of whole biological communities unique to those soil types. McBratney (1995) extended this subject on soil and landscape, highlighting the need for soil type preservation. Phillips (2001) viewed pedodiversity as extrinsic (external or observable environmental variation) or intrinsic (deterministic chaos, dynamic instability, and divergent self organization in pedogenesis and soil variation). Whittaker (1977) distinguished four levels of pedodiversity based on the ecological entity and size of geographical area: (i) microhabitat—polypedon size; (ii) habit—the smallest soil map unit size; (iii) landscape—soil landscape unit size; (iv) region—soil unit size.
It is currently possible to measure landscape change over large areas and determine trends in environmental condition using advanced space-based technologies accompanied by geospatial analyses of the remotely sensed data. During the past two decades, important advances in the integration of remote imagery, computer processing, and spatial-analysis technologies have been used to develop landscape information that can be integrated within sensitive bioindicators of short-term land use impact on pedodiversity and make predictive inferences about the future.
In this report a case of study is presented to share the soil microbial diversity analysis to examine the spatial-temporal change of pedological assemblages and pedodiversity induced by land use change and management.

***Bibliography***

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*McBratney, A. B. 1995. "Pedodiversity: Newsletter of International Society of Soil Science Working Group on Pedometrics," Pedometron 3, 1–3.*
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**Edoardo Puglisi**

*Istituto di Microbiologia, University Cattolica del Sacro Cuore, Piacenza, Italy*

## Approaching the puzzle of plant, microbes and organic matter interactions in the rhizosphere

The rhizosphere is a hotspot of soil fertility, where reciprocal interactions between plants roots, soil constituents and microorganisms strongly influence the core process of soil fertility, i.e., the plants acquisition of nutrients.

Chemical, microbiological and biomolecular advancements are constantly improving our knowledge on rhizosphere processes. At soil level, we are appreciating at fine scale level the supra-molecular architecture of humic substances as well as the plentitude of their chemical constituents, many of which are biologically active. At microbial level, the post-genomic era is giving us for the first time tools such as high-throughput sequencers that can realistically attempt resolving the vast microbial diversity inhabiting the soil and the rhizosphere. Finally, at plant level, not only more and more genomes are being sequenced and functionally annotated, but also the composition and role of chemical constituents and root exudates is being progressively analyzed and understood.

The current situation of rhizosphere studies can be thus assimilated to a "puzzle": we are deepening our understanding of single components, but we still need to gain a complete vision of the whole system. An interesting case study for a multidisciplinary assessment of the rhizosphere system is the effect of humic substances on rhizodeposition processes. One straightforward approach for linking the structure of humic substances with their biological activity in the rhizosphere is the use of rhizoboxes, which allow applying a treatment (e.g., an amendment with humic substances) in an upper soil-plant compartment and take measurements in a lower isolated rhizosphere compartment that can be sampled at desired distances from the rhizoplane. Rhizoboxes experiments can be coupled with bacterial biosensors for the detection and quantification of bioavailable nutrients, chemical analyses of main rhizodeposits constituents, advanced chemical characterizations of humic substances, DNA-fingerprinting of microbial communities, and multivariate statistical approaches to manage the dataset produced and to infer general conclusions.

During the lesson, PhD students will be guided through multidisciplinary studies in rhizosphere ecology, learning how advanced chemical, microbiological, biomolecular and bioinformatics approaches can help us gaining a wider vision and understanding of one of the most fascinating Earth micro-ecosystems, the rhizosphere.

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**Stefano Amaducci**

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## Sustainable Crop Productions

The major goal of sustainable agriculture, which in short is the long term stability of its production systems, is far from being achieved and is now complicated by a set of challenges that have to be faced in the near future. Limited resources and an increasing demand of goods (food, energy and raw material for industrial applications) suggest that a progressive intensification of agricultural practices is needed to "close the yield gap" and achieve higher crop yield in specific areas, sparing sensitive environments for biodiversity conservation.

A sustainable intensification of cropping techniques should be achieved, integrating the knowledge available at various levels of the production systems, fostering their resilience.

Overall sustainability will be achieved not only with more efficient production techniques but also through more efficient utilization of agricultural products. Considering the high number of undernourished people and an ever-growing world population recent reviews have pointed out that non-food destinations of agricultural land should be reduced and limited. Even though it can be recognized that shortsighted policies in favour of biofuels have had a negative impact on food production and the environment, the use of agricultural biomasses for non-food applications is nonetheless essential and difficult to substitute. A more efficient use of agricultural products will be achieved by designing modern biorefineries and planning the sequential use of agricultural biomass.

In view of this overall situation this lecture will provide an overview on various cultivation strategies and biomass applications that support sustainable agricultural production.

SOCIETA' ITALIANA DI CHIMICA AGRARIA

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## Problems of economic impact assessment of climate change

The economic analysis of the impact of climate change and adaptation strategies of our agriculture is subject to various problems of specification. One is related to the different perspective of research of climatology, agronomy and cattle breeding, and of economics and agricultural policy. The climate research has a long-term horizon: 2030-2050 looking for climate projections based on solid scientific foundations and not influenced by variability of meteorological phenomenon. Instead, the transience of future economic conditions means that in the long term horizon, that is typical of the studies on CC, there will be no more the corporate structures, technologies and market equilibria that are represented in economic models. Thus, simulating the effect of CC on the firm types and current technologies could even provide distorted guidance on the adaptation measures. Another element determines the need to evaluate processes of CC in a short time horizon. This concerns the nature of the measures of the Rural Development Policy for the adaptation of farms to Climate Change. These measures are, in fact, all co-financed, in other words require a commitment from the farm. Now, farmers will commit investing their financial resources only to address management or development problems that they perceive as relevant to their economy. In other words, farms can not be reactive to problems that arise in too remote outlooks, and do not use the financial resources allocated under expenditure headings that relate to the adaptation to CC.
One possibility to address this problem is to examine changes in climate variability rather than climate change itself. In this presentation we show how the problem has been addressed. Another relevant aspect is that the effects of climate change in agriculture are determined through multiple weather variables and at different cycles of crops or farm management. Thus, even when analyzing limited, specific aspects of farm management, many physical and technical reports should be represented. This poses several calculation and analysis problems when working with territorial economic models, representing more different types of farms. One possibility being discussed in this presentation is to work on net evapotranspiration (ETN), estimated with agronomic models (EPIC), as a summary of the main physical factors considered in decisions on irrigation farmer. The probability distribution of ETn is inserted into a territorial model of DSP that represents the agricultural decisions in conditions of uncertainty about water availability and irrigation requirements of crops. Recent trends of ETn indicate for the near future an appreciable change in the probability distribution of this variable. It is also expected an increase of variability in water availability due to changes in the rainfall. These changes increase the uncertainty of management and, with this, the costs incurred by the farm typologies of the study area, which in many cases suffer an appreciable drop in income.

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## Composting process, compost application and greenhouse gases emission

The recent climate changes have been caused by the "Global warming" and refer to rising global temperatures. Warmer global temperatures lead to climate changes affecting rainfall patterns, storms and droughts, growing seasons, humidity and sea level. The global warming has been caused by the enhancement of greenhouse gas (GHG) emissions, such as $CO_2$, $CH_4$ and $N_2O$ and the changes in agricultural practices and land use may have significantly effect on climate change. The application of organic materials to soils has gained importance as a consequence of atmospheric concentrations of emissions, as well as the potential of arable soils to sequester C. It is well known that the composting of organic matter (aerobic process) leads to not only a reduction in waste, but also the agronomic use of compost leads to improve soil fertility, improving the C stocks into the soil; meanwhile, the C and N losses during composting contribute also to emissions of GHGs. In contrast to $CO_2$ emitted by fossil fuel combustion, $CO_2$ derived from organic matter degradation does not contribute to global warming, because the emissions are balanced by the $CO_2$ previously fixed by photosynthesis. Whereas the $CH_4$ and $N_2O$ emissions are the products of methanogenesis and nitrification/denitrification respectively, contribute directly to the enhancement of the greenhouse effect. In particular the $CH_4$ emission might be related to the early stage of the composting and positively correlated e.g. with total inorganic nitrogen content in the mixture of raw materials or it might be use just as a parameter of anaerobic conditions. Whereas the $N_2O$ emission can be a result of nitrification and denitrification which occur respectively at the initial and the final stage of the composting.

Moreover, the application of organic matter to soils may have an influence on the global warming, since that the GHG emissions are related by the amount and the quality of organic matter added. The degree of stability of the organic materials obtained by aerobic treatment may reduce the GHG emission after application to arable soils, particularly with regard to the $CO_2$ emission. It can be explained by the gradual decrease in dissolved organic C during composting and the following reduction in microbial respiratory activity after soil amendment; in contrast the use of no stabilized organic materials such as animal manure leads to a significant increase of $CO_2$ emissions due by the input of labile organic matter, source of C and energy for soil microorganisms.

Therefore, the agricultural sector can reduce the global warming through the implementation of improved management practices as the composting of organic materials, particularly in terms of $CO_2$ balance.

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## Organic and organic-based fertilizers: agro-environmental and legislative aspects

Organic and organic-based fertilizers, such as the mineral products, are necessary in supplying nutrients to plants growth. This practice is needed in all agricultural systems because natural soil fertility is not able to provide nutrients in due time according to plant needs. However, farmers need high quality fertilizers (mineral, organic, organo-mineral, amendment, ling materials, growing media, etc.) that must ensure safety for soils, ground and surface waters, air, food-chain and feedstuffs.

The use of by-products of vegetable, animal and human origin to restore or to increase soil fertility has been well known for over 2000 years and since Columella (Lucius Iunius Moderatus Columella, Cadice, Spain, I Century) in Roman Empire times described how organic wastes had to be processed before their use in soil. Manures of different origin were the basic products used in soil fertilization for many centuries. Large amounts of wastes containing different amounts of organic carbon as energy from agro-industrial and municipal origins, and nutrients that are produced daily, mainly in the "developed societies". However, since the end of World War II the use of organic for land fertilisation has decreased and farmers in developed countries have markedly increased the use of mineral fertilisers in place of organic fertilisers and amendments. Concurrently, the amounts of organic materials from municipal solid wastes, sewage sludges and wastes of agro-industrial origins have increased exponentially, and millions of tonnes of organic matter were and are still landfilled or incinerated and transformed into methane, carbon dioxide, nitrogen oxides, sulphur oxides, and other greenhouse gases.

The increasing sensitivity about environmental problems, the need to find a sink for the growing amounts of waste mainly produced in developed societies, and the necessity to reduce the utilisation of non-renewable materials (e.g., peats), have markedly increased the use in recent times of organic waste-based fertilisers in modern agriculture (Council of the EC, 1999). Biomass and crop residues can be recycled into the soil with or without composting or stabilization processes of the organic carbon.

The presentation will focus the agro-environmental and legislative aspects of organic and organic-based fertilizers at national and international level. Particular attention will devoted to chemical contaminants (heavy metals and organic substances), pathogens and other risk factors to be controlled in organic and organic-based fertilisers and related products. The list of contaminants should be based on current practices in the Member States and taking into account relevant existing EU legislation relating to the protection of soils, ground and surface water and/or setting limit values for contaminants in food- and feedstuffs. It should be mindful that a balance has to be struck between the safety requirements and the costs of implementation taking into consideration the availability of fertilisers of different types and from different raw materials, as well as costs and capacities of analyses for compliance monitoring with regard to all relevant sub-categories of fertilising materials that will be included in the scope of the future fertilisers regulations.

SOCIETA' ITALIANA DI CHIMICA AGRARIA

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## Biochar: what we know and what we do not know (but hopefully we will)

The charcoal (biochar, BC) produced by the Indios in South America 3000 years ago, has contributed to the formation of anthropogenic soils, the so called *terra pretas*, which are still extremely fertile and rich in recalcitrant carbon. Today, BC is one of the products of the pyrolysis, a process that involve heating biomass without oxygen in order to obtain a gas (syngas) used for energy purposes. Several studies have confirmed that when BC is added to the soil can store carbon in a stable manner and is able to increase soil fertility and crop productivity. The integration of these processes allows the creation of the only energy supply chain able to produce energy, to permanently store atmospheric CO2 and to simultaneously increase productivity and product quality, key factors for the agricultural sector. However, the actual use of BC on large scale is still under investigation because of the lack of knowledge about its chemical and physical properties, interactions with soil, plants and microbial communities and the possible toxic effects related to polycyclic aromatic hydrocarbons (PAHs ) often associated with this compound. Furthermore, agricultural feedstocks availability to sustain all the process is still questioned. All these aspects will be discussed in details and some case studies will be shown.

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## The complex effects of the addition of agricultural biomasses and biomass energy waste on soil properties and C sequestration.

Addition of agricultural biomasses and biomass energy waste to soil can help to increase organic matter levels in arable soils and therefore reduce risk of degradation of soil structure, erosion and compaction, as well as contribute to a reduction in $CO_2$ and other greenhouse gas (GHG) emissions, due to lower energy inputs for machinery use and reduced need of mineral fertilizers. This is particularly true for Southern Europe, where a large proportion of agricultural lands have been degraded by organic matter loss or other processes that reduce productivity (Hill et. al. 1995; Foley et al., 2005). However, improper management or use of non stabilized biomasses can lead to negative, albeit transient, effects. Caution must also be used in allowing massive addition of biomass energy wastes, whose impacts have not yet been fully investigated. The case of biochar, which has been presented as a win-win strategy that combines energy production with C sequestration, will be discussed in detail.

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## Anaerobic Digestion, renewable nutrients and environmental impacts

Recently, in European countries, between the biological processes applied for the treatment of organic waste, the interest in anaerobic digestion (AD) has increased a lot. AD is a biological process by which, in the absence of oxygen, organic matter is transformed into biogas which principally consists of methane (50-80 % v/v) and carbon dioxide, of which the former can be used to produce energy and heat. The anaerobic treatment is, in addition, a useful process to control odors emissions, and produces a stable and partially hygienic biomass, called digestate, which is rich in both nutrients and organic matter.

The benefits getting with AD in joint with the incentivizing politics at EU level, is doing the substation of composting process with AD as useful practice to treat the organic fraction from source separate collection of municipal solid waste, animal slurry and agro-industrial wastes. AD allows benefits with respect to the composting because of short treatment length, low plant cost, easily management of both process and environmental issues. LCA studies agree in confirming AD as better than composting form both economical, energetic and environmental points of view. Environmental issues are not less important. Agriculture contributes to at least 90 % of the total ammonia in the atmosphere, which caused dry deposition, acidification and above all secondary PM10 production, which contribute for 30 % to the total air particulate with risk for public health. In this way AD is candidates to contribute to better manage N surplus contributing to clean both groundwater and air because it allows nutrient preservation and recycling. This issue is very important if it is takes into consideration that K an P are fossil limited resources and that N needs to be produced, a lot of energy consumption, producing large amount of $CO_2$ of fossil origin. In this way AD not only became important as it allows renewable energy production but, also, because allow to produce nutrients (Renewable Nutrient®, by Gruppo Ricicla).

The GRUPPO RICICLA of the University of Milan (Italy) is outlined a set of note and criteria in order to prove the feasibility and the utility of agricultural use of digestate, taking into account both fertilizing value and environmental impacts. The proposed criteria are based on data collected on field study during the research work of GRUPPO RICICLA and Lombardy Region group in the last 4 years and of international peer-reviewed literature.

By now, little is available in literature about "the agronomic and chemical" characteristics of the digestate. The fact that digestate is rich in fertilizing elements under available forms, i.e. $N\text{-}NH_4$, $H_3PO_4$, $K^+$, $Ca^{2+}$, $Mg^{2+}$ etc. suggests its use as "ready to use" fertilizer, as an alternative to traditional chemical fertilizers. As consequence of the complex transformations occurring during anaerobic digestion, the digestate, with respect to the corresponding ingested material, is characterized by higher concentrations of ammonium, dissolved into the liquid phase, and biologically stabilized organic matter. In this way AD gave benefits with the possibility to replace completely inorganic fertilizers with digestate.

Nevertheless in the case in which agricultural use cannot be proposed, our group is proposing new technology able to recover surplus N under transportable form, producing fertilizers.

Therefore nutrient recycling, waste treatment and environmental issue are the key words of the lecture.

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**Marco Barattieri**
FaST, University of Bozen/Bolzano, Italy

## Biomass upgrading into gaseous and liquid fuels: thermo-chemical and biochemical processes

Despite biomass provides only a relatively small amount of the current world energy needs, it has a great potential - as possible substitute for fossil fuels - to increase its share in the global spectrum of energy resources. In particular, lignocellulosic biomass are of interest because of their lower impacts on the soil and land use and their lower interaction with the food production chain. In this context, thermochemical and biochemical processes are considered as viable fuel upgrading paths, allowing the transformation of a solid fuel into gaseous or liquid energy vectors. This chance is particularly interesting for the current scenario, in which small and medium size conversion plant technologies could be integrated in a distributed energy generation model that is expected to increase its diffusion.

This lecture provides an overview on the different technologies for producing synthesis gas (i.e., syngas) or ethanol from lignocellulosic biomass giving also an insight on the major research trends. The bio- or thermo-chemical conversion of different lignocellulosic feedstocks - such as forest and agricultural residues, or dedicated lignocellulosic crops - offers several benefits but its development is still hampered by economic and technical obstacles.

Regarding the biochemical pathways to ethanol, the complexity of the biomass processing is pointed out through the analysis of the different stages involved in the conversion of lignocellulosic complex into fermentable sugars. In particular there will be a focus on the most interesting pretreatment technologies and the interrelated factors between pretreatment, hydrolysis and fermentation.

Pyrolysis and gasification will be considered as thermo-chemical processes considering different operating parameters. In particular air and steam gasification will be considered describing the different available technologies and also taking into account the effect of the use of different biomass on the syngas composition and conversion efficiency.

Finally, reference will be made to combined heat and power generation technologies that are capable to exploit efficiently the upgraded fuels, considering traditional and innovative technologies.

SOCIETA' ITALIANA DI CHIMICA AGRARIA

PhD Summer School

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# Selected Posters of PhD Students

University of Viterbo

University of Bozen-Bolzano

UNIVERSITÀ CATTOLICA del Sacro Cuore

SOCIETA' ITALIANA DI CHIMICA AGRARIA

PhD Summer School

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# Arsenic removal from contaminated waters by low-cost synthetic sorbents (Layered Double Hydroxides)

S.M.G.G. Azam, A.G. Caporale, A. Sommella, M. Pigna, M.A. Rao, A. Violante

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Arsenic (As) is a very toxic to living organisms. Because of its frequency in the environment and the risks to human health, As is the first among the toxic elements listed by the U.S. Environmental Protection Agency. Arsenic forms several organic and inorganic compounds in soil and is mainly present in inorganic form, such as arsenate As(V) and/or arsenite As(III). The As(III) is more mobile and toxic than As(V) and prevails under reducing conditions, while the As(V) predominates in oxidizing conditions.

The As presence in groundwaters was considered an important issue in Southeast Asia and other parts of the World, but not in Italy. However, in the last few years, many reports have been published on the presence of high concentrations of As in the groundwaters of several Italian areas, such as Lazio and Tuscany.

During this Ph.D. project the possible As removal from contaminated waters by low-cost synthetic materials will be studied. Among these materials, we are going to carry out experiments on different anionic clays, also called Layered Double Hydroxides (LDH). We will synthesize different LDHs to select which is the best to remove As from contaminated waters. One of them will be synthesized by coprecipitating of $Mg(NO_3)_2$ and $Al(NO_3)_3$ (initial molar ratio Mg/Al equal to 2) with NaOH in presence of $Na_2CO_3$ (1 mol $L^{-1}$).

The use of these low-cost materials, characterized by a high As(III) and As(V) sorption capacity, allows to reduce drastically As concentration in drinking-water and groundwaters used for agricultural purposes.

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# Further investigation of the relationship between $^{137}Cs$ and $^{210}Pb_{ex}$ flux and sediment output from two small experimental catchments in Calabria, southern Italy

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Information on rates of soil loss and associated rates of soil redistribution are increasingly seen as an important requirement for effective environmental management. Many models and prediction procedures have been developed to estimate likely rates of soil loss and soil redistribution using information on the local topography, hydrometeorology, soil type and land management, but there is still a need for empirical measurements of soil redistribution rates, in order to provide data for validation and calibration of such models and prediction procedures. The use of fallout radionuclides and more particularly caesium-137 ($^{137}Cs$) and excess lead-210 ($^{210}Pb_{ex}$) to document rates of soil and sediment redistribution in the landscape has attracted increasing attention in recent years, as this approach is able to overcome several of the limitations associated with more traditional methods. A detailed investigation of sediment and sediment-associated $^{137}Cs$ and $^{210}Pb_{ex}$ fluxes has been initiated in two small experimental catchments located southern Italy. For both catchments, information on the sediment and radionuclide fluxes associated with 50 individual storm events has been assembled for the period 2005-2011. This measurement programme has identified a number of differences in behaviour between the two catchments in terms of sediment and radionuclide fluxes and the relationship between the radionuclide activity in soils and sediments. These contrasts highlight differences in the erosional response on the two catchments and provide a useful demonstration of the further potential for using $^{137}Cs$ and $^{210}Pb_{ex}$ measurements to shed light on the internal functioning of a catchment, in terms of sediment mobilization and delivery.

**Keywords** caesium-137; lead-210; soil erosion; suspended sediment; sediment dynamics, sediment delivery, Italy.

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# Relazione tra qualità del suolo e qualità dell'olio di oliva per differenti cultivar di *Olea europea* L.

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La Dieta Mediterranea è ormai riconosciuta come patrimonio dell'umanità e l'olio di oliva riveste in essa un'importanza notevole ed è ritenuto un elemento essenziale nel settore gastronomico, nutrizionale e terapeutico. La composizione dell'olio è influenzata fortemente dalla cultivar, dall'area di produzione, dalle condizioni climatiche ed edafiche, dal tempo di coltivazione, dallo stadio di maturazione e dall'integrità del frutto, nonché dalle tecnologie utilizzate per la sua produzione. In particolare, ciascuna cultivar è generalmente associata a specifiche proprietà edafiche e d'altra parte può influenzare le caratteristiche chimiche, fisiche e biologiche del suolo. L'obiettivo del presente lavoro è stato quello di mettere in relazione il profilo qualitativo di oli extravergini di oliva con le caratteristiche pedologiche e le proprietà fitochimiche delle cultivar analizzate. In particolare sono state prese in esame due cultivar di *Olea europaea* L. coltivate nell'area produttiva della provincia di Avellino, ricadente nel territorio DOP "Irpinia Colline dell'Ufita". Le cultivar analizzate sono caratterizzate da oli con un contenuto di polifenoli totali compresi tra 96-159 mg GAE/Kg olio e i diversi valori ottenuti riflettono le differenti condizioni pedologiche quali pH e contenuto di sostanza organica dei suoli esaminati. Il maggior contenuto di oleuropeina e idrossitirosolo, antiossidanti naturali tipici dell'olio, è stato ritrovato in corrispondenza dei suoli più alcalini e ricchi in carbonio, con un più alto contenuto di biomassa microbica e fungina, e una minore attività della comunità edafica.

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# Individuazione di zone fitoclimatiche per lo studio delle emissione di gas serra nei vari ambienti naturali italiani basandosi sulla cartografia disponibile.

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I principali scambiatori naturali di C con l'atmosfera sono la vegetazione e il suolo. Le emissioni di un ambiente dipendono quindi dal metabolismo vegetale e da quello microbico del terreno che sono intimamente legati tra loro. I fattori che regolano questi processi sono molteplici e legati alle specifiche condizioni del sito.
Lo studio delle zone fitoclimatiche nasce dalla necessità di quantificare le dinamiche del C all'interno degli ambienti naturali italiani con un dettaglio maggiore di quello dei biomi individuati da Field a scala globale nel 1998.
L'indagine, a livello nazionale, si basa sull'analisi della bibliografia utilizzando software GIS per confrontare le fonti cartografiche.
I parametri inizialmente considerati sono stati il clima, l'altimetria e la pedologia; ma per gli ultimi due le fonti scarseggiavano. Si è quindi considerata direttamente la vegetazione potenziale come il risultato di tutti i fattori ambientali. Il territorio è stato suddiviso nelle 5 regioni fitoclimatiche descritte dal Pavari e rivisitate da De Philippis (1937), ma si sono utilizzati i confini della Carta della Vegetazione Naturale Potenziale d'Italia del Tomaselli (1970). Grazie all'analisi delle specie arboree si sono potute confrontare le due differenti legende. Utilizzando la cartografia INFC (1985) è stato possibile identificare le specie arboree più diffuse e stimare un valore di NPP basato sulla produzione di legname reperito in testi di silvicoltura.
Ne è scaturita la Carta delle Zone Fitoclimatiche a cui sono associati valori di NPP che rispecchiano un gradiente climatico (massimo nel Picetum e minimo nel Lauretum) in accordo coi valori di Field.

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# Effect of organic management on quality and nutritional characteristics of processing tomato

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Tomato organic cultivation is a growing business in Italy: an increased cultivated area has been detected during last years. Organic tomatoes are considered superior in sensory quality and content of vitamins and minerals to those grown conventionally. A lack of information exist concerning of organic tomato production. Therefore it is necessary to know how to maximize organic production in terms of both quality and quantity.
The aim of this study, within a national project, is to identify cultivars of tomato suitable for organic agriculture by evaluating the quality of two processed cultivars of Solanum lycopersicum, grown in two different farms of the Sele River Plain (Campania Region, South Italy), under organic and conventional management.
Before seedling transplanting, soils were characterized for main physico-chemical (particle-size distribution, pH, electrical conductivity, cationic exchange capacity, organic carbon, macro and micronutrients total content), biochemical (activity of dehydrogenase, β-glucosidase, invertase, phosphatase, urease, arylsulphatase and fluorescein diacetate hydrolase), and biological (microbial biomass, respiration) properties.
Tomato leaves were periodically analyzed for total content of macro and micronutrients to understand plant development and nutritional status.
Basic quality determinations (°Brix, pH, color, total sugars, total acidity, etc.), specific nutritional assessment (carotenoids, ascorbic acid and polyphenols), and proteomic evaluation were carried out on both fresh tomatoes and processed products.
Results showed a lower productivity under organic management, due likely to the reduced availability of nutrients, reduced use of pesticides, organic tomatoes as well as the processed products (puree and peeled) showed a higher antioxidants content respect to the conventional ones.

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# Development and application of chemical, physical, and biological parameters to evaluate soil quality

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The soil fulfils some central functions in support of life, human activities, biodiversity and climate regulation. For these reasons it is considered heritage and non-renewable natural resource. However, it is subject to environmental degradation which is promoted or contrasted by human activities. Nevertheless, before realizing any plan to support and protect health, we should know it deeply, and this is possible only whit the development of a monitoring system, based on an interdisciplinary chemical, physical and biological model, which takes into consideration the aspects of the biodiversity and the bioindication.
The aim of this project is to evaluate the quality of the soils from an environmental and an agronomical point of view, considering all the territory of the Lombardy Region.
The potential sources of pollution are represented by sewage sludge, fertilizers, pesticides, herbicides, dioxins, radionuclides (accidents or contamination), heavy metals, PAHs, PCBs, etc., in addition to the illegal dumping of toxic waste.
Lombardy has an high urbanization and industrialization rate, and the agricultural soil is subject to different anthropogenic pressures. The area that will be investigated is used primarily for agricultural purposes and only in certain specific cases it will be investigate soils whose intended use is reserved to the many facets of the industry.
The study will be developed through a multidisciplinary research that will bring together experts from a dozen universities and research centers, national and international.
The survey will take into account important aspects of the chemistry, radiochemistry, physics and biology of surface soils and in some cases of deep soils.
The results of monitoring will be completed in 2014 and will be collected in databases, compared and integrated with existing data.

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# Lignocellulosic supply chains for bioenergy: sustainability in Mediterranean agroecosystems. The case study of Miscanthus.

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Among bioenergy crops, the use of perennial rhizomatous grasses, as miscanthus, seems promising due to their high productivity, low nutrient requirement and great potential for C mitigation.
The objective of the study is twofold: to deepen the understanding of the influence of soil texture (silty clay (SIC) vs. sandy loam (SL)) and of alternative agricultural intensification regimes (nitrogen fertilization (0, 50, 100 kg $ha^{-1}$) and irrigation (0% vs. 75% of the $ET_0$)) on miscanthus productivity, soil $CO_2$ emissions and carbon dynamics.
First year results highlighted the influence of soil texture and date of harvest on 2-year old miscanthus productivity. No influence of nitrogen and irrigation was observed. Loss of leaves were responsible for about 60% to the yield reduction during senescence. $CO_2$ flux was generally higher in the SIC soil in the summer period, while the opposite occurred throughout the cold period. The overall parallel pattern between soil temperature and soil $CO_2$ flux may suggest an influence of the former over the latter; indeed, an exponential relationship is very well suited to describe this relationship. In SIC soil, total carbon losses from late July to late March sum up to about 570 g $m^{-2}$ whereas carbon return to soil as litterfall reaches about 150 g $m^{-2}$. Hence, basing on preliminary results, the role of the belowground portion biomass seems fundamental to long term soil carbon enhancement.
Finally, according to the research schedule, gathered data will be used to implement a system sustainability evaluation, in a LCA perspective.

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# Mobility of heavy metals in soil assessed by column leaching and sequential extraction

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The BCR procedure has been applied to fractionate the iron, manganese, copper, lead and zinc contents in pasture soil samples from an area in Harghita county, Romania, heavily affected by mining activities. Sequential extraction methods allow the determination of metals from operationally defined fractions: ionic exchangeable fraction, fraction adsorbed onto iron and manganese oxyhydroxide surfaces, fraction linked by organic matter and that linked by mineral networks. Fractionation of the trace element content of environmental solids by application of a series of extractants provides information on reservoirs of metal that are likely to respond in different ways to changes in ambient conditions such as pH or redox potential. The studied soil was submitted to alternative aerobic-anaerobic conditions and the behaviour of the heavy metals, i.e. their transformation and mobility was monitored over a period of 23 days. At the end of this period, the soil was dried and the sequential extraction procedure was applied. Iron was found mainly in association with the residual phase of the soil matrix, copper was present in the reducible, oxidisable and residual fractions, whilst zinc was found in all four sequential extracts. Manganese was strongly associated with reducible material as well as lead which is of concern because the potential exists for remobilization under reducing conditions.

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