University of Milano-Bicocca
PhD Course in Chemical, Geological and Environmental Sciences
Call for Interest 38th cycle - Curriculum Terrestrial and Marine Environmental Sciences

Nr 1		**Supervisor**	**Roberto Comolli**
Title	**Effects of compaction on urban soil functions**		

Compared to natural soils, urban soils are highly affected by anthropic activities that alter their properties. However, despite high levels of disturbance, urban soils can provide many ecosystem services: they support plant, animal, and microbial organisms and mediate hydrological and biogeochemical cycles.

Compaction is one of the causes of physical soil degradation; it modifies soil structure, reducing air and water permeability and creating an unsuitable habitat for plant growth and soil biodiversity. While this issue has been extensively studied in the agricultural context, little is known about urban soil compaction, despite its impact on ecosystem functioning.

The purpose of this project is to assess the ability of urban soils to provide ecosystem services and to support viable biological communities (plants, soil fauna) in relation to their compaction status.
Within the metropolitan area of Milan, different land uses (parks, small green patches, tree rows, urban green, etc.) with a wide range of physical disturbances (for intensity and duration) will be selected and compared; to better understand the dynamics and effects of soil compaction, vegetation type and soil biodiversity (limited to some taxonomic groups, e.g. earthworms, arthropods, etc.) will also be studied simultaneously. The research will include field activities (soil sampling, field hydrogeological measurements, soil fauna sampling, vegetation characterization, etc.), laboratory activities (analysis of soil samples, soil fauna identification, etc.) and statistical analysis, aimed at verifying the significance of the relationships between compaction and the other environmental variables.

The candidate will have to spend a period abroad for six months; possible collaboration with University of Aarhus (Denmark) and University of Nantes (France).

Supervisor web page: https://www.unimib.it/roberto-comolli

University of Milano-Bicocca
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Nr 2		**Supervisor**	**Chiara Ferré**
Title	**Functional recovery of urban and peri-urban soils through de-sealing techniques**		

Soil sealing, namely the permanent covering of soil with impermeable materials (e.g. asphalt or concrete), is a main soil degradation process and is a consequence of urbanization and infrastructure construction. The impermeable layer prevents the exchange of matter and energy between the soil, atmosphere and hydrosphere, leading to compromise or cancel a large number of ecosystem functions.

The aim of the project is the evaluation of the functional recovery of sealed urban and peri-urban soils, through de-sealing processes. Alongside the conventional technique of removing the impermeable layers, innovative approaches will be tested, such as in-situ crushing of these layers and their use as soil-forming materials. The study will be conducted in dismissed sites in the Milan metropolitan area. Different intervention techniques will be used and compared, such as the addition of external topsoil, compost and biochar, planting of native or non-native plants, fertilizer application and irrigation. In order to monitor over time the restoration of the unsealed soil functionality, compared to the still-sealed control site, soil quality indicators will be examined: the organic matter will be characterised, the microbiological activity will be investigated, also through soil respiration measurements, and soil biodiversity will be evaluated. The sampling, by topsoil and subsoil, will be followed by laboratory analyses for the determination of physical, chemical and biological properties and statistical comparison of the results obtained with the different de-sealing approaches. Alongside the technological aspects, the economic-environmental costs of the techniques will be evaluated and the best Nature-Based Solutions (NBS) will be suggested.

The candidate is expected to spend a period abroad at *Wageningen University (NL) and Ecologic Institute (Berlin).*

Supervisor web page: https://www.unimib.it/chiara-ferre

University of Milano-Bicocca

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Nr 3		**Supervisor**	**Sandra Citterio**
Title	**Soil phytoremediation: exploring the potential of plant-microbe interactions**		

Nowadays, one of the most concerning issues that the word is facing is environmental contamination that is endangering human health and the ecosystem. The identification and proper implementation of suitable technologies for remediation of contaminated sites is, thus, a prerequisite for sustainable development. Among nature-based solutions, there is the phytoremediation technology, defined as "the use of green plants and the associated microorganisms, along with proper soil amendments and agronomic techniques to either contain, remove or render toxic environmental contaminants harmless". Although phytoremediation is not a new technology, its application is still limited, in particular due to the low bioavailability of pollutants and/or the limited tolerance of plants to contaminants. This project aims at exploring the potential of plant-microbe interactions for the remediation of soils polluted by metals and hydrocarbons. The project will investigate the role of rhizosphere and root endophytic microbial communities in both plant tolerance to major inorganic and organic pollutants and the plant efficiency to remove pollutants from soils. In addition, the effect of soil amendments, such as biochar, on the plant-microbe symbiosis and on the phytoremediation process will be studied. Experiments will be undertaken under laboratory and field conditions. Biomolecular techniques, including microscopy and flow cytometry, along with pedolological and chemical methodologies, will be applied. The project will involve foreign institutions active in the study of plant symbioses.

Supervisor web page: https://www.unimib.it/sandra-citterio

University of Milano-Bicocca

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Nr 4		**Supervisor**	**Chiara Urani**
Title	**Which is the role played by environmental metal contamination in neurotoxicity and neurodegeneration?**		

Neurotoxicity and neurodegenerative diseases are closely linked to environmental contamination. Neurological disorders are pathological conditions in which the brain's biochemistry is affected, causing cell dysfunction and deficiencies. Epidemiological and environmental data suggest a role played by metal exposure through inhalation and ingestion to an increased risk of developing amyotrophic lateral sclerosis (ALS). Only around 10% of ALS cases are of familial origin; the remaining 90% are related to environmental factors, or to an interplay between the environment and genetic causes. Studies in the past two decades have highlighted possible roles of metals, and ionic homeostasis dysregulation in neurodegeneration (de Jesus and Zezzi Arruda, 2020; Tesauro et al., 2020).

The general aim of the project is the identification of essential and non-essential metals' role in processes of neurotoxicity and neurodegeneration, with particular attention to ALS.

The research work will comprise the following integrated approaches:

1) Data and samples collection, elaboration, and analyses from two environmental matrices (air and soil) in areas with a high incidence of ALS (Piedmont and Western Lombardy).

2) Analytical approaches (e.g., ICP-MS) to quantitatively assess the speciation of the metals in biological fluids (e.g., urine, serum) from controls and ALS affected patients, to be possibly correlated to environmental and/or occupational exposure and to personal habits.

3) *In vitro* biological approaches using cell models for mechanistic and possible recovery studies of neurotoxic metals' effects.

The project has components of data and environmental samples' collection and elaboration, to be supported and integrated with laboratory work and analyses.

This interdisciplinary research will be carried out in collaboration with the Geopedology Unit of DiSAT, the ALS Centre, Department of Neurology-Maggiore della Carità University Hospital (UPO University, Novara), the University of Milan, and the Interuniversity Research Centre MISTRAL (University of Milano-Bicocca, University of Brescia and University of Verona).

The candidate is expected to spend a period abroad at the Thomas Jefferson University, Philadelphia USA.

Supervisor web page: https://www.unimib.it/chiara-urani

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Nr 5		**Supervisor**	**Chiara Urani** **Susanna Alloisio (ETT S.p.A.)**
Title	**Nanoplastics: environmental impact and possible neurotoxicity**		

This research activity will be carried out in the frame of a High-Level Training Apprenticeship PhD. This PhD course allows an Enterprise to hire a young graduate (under 29 years old) through an apprenticeship contract, who will work in the Enterprise and carry out a research project of common interest. Training periods in the Enterprise and at the University are specified in the contract, as well as the PhD course to be attended. The company involved is ETT Spa, a digital and creative industry focused to technological innovation for process efficiency and optimisation. This PhD project deals with the characterization and study of possible neurotoxicity of nanoplastics. The biogeochemical cycle of plastics includes all environmental compartments and thus it should be considered a ubiquitous problem. Marine ecosystems are particularly vulnerable, as nearly 10% of the plastic produced annually is transported to seas and oceans, mostly via rivers. Moreover, especially small particles can also be easily spread by wind, making atmospheric air an important vehicle for micro- (MPs) and nanoplastics (NPs) distribution.

MPs and NPs are of special relevance from a public health perspective, because the smaller polymer size facilitates their dispersal and contamination of ecosystems, favouring the exposure and entry into the humans. Moreover, inhalation exposure results from MPs and NPs released from textiles, synthetic rubber tires and plastic covers. Therefore, besides the dietary pathway, MPs in the environment can also gain access via the respiratory pathway.

Besides the potential adverse effects induced by the physical presence of MPs and NPs, they can act as carrier for various (chemical) contaminants, including metals, persistent organic pollutants, antibiotics and (pathogenic) micro-organisms. NPs enhance the co-transport of heavy metals such as Co, Al, Cr, Pb, Ni, Zn, Co, Cd and Hg due to high surface charge density.

Given the limited data on the neurotoxic effects of NPs available, the project aims to assess the neurotoxic hazard of plastic particles and metals more frequently discovered in organisms and found in environmental matrices (e.g., soil, and sea water).

To this purpose, this project aims also to develop technical procedures for environmental sample characterization.

In addition, aim of the project will be to fine-tune the experimental procedure to automatically recognize and evaluate the presence of NPs in water samples, and possibly in samples from contaminated soils.

The investigation of the effect of NPs on nervous system will be performed by using both in vitro and in vivo models. Furthermore, since NPs may adsorb environmental chemicals, such as metals, it will be also evaluated the eventual synergistic effect of NPs and metals co-exposure.

The ETT company will contribute to this project providing its knowledge and skills in the field of in vitro neurotoxicology and make available the technical equipment and platforms for NPs characterization for reaching the project's goals.

The project will be developed in collaboration with the Interuniversity Research Centre MISTRAL, of which University of Milano-Bicocca and Susanna Alloisio are part.

Notes: *Advanced Apprenticeship PhD at ETT S.p.A. (This type of contract is reserved for those who have not yet reached the age of 30 at the time of recruitment)*

Supervisor web page: https://www.unimib.it/chiara-urani

University of Milano-Bicocca
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Nr 6		**Supervisor**	**Paolo Galli** **Athanassia Athanassiou (IIT)**
Title	**Biomaterials for the healing of corals and conservation of reefs biodiversity**		

Coral diseases and bleaching are threatening the existence of the corals and of the ecosystems that depend on them. The affected corals need immediate treatments, but so far, no efficient and scalable therapies have been found, highlighting the necessity for an immediate action before the reefs' disappearance.

The PhD project will be focused on the design and development of sustainable, biocompatible, biodegradable and easily scalable polymeric biocomposites, for the underwater controlled delivery of therapeutic agents directly onto the corals to tackle the various coral diseases. In the end of the project, prototypes of biocomposites with proved therapeutic effects and biodegradability, tested in a real coral reef ecosystem, will be delivered.

The project will combine the most recent advances in sustainability, material science, and pharmaceutics in order to give a chance of survival to the coral ecosystems. Solvent mixing, preparation of emulsions, spray drying, casting, rod coating will be some of the technologies that will be followed for the materials' development. For the characterization of the materials and their efficacy will be used a variety of methods like spectroscopic techniques, optical and electronic microcopy, antioxidant and antibacterials tests, biochemical oxygen demand, to name few.

Notes: *Scholarship funded by Fondazione Istituto Italiano di Tecnologia*

Supervisor web page: https://www.unimib.it/paolo-galli

University of Milano-Bicocca
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Nr 7		**Supervisor**	**Paolo Galli**
Title	**Ocean bioprospecting: Exploring the pharmaceutical potential of tropical corals**		

Oceans cover over 70% of the earth's surface. Marine environments are among the richest and most diverse ecosystems, with an enormous diversity of different life forms. Over 200,000 species of invertebrates and algae have been identified, and this number is estimated to be only a small fraction of what is yet to be discovered. Harsh chemical and physical conditions in the marine environment are important drivers for the production of a wide range of bioactive natural products with structurally unique features. These marine natural products exhibit a variety of bioactivities that have potential applications in the pharmaceutical and medical fields.

Among marine invertebrates, coral are promising providers of marine bioactive compounds. Some are these marine natural products are used by corals for chemical defense to slow and prevent cell growth of invading sponges. Studies suggest that these natural products from corals can stop the uncontrolled division of cancer cells in humans. In this vein, this proposed study aims to explore the anticancer potential of selected tropical corals from the Maldives (a biological hotspot) with the objective to identify bioactive extracts that can open new avenues in the global hunt for novel chemotherapeutics.

The project will employ advanced chromatographic techniques to extracted, purify, and isolate natural products. Their structures will be characterized via mass spectrophotometry. The cytotoxic potencies of the isolated compounds will be evaluated against a panel of cancer cell lines using cellular cytotoxicity assays.

Overall, this project will present a great opportunity to explore the application of marine derived compounds as anticancer therapeutics.

Supervisor web page: https://www.unimib.it/paolo-galli

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Nr 8	BIO/07	**Supervisor**	**Barbara Leoni**
Title	**Expand the frontiers of Raman microspectroscopy as a tool for environmental and ecological studies**		

Raman spectroscopy has undergone rapid development over the last few decades. This powerful technique is mainly used for mineralogy and petrography, but it has great potential, still largely unexplored, for environmental and ecological applications. Indeed, it is a nondestructive analytical technique, requires no or limited sample preparation, and can analyze samples in aqueous solutions. Therefore, this technique could potentially be applied to a large range of environmental issues spanning from the analysis of photosynthetic pigments to the detection of several classes of environmental pollutants. For instance, Raman microspectroscopy is gaining ground in the analysis of microplastics, especially due to its high spatial resolution that allows the investigation of small plastic particles, but its application in this research field can be further explored.

The present research line aims to expand the frontiers of Raman microspectroscopy and develop highly advantageous analytical methods for environmental monitoring through the use of this technique. The research will be developed in collaboration with the Raman microspectroscopy laboratory at DISAT-UNIMIB which is provided with a Raman spectrometer Horiba Jobin Yvon LabRAM HR Evolution, equipped with two lasers (532 nm, 785 nm), two diffraction gratings (1800 and 600 grooves/mm), and a CCD detector (1024 x 256 px, -60°C). For additional information about the laboratory click here: https://www.disat.unimib.it/en/research/facilities/raman-microspectroscopy-lab

Supervisor web page: https://www.unimib.it/barbara-leoni

University of Milano-Bicocca

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Nr 9		**Supervisor**	**Barbara Leoni**
Title	**Unravelling the plastisphere in freshwaters: interaction of microplastics with primary producers**		

Among the multiple stressors that affect freshwater ecosystems, plastic pollution has been widely documented as a widespread and pervasive environmental issue and the role of lakes and rivers in global plastic pollution has been increasingly recognized (Horton et al., 2017). These pollutants can interact with aquatic biota, and this interaction starts from low trophic levels. Different studies highlighted the interplay between plastic particles and primary producers (microalgae) and the subsequent impacts on their respective fates (Yokota et al., 2017). Existing studies on this topic have been mainly focused on the toxic effects of microalgae after exposure to microplastics, reporting effects on growth (Venâncio et al., 2019; Zhao et al., 2019), photosynthetic activity (Mao et al., 2018; Zhang et al., 2017), and morphological changes (Mao et al., 2018). However, the interaction between microplastics and microalgae is far more complex with a wide range of consequences. This interaction may affect plastic degradation processes, either having potential for biodegradation or, on the contrary, protecting plastics from ultraviolet radiation and photo-catalysis (Carson et al., 2013). Furthermore, the formation of a biofilm on the microplastics (biofouling) causes an increase of microplastic density and, thus, may affect their vertical fluxes, determine their position along the water column, and consequently their bioavailability (Kooi et al., 2017; Long et al., 2015). At a broader scale, it has been argued that this interaction may also have effects at the ecosystem level since it can affect primary productivity with consequences for aquatic ecosystem functioning (Zhang et al., 2020). Despite the relevance of this topic, studies addressing the interaction with organisms at the base of aquatic food webs are still extremely limited, especially in freshwater ecosystems (Wang et al., 2019).

The present Ph.D. proposal is aimed at studying the effects of plastics on the aquatic food web and ecosystem functioning through experimental assessment of the interaction with key organisms, i.e. microalgae. The overreaching goal is to discover whether plastics and microplastics represent a new niche in aquatic systems for microalgal community and determine whether their presence can trigger effects throughout the food web with potentially detrimental effects for aquatic ecosystems.

Supervisor web page: https://www.unimib.it/barbara-leoni

University of Milano-Bicocca

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Nr 10		**Supervisor**	**Giovanni Zambon**
Title	**Evaluation of the quality of an environment through the analysis and definition of the most suitable acoustic and bioacoustic indicators characterizing the local soundscape**		

Sounds of geophonic or biophonic origin have been recognized as powerful proxies to characterize environmental quality or to detect the first symptoms of environmental stress, also with reference to human intrusion.

The aim of this project is to propose an ecoacoustics approach to investigate the state of community, ecosystems and landscapes as an innovative tool that can support and interact with other traditional technologies.

A widespread range of recording instruments, sensors and sampling techniques allow to acquire sounds for long periods in terrestrial and underwater context; at the same time, statistical analysis based upon different acoustic metrics is the way to define the best indicators which can return a picture of the environment and its dynamics.

Collaborations with the following universities are planned to carry out the activities:

University of Pavia - Department of Earth and Environment Science (DSTA)

University of Salerno - Department of Civil Engineering (DICIV)

University of Barcelona La Salle - Department of Engineering - Research Group on Media Technologies (GTM)

During the PhD period, the student is expected to stay at the University of Barcelona for a period of at least 6 months

Supervisor webpage: https://www.unimib.it/giovanni-zambon

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Nr 11		**Supervisor**	**Sandra Citterio**
Title	**Production and chemical functionalization of biochar for environmental applications**		
The proposed project is in the frame of the Join Research Agreement between ENI and University of Milano Bicocca and aims at developing a new products to be applied in bioremediation of soil contaminated by hydrocarbons. Bioremediation technologies exploit the ability of natural microorganisms to efficiently remove organic pollutants. Biochar is a co-product of biomass pyrolysis. It is in fact a biological material produced in the absence of oxygen, at temperatures below 700 ° C, to generate more permeable, less dense and carbon-rich products. The presence of pores, the high surface area, the ability to bind and retain nutrients (N and P) as well as organic pollutants, make biochar a good support for persistence and microbial growth (bacteria and fungi), to be applied as a soil improver to maintain and increase the physical, chemical and biological properties/ activities of the soil. Recently, it has been suggested that applying biochar to contaminated soil helps plant-microorganism systems reduce hydrocarbon concentrations. Indeed, plant-microorganism interaction can support the enzymatic ability of bacteria and fungi to degrade hydrocarbons. The aim of the project is to develop and validate a microbiologically activated biochar (Microbe-activated-Biochar (MaB)), to be applied to the biological treatment of soils contaminated by hydrocarbons. The planned activity for this project are: A) production of biochar from biomass through pyrolysis, followed by physical and chemical characterization of the biochar (proportion between the pyrolysis product and the original biomass, absorption capacity, specific surface, porosity, composition, etc.); B) functional activation of biochar in order to increase its chemical and biochemical compatibility with the strains of selected microorganisms. Functional modification of the biochar can be performed through physical or chemical activation; C) the effectiveness of the MaB obtained in WP3 will be evaluated in the bioremediation of soils contaminated by hydrocarbons by laboratory tests and pilot experiments in the field.		
Supervisor webpage: https://www.unimib.it/sandra-citterio			
Notes: *Might be funded with scholarship by ENI (to be confirmed)*			

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Nr 12		**Supervisor**	**Andrea Franzetti**
Title	**Phenotypic and genotypic characterisation of bacterial strains for biological functionalization of biochar**		

The proposed project is in the frame of the Join Research Agreement between ENI and University of Milano Bicocca and aims at developing a new products to be applied in bioremediation of soil contaminated by hydrocarbons. Bioremediation technologies exploit the ability of natural microorganisms to efficiently remove organic pollutants. Biochar is a co-product of biomass pyrolysis. It is in fact a biological material produced in the absence of oxygen, at temperatures below 700 ° C, to generate more permeable, less dense and carbon-rich products. The presence of pores, the high surface area, the ability to bind and retain nutrients (N and P) as well as organic pollutants, make biochar a good support for persistence and microbial growth (bacteria and fungi), to be applied as a soil improver to maintain and increase the physical, chemical and biological properties/ activities of the soil. Recently, it has been suggested that applying biochar to contaminated soil helps plant-microorganism systems reduce hydrocarbon concentrations. Indeed, plant-microorganism interaction can support the enzymatic ability of bacteria and fungi to degrade hydrocarbons. The aim of the project is to develop and validate a microbiologically activated biochar (Microbe-activated-Biochar (MaB)), to be applied to the biological treatment of soils contaminated by hydrocarbons. The planned activity for this project are: A) selection of microorganism strains: bacteria and fungi will be found / isolated and monitored in order to obtain strains with the following metabolic characteristics: i) ease and low costs of cultivation, ii) biodegradation capacity of hydrocarbons, iii) promotion of plant growth (MaB + plant system). B) phenotypic and genotypic characterization of the selected strains: biodegradation tests will be performed on different hydrocarbons; for plant growth promoting microorganisms, metabolic capacities such as nitrogen fixation, phosphate solubilization and production of siderophores, phytohormones, 1-aminocyclopropane-1-carboxylate (ACC) deaminase and indole-3- acid will be investigated. acetic (IAA); determination and sequencing of the genetic determinants of the metabolic properties listed above; sequencing and annotation of complete genomes of selected strains.

Supervisor webpage: https://www.unimib.it/andrea-franzetti

Notes: *Might be funded with scholarship by ENI (to be confirmed)*

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Nr 13		**Supervisor**	**Isabella Gandolfi**
Title	**Plant-bacteria systems as tools for atmospheric pollution mitigation**		

Air pollution in urban areas is a global concern due to its detrimental effects on human health and ecosystem functioning. Currently, this issue is managed by both emission reduction and local mitigation strategies. Among the latter, the role of vegetation in urban areas is gaining interest since plants have been suggested to effectively contribute to air pollution reduction mainly through the adsorption of both organic and inorganic pollutants onto leaves. After that, adsorbed contaminants can be partly transferred to the soil and rhizosphere through leaf fall and runoff. In this context, plant-associated microorganisms can play a pivotal role in pollution mitigation, both by degrading, detoxifying or sequestrating organic and/or inorganic pollutants, and by promoting plant growth. In fact, plants are known to host abundant and highly specific microbiomes, both in the phyllosphere, comprising the aerial parts of plants and dominated by leaves, and in the rhizosphere. All these communities are shaped by selection processes that result, at least partially, in predictable microbial communities that can however show both temporal and spatial dynamics and can vary among plant host species. Nevertheless, such variability, together with factors influencing microbial community assembly, are still far from being completely elucidated.

This project aims at filling some knowledge gaps in the ecology of plant-associated microorganisms. Particularly, microbiomes hosted by different plant species, living in different environmental conditions and exposed to different pollution levels, will be deeply characterized through molecular methods, mainly the high-throughput sequencing platform Illumina MiSeq. The potential abilities of different bacterial communities and different plant-bacteria systems to remove atmospheric pollutants will be evaluated with quantitative and semi-quantitative methods (e.g., qPCR).

Possible collaborations are envisaged with other Italian and foreign universities, which have already been involved in shared projects on this research topic, e.g., University of Perugia and University of Palermo, as well as University of Antwerp (Belgium), where the Ph.D. student may spend a period abroad.

Supervisor webpage: https://www.unimib.it/isabella-gandolfi

University of Milano-Bicocca

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Nr 14		**Supervisor**	**Elena Collina**
Title	**Upgrading of biogas using iron nanoparticles produced by HTC**		

Over the past years, there has been a growing interest in the use of biogas produced by the anaerobic digestion of waste. Biogas has a high methane content making it a good candidate as a renewable substitute for natural gas. In addition to methane, biogas contains significant amounts of carbon dioxide and hydrogen sulfide that must be removed before being used as natural gas.

Zerovalent iron nanoparticles (nZVI) can play a valuable role in upgrading biogas since iron has a great capacity to react with hydrogen sulfide which would allow its elimination. Zerovalent iron can generate hydrogen that at the same time can react with carbon dioxide to produce methane. In this way, these two compounds would be eliminated by increasing the content of the methane in biogas. The nZVI can be used directly in anaerobic digestion or in subsequent biogas treatments.

The research project will be focused on studying how these nanoparticles can be used to produce biomethane from biogas in anaerobic digestion.

Iron nanoparticles will be manufactured from agricultural residues using the hydrothermal carbonization technique (HTC). Among other residues, olive waste mill can be used which is a typical waste of Spanish-Italian industry. The nanoparticles produced by this method are of high quality and are susceptible to being used to upgrade biogas. The effect on the improvement of biogas will be studied at lab-scale in a reactor using the nZVI as catalyst. The reactor can be inoculated with specific bacteria to enhance the biogas upgrading performance (Dupnock and Deshusses, 2019 and 2020).

The project will be performed in collaboration with the University of Alicante. The candidate is expected to spend a minimum of 12 months abroad for the nZVI manufacturing and characterization.

Supervisor webpage: https://www.unimib.it/elena-maria-collina

Notes: *in collaboration with the University of Alicante (Spain)*

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Nr 15		**Supervisor**	**Daniela Basso**
Title	**Coralline-engineered bioconstructions and climate changes**		

Coralline algae are autogenic habitat engineers responsible for the formation of calcareous intertidal algal rims, rhodoliths, and algal reefs known in the Mediterranean as Coralligène (Coralligenous = C). These are prominent biogeological systems of European seascapes, unique hotspots of marine biodiversity, major carbonate factories, and targets of EU environmental protection, due to their sensitivity to direct and indirect human impacts, such those expected from the ongoing climate change. Beyond Europe, rhodoliths are common on most shelves of the world, such as the rhodolith beds covering more than 230000 km^2 of the Brazilian continental shelf. The coralline-engineered habitats are historical structures shaped by a range of geo-biological processes over geological times, and are complex archives of past ecological baselines predating the Anthropocene.

The research is aimed at modelling the algal bioconstruction from inception and development to possible demise, in the framework of the Holocene climate fluctuations and the ongoing marine acidification and temperature rise. Material collected through the entire Mediterranean basin will be analyzed and compared with extra-Mediterranean samples in term of substrate, carbonate content, radiocarbon age, structure, components and growth style. The algal components and the geochemical proxies (stable isotopes; macro and microelements) recorded in the algal thalli will be special targets of the investigation, in order to explore potential biogeographic and oceanographic patterns.

This research develops in the wake of the national project FISR CresciBluReef. At least 6 months of mobility is planned, based on agreements with the University of Haifa (Israel), University of Malta, collaborations with the Arctic University of Norway, the University of Iceland, and the Universidade Federal Fluminense (Brazil).

Supervisor webpage: https://www.unimib.it/daniela-maria-basso

University of Milano-Bicocca

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Nr 16		**Supervisor**	**Micol Rossini** **Gabriele Candiani (CNR-IREA)**
Title	**Crop trait retrieval from Earth Observation multispectral and hyperspectral imagery for a sustainable agriculture**		

The PhD project falls within the framework of remote sensing of environment. Space spectroscopy is considered a fundamental technology for Earth Observation in order to extract quantitative value-added information of land surface properties. Thanks to national and international space agency initiatives, a new era for spaceborne hyperspectral remote sensing is occurring. Among these initiatives, the PRISMA (PRecursore IperSpettrale della Missione Applicativa) satellite, launched on March 22nd, 2019 by the Italian Space Agency (Agenzia Spaziale Italiana - ASI), represents the most advanced spaceborne sensor for Earth Observation, devoted to test the potentiality of new-generation hyperspectral sensors and products for environmental monitoring.

The PhD activities will be carried out within the project PRIS4VEG, funded by the Italian Space Agency. The project goal is to develop the fundamental knowledge to generate useful agronomic information related to crop bio-physical, biochemical and eco-physiological variables, starting from PRISMA data, to support precision farming activities for a sustainable agriculture. The availability of spaceborne hyperspectral data allows the development of new approaches for the operational mapping of important vegetation biophysical variables. Among these variables, chlorophyll and nitrogen content are of extreme interest given their importance in agricultural monitoring and specifically for the assessment of crop nutritional status. In particular, nitrogen (N) is the most important macro-nutrient for vegetation growth and productivity. Its management based on spatio-temporal information on actual crop status is fundamental for smart agriculture applications devoted to guarantee sustainable crop production and to reduce environmental impacts. Moreover, N estimation is considered important to assess final yield and crop quality such as grain protein content of cereals, fundamental to forecast crop production for the value chain of agroindustry.

The candidate will develop methodological approaches and algorithms for the monitoring of vegetation compound with optical multispectral and hyperspectral data. In particular, the candidate will investigate machine learning techniques based on training data from ground measurements or simulations based on radiative transfer models, to estimate crop parameters of interest in the agro-sector as a contribution to a more sustainable agriculture. The candidate will conduct field campaigns contemporary to Earth Observation data acquisition to both i) collect spectro-radiometric measurements for CAL/VAL activities of PRISMA data and ii) estimate crop parameters to validate the retrieval approach. The final goal of the study is to provide a scenario for operational production of crop-parameter maps in the context of future downstream services for agro-monitoring.

Possible collaborations are envisaged with other Italian and foreign universities, which are involved in the PRIS4VEG project, e.g. University of Twente, Faculty of Geo-information Science and Earth Observation (ITC), The Netherlands.

Notes: *Might be funded with scholarship by CNR-IREA (to be confirmed)*

Supervisor web page: https://www.unimib.it/micol-rossini

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Nr 17		**Supervisor**	**Alessandra Savini**
Title	**The use of advanced geomorphological mapping techniques for innovative research in the science of marine geohazard and environmental changes in coastal environments**		

The project is aimed at studying the environmental and geological risks induced by climate changes, proposing new tools and solutions of interest to coastal and marine regions. Along coastal systems, climate change, sea level rise and other geological hazards represent environmental issues with considerable social, economic and political implications. Moreover, terrestrial and marine environments are still mostly investigated separately, generating additional uncertainties and incomplete data sets for modelling future scenarios or developing effective risk management and mitigation measures. This disconnection has generated as yet unresolved challenges for the implementation of land-use management aimed at the sustainability of marine resources, especially with regard to the ecological relevance of benthic habitats.

Our project aims to be innovative in proposing advanced approaches in visualization, analysis, modeling, interpretation and communication of geological and environmental data in 3D for coastal and marine environments. It will focus on providing ground-breaking techniques for the production of marine and coastal geomorphological maps (with a seamless integration of geospatial marine and terrestrial dataset), aimed at emphasizing the role of the abiotic component in determining the spatial extent and distribution of benthic habitats of ecological importance.

The application of advanced algorithms for the generation of 3D models, with the integration of multi-source data, and of data analysis approaches based on the use of AI (Artificial Intelligence) and VR (Virtual Reality) techniques, will represent the methodological aspects that will be most developed, aimed at increasing the effectiveness of the interpretation processes as well as the recognition and mapping of geological phenomena and anthropogenic impacts in marine areas. The expected results aim to have important implications for the industry, (infrastructure, oil and gas, renewable energy, etc.), for marine spatial planning strategy and in all management practices of the coastal and offshore marine environment.

The project integrates the collaboration of national (CMCC - Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici) and foreign partners (in particular with the "Marine Geology & Seafloor Surveying group" of the University of Malta and with the Universidad Nacional de Colombia) through the participation in ongoing projects (i.e.: RENOVATE: ecosystem appRoach to assessing and testing compENsation and mitigation actiOns in the marine enVironment: the cAse of the civiTavEcchia port hub - CMCC funding; BridgET: Bridging the gap between the land and the sea in a virtual environment for innovative teaching and community involvement in the science of climate change-induced marine and coastal geohazard – Erasmus+ KA220-HED funding). The candidate is expected to spend a period abroad of at least 6 months at the Universidad Nacional de Colombia.

Supervisor webpage: https://www.unimib.it/alessandra-savini

University of Milano-Bicocca

PhD Course in Chemical, Geological and Environmental Sciences

Call for Interest 38th cycle - Curriculum Terrestrial and Marine Environmental Sciences

Nr 18		**Supervisor**	**Marco Rotiroti**
Title	**Potential climate change impacts on groundwater resource management in the medium and long term**		

The proposed project falls in the scope of assessing the effects of climate change on groundwater resources to support mitigation and adaptation strategies planning. Groundwater resources are the primary source of drinking water supply for the Italian population, constituting a strategic asset.

Climate change will threaten both groundwater quantity and quality (i.e., chemical characteristics). Indeed, climate change can decrease the aquifers' recharge causing the depletion of the groundwater reservoirs. This decrease in recharge can be generated by the precipitation and snow accumulations' decrease and by the increase in evapotranspiration caused by a temperature increase. Prevention, mitigation and adaptation measures planning requires integrating different skills and a detailed knowledge framework to support an assessment of the present and future water resource availability. This project aims to deepen the understanding of groundwater bodies concerning water availability and their vulnerability to possible climate change scenarios, identifying, in particular, the mitigation actions that can be implemented to respond with resilience to changes.

The study will be developed using advanced statistical and geostatistical techniques and the study of conservative tracers (stable water isotopes and chemical species/parameters such as Cl, EC, etc.) to understand the recharge mechanisms of aquifers.

The main expected impact of the project is to counteract the negative effects of climate change on drinking water resources ensuring the access to safe drinking water for local population and economic activities, providing a green and resilient recovery.

Development of the project will be carried out in cooperation with the United States Geological Survey, through an abroad experience.

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Nr 19		**Supervisor**	**Sergio Cogliati**
Title	**Developing novel strategies for cal/val activities in the context of ongoing ESA and ASI satellite missions**		

Remote sensing provides a unique opportunity to map in space and time several biophysical and structural parameters of the terrestrial vegetation (e.g., leaf area index, chlorophyll content etc.) and to infer functional processes such as the solar-induced fluorescence. The knowledge of these parameters is crucial to quantify the vegetation status and allow performing different applications encompassing precision farming and photosynthesis studies, as example.

The advent of high-performance and compact instruments operated aboard of drone platforms offer unprecedent observations with high spatial and temporal resolutions of the investigated target. These observations prompt novel studies and could greatly support the calibration/validation (cal/val) and interpretation of satellite measurements. Furthermore, the integration of data collected by optical imaging spectrometer and LiDAR instruments, recently available from the *Geo-Environmental Measuring and Monitoring from multiple plAtforms* (GEMMA) Laboratory, represent a valuable approach to improve the Earth surface characterization. Imaging spectroscopy primarily provides quantitative insights about vegetation biochemistry, while LiDAR measurements offer information on vegetation canopy structure. However, drone measurements require dedicated processing workflow to account for the specific measurement set-up, but also novel methods to fully exploit and interpret the data. In this regard, Radiative Transfer (RT) models represent a valid support for linking remotely sensed data to the surface parameters, especially 3D models that well describe complex geometric scenes and could strongly support the interpretation of high-resolution data from drone.

In this context, the research project aims to develop a novel method to detect vegetation parameters and fluorescence from the synergistic exploitation of imaging spectroscopy, LiDAR and thermal data collected in different experiments from drone platforms and by using the state of the art of physical RT models. The main goal is to set up an operational procedure to map spatial and temporal variability of vegetation parameters in selected sites and to make a comparison with satellite retrievals for cal/val activities. This study will be conducted in experimental sites and in the framework of new space missions promoted by the European Space Agency (ESA) and by the Italian Space Agency (ASI).

The activity will include the participation to field surveys at national/international level, the processing of remote sensing and drone data, and development of dedicated retrieval algorithms. Collaborations with abroad universities and research institutes are foreseen during the project.

Supervisor webpage: https://www.unimib.it/sergio-cogliati

University of Milano-Bicocca
PhD Course in Chemical, Geological and Environmental Sciences
Call for Interest 38th cycle - Curriculum Terrestrial and Marine Environmental Sciences

Nr 20		**Supervisor**	**Claudia Pasquero**
Title	**Effects of land cover on extreme precipitations**		

The project builds upon previous studies on the relationship between land surface properties and precipitation. For instance, the observational and modeling investigations performed in the framework of the international AMMA project showed that precipitations in semi-arid regions are affected by soil moisture gradients, favoring precipitations on drier land next to moister surfaces. The importance of surface gradients has also been studied over the oceans, demonstrating that precipitations are favoured over strong sea surface temperature fronts. Current studies are also indicating that extreme precipitations in urban areas have been increasing over the last few decades more than in rural areas. These studies indicate that the reasons at the base of the generally observed increase in occurrence and/or intensity of heavy rainfall events might be both related to global climate change and to local land use change. Discovering under what circumstances one of the two processes dominates is of paramount importance for policymakers and administrators, in order to tackle the problem in the correct way and reduce risks associated to strong meteorological events.

In this project, high resolution precipitation and land surface properties datasets will be analysed to investigate the presence of links between land cover and its gradient with extreme precipitations. Based on the results of this data analysis part, physical hypothesis on the possible mechanisms at play will be formulated, most likely involving surface fluxes, boundary layer dynamics, and stability of the air column. In the second part of the PhD, high resolution numerical modelling tools will be used to test the hypothesis and study the sensitivity to large scale climatic conditions (such as, for instance, sub-tropical vs mid- and high-latitude settings).

The project will be performed in collaboration with the Ecole Normale Superieure in Paris, where the PhD student is expected to spend 12 months. It is foreseen that a joint PhD agreement will be signed by the two Universities, with the possibility of awarding two PhD degrees.

Supervisor webpage: https://www.unimib.it/claudia-pasquero

University of Milano-Bicocca
PhD Course in Chemical, Geological and Environmental Sciences
Call for Interest 38th cycle - Curriculum Terrestrial and Marine Environmental Sciences

Nr 21		**Supervisor**	**Claudia Pasquero**
Title	**The effect of sea surface temperature anomalies on tropical cyclone intensification rate**		

Tropical cyclones undergo periods of rapid intensification whose dynamics are currently not understood and therefore not correctly forecast. Considering the huge demographic, societal, and economic effects of hurricane and typhoons, it is of paramount importance to study those events. Recent work indicates that small scale asymmetries embedded in the cyclonic structure can be important in affecting the intensification rate. Using newly developed diagnostics, such as the boundary layer ventilation metric, this study will investigate the role of small scale sea surface temperature features on the evolution of tropical cyclones.

Considering that typically atmospheric models correctly generate the observed distribution of intensification rates of tropical cyclones (although not at the right time and location), aim of this work is to use such models to investigate the links between small scale dynamics and the evolution of tropical cyclone intensity. To this aim, both CMIP6 and HighResMIP outputs will be analyzed and hypothesis on the relevant processes will be formulated. Convection permitting numerical simulation will then be run in idealized configurations to test the hypothesis.

The project will be performed in collaboration with ISTA (Institute of Science and Technology Austria), where the PhD candidate is expected to spend at least 6 months.

Supervisor webpage: https://www.unimib.it/claudia-pasquero