UNIVERSITY OF L'AQUILA

Department of Health, Life and Environmental Sciences

2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS

Laurea Magistrale in BIOLOGIA AMBIENTALE E GESTIONE DEGLI ECOSISTEMI

Course Catalogue

Academic year starts the last week of September and ends the first week of June.
1st Semester - *Starting date:* last week of September, *end date*: 3rd week of January
2nd Semester - *Starting date:* last week of February, *end date:* 1st week of June
Exams Sessions: I) from last week of January to 3rd week of February, II) from 2nd week of June to end of July, III) from 1st to 3rd week of September

Comprehensive Scheme of the 2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS

Track ENVIRONMENTAL BIOLOGY

YEAR	CODE	COURSE	Credits (ECTS)	Semester
I	F0259	Environmental Chemistry	6	1
	DM225	Environmental Physics and Global Change and Modeling	12	1
	F0324	Geographic Information Systems	6	1
	DM0228	Ecology and Biomonitoring of Inland Waters	9	2
	DM0224	Environmental Law and Economics	6	2
	F0258	Aerobiology	6	2
	DM0149	Experimental analysis of biodiversity	10	2
	F0181	English training course	3	1-2
II	DM0146	Conservation Biogeography	6	1
	F1073	Data Analysis in Experimental Biology	6	1
	DM0226	Evolutionary Genetics	6	1
	F1072	Microorganisms and Ecosystem Functioning	6	1
	F1150	Free choice courses/activities	8	1-2
	F0103	*Experimental Thesis*	30	1-2

Comprehensive Scheme of the 2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS

Track ENVIRONMENT MANAGEMENT AND PROTECTION

I	F0259	Environmental Chemistry	6	1
	F1058	Environmental Physics	6	1
	DM0146	Conservation Biogeography	6	1
	DM0223	Geographic Information Systems and Techniques for Environmental Assessment	12	1
	DM0156	Environmental Botany	9	2
	DM0228	Ecology and Biomonitoring of Inland Waters	9	2
	DM0224	Environmental Law and Economics	6	2
	F0181	English training course	3	1-2
II	DM0227	Soil Bioengineering and Eco-Hydraulics	9	1
	DM0226	Evolutionary Genetics	6	1
	F1046	Hydrogeology and Environmental Risk	6	1
	DM0153	Mycology and Microbial Ecology	10	2
	F1150	*Free choice courses/activities*	9	1-2
	F0103	*Experimental thesis*	23	1-2

Programme of "CHIMICA DELL'AMBIENTE" "*ENVIRONMENTAL CHEMISTRY*"		
F0259, Compulsory **2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS, Track *ENVIRONMENTAL BIOLOGY* and Track *ENVIRONMENT MANAGEMENT AND PROTECTION*, 1st Year, 1st Semester**		
Number of ECTS credits: 6 (workload is 150 hours; 1 credits =25 hours)		
Teacher: Fabrizio RUGGIERI		
1	Course objectives	The aim of the course in environmental chemistry is to give students a thorough understanding of the natural and anthropogenic process that occur on nature. Knowledge of these processes is necessary to understand the balance in ecosystems, and to manage the risks associated with anthropogenic activities.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: General information on toxic organic molecules (pesticides, dioxins, dibenzofurans, polychlorinated biphenyls, polycyclic aromatic hydrocarbons), indices of toxicity, biodegradation of chlorinated pesticides, dioxins and PCBs in the environment. Water cycle, Aquatic systems and carbonate-bicarbonate equilibrium, degradation of silicates and pyrite. Phosphates, dissolved oxygen, pH and pE in environmental systems. Solubility of aluminium and iron in aquatic systems. Construction and interpretation of the pH and pE diagrams. Anaerobic decomposition of organic matter. Potable water, removal of colloids systems, disinfection systems and wastewater treatment. Use of photocatalysts in advanced oxidation systems. Nitrogen compounds and nitrogen cycle. Biogeochemical cycles, colloidal particles and clay minerals. Role of sediments in the processes of adsorption, cation exchange capacity, adsorption isotherms. Heavy metals in the environment (Mercury, Lead, Cadmium, Arsenic, Chromium), natural and anthropogenic sources, speciation of metals in different environmental compartments. Treatment and disposal of municipal waste. Disposal of toxic waste. Techniques for remediation of contaminated soils. On successful completion of this module the student should o have profound knowledge of chemical process in the environment; o have knowledge and understanding of human activity on the environment and related changes; o be able to explain the natural and anthropogenic chemical process in environment; o demonstrate skill in evaluation of environmental problems and ability to explain them; o demonstrate capacity for reading and understanding other texts on related topics; o be able to apply the acquired knowledge to concrete cases as occurring in the professional life; o demonstrate concern on environmental issues; o be able to work in team; o demonstrate capacity to be critical and self-critical.
3	Prerequisites and learning activities	The student must know the basic notions of Inorganic and Organic Chemistry.
4	Teaching methods and language	Lectures. Language: Italian Ref. Text books: -Colin Baird, Michael Cann *"Chimica Ambientale",* Zanichelli Editore, 2013. -Stanley E. Manahan *"Chimica dell'ambiente",* Casa Editrice Piccin, 2000.
5	Assessment methods and criteria	Formative Assessment: the students are invited to discussions on concrete examples and the active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: Oral Examination (100%): the student must provide evidence of the acquired knowledge and skills by proving in half an hour the achievement of the main Learning Outcomes.

Programme of "FISICA DELL'AMBIENTE E MODELLI PREDITTIVI E CAMBIAMENTI CLIMATICI"
"ENVIRONMENTAL PHYSICS AND GLOBAL CHANGE AND MODELING"
This Course is composed of two Modules: 1) Environmental Physics; 2) Predictive Modeling And Climate Change

DM0225, Compulsory
2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS, Track ENVIRONMENTAL BIOLOGY, 1st year, 1st semester

Number of ECTS credits: 12 (workload is 300 hours; 1 credits =25 hours)

1) *F1058 "ENVIRONMENTAL PHYSICS" (6 ECTS)*

Compulsory, Track *ENVIRONMENTAL BIOLOGY* and Track *ENVIRONMENT MANAGEMENT AND PROTECTION*

Teacher: Giovanni PITARI

1	Course objectives	The course is finalized to give the student a comprehensive introduction to short-lived atmospheric pollutants, atmospheric and ocean dynamics and links to the carbon cycle and other global biogeochemical cycles.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: - Short-lived atmospheric pollutants (PM, NOx, O_3) and measurement techniques. - Bio-geo-chemical carbon, sulphur and nitrogen cycles. - Introduction to atmospheric dynamics and thermodynamics. - Ocean-atmosphere coupling. Ekman circulation. - Global thermoaline circulation and climate change impact. On successful completion of this module, the students should: o Acquire knowledge and understanding on atmospheric pollutants and driving mechanisms of their abundance. o Be able to apply knowledge and understanding of atmosphere-ocean dynamics on biological, physical and chemical processes driving the carbon cycle and other global biogeochemical cycles. o Be able to make informed judgments on process driving the climate change and climate feedbacks on atmosphere – ocean coupling. o Be able to communicate the results of their studies in the course with written tests. o Acquire capacities to continue learning in environmental physics o demonstrate capacity for reading and understanding other texts on related topics.
3	Prerequisites and learning activities	The student must follow in parallel the course "Environmental Chemistry".
4	Teaching methods and language	Introductive lectures to atmospheric and ocean dynamics and their coupling. Language: Lectures (or summaries) are given in English upon request of non-native Italian speakers. Ref. Text books: -Jacob D. J.: *Introduction to Atmospheric Chemistry*, Princeton University Press, 1999. -Open University Course Team: *Ocean Circulation*, Butterworth – Heinemann, 2001.
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: continuous written assessments.

2) F1061 "PREDICTIVE MODELING AND CLIMATE CHANGE" (6 ECTS)

Compulsory, Track *ENVIRONMENTAL BIOLOGY*

Teacher: Gianluca REDAELLI

1	Course objectives	The course is finalized to give the student a comprehensive introduction to modeling techniques for atmospheric processes and to the mechanisms of global climate change.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: - Principal approaches to the modeling of atmospheric processes. - Introductions to methods of solving the equations for atmospheric chemistry - Chemistry of stratospheric and tropospheric Ozone and its interaction with climate. - The Climate System and its components. - Mechanisms of global climate change - Energy balance models On successful completion of this module, the student should: o Have good knowledge of processes driving the climate changes and of the techniques

		used for their numerical modelling o Understand and explain the role of chemistry and energy balances in the global climate changes o Demonstrate capacity for estimating the role of different processes driving the climate change. o Demonstrate capacity for reading and understanding other texts on related topics.
3	Prerequisites and learning activities	The student should follow in parallel the course "Environmental Physics".
4	Teaching methods and language	Lectures on the topics of the course. Use of simple atmospheric computer models. Lectures (or summaries) are given in English upon request of non-native Italian speakers. Ref. Text books: - Jacobson M. Z., *Fundamentals of Atmospheric Modelling*, Cambridge University Press, 1999 - Jacob D. J.*: Introduction to Atmospheric Chemistry,* Princeton University Press, 1999 - AA. VV., *IPCC Third Assessment Report - Climate Change 2001*.
5	Assessment methods and criteria	Formative Assessment: The students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: Formal Oral Examination (100%). Oral exam: the student must provide evidence of the acquired knowledge and skills by proving in half an hour the achievement of the main Learning Outcomes.

Programme of "SISTEMI INFORMATIVI TERRITORIALI E TECNICHE DI VALUTAZIONE AMBIENTALE"

"GEOGRAPHIC INFORMATION SYSTEMS AND TECHNIQUES FOR ENVIRONMENTAL ASSESSMENT"

This Course is composed of two Modules: 1) Geographic Information Systems; 2) Techniques for Environmental Assessment

DM0223, Compulsory
2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS, 1st year, 1st semester

1) F0324 "GEOGRAPHIC INFORMATION SYSTEMS" (6 ECTS)

Compulsory, Track *ENVIRONMENTAL BIOLOGY* and Track *ENVIRONMENT MANAGEMENT AND PROTECTION*

Teacher: Francesco ZULLO

1	Course objectives	The goal of this course is to introduce the students into the complex world of Geographic Information System by the acquisition of basics concepts GIS essential for the environmental analysis and diagnosis.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: - Characteristic and potentiality of Geographic Information System. - Description and correct use of geographical information. - Characterization of main reference systems and geographic projections and those used in Italy (World Geodetic System 1984, European Datum 1950, Roma 40, European Terrestrial Reference System; Gauss-Boaga, Universal Transversal Mercatore). - Type of GIS data: Vector, Raster, tables and 3D model . - GIS tools for environmental analysis (open source): QGis, Entry level program: primary data visualization and creation, georeferencing, database implementation, layout and maps, some geoprocessing techniques (clip, overlay, summarize) for environmental indices implementation. On successful completion of this module the student should: o have profound knowledge about Geographic Information System and GIS techniques; o have knowledge and understanding how to apply the methodologies learnt for territorial analysis; o be able to explain the relevant techniques for Geographic environmental data capture using appropriate scientific and technical language; o demonstrate skills in GIS methodologies and ability to use them to environmental management; o demonstrate capacity for reading and understand other texts on related topics; o be able to apply the acquired knowledge to concrete cases as occurring in the professional life;

		o demonstrate concern to GIS land analysis and management; o be able to work in team showing commitment to tasks and responsibilities; o demonstrate capacity to be critical and self-critical.
3	Prerequisites and learning activities	Basic knowledge on geography and mapping concept.
4	Teaching methods and language	Lectures, team work, exercises, PC laboratory Language: Italian Ref. Text books: -Romano B., 2014. *Pianificazione sostenibile del territorio*. Verdone ed. -Zullo F., 2016. *Sistemi Informativi Territoriali per la diagnosi ambientale e la pianificazione territoriale*. Cogecstre edizioni. In press
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: formal written examination (60%) and oral examination (40%) Written exam: 1 hour and an half. GIS test on the geographic database implementation, layout and maps. Oral exam: The student must provide evidence of the acquired knowledge and skills by proving in twenty minutes the achievement of the main learning outcomes.
2) F1180 "TECHNIQUES FOR ENVIRONMENTAL ASSESSMENT" (6 ECTS)		
Compulsory, Track *ENVIRONMENT MANAGEMENT AND PROTECTION*		
Teacher: Bruno CICOLANI		
1	Course objectives	The module is addressed to provide the basic knowledge to the students of the main information related to the Environmental Impact Assessment. Among all, the cornerstone of the course is represented by all the analyses needed for decision-making on the environmental consequences of proposed actions; and for promoting environmentally sound and sustainable development through the identification of appropriate enhancement and mitigation measures.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: The aims and objectives of the module can be divided into two categories. The immediate aim of the module is to offer to the students the information inhering the process of decision-making by identifying the potentially significant environmental effects and risks of development proposals. The latter (long term) scope is to promote sustainable development securing ecological functions or the well-being, lifestyle and livelihood of the communities and peoples who depend on them. The course is articulated as follow: - Background knowledge and national and EU-rules and Italian legislation on the matter. - How to measure the Environmental Impact Assessment (EIA) - Public Involvement - EIA reporting: how to write an EIA report – case study - Strategic Environmental Assessment and Processes Involved- case studies On successful completion of this module the student should: o Have deep understanding of the EIA principles. o Have knowledge about the motivation and background for performing environmental impact assessments. o Demonstrate ability and skills in relation to the framework and procedures of environmental impact assessment with specific regard to its basic principles, definitions, procedures and applied methods. o Get basic knowledge and skills to practice a number of selected methods used in Environmental impact assessments.
3	Prerequisites and learning activities	Basic knowledge of Environmental Law and Economics, good knowledge of biodiversity and ecosystem functioning, for both terrestrial and freshwater environments.
4	Teaching methods and language	Lectures. Field experiences. Language: Italian Ref. Text books: -Massimo Aleo, *VALUTAZIONI AMBIENTALI: Le procedure di VAS, VIA , AIA nel governo del territorio,* 2.ed.2012, GRAFIL S.r.l. Palermo -Andrea Martelli, *Valutazione di Impatto Ambientale*, Esselibri S.p.A, 2003, Napoli
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: oral examination (100%)

		Oral exam: The student must provide evidence of the acquired knowledge and skills by proving in 30 minutes the achievement of the main learning outcomes.

Programme of "ANALISI SPERIMENTALE DELLA BIODIVERSITA"
"EXPERIMENTAL ANALYSIS OF BIODIVERSITY"

This Course is composed of two Modules: 1) Statistical Approach to Biodiversity Measurement, 2) Experimental Assessment of Biodiversity Patterns

DM0149, Compulsory
2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND ECOSYSTEMS MANAGEMENT, 1st year, 2nd semester

Number of ECTS credits: 10 (workload is 250 hours; 1 credits =25 hours)

1) DM150 "STATISTICAL APPROACH TO BIODIVERSITY MEASUREMENT" (5 ECTS)

Compulsory, Track *ENVIRONMENTAL BIOLOGY*

Teacher: Barbara FIASCA

1	Course objectives	The course is focused to provide an overview of the main tools for quantitative and qualitative assessment of biodiversity, and experimental/monitoring design strategies. Biodiversity statistics methods will be illustrated and deepened. Exercises and computation will help students to critically apply the methods and the techniques presented. Knowledge of these topics will improve students ability on biodiversity assessment and environmental monitoring concerns.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: Quantitative and qualitative methods for assessing biodiversity. Basic principles of sampling. Sampling design strategies. General field techniques. Biodiversity statistics, including rarefaction and accumulation analyses, estimators of species richness, diversity indices, and similarity measures. Computation will help the students to critically apply methods and techniques presented. For the successful completion of this module the student must reach the following results: o have deep understanding of the principles of sampling. o have knowledge of different sampling methods and techniques. o demonstrate skills to critically choose the most suitable methods and techniques to a case study. o demonstrate ability to manage data set. o demonstrate ability to perform statistical analyses and calculate simple and multimetric indices. o get ability in setting up robust experimental/monitoring strategy.
3	Prerequisites and learning activities	Basic knowledge of animal and plant biology and ecology. Principles of biological diversity, descriptive statistics.
4	Teaching methods and language	Lectures and laboratory activities Ref. Text books: -Power point presentations given during classes. -Magurran A.E. & B.J. McGill (2011) *Biological Diversity. Frontiers in Measurement and Assessment*. Oxford University press. -Elzinga C.L., Salzer D.W., Willoughby J.W. Gibbs J.P. (2001) *Monitoring Plant and Animal Population*. Blackwell Science -Hayek L-A.C., Buzas M.A. (2010) *Surveying Natural Population*. Columbia University Press
5	Assessment methods and criteria	Formative Assessment: the students are invited to participate to discussions on concrete examples eventually based on their own experience or dataset. Summative Assessment: Oral exam: the student must provide evidence of the acquired knowledge and skills by proving in half an hour the achievement of the main Learning Outcomes.

2) DM151 "EXPERIMENTAL ASSESSMENT OF BIODIVERSITY PATTERNS" (6 ECTS)

Compulsory, Track *ENVIRONMENTAL BIOLOGY*

Teacher: Diana Maria Paola GALASSI

1	Course objectives	The course have the following main objectives: - To introduce the students to the practical concerns of species distribution across different habitat types; - To select the most appropriate monitoring procedures by analyzing all the ones used and known; - To acquire skills in "reading" the environment under different spatial scales, from the landscape scale to the microhabitat scale; - To put the knowledge acquired into practice by coupling sampling procedures and species identification and counting in a policy context (e.g. Directive 60/2000/CE; Directive 118/2006/EC, Habitat Directive, etc.

		- To translate operational activities on the field and in the laboratory in an environmental impact assessment scoring, by integrating the biodiversity response to the presence of hazard centers, farming, wastewater and industry discharges, urbanization, man-induced habitat alterations. - To make students aware of the step by step - protocol procedures required to be confident with inherent professional and scientific activities.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: - Measuring biological diversity, general framework. Setting the objectives. Freshwater invertebrate biodiversity: legislation at EU and national levels. - Sampling methodology: putting theory into practice. Key-stone structure concept in assessing habitat heterogeneity. Field activity (selected environments: hyporheic zone, epibenthic layers of streambed sediments, springwaters, caves). - Biodiversity assessment by species or species-group taxonomic identifications. - Selection of appropriate sampling devices. Laboratorial activity: sorting, storing, counting and identification of sampled species. The spatial and temporal scales of biodiversity measurements. The ecological and the historical scales and their role in shaping species richness and diversity. - The taxonomic diversity and implications in biomonitoring. - Biodiversity sampling on the field with different sampling devices and under different pressures and impacts. - Practice in sorting, counting, analyzing invertebrate fauna - Capacity building to write a technical report in English and in Italian, following an articulation in aim of the work, how the work must be correctly performed. For the successful completion of this module the student must reach the following results: o high level knowledge and understanding of the biodiversity sampling protocols and species identification with special emphasis to invertebrates o ability to apply knowledge and understanding following a *practical agenda* in order to efficiently translate theory into practice in biodiversity assessment for the evaluation of the environmental quality and for biodiversity conservation issues. o high-level skills in biodiversity monitoring and assessments in order to develop a self-critical choice of the best procedure to be adopted in environmental situations also different from the ones analyzed in the study cases during the course. o capacity to extrapolate and apply what is learned to concrete cases, being able to defend their position. o development of critical view in determining the causes of variance in performance of the different methodologies analyzed and then adopted for biodiversity assessment, o development of communication skills in both oral and written reports, including a good scientific English understanding.
3	Prerequisites and learning activities	General knowledge of systematic zoology, botany, fundamental ecology, descriptive statistics, English language (intermediate/high level)
4	Teaching methods and language	Lectures and field and laboratory activities. Language: Italian or English Ref. Text books: -Scientific papers and EEA reports. -Elzinga et al., *Monitoring plants and animal populations*. Blackwell Science, 2001. -*Guide C.N.R. monografiche al riconoscimento della fauna acquatica a invertebrati*. -Gibert J. et al., *Groundwater Ecology*, Academic Press, 1994.
5	Assessment methods and criteria	Formative assessment: the students are directly involved during classes, their participation is supported also by short Q&A sessions. Summative assessment: Evaluation of a written report with summary in English language, which must have the typical structure of a scientific paper accompanied by a Power Point oral presentation (presentation no longer than 30 minutes).

Programme of "AEROBIOLOGIA" ***"AEROBIOLOGY"***
F0258, Compulsory **2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND ECOSYSTEMS MANAGEMENT, track *ENVIRONMENTAL BIOLOGY*, 1st year, 2nd semester**
Number of credits: ECTS 6 (workload is 150 hours; 1 credit = 25 hours)

Teacher: Loretta Giuseppina PACE		
1	Course objectives	The goal of this course is to provide the students with scientific bases of the Aerobiology and skills for the application of a correct methodology in monitoring of pollen and spores. On successful completion of this module, the student is expected to have knowledge of aerodynamics, influence of environment on pollen and spore dispersals, modeling dispersal of aeroallergens, determination of pollen and fungal spore amount in the air, indoor and outdoor air quality, epidemics and pandemics of airborne diseases, use of epidemiological investigations in disease control. Special emphasis will be give to practical sessions covering aspects like operation of volumetric traps and sampling processing, pollen and fungal spore identification by optical microscopy or laboratory management of protocols.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: - Aerodynamics and dispersal of airborne particles (pollen, fungal spores). - Sampling technologies of bioaerosol and aeroallergens. - Pollen biology, structure, function, morphology. - Fungal spores: production and release. - Microscopic techniques in aerobiology. - Statistical techniques applied to aerobiology. - Plant taxonomy and identification. - The European Pollen Information system and the European Allergen Network. - Analysis of the relationship between pollen in the atmosphere and the occurrence of respiratory disease including allergic responses, hay fever and asthma. - Analysis of the potential shifts occurring in flowering seasons of major pollen (and allergy) producing plants with respect to current and future climate change. On successful completion of this module the student should o have profound knowledge of aerobiological studies; o be able to explain the relevant aerobiological monitoring techniques using appropriate scientific language; o demonstrate capacity for reading and understand scientific texts on related topics; o be able to apply the acquired knowledge to concrete cases as occurring in the professional life; o be able to investigate the relationship between pollen in the atmosphere and the occurrence of respiratory disease including allergic responses, hay fever and asthma; o be able to investigate the potential shifts occurring in flowering seasons of major pollen (and allergy) producing plants with respect to current and future climate change; o be able to interact with others in a constructive manner, even when dealing with difficult issues; o demonstrate capacity to be critical and self-critical.
3	Prerequisites and learning activities	The student must know the basic notion on the reproduction of plants and pollen formation.
4	Teaching methods and language	Lectures. Language: Italian Ref. Text books: -Feliziani V., *Pollini di interesse allergologico, guida al loro riconoscimento*, Masson Italia, 1986. -Riccardo Bottelli et al., *I Pollini e la Pollinosi*, Piccin Editore-Padova, 1982. Paolo Mandrioli, Paul Comtois, Vincenzo Levizzani, *Methods in Aerobiology*, Pitagora Editrice Bologna,1998 Christopher S. Cox, Christopher M. Wathes, *Bioaerosols Handbook*, CRC , 1995.
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: Oral exam: the student must provide evidence of the acquired knowledge and skills by proving in half an hour the achievement of the main Learning Outcomes and recognition of pollens by optical microscope.

Programme of "ECOLOGIA E BIOMONITORAGGIO DELLE ACQUE INTERNE"
"ECOLOGY AND BIOMONITORING OF INLAND WATERS"

DM0228, Compulsory **2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS, Track *ENVIRONMENTAL BIOLOGY* and Track *ENVIRONMENT MANAGEMENT AND PROTECTION*, 1st Year, 2nd Semester**		
Number of ECTS credits: 9 (workload is 225 hours; 1 credit = 25 hours)		
Teacher: Antonio DI SABATINO		
1	Course objectives	The Module is mainly focused on providing the students with knowledge and capacities i) to examine the relationships between freshwater organisms and their environment, ii) to analyze the physical, chemical, and biological factors that govern inland waters such as lakes, streams, and springs, and iii) to highlight interactions between human needs and water resources and discuss these challenges and opportunities in conservation and management. Applications of specific concepts will be illustrated and discussed in a series of case studies. Lab exercises and field trips will help the students to apply ecological concepts to aquatic systems and to understand the impacts of human activities on freshwater ecosystems. Special emphasis will be given to the analysis and applications of new methods and standard procedures in freshwater biomonitoring program, following the implementation of the 2000/60 EC Directive.
	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: Running waters, lakes, springs, abiotic parameters, freshwater biota, biotic interactions, energy inputs and flows, natural and human disturbance, human alterations of freshwater resources, global changes, ecosystem services, case studies, experimental design and data analysis, biomonitoring. Biological Quality Elements BQE (Macroinvertebrates, Diatoms, Fish, Macrophytes), reference sites and reference conditions, EQR (Ecological Quality Ratio), multimetric indices, ecological status, chemical status. At the completion of the course, students should: o have a profound knowledge of the physical, chemical, and biological characteristics of inland waters, o understand how human activities affect aquatic ecosystems and explain how these changes affect society, o be able to analyze temporal and spatial changes that occur in aquatic environments, o be able to make a hypothesis, design simple experiments, analyze data and interpret results, o demonstrate skill in freshwater biomonitoring and ability to apply methods and indices, o have capacity for reading and understanding other texts on related issues, o demonstrate concern to ecosystem services, natural capital and sustainable development.
3	Prerequisites and learning activities	The student must know the basic principles of General Ecology and Data Analysis
4	Teaching methods and language	Lectures, Lab. work and exercises, field trips Language: Italian, PPT slides mostly in English Text books: -J. D. Allan & Maria M. Castillo, *Stream Ecology, Structure and function of running waters*, 2nd edition. Springer, 2007. -R. G. Wetzel, *Limnology,* Third edition, Academic Press, 2001. -Bettinetti, Crosa, Galassi, *Ecologia delle Acque Interne*, Città-Studi Ed., 2007. -Fenoglio, S. Bo,T., *Lineamenti di Ecologia Fluviale*, Città-Studi Ed., 2009.
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: formal oral examination (100%) Oral exam: the student must provide evidence of the acquired knowledge and skills by proving in an hour the achievement of the main Learning Outcomes.

Programme of "DIRITTO ED ECONOMIA PER L'AMBIENTE" ***"ENVIRONMENTAL LAW AND ECONOMICS"***
DM0224, Compulsory **2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS, Track *ENVIRONMENTAL***

***BIOLOGY* and Track *ENVIRONMENT MANAGEMENT AND PROTECTION*, 1st year, 2nd Semester**		
Number of ECTS credits: 6 (workload is 150 hours; 1 credit = 25 hours)		
Teacher: Mario TOCCI		
1	Course objectives	The course aims to provide the students with theoretical knowledge about the main discipline regarding the environment protection
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: Sources of environmental law - The contribution to the development of the case law of environmental law - Administrative functions in environmental matters - The organization of the Ministry for the Environment, Land and Sea - The protection of soil and landscape; the landscape asset - The economic management of the sites of environmental interest - The system of waste - Air protection - Water protection - Electromagnetic pollution - Environmental certification - The environmental impact assessment (legal aspects) - Environmental damage - Nods to the energy system At the completion of the course, students should: o demonstrate skill in environmental law and ability to apply the rules to practical study-cases, o have capacity for reading and understanding other texts on related issues. o have a good knowledge the main rules defining the law frame under which the student can develop projects related to environmental monitoring and management plans (practical agenda) o understand how to use and interpret the environmental law setting under both European and Italian scales o be able to analyze the environment under a law perspective o have capacity for reading and understanding other texts on related issues.
3	Prerequisites and learning activities	None.
4	Teaching methods and language	Lectures. Language: Italian Text books: -*"Diritto dell'ambiente"'* a cura di G. Rossi, Giappichelli 2015 (limitatamente agli argomenti del programma) Testo consigliato per la parte speciale: -G. Delle Cave, *"Le politiche pubbliche ambientali"*, Aracne 2015
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: formal written exam (100%) Written exam: 1-hour Multiple choice test on the main topics of course and resolution of a short case study.

Programme of "ANALISI DEI DATI SPERIMENTALI IN BIOLOGIA" ***"DATA ANALYSIS IN EXPERIMENTAL BIOLOGY"***		
F1073, Compulsory **2nd Cycle in ENVIRONMENTAL BIOLOGY AND ECOSYSTEMS MANAGEMENT, Track *ENVIRONMENTAL BIOLOGY*, 2nd year, 1st semester**		
Number of ECTS credits: 6 (workload is 150 hours; 1 credit = 25 hours)		
Teacher: Simone FATTORINI		
1	Course objectives	This course provides a thorough introduction to the key statistical principles and methods used by ecologists and field biologists. It will help students to understand ecological literature, to improve their ability to display ecological data, and to use descriptive and inferential statistics to analyse the results

		from field surveys. The course introduces students to the use of the following software: Excel, PAST and R. R is a free software environment for statistical computing, and can run on a wide variety of backgrounds; PAST is a free software that offers an easy to follow way of exploring a variety of statistical methods, with emphasis on multivariate analyses.
2	Course content and Learning outcomes (Dublin descriptors)	The topics covered in the course in Statistical Ecology include: - The use of statistics: What is statistics and why is it needed; Planning surveys, experiments and collecting data; Sampling animal and plant populations; Estimating population size; Models of spatial distributions; Models of population dynamics and species-interactions (predator–prey equations, host-parasite networks, competition). Models in community ecology with PAST. Niche models. - Descriptive statistics: Types of data; Types of distributions; Finding the average (mean, median, mode); Standard deviation, variance and standard error; Degrees of freedom and coefficient of variation; Calculating descriptive statistics and probability distributions with Excel and R. Processing and presenting data: Displaying whole data sets; Displaying summarised data; Presenting data with Excel, PAST and R. The normal distribution. Data transformations. - Hypothesis testing, confidence intervals and comparisons of two sample means; Testing for equal variances; Parametric vs. non-parametric tests; Paired vs. non-paired tests; Comparing means with equal or unequal variance; t-tests. - Analysing frequencies: Chi-square test, goodness of fit and contingency tables; G-test; Using Excel and R for each. - Finding correlation: Correlation, covariance and the correlation coefficient; Pearson product moment correlation coefficient; Coefficient of determination; Using R for each. Regression analysis: Simple linear regression; Residuals, confidence intervals, transformation of axes; Using Excel and R for each. Introduction to nonlinear regressions and multiple regressions. - Introducing analysis of variance: One-way and two-way ANOVAs; Post-hoc tests; Vraious type sof ANOVA designs; Using R and PAST to analyse variances. Introduction to ANCOVAs and nested ANOVAs. - Non-parametric statistics: Mann-Witney U-test; Wilcoxon test; Kruskall-Wallis test; Spearman rank correlation coefficient; Non-parametric statistics with and R. - Introduction to multivariate statistics. Using PAST for multivariate analyses such as PCA, Cluster Analysis, Multidimensional Scaling, Discriminant Analysis. On successful completion of this module, the student should: o have a practical knowledge of the principal statistical analysis techniques; o have knowledge and understanding of R for practical purposes; o understand and explain statistical terminology and R language; o demonstrate skill to extract meaningful information from data set.
3	Prerequisites and learning activities	Though there are no formal prerequisites for the course, students should have a good background in mathematics.
4	Teaching methods and language	Lectures, computer demonstrations. Language: Italian. Lectures are given in English upon request of non-native Italian speakers. Ref. Text books: -J. Fowler, L. Cohen. *Statistica per ornitologi e naturalisti.* Franco Muzzio ed. -H. Van Emden. *Statistics for terrified biologists*. Blackwell -Power point presentations given during classes.
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: Formal Oral Examination (100%). Oral exam: The student must provide evidence of the acquired knowledge and skills by proving in half an hour the achievement of the main learning outcomes. On voluntary basis, students may also prepare a Power Point presentation or a short essay on a specific issue that will be object of a discussion during the oral exam.

Programme of "BIOGEOGRAFIA DELLA CONSERVAZIONE"

"CONSERVATION BIOGEOGRAPHY"

DM0146, Compulsory
2nd Cycle in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS,
Track *ENVIRONMENTAL BIOLOGY*: 2nd year, 1st semester;
Track *ENVIRONMENT MANAGEMENT AND PROTECTION*: 1st year, 1st semester

Number of ECTS credits: 6 (workload is 150 hours; 1 credit = 25 hours)		
Teacher: Maurizio BIONDI		
1	Course objectives	1. To inspire and encourage an interest in conservation biogeography and statistical analysis of environmental data . 2. To acquaint students with the modern methods of conservation biology. 3. To make students aware of the various disciplines encompassed by the field of zoology, botany, biogeography and ecology and to encourage them to pursue those areas that interest them through further reading and coursework. 4. To encourage the development of a interdisciplinary approach to promote better study and test-taking skills necessary for this course.
	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: Methods and aims of the biogeographical approach. Biogeography in the modern evolutionary biology and the environmental conservation. Geographical distribution in time and in space. Ecological and dynamic zoogeography. Mac Arthur and Wilson equilibrium theory of island biogeography. How continental drift and glaciations affected the geographical distribution in animals. Refugial areas and areas of endemism. Zoogeographical regions. Statistical methods in Biogeography. Zoogeography and animal conservation. Hot-spots and cold-spots. Flag, key and umbrella species. Problem of the alien species. Vertebrates as useful tool for environmental conservation. Italian fauna: origin, distribution and peculiarities. Basic concepts of the biometrical analysis. Data-bases and tools of analysis. Statistical approach to environmental quality assessment. Statistics and taxonomy. On successful completion of this module the student will be able: o To understand the importance of the biodiversity and its conservation. o To study comparative structure and function of the different organ systems and their physiological importance in relation to habits and habitat of the organism, with special regard to the reproductive strategies. o To have advanced knowledge on different aspects of biogeography such as ecological and historical biogeography, multivariate statistical methods applied to biological conservation, endemism and areas of endemism. o To have adequate knowledge for pursuing advance studies in various fields of conservation biology by research.
3	Prerequisites and learning activities	The student must have basic notion of animal and plant biology, ecology and statistics
4	Teaching methods and language	Lectures. Language: Italian or English Ref. Text books: -Ladle R. J. & Whittaker R. J. 2011 - *Conservation Biogeography* - Wiley-Blackwell. -Pough F.H., Janis C.M., Heiser J.B.2011 - *Zoologia Dei Vertebrati* - Casa Editrice Ambrosiana. -Primack R.B. & Boitani L. 2013 – *Biologia della Conservazione* – Zanichelli.
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: Formal Oral Examination (100%) Oral exam: Half an hour discussion on the main topics of the course and presentation of a depth report on an argument chosen by the student.

Programme of "GENETICA EVOLUTIVA" *"EVOLUTIONARY GENETICS"*		
DM0226, Compulsory **2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS, Track *ENVIRONMENTAL BIOLOGY* and Track *ENVIRONMENT MANAGEMENT AND PROTECTION*, 2nd year, 1st semester**		
Number of ECTS credits: 6 (workload is 150 hours; 1 credit=25 hours)		
Teacher: Anna M.G. POMA		
1	Course objectives	The goal of this course is to provide the students with the basis of the genetic aspects of biological evolution and address the main fields of study of modern evolutionary genetics
2	Course content and	Topics of the module include:

	Learning outcomes (Dublin descriptors)	- Elements of General Genetics (the pattern of inheritance, inheritance of single genes; Mendel; the gene interaction; the basic principles of chromosomes mapping; the nature of DNA and its replication; gene and chromosomal mutations). - Genetic variation and its modulation. - Genetic structure of populations. Phenotypic, genotypic, allelic frequencies. The Hardy-Weinberg equilibrium. The heterozygosis. - The forces of evolution, mutation, migration, selection, genetic drift. Analysis of mitochondrial DNA and the study of inter-individual variation. - Evolution of genes and characters. Mechanisms of genome evolution. Centromeres, neocentromeres and evolution. - Practical exercises will be done by the students as laboratory experience (ancient-DNA extraction). On successful completion of this module the student should o have knowledge of human and comparative evolutionary genetics, o have knowledge and understanding of the fundaments of the genes and genomes and their evolution, o be able to explain the fundaments of heredity and evolutionary genetics, o demonstrate skill in finding connections and ability to perform genetic analysis and quantitative genetics applied to evolutionary biology, o -demonstrate capacity in explaining the most significant scientific experiments that deal with the genetic basis of evolution, o be able to apply the acquired knowledge to concrete cases as occurring in the professional life, o demonstrate concern for health, well-being, safety and environment, o be able to work in team showing commitment to tasks and responsibilities, o demonstrate capacity for reading and understanding other texts on related topics. o demonstrate capacity to be critical and self-critical.
3	Prerequisites and learning activities	The student must know the basic notion of Cell Biology, Plant Biology, Zoology and Biochemistry
4	Teaching methods and language	Lectures Language: Italian; laboratory experience (ancient-DNA extraction), available to be done in English. Ref. Text books: -Griffiths A.J.F. et al., *Genetica: principi di analisi formale*, 7^ ed., Zanichelli, 2013. -Russell P. J., *I-Genetica,* Edit. EdiSES, 2007. -Hartwell L.H., *Genetica: dall'analisi formale alla genomica*, McGrawHill, 2004. -D.J. Futuyma, *L'evoluzione,* Zanichelli, 2008.
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: Formal Oral Examination (100%) Oral exam: the student must provide evidence of the acquired knowledge and skills by proving in half an hour the achievement of the main Evolutionary Genetics Learning Outcomes.

Programme of "MICROORGANISMI E FUNZIONAMENTO DEGLI ECOSISTEMI" ***"MICROORGANISMS AND ECOSYSTEM FUNCTIONING"***		
F1072, Compulsory **2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS, Track ENVIRONMENTAL BIOLOGY , 2nd year, 1st semester**		
Number of ECTS credits: 6 (total workload is 150 hours; 1 credit = 25 hours)		
Teacher: Maddalena DEL GALLO		
1	Course objectives	The course gives advanced knowledge of the role of microorganisms in the different Earth ecosystems and of their use in environmental pollution and environmental recovery. Aim of the course is giving to the students an advanced knowledge on microbiology and to provide them with the basis for understanding the role of microorganisms in the functioning of the ecosystems. At the end of the course the student should be able to analyze the role of microorganisms in a given environment and must be able to design a utilization of microorganisms in the recovery of

		a degraded ecosystem.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: - Introduction to genetics and, in particular, methods of molecular biology applied to the study of different environments. - The biogeochemical cycles and the role played by microorganisms in them: Carbon cycle, with particular emphasis on the role of humus as tank and CO_2 capture. Nitrogen cycle, with particular emphasis on biological nitrogen fixation and its potential applications in agriculture. Sulfur cycle, Phosphorus cycle, minor cycles: the role of microorganisms in the recycling of matter. - Microorganisms in water, soil and air; Gaia Hypothesis and implications for future policy development; the role and use of microorganisms in agriculture: environmentally friendly and with less impact agriculture. - Role of microorganisms in the bioremediation of pollution caused by man and his presence. - Cycling of matter in special environments such as caves, oceanic hydrothermal vents, etc. - Analysis of some specific environments. For the successful completion of this module the student must reach the following results: o high-level knowledge and understanding of the structure and function of different ecosystems; o capacity to extrapolate and apply what is learned to concrete cases as occurring in professional or in research activity; o capacity to make informed judgments and ability to defend their position; o development of communication skills in both oral and written reports, including a very good scientific English understanding.
3	Prerequisites and learning activities	Good knowledge of general microbiology, elements of genetics and molecular biology.
4	Teaching methods and language	Lectures. Language: Italian (or English, if required) Ref. Text books: P. Barbieri, G. Bestetti, E. Galli, D. Zannoni, *Microbiologia ambientale ed elementi di ecologia microbica*, ed. CEA, 2008. -Biavati B., Sorlini C., *Microbiologia Agroambientale*, CEA, 2008. -Atlas R.M. and Bartha R., *Microbial Ecology*, Benjamin Cummings ed., 1997., -Lecture notes. Power point presentations given by the lecturer.
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment; students are asked for a written report and oral examination (30 minutes).

Programme of "BOTANICA AMBIENTALE" ***"ENVIRONMENTAL BOTANY"***		
DM0156, Compulsory **2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS,** **Track *ENVIRONMENT MANAGEMENT AND PROTECTION*, 1st year, 2nd semester**		
Number of ECTS credits: 9 (workload is 225 hours; 1 credits =25 hours)		
Teachers: Annarita FRATTAROLI – Giovanni PACIONI		
1	Course objectives	The goal of this course is to provide the students with scientific bases of the integrated analysis of the plant biodiversity from the level of populations to the landscape and their applications to territory management.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: - Plant biodiversity of the Earth, Europe, and Italy; - Study of the flora. The species wealth of the territory. The distribution areas: typologies, their description and dynamics. Endemism, relicts, vicariance; - Chorotypes. Autocthonous and exotic species; invasive species. The chorotypes as

		environmental indicators; - Floristic divisions of the Earth. Floristic kingdoms. Floristic regions of the Holarctik kingdom; - History of the flora. The Tertiary. The glaciation and post-glaciation. Origins and evolution of the Italian flora. Particularities of the central Apennine flora; - The vegetation. Concepts and methods of study. Historic outline. Techniques of sampling and analysis of data in the study of the vegetation; - The phytosociological method. The plant associations. Phytosociological relevés. Structural studies. Data analysis. Phytosociological tables. The characteristic, differential and associated species. Classification and ordering of the vegetation. Syntaxonomy. Integrated phytosociology. Syndynamics. Serial and chain contacts. Vegetation series. - The territorial hierarchical classification. Problems of scale. Landscape units; - Zones and belts of vegetation. Present and potential vegetation. The vegetation zones and belts in Italy, in Europe, and in the world.; - Thematic cartography. Geobotanical maps: floristic, phytogeographical and vegetational maps. Geographical information system (GIS) methodologies in geobotanical cartography; - Role of fungi in the environment; - Fungal biodiversity monitoring; - Use of lichens in environmental monitoring. On successful completion of this module the student should: o have profound knowledge of how to apply the methodologies learnt for the study of the floristic and vegetational diversity. o have knowledge and understanding of how to judge the environment and understand the physiology of the plant landscape systems of the territory. o be able to explain the relevant techniques for integrated analysis of the plant biodiversity from the level of populations to the landscape using appropriate scientific language; o demonstrate skill in analytical evaluation and ability to perform the phytosociological method and GIS methodologies and their applications to territory management o demonstrate capacity for reading and understand other texts on related topics. o be able to apply the acquired knowledge to concrete cases as occurring in the professional life; o demonstrate concern to plant biodiversity, plant ecology and management; o be able to work in team showing commitment to tasks and responsibilities o - demonstrate capacity to be critical and self-critical.
3	Prerequisites and learning activities	The student must know the basic notions of Plant Biology and Ecology.
4	Teaching methods and language	Lectures. Language: Italian Ref. Text books -Davide Ubaldi, *Flora, fitocenosi e ambiente*. CLUEB, Bologna. -Sandro Pignatti, *Ecologia del Paesaggio*. UTET, Torino. -Franco Pedrotti, *Cartografia geobotanica*. Pitagora Editrice Bologna. -Handouts and articles distributed in the lectures.
5	Assessment methods and criteria	Formative assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative assessment: oral exam (100%) (45 minutes).

Programme of "INGEGNERIA NATURALISTICA ED ECOIDRAULICA" ***"SOIL BIOENGINEERING AND ECO-HYDRAULICS"***
DM0227, Compulsory **2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS, Track ENVIRONMENT MANAGEMENT AND PROTECTION, 2nd year, 1st semester**
Number of ECTS credits: 6 (total workload is 150 hours; 1 credit = 25 hours)
Teacher: Lino RUGGIERI

1	Course objectives	The course is mainly focused : i) to use of soil bioengineering techniques for riparian restoration and for fish passage systems ìi) to examine the relationships between hydromorphological and ecological aspects of river ecosystems; iii) to have knowledge and understanding of the evolution of legislation at EU and national levels about the field of water policy (Directive 2000/60/CE; Directive 2007/60/CE; Directive 92/43/CE; D.Lgs 152/2006; D.Lgs 49/2010; DPR 120/203) iv) to plan subsurface and surface flow phytodepuration systems Applications of specific concepts will be illustrated and discussed in a series of case studies. Field trips will help the students to apply eco-hydraulic concepts.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: - Global changes and soil erosion control; - Ecological and agriculture resilience; - Rooting ability of vegetative components; - Characteristics, principles, design, and construction techniques of soil bioengineering; - Fish passage systems; - Wastewater treatment: active sludge and wetland process; minimum flow and ecological flow. At the completion of the course, the student should: o have a profound knowledge of the relationships between the ecological and hydromorphological aspects of river ecosystems; o be able to plan multiple benefits environmental systems o demonstrate skill in freshwater monitoring and ability to apply methods and indices (IFF, IQM, ISECI); o have capacity for develop a holistic approach to river ecosystem; o acquire high-level skills in value the use of different soil bioengineering techniques, in different types of contexts; o demonstrate capacity to have a critical and self-critical view o be able to work in team.
3	Prerequisites and learning activities	The student must know the basic knowledge on Freshwater Ecology and Geomorphology and of Plant Biology and Ecology
4	Teaching methods and language	Lectures and field Language: Italian Power point presentations given during classes Text books: -Cornelini P.;Sauli G. (2015), *Compendio di Ingegneria Naturalistica,* Lazio 228pp. -Rinaldi M., Surian N., Comiti F., Bussettini M. *(2014)*: *IDRAIM – Sistema di valutazione idromorfologica, analisi e monitoraggio dei corsi d'acqua – ISPRA – Manuali e Linee Guida* 113/2014. Roma, giugno 2014. -*AA*.VV. (2007) IFF *Indice di Funzionalità Fluviale – APAT* -Other material will be extracted from several advanced books and scientific articles
5	Assessment methods and criteria	Formative assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative assessment: oral exam (100%) (45 minutes).

Programme of "IDROGEOLOGIA E RISCHIO AMBIENTALE": ***"IDROGEOLOGY AND ENVIRONMENTAL RISK"***		
F1046, compulsory **2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS,** **Track *ENVIRONMENT MANAGEMENT AND PROTECTION*, 2nd year, 1st semester**		
Number of ECTS credits: 9 (total workload is 225 hours; 1 credit = 25 hours)		
Teacher: Gianluca FERRINI		
1	Course objectives	This course will introduce the Earth System as a basis for characterizing and understanding natural hazards, their causes and consequences. The major types of natural hazard will be described, analyzed and assessed in terms of their underlying causes as well as their socio-economic and environmental impacts. This Course capitalizes on natural synergies between

		subsurface, surface and human dimensions of the Earth System.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: - Hazards to be considered: earthquakes and tsunamis, volcanic hazards (local, regional and global scale), meteorological hazards (hurricanes, tornados, dust storms, El Nino, flooding and coastal erosion), topographic hazards (collapse of unstable slopes), hazards arising from climate change, and hazards associated with bolide impacts. - evidence for past natural catastrophes and hazards, recorded in natural archives (described with remote sensing methods for documenting current hazards and hazard risk. - principles and application of risk assessment and analysis considered with respect to case studies. - final overview of human settlement, planning and policy in relation to natural hazards in the light of their socio-economic impacts. On successful completion of this module, the student will: o have profound knowledge of the main natural hazards and therefore be capable of recognizing, defining and describing the variety and diversity of natural hazards that affect the Earth's surface environments. o understand and explain the relationships between geohazards (earthquakes, tsunamis, volcanism, slope collapse), active tectonic processes expressed on the Earth's surface and underlying processes in the Earth. o understand and explain the relationships between meteorological hazards and the underlying physical processes operating in the atmosphere. o demonstrate capacity to develop an appreciation of the incidence and significance of impacts as hazards both at present and in the past. Using routine techniques in natural hazard analysis (natural and historical records and remote sensing of present-day images) o be able to appreciate the basic principles of natural hazards and to apply the for determining the risk associated with specific types of natural hazard, and understand complexity of dealing with these issues at the professional level.
3	Prerequisites and learning activities	The student must have a strong basic knowledge of geologic and geomorphologic processes. In addition students must have basic computer skills to support current study of the discipline.
4	Teaching methods and language	Lectures and exercises in class. Fieldwork. Team work. Language: Italian (slides in English) Ref. Text books: -Alexander, D. (2000). *Confronting Catastrophe*. Oxford University Press, New York. -Blaikie, P.M., Cannon, T., Davis, I. and Wisner, B. (1994). At Risk: Natural Hazards, People's Vulnerability and Disasters. Routledge, London. -and other books and journal articles that will be provided during the course.
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: final oral exam (30 minutes). The student prepares and presents a dissertation about a catastrophic event of the past of his choice: questions and insights followed. The final oral exam follows the standard grading system, i.e., 30 is the highest grade and 18 is lowest passing grade.

Programme of "MICOLOGIA GENERALE E ECOLOGIA MICROBICA"
"MYCOLOGY AND MICROBIAL ECOLOGY"

This Course is composed of two Modules: 1) Mycology, 2) Microbial Ecology

DM0153, Compulsory
2nd Cycle Degree in ENVIRONMENTAL BIOLOGY AND MANAGEMENT OF ECOSYSTEMS,
Track *ENVIRONMENT MANAGEMENT AND PROTECTION*, 2nd year, 2nd semester

Number of ECTS credits: 10 (total workload is 250 hours; 1 credit = 25 hours)

1) DM0154 "MYCOLOGY" (6 ECTS)

Teacher: Giorgio LALLI

1	Course objectives	The aim of the course is to teach the systematics and biology of the organisms belonging to the kingdom Mycota according to the latest scientific knowledge. Another objective is to provide methods to monitor and determine the major taxonomic groups, mainly the "macrofungi".
2	Course content and Learning outcomes (Dublin descriptors)	Topics of the module include: - General characteristics of fungi. The fungal cells. Organization of mycelium. - Reproduction in fungi. False Fungi (cellular and plasmodial Myxomycetes, Oomycetes, Saprolegnales and Peronosporales) - True Fungi (Chitridiomycetes, Zygomycetes, Glomeromycetes, Ascomycetes (yeasts), Basidiomycetes, Mitosporic fungi) - Elements of determination of micro- and macrofungi with field and laboratory activities. On successful completion of this module the student should o have basic knowledge of biology and systematics of Fungi; o have basic knowledge about techniques of studying Fungi; o demonstrate capacity for determining the major systematic group; o to acquire capacity to infer and apply what is learned to concrete cases as occurring in professional life; o be able to work in team; o demonstrate capacity to be critical and self-critical.
3	Prerequisites and learning activities	Basic knowledge on systematics
4	Teaching methods and language	Lectures. Laboratory activity (compulsory attendance) Language: Italian Ref. Text books and software: -Pasqua G. Abbate G. & Forni C., 2008 - *Botanica generale e diversità vegetale*. Piccin. Padova. (cap. 23) -Carlile M. J., Watkinson S. C. & Gooday G. W., 2001 - *The Fungi.* Academic Press http://www.mycolog.com/fifthtoc.html www.ambbresadola.org -Moore D., Robson G. D. & A. P. J. Trinci, 2011 - *21st Century Guidebook to Fungi*. Cambridge University Press, New York. BioEdit
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some collective work and to participate to discussions on concrete examples. The active participation is supported and stimulated also by short Q&A sessions. Summative Assessment: Formal Oral Examination (100%). Oral exam: Half an hour discussion on some of main topics of course and determination of two/three genera of micro - or macrofungi.
2) F0374 "MICROBIAL ECOLOGY" (4 ECTS)		
Teacher: Maddalena DEL GALLO		
1	Course objectives	The course gives advanced knowledge of the role of microorganisms in the different Earth ecosystems. Aim of the course is giving to the students an advanced knowledge on microbial ecology and to provide them with the basis for understanding the role of microorganisms in the functioning of the ecosystems. At the end of the course the student should be able to understand the role of microorganisms in a given environment and must be able to design a utilization of microorganisms in the recovery of a degraded ecosystem.
2	Course content and Learning outcomes (Dublin descriptors)	Topics of this Module include: - Microorganisms and the first Earth ecosystems - Microbial growth and the adaptation to the natural environments: growth, structure and functions. Biofilms and "quorum sensing" - Methods for studying the microorganisms in the different environments. Composition, structure and dynamic of microbial communities. Culturable and unculturable microorganisms. - Conventional methods of isolation. Methods based on total DNA analysis, Biolog, PCR and quantitative PCR of microorganisms in the environment, DGGE and pyrosequencing - Methods for identifying microbial isolates and for the analysis of the composition of a microbial community, Microarrays.

		- Metagenomic analysis of a microbial community: statistical analysis, *in situ* monitoring of microorganisms, the FISH, data banks for the analysis of ribosomal genes sequences (BLAST) - The role of the microorganisms the cycling of the elements - Role of microorganisms in the different environment - Interactions among microorganisms and other organisms - Microorganisms and metals - Bioremediation Molecular strategy test: study of an endophytic microbial community The study of a microbial community *in toto* Laboratory modelling: the Vinogradskij column, the microcosm, the chemostat, how to follow the bacteria in the environment On successful completion of the Module the students should have acquaired: o high-level knowledge and understanding of the structure and function of different ecosystems; o capacity to extrapolate and apply what is learned to concrete cases as occurring in professional or in research activity; o capacity to make informed judgments and ability to defend their position; o communication skills in both oral and written reports, including a very good scientific English understanding.
3	Prerequisites and learning activities	Good knowledge of general microbiology, elements of genetics and molecular biology.
4	Teaching methods and language	Lectures. Language: Italian (or English, if required) Ref. Text books: P. Barbieri, G. Bestetti, E. Galli, D. Zannoni, *Microbiologia ambientale ed elementi di ecologia microbica*, ed. CEA, 2008. -Biavati B., Sorlini C., *Microbiologia Agroambientale*, CEA, 2008. -Atlas R.M. and Bartha R.*, Microbial Ecology*, Benjamin Cummings ed., 1997., -Lecture notes. Power point presentations given by the lecturer and by students
5	Assessment methods and criteria	Formative Assessment: the students are invited to make some homework and to participate to discussions on concrete examples and, possibly, each to give an hour lecture on a subject of interest. The active participation is supported and stimulated by short Q&A sessions. Summative Assessment; students which are not given a lecture are asked for a written report and oral examination (30 minutes).