UNIVERZITET U SARAJEVU PRIRODNO-MATEMATIČKI FAKULTET

ELABORATE ON THE ESTABLISHMENT OF THE STUDY PROGRAM

II CYCLE OF STUDIES

"Ecological monitoring and biological assessment of water quality (EMAB)"

Sarajevo, February 2021

Stalni sudski tumač za engleski jezik
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COMMISSION FOR PREPARATION OF STUDIES

Pursuant to Article 135, paragraph (3) of the Law on Higher Education (Official Gazette of Sarajevo Canton No. 33/17) and Article 104 of the Statute of the University of Sarajevo, in accordance with the provisions of the Ordinance on the procedure for proposing, evaluating, adopting new and amending existing study programs and curricula at the University of Sarajevo and based on the Decision number: 01/06-737/15 from 9th December 2020 and number: 01/06-737/16 from 10th December 2020 at the 9th electronic session held on December 11 2020, the Council of the Faculty of Science of the University of Sarajevo, made a decision on the introduction of the study program "Environmental Monitoring and Biological Water Quality Assessment (EMAB)" in the second cycle of studies of the Department of Biology .

Members of the Commission for the preparation of the Study Program are:

Prof. Dr. Rifat Škrijelj, President

Prof. Dr. Nusret Drešković, Member

Prof. Dr. Samir Đug, Project Coordinator, Member

Prof. Dr. Elvedin Hasović, Vice Dean for Teaching and Research, Member

Doc. dr. Adi Vesnić, member

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Content

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1. INTRODUCTION

1.1. INSTITUTION PROPOSING A STUDY PROGRAM

Name and address of higher education institution

Name of high education institution	University of Sarajevo, Faculty of Science
Address	Zmaja od Bosne 33 – 35, 71000 Sarajevo
Phone and fax	+387 33 723 723
E-mail	pmf@pmf.unsa.ba
Web address	www. pmf.unsa.ba
Responsible person	Prof. dr. Nusret Drešković, Dean
Contact data of responsible person	+387 (0)33/723-723

Establishment and development of the Faculty of Science of the University of Sarajevo

A significant stage in the development of education, science and culture in Bosnia and Herzegovina was the founding of the University of Sarajevo on December 2, 1949, which included already established higher education institutions: Higher Pedagogical School (1946), Faculty of Medicine (1947), Faculty of Law (1947), Faculty of Agriculture and Food (1948) and Technical Faculty with the Department of Civil Engineering and Architecture (1949). The next year, the Faculty of Philosophy with two departments: the Department of Philosophy and the Department of Natural and Mathematical Sciences. was established by a decree of the Government of Bosnia and Herzegovina of February 14, 1950.

Since 1960, by the decision of the People's Republic of Bosnia and Herzegovina ("Official Gazette" No. 50/60), the Faculty of Science has been separated from the Faculty of Philosophy and has become an independent scientific and educational institution, uniting natural and mathematical sciences. The Faculty of Science has the following scientific and teaching departments: Department of Biology, Department of Physics, Department of Geography, Department of Chemistry and Department of Mathematics. Each teaching and scientific department represents a complete teaching and scientific unit, which consists of teaching and scientific chairs and scientific research centers.

After its independence (1960), the development of the Faculty was permanently marked by the positioning of the natural and mathematical sciences at the University of Sarajevo and the system of education and science in Bosnia and Herzegovina. Curricula have been adjusted to the stated objectives in the statutes adopted in the period from 1966 to 1992.

In 1992, the Faculty of Science of the University of Sarajevo employed 234 workers, of which 26 were full-time masters of science, 79 full-time doctors of science and 3 part-time doctors of science.

The faculty is located in two buildings and had 76 laboratories, of which a smaller number was used exclusively for scientific research. The laboratories were modestly equipped, with obsolete equipment or

equipment that did not meet the world standards. With the declaration of war and the outbreak of hostilities, there was a significant reduction in the number of employees, so that in June and July 1992, 115 workers were on duty, including 49 teachers, 23 assistants and 43 employees from all departments of the Faculty. Although the difficult staffing situation of the Faculty was especially evident at the beginning of the war, with 50 doctors of science and 13 masters who remained to work at the Faculty and about 30 scientists in natural and mathematical fields in other institutions in the city, the Faculty managed not only to maintain continuity, but also to be a support to a significant part of the University, by its teachers and associates taking over the teaching of appropriate subjects at other faculties of the University of Sarajevo.

Today, the Faculty of Science of the University of Sarajevo is a respectable higher education institution, not only at the University of Sarajevo, but in the whole of Bosnia and Herzegovina. The results of the teaching and scientific staff of the Faculty in the field of scientific-teaching and scientific-research work are recognizable beyond the borders of the state of Bosnia and Herzegovina. The fields of natural sciences and mathematics are native to numerous organizational units of the University of Sarajevo as well as other faculties throughout Bosnia and Herzegovina. In addition, the Faculty has established successful cooperation with other universities outside Bosnia and Herzegovina. To date, researchers at the Faculty have published hundreds of scientific publications, including those published in the world's elite journals in relevant fields. A relatively rich publishing activity has been developed, within which dozens of books, textbooks and manuals have been published.

The Faculty of Science of the University of Sarajevo started the realization of the Bologna Process in 2005. The existing curriculum has been substantially changed in relation to the previous curriculum. New study roups were introduced at the departments, which made the study at the Faculty of Science of the University of Sarajevo very attractive. The Faculty of Science of the University of Sarajevo is currently implementing the teaching process through 18 study programs of the first cycle of studies, 17 study programs of the second cycle of studies and 6 study programs of the third cycle of studies.

Organization of the Faculty

Teaching and scientific process at the Faculty of Science, University of Sarajevo is organized within five departments:

- Department of Biology
- Department of Physics
- Department of Geography
- Department of Chemistry
- Department of Mathematics

There are the following departments, institutes, chairs and centers within the Department:

Department of Biology:

- Chair of General Biology

- Chair of Biosystematics
- Chair of Biochemistry and Physiology
- Chair of Ecology and Environmental Protection
- Cabinet for Biology Teaching Methodology
- Institute of Biology
- Center for Ichthyology and Fisheries
- Center for Ecology and Natural Resources

Department of Physics:

- Chair of General Physics
- Chair of High Energy Physics
- Chair of Condensed Matter Physics
- Chair of Atomic, Molecular and Optical Physics
- Chair of Physics Teaching Methodology
- Center for Applied Physics
- Computer Center

Department of Geography:

- Chair of Physical Geography
- Chair of Social Geography
- Chair of Regional Geography
- Chair of Geology
- Cabinet of Geography Teaching Methodology
- Institute of Regional and Spatial Planning
- GIS Center

Department of Chemistry

- Chair of General and Inorganic Chemistry
- Chair of Organic Chemistry and Biochemistry
- Chair of Physical Chemistry
- Chair of Analytical Chemistry
- Cabinet of Chemical Technology
- Cabinet of Radiochemistry
- Cabinet of Teaching Methods of Chemistry
- Institute of Chemistry
- Center for Applied Research in Chemistry

Department of Mathematics

- Chair of Algebra and Geometry

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- Chair of Analysis
- Chair of Probability and Statistics
- Chair of Numerical and Applied Mathematics
- Chair of Theoretical Computer Science
- Cabinet of Methods of Teaching Mathematics and Informatics
- Institute of Applied Mathematics and Informatics
- Computer Center

Administrative and professional activities related to the activities of the Faculty are carried out through the following services:

- Legal, Administrative and General Affairs Service
- Finance and Accounting Service
- Student Welfare
- Library Service
- Insurance and Maintenance Service

Mission of the Faculty

Conducting scientific research of interest to Bosnia and Herzegovina and education based on them through all three cycles of study, the Faculty creates highly qualified and respected experts capable of meeting the requirements of a dynamic environment and the needs of sustainable development of the community in which it operates.

Through study programs and cooperation with the economy, mobility within the international academic community and additional extracurricular activities, the Faculty provides students with professional development with the aim of successful employment. Also, the Faculty takes care of the development of human resources, constant growth of quality and improvement of international competitiveness of teaching and research activities

Also, the Faculty is committed to developing learning skills as well as general professional competencies that enable the continuation of education in terms of training for scientific research in specialized areas. The mission of the Faculty is in line with the goals of the program. The alignment of the mission and goals is periodically reviewed, evaluating the complementarity of study programs with the needs of planning and development of the local and wider community.

Vision of the Faculty

The main vision directions of the Faculty are: - integration into the single research space of Europe and the European Higher Education Area, ensuring the competitiveness of study programs, establishing exchange of students and academic staff through joint international study and research projects; - designing socially useful educational programs and implementing joint projects with the economy that will encourage the creation of new solutions and ideas through scientific research and become a pillar of sustainable development of Bosnia and Herzegovina based on knowledge and strengthen the recognition

of the Faculty of Science as a reliable and desirable institution. Bosnia and Herzegovina and abroad; - enabling enrollment in European higher education institutions in accordance with the reform of the education system with the recommendations from the Bologna Declaration on Higher Education; - promoting the quality system in higher education through cooperation with higher education institutions in the region and Europe, as well as the development of joint study and research programs in the field of natural and mathematical sciences.

Quality policy of the Faculty

Quality is the term most often mentioned in debates on higher education in the last decade. Quality assurance, improvement of the process of education and research and learning outcomes is a preliminary obligation of educational and scientific research institutions. The notion of quality directly depends on those who use the term as well as on the circumstances in which it is used. Quality is a dynamic category that varies from one generation to the next and is the link between higher education and moving society. In this context, profound changes are taking place in the higher education sector in terms of new content, study programs and research activities. The scope of work of teachers and students is increasing, the number of higher education institutions is growing, the number of students is increasing. On the other hand, resources are decreasing, demands for responsibility are increasing, the state's interest in protecting investments is growing, as well as global care for quality and standards. At the same time, there is the problem of trust in the ability of the academic community to critically evaluate its own activities.

Higher education institutions are faced with the need to justify, on the one hand, the autonomy entrusted to them and, on the other hand, the public funds they receive. In accordance with Article 11 of the World Declaration on Higher Education for the 21st Century, the educational service is required to meet the needs, requirements or wishes of clients. Students, academia, government and society as a whole are clients or beneficiaries of higher education, and one of the most important quality assurance mechanisms is accreditation. Quality in higher education is a multidisciplinary concept that encompasses all its functions and activities: knowledge transfer, academic programs, research, staff, students, space, equipment, academic environment, services and community.

Quality assurance is a key element of higher education reform and a condition for the creation of a European Higher Education Area. Its creation and functioning are possible with a built quality assurance system, which will enable comparability of higher education institutions and their programs and open the possibility of recognizing qualifications regardless of where they were acquired. The primary responsibility for quality assurance in higher education lies with each individual institution, which is also responsible for the quality of education it provides to students. Thus, quality assurance becomes a concern of all participants in the process of higher education, but also more than that: continuous quality improvement requires a professional system of built mechanisms and processes. These mechanisms include the development of a culture of quality, which means changing the attitudes and behavior of all participants involved in the work of higher education institutions, actively working to improve all segments of the institution and its creative and innovative potential.

Quality is directly related to its users. For students and professors, it is the process of education, while for financiers, the result of higher education is a priority. The categorization of the concept of quality in higher education includes the following:

1. Quality as a threshold, the definition of which means setting certain norms, criteria or standards. Any program, faculty or institution that meets the set norms or criteria is declared quality. The advantage of this concept is objectivity and the possibility of certification, which is achieved by defining a threshold. Such an approach, however, leads to the uniformity of the education system, which is negatively reflected if the principle is accepted: Do only what is enough to reach and accept the minimum.
2. Quality as the fulfillment of the set goal, where it is required that the educational service meets the needs, requirements and wishes of users, and quality is measured by the degree of achievement of these goals. Users may have different views on both the purpose and the goals set. The advantage of this concept is customer-orientation, and the weakness is the diversity of expressed needs and their relevance.
3. Quality as an established spiral of ascent in improvement. This concept emphasizes the effort to continuously improve quality indicators, and is based on the opinion that quality is essential for the academic spirit and that members of the academic community themselves know best what quality is in education and science. The disadvantage of this concept is that it is difficult to measure improvement and that evidence of improvement is often not clear and immediately apparent.

The notion of quality and the basic settings of individual concepts are mixed, intertwined and changed due to constant changes in the environment in which higher education institutions operate, as well as due to the increase in the level of knowledge within educational systems and institutions. The management of the Faculty of Science, University of Sarajevo plans to gradually develop its own concept of quality and models of evaluation and quality management in accordance with the recommendations of the Agency for Higher Education Development and Quality Assurance, which are visible in the document "Minimum standards and norms in higher education in Bosnia and Herzegovina " and European standards for internal and external quality assurance in higher education. In accordance with the above, the management issues the Declaration of Quality as a public document in which it addresses users with promising views related to building a quality system as a guarantee of fulfillment of the directions stated in the mission of the Faculty. The management of the Faculty of Science of the University of Sarajevo will continuously improve the quality of services to meet the requirements of users and partners. Quality activities will be implemented through all organizational levels based on quality documentation. By building a quality system, by defining the documentation and its implementation, the management will receive and analyze the achieved quality parameters as well as mechanisms for finding new solutions. Management guarantees quality assurance in close cooperation with state institutions and partners in the design of new educational content and research projects.

The main determinants of this quality policy are:

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1. modern educational contents under accessible conditions;
2. identification and understanding of current and future needs of users;
3. quality assurance by developing quality awareness at all levels;
4. improvement and development of educational contents;
5. building trust and increasing the number of service users;
6. creating conditions for increased efficiency of teaching changes in the organization;
7. developing partnerships with government institutions and other higher education institutions due to the possibility of comparing results;
8. continuous and professional education of staff through seminars and participation in international conferences on quality;
9. advocating and strengthening the idea of the European Union in the field of education;
10. Improving the quality management system of services in accordance with the requirements of users and international standards;
11. quality planning with the conception and design of new educational content.

In case of serious difficulties in achieving the planned levels of quality characteristics of education and research services, which could cause the need to recall those responsible, the management will involve the competent authorities.

The goals of quality are:

- to improve the existing reputation and increase the number of users of our services;
- to improve the existing level of service quality characteristics;
- to strengthen the influence on the legislative and executive branches in order to fulfill their obligations;
- to train the teaching and professional staff of the Faculty for the provision of services, in compliance with the recommendations of the World Declaration on Higher Education.

Faculty Resources

SPACE	Number of spatial units	Area (m^2)
Amphitheater	3	542,27
Classrooms	19	1042,48
Laboratories	73	3040,97
Offices	148	2518,35
Library	14	440,64
Reading Room	4	187,76
Other	273	6471,98

1.2. REASONS TO START STUDIES

The aim of ECOBIAS is to develop and improve the knowledge / skills / technical resources of higher education institutions in partner countries in environmental monitoring and biological assessment of freshwater resources in accordance with national and European Union policies. The specific objectives of

the project are: - development and implementation of an advanced master curriculum in Environmental Monitoring and Biological Water Quality Assessment (EMAB) in higher education institutions in the Western Balkans, in accordance with Bologna and national accreditation standards; - development and implementation of lifelong learning courses for the environmental monitoring sector in accordance with the European Union Water Framework Directive (WFD) in higher education institutions in the Western Balkans; - equipping seven laboratories for environmental monitoring and biological assessment of water quality (EMAB) in higher education institutions in the Western Balkans; - development of a regional academic ECOBIAS network with the aim of organizing and promoting regional cooperation in the field of ecological monitoring and biological assessment of aquatic ecosystems. Students in higher education institutions in partner countries will be more likely to get a job after graduation or certification under the EMAB Lifelong Learning Program because there is a clear need for EMAB experts in partner countries. According to the Federal Ministry of Agriculture, Water Management and Forestry (Sava River Basin Management Agency; Adriatic Sea Basin Management Agency), the Water Management Strategy in the FBiH and the RS Ministry of Agriculture, Forestry and Water Management and the Strategy for Integrated Water Management in Republika Srpska until 2024 "as well as the Ministry of Agriculture and Rural Development and" Water Management Strategy of Montenegro ", harmonization of national environmental monitoring and biological assessment system of surface water quality is a national priority in the field of water management. This implies an increasing need for EMAB experts in the Western Balkans.

After equipping laboratories and acquiring / sharing knowledge / skills / practices in the field of EMAB, teaching and technical staff in the field of EMAB in partner countries will expand opportunities for cooperation with other higher education institutions and stakeholders in the Western Balkans. This cooperation will result in the preparation of project proposals for other European Union grants and the publication of scientific papers. A comparative analysis of existing data on water resources in the Western Balkans indicates a lack of reliable data, which hinders the assessment of the current and future state of water resources. Also, this analysis indicates the high sensitivity and vulnerability of water resources in the Western Balkans region as well as the lack of coordinated water management. Therefore, this attractive environmental and scientific issue is a burning issue in the field of environment suitable for the development of future cooperation and writing project proposals. Equipping the laboratory was done with regard to the list of courses that are being developed as well as the list of existing equipment at the Faculty of Science, University of Sarajevo. Laboratories are equipped with equipment sufficient for efficient ecological monitoring and biological assessment of freshwater ecosystems. Within the project, 15 MSc courses were developed, covering all fields of environmental monitoring and biological assessment: monitoring of macrophytes, macroinvertebrates, algae, fish, coastal habitats, hydromorphology, freshwater microbiology, ecotoxicology, European Union legislation in freshwater conservation and management, GIS and freshwater management. remote sensing, advanced techniques and approaches to data processing, and laboratory and fieldwork. Learning materials and field protocols were prepared by the program countries and translated into the official languages of Bosnia and Herzegovina by experts from partner countries. Written textbooks were reviewed by independent experts. Learning materials will be published online to also be accessible to students and teachers from other higher education institutions in the Western Balkans.

1.3 ASSESSING THE SIGNIFICANCE OF STUDIES WITH REGARD TO THE LABOR MARKET NEEDS IN THE PUBLIC AND PRIVATE SECTOR

The European Union's Water Framework Directive requires the use of different multimedia water quality assessment systems. The European Union has funded many projects aimed at developing a framework for a future European water quality assessment system based on algae, benthic macroinvertebrates, aquatic macrophytes and fish with multimetric index output (AQEM, 2002; Fame Consortium, 2004; 2009; Schmutz & Sendzimir, 2018). The Water Framework Directive (WFD) is linked to a number of other European Union directives: directives on the protection of biological diversity (birds and habitats directives), directives on specific water uses (directives on drinking water, bathing water and municipal waste). waters) and directives concerning the regulation of activities undertaken in the environment (industry guidelines on environmental impact assessment). The development of an environmental assessment and classification system is not a simple matter, but one of the most important and technically demanding parts of the implementation of the Water Framework Directive. Additional skills and knowledge are necessary for successful environmental monitoring and bio-assessment, which mainly relates to data processing skills and administrative tasks related to the European Union and national legislation and water quality policy and conservation of freshwater ecosystems. According to the Water Framework Directive (WFD), not only highly industrialized but also developing countries are obliged to protect and restore all their aquatic ecosystems so that their water bodies (lakes, rivers and groundwater bodies, transitional and coastal waters) are in good condition. environmental status by 2027 at the latest. The study "Environmental Monitoring and Biological Water Quality Assessment (EMAB)" directs and accelerates capacity building processes for successful monitoring of freshwater ecosystems and biological assessment, especially in developing countries, where existing capacities are technically and humanly limited. All institutions working in the field of freshwater monitoring and bioevaluation should ensure the optimal number of employees who have the appropriate skills to facilitate the transfer of scientific data analysis to the general public. Biomonitoring of freshwater ecosystems must be based on scientific data and understanding of freshwater ecosystems and their main components, hydrological and ecological processes.

Modernization of master's programs in the countries of the region and improvement of education of future experts with specific skills in monitoring the quality of freshwater ecosystems and bio-assessment is a crucial step in creating different profiles on the labor market in Bosnia and Herzegovina. The availability of all necessary profiles in the field of freshwater biomonitoring and environmental engineering will enable effective monitoring in accordance with the Water Framework Directive in the future. The project analyzed the need of the labor market in environmental monitoring and bioavailability of freshwater in partner countries and Bosnia and Herzegovina, to assess the optimal annual number of ECOBIAS master students, results and studies at: https://www.ecobiaserasmus.com/wpcontent/uploads/2020/06/ECOBIAS_TASK-1_4-REPORT.pdf

1.4 COMPLIANCES WITH THE MISSION OF THE UNIVERSITY AND THE STRATEGY OF THE PROPOSER OF THE STUDY PROGRAM AS WELL AS WITH THE CURRENT STRATEGIC DOCUMENT OF THE UNIVERSITY

Through its mission, the University of Sarajevo emphasizes, among other things, that "UNSA creates an inspiring, inclusive and attractive environment for learning, teaching, research and artistic work, which allows students, researchers and teachers and other actors to critically reflect and understand the dynamics of global and local socio-economic, technical-technological and political processes, as well as sustainable and innovative solutions to improve the quality of life for all." **Through this study program, students will acquire knowledge, skills and competencies that will enable them to contribute to the improvement of the quality of life in our society, primarily from the aspect of environmental and nature protection.**

In addition, the proposed study program is in line with its structure, goals and outcomes in line with the Development Strategy of the University of Sarajevo for the period 2019-2023. yr. through strategic goals in the field of teaching (N1 Promotion and support of excellence in the teaching process; operational goal N1.1 Strengthening competencies through functional study programs) and in the field of internationalization (M1 Institutionalization of the internationalization process at UNSA; operational goal M1.1 Strengthening the capacity of organizational units, teachers , administration and students to design and implement the process of internationalization), given that this is a study program that is created and developed through international cooperation supported by the ERASMUS + project.

1.5 COMPARABILITY OF THE STUDY PROGRAM WITH THE PROGRAMS OF ACCREDITED ACCORDING STUDY PROGRAMS IN BOSNIA AND HERZEGOVINA AND THE COUNTRIES OF THE EUROPEAN UNION

Untouched aquatic ecosystems are a prerequisite for sustainable development. In order to reliably assess the ecological status of freshwater ecosystems, bio-assessment procedures and continuous data collection through biomonitoring are important. Environmental assessments are legally binding and are part of the European Water Framework Directive (WFD, 2000/60 / EC) and have been established in all EU Member States. Therefore, professionals in the field of environmental biomonitoring are needed who are also familiar with new methods such as DNA-based bioassay. The project identified existing university curricula relevant to Environmental Monitoring and Biological Water Quality Assessment (EMAB) at the master's level in Program Countries (PgC) (Germany, Serbia and Croatia) and Partner Countries (PCs) (Montenegro and Bosnia and Herzegovina).). In addition to traditional approaches in water quality assessment, modules covering the most modern molecular genetic methods have been analyzed and proposed. Modernization of master's programs in the Balkans, and thus the education of future experts, is an important step towards effective monitoring and restoration of key freshwater bodies in Bosnia and Herzegovina under the Water Framework Directive. An analysis of existing curricula reveals that, although few universities in PgC and PC systematically teach and train staff for methods based on DNA environmental monitoring, there are many modules with EMAB-related content that use morphotaxonomic approaches. Also, in the field of ecotoxicology there are a number of progressive

modules as well as modules in remediation ecology. The Balkan countries can benefit from the experience of established master programs / modules that exist in European countries. In terms of structure and focus of studies, the EMAB program is comparable to the study of biology in the field of ecology at the Department of Biology, Faculty of Science, University of Sarajevo. Individual modules related to water management and ecology of aquatic ecosystems exist at universities through curricula: The University of Tuzla has a study of applied biology http://pmf.untz.ba/wpcontent/uploads/2017/04/Primijenjena_biologija.pdf; University of Bihać study program Protection environment https://btf.unbi.ba/?page_id=1122 University of Banja Luka study program Ecology and Environmental Protection https://pmf.unibl.org/wp-content/uploads/2019/05/2-ciklus-ekologija-zivotinja.pdf. In addition to the above modules in the countries of the region and Bosnia and Herzegovina, in the European Union, e.g. in Germany, there are teaching modules compatible with the proposed modules of the EMAB curriculum to be introduced at the University of Sarajevo, Table 2. (https://www.ecobiaserasmus.com/wpcontent/uploads/2020/04/ECOBIAS-REPORT -CURRICULA.pdf). Also, in the European Union there are developed master study programs in ecology and ecological monitoring and water biomonitoring, only in Germany there are 35 master programs, for example, the University of Duisburg - Essen has master programs: Environmental Toxicology (EnviTox) https: // www .unidue.de / studienangebote / studiengang.php? id = 40; Transnational ecosystem-based Water Management https://www.uni-due.de/studienangebote/studiengang.php?id=103; The University of Stuttgart offers a master's program: Water Resources Engineering and Management (WAREM) https://www.warem.unistuttgart.de/. The goal of the ECOBIAS project is to develop professional staff in the field of ecological monitoring and bioindication of aquatic ecosystems, as well as capacity building and networking of higher education institutions with the aim of joint cross-border cooperation and application for European Union projects. The establishment of a single methodological framework in inland water biomonitoring in the Western Balkans region provides the necessary conditions for the joint intercalibration of ecological status assessment methods within the Eastern Continental Intercalibration Group.

https://www.ecobiaserasmus.com/wp1-preparation-uni/

1.6. STUDENT MOBILITY

The ECOBIAS Regional Academic Network and Internet Platforms have been created as there is currently no cooperation and partnership among EMAB experts in the Western Balkans. The ECOBIAS-NET platform will enable users to connect and collaborate; search for data on experts in a particular field of EMAB; efficient creation of project proposals; sharing publications and results; asking questions, getting answers and solving research problems; sharing news about current projects; reporting on EMAB news and research in the Western Balkans region; informing students about: opportunities for studying in the field of EMAB in the Western Balkans, topics of MSc and PhD theses relevant to stakeholders, opportunities for projects / funding of MSc and PhD theses in the field of EMAB.

1.7. CONNECTION WITH THE LOCAL COMMUNITY

One of the strategic goals of the Faculty of Science in Sarajevo is to build a recognizable identity in the regional, national and European context, as well as cooperation and partnership with local and state administration units and state institutions. Therefore, the Faculty of Science of the University of Sarajevo is open to the public, citizens and the local community, promotes respect for and affirmation of human rights and develops a sense of social responsibility of students, academic staff and other employees.

The Faculty of Science of the University of Sarajevo has a very successful cooperation with the local community, ie Sarajevo Canton and the Municipality of Novo Sarajevo, which recognized the importance of cooperation and implementation of knowledge in solving problems in the field of natural sciences, resulting in joint research projects.

1.8 COMPLIANCE WITH THE REQUIREMENTS OF PROFESSIONAL ASSOCIATIONS

In designing the program, the source Tuning Educational Structures in Europe (http://www.unideusto.org/tuningeu/) was taken into account, especially the part related to general competencies (http://www.unideusto.org/tuningeu/competences/generic.html) and specific competencies in the field of biology. The purpose of the study is to train students for independent research work and for other jobs that require a scientific approach: conducting fundamental and applied research at a high level in accordance with international standards. Learning outcomes at the level of this study program are defined in accordance with the needs of professional associations and the labor market. Therefore, this master's study can be useful for employers as well as members of various professional associations and other interested groups in the private and public sector that aim to improve their employees and members in the field of environmental monitoring. By including students from the economy in this master's program, it is possible to gradually organize research and development units in the economy.

1.9 POSSIBLE PARTNERS OUTSIDE THE HIGHER EDUCATION SYSTEM

1. Competent state, entity and cantonal ministries and bodies

Competent constitutions include: Ministry of Agriculture, Water Management and Forestry of the Federation of Bosnia and Herzegovina, Ministry of Agriculture, Water Management and Forestry of Republika Srpska, Federal Ministry of Environment and Tourism, Department of Agriculture, Forestry and Water Management Brcko District. Human resources in the federal and cantonal ministries of the water sector as well as within the accompanying professional institutions are insufficient to meet all the

necessary tasks. An illustrative example is the level of staffing of cantonal ministries with professional staff in this field: currently employed staff in relation to planned jobs is 53%, and it can be concluded that there is a problem of lack of staff in line cantonal ministries and competent institutes. with regulations. Even in professional institutions, this relationship is not much better, which indicates the picture of the lack of necessary human resources. The personnel structure of human resources indicates the inadequate representation of certain experts. This is especially true for cantonal ministries, which will face increasingly complex requirements in the future, given that staff development at the local level is the basis for successful water management. It should be noted that the process of adapting domestic legislation and institutional structure to the organization of water management in the European Union involves different personnel profiles than is currently the case. There is an obvious lack of quality multidisciplinary professional staff, and the key thing in sustainable water management is professional and trained staff in all professional disciplines needed in water management processes.

2. Institutions dealing with water quality testing

In Bosnia and Herzegovina, there is a long tradition of state bodies and organizations formed and in charge of water care. In the Federation of Bosnia and Herzegovina, the Public Enterprise for the Sava River Basin Sarajevo was established in accordance with the Law on Waters of the Federation of Bosnia and Herzegovina adopted in 1998 (Official Gazette of the Federation of Bosnia and Herzegovina No. 18/98). It can be seen that the company's competence relates to rivers, ie waters in the Federation of Bosnia and Herzegovina that flow into the Sava River, ie belonging to the Black Sea basin. Water management is divided according to basins, so that all rivers and waters that flow into the Adriatic Sea (Neretva, Cetina, etc.) belong to the jurisdiction of the Agency for the Adriatic Sea Basin, which is established in accordance with the Law on Waters ("Official Gazette of the Federation of Bosnia and Herzegovina" No. 70/06) in Mostar. The Agency's activities cover the Adriatic Sea basin, ie the Neretva, Cetina and Krka river basins within the borders of the Federation of Bosnia and Herzegovina. The activity of the Agency is prescribed by Art. 29, 155 and 156 of the Law on Waters, including the following activities: organization, collection, management and distribution of data on water resources in accordance with the provisions of the Law, including the establishment and maintenance of water information system and organization of hydrological and water quality monitoring , monitoring the ecological status of surface waters and monitoring groundwater, preparing reports on the status of waters and proposing the necessary measures. Regional offices operate within these agencies. In the Republika Srpska, there is the Agency for

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Waters of the Sava River Basin in Bijeljina and the Agency for Waters of the Trebišnjica Regional River Basin in Trebinje. Regional offices operate within these agencies.

3. Laboratories for testing water quality

In the Federation of Bosnia and Herzegovina, there are currently 14 authorized laboratories for testing the composition and quality of wastewater from public drainage systems, process water and leachate from landfills for testing water.

4. Scientific research institutions

Faculties: natural and mathematical, institutes and institutes.

5. Business entities and public institutions

Positions in the field of biology, ecology and environmental protection.

6. Official control

The Federal Water Inspectorate operates within the Federal Administration for Inspection Affairs. The Federal Ministry of Agriculture, Water Management and Forestry has an Inspectorate for Water Management Inspection. The Inspectorate of Sanitary, Health and Pharmaceutical Inspection and the Food Inspection operate within the Cantonal Administration for Inspection Affairs.

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2. GENERAL INFORMATION ABOUT THE STUDY PROGRAM

PROGRAM NAME	Environmental Monitoring and Biological Water Quality Assessment (EMAB)
TYPE OF PROGRAM	Academic
PROGRAM LEVEL	Second cycle of higher education
OBJECTIVES OF THE PROGRAM	Main objectives: • training students for independent work in the field of environmental monitoring and biological assessment of water quality, • introducing students to basic terms, principles and concepts in the field of biomonitoring, • introducing students to environmental principles in analyzing the relationship between habitats and organisms occur. Specific objectives: • Improving the competencies of students in the field of water resources management according to the standards of the Water Framework Directive, • Providing opportunities for students to get acquainted with standards in the field of water resources management, • Providing opportunities for students to develop basic skills important for laboratory work, • providing students with the opportunity to develop basic skills of understanding problems in the field of environmental protection and the application of tools for analysis and evaluation of the state of ecosystems
PROGRAM HOLDER	Faculty of Science, University of Sarajevo, Department of Biology

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SCIENTIFIC FIELDS TO WHICH THE STUDY PROGRAM BELONGS	Field: Biological sciences Scientific field: Ecology
ORGANIZATION OF THE STUDY PROGRAM	The teaching-scientific process is organized through lectures, seminars and exercises. Students attend three compulsory and two elective courses in the first semester of study and two elective courses in the second semester. Each of the courses was evaluated with 6 ECTS credits. At the beginning of the second semester, students choose the topic of the final thesis, which is evaluated with 18 ECTS credits.
DURATION OF THE STUDY PROGRAM	It is envisaged that the study program lasts one year, ie. two semesters. To complete the study program, it is necessary for the student to achieve a minimum of 60 ECTS credits.
LANGUAGE IN WHICH THE STUDY PROGRAM IS PERFORMED	Bosnian / Croatian / Serbian language
ACCESS TO THE STUDY PROGRAM	The general procedure for enrolling students is defined by the rules for enrolling students in the second cycle of studies prescribed by the Faculty of Science and the University of Sarajevo. Minimum conditions for enrollment, the first cycle of studies with 240 ECTS credits has been completed. The ranking of candidates is done on the basis of the average grades in the first cycle of studies and other criteria determined by the competition.
QUALIFICATION INFORMATION	Title of qualification: Master of Biology - Environmental Monitoring Level of qualification: second cycle of higher education; level 7 in the Fundamentals of the National Qualifications Framework. Along with the diploma of the completed second cycle of studies, a diploma supplement is attached, which contains information on the competencies, skills and qualifications of the candidate for work in the

	field of environmental monitoring and a list of exams passed by the student with ECTS credits.
ANALYSIS OF EMPLOYMENT OPPORTUNITIES	For the purpose of launching this study program, a labor market analysis was performed, which included a total of 18 institutions dealing with environmental monitoring and biological assessment of water in Bosnia and Herzegovina in order to estimate the number of new jobs needed. Institutions included in this study expressed the need for staff trained to perform the following activities: - monitoring of aquatic macrophytes, - monitoring of macroinvertebrates, - microbiological monitoring of aquatic ecosystems, - monitoring and assessment of fish populations, - monitoring of coastal habitats, - monitoring of macroalgae and cryptogamous flora, - GIS and remote sensing, - ecological engineering and water protection technology, - data processing, - administrative affairs related to national and European Union legislation and policy in the field of water quality and freshwater ecosystem conservation, - writing project proposals, - molecular methods for routine monitoring of aquatic ecosystems. The results of the analysis of employment opportunities show that the labor market has the greatest needs for professionals who have knowledge and skills related to environmental engineering and water protection technologies. This is followed by experts in the field of administrative affairs related to national and legislative and European Union policy in the field of water quality and conservation of

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	freshwater ecosystems and writing project proposals followed by the need for experts in GIS and remote sensing
PASSABILITY OF STUDIES	EMAB study program is an academic program compatible with the first cycle of studies at the Faculty of Natural Sciences and Mathematics and the Faculties of Biotechnical Sciences, which have provided 240 ECTS credits. During their studies, students can choose elective courses from the study programs that are realized within the ECOBIAS project, which ensures horizontal possibility. A student who successfully completes the study program has the right to access the third cycle of studies of the Department of Biology and related scientific disciplines in the fields of natural and biotechnical sciences.
SCORING AND EVALUATION	Students are continuously evaluated during the semester. All activities are evaluated with a certain number of points. In most courses, students can earn points by performing activities such as: homework, seminars, partial exams and final exams. At the beginning of the academic year, the Faculty Council adopts a scoring scale and grading criteria for each individual subject.
QUALITY ASSURANCE	The quality assurance of the study program Ecological monitoring and biological assessment of water quality is based on the evaluation of the work of teachers and assistants as well as the evaluation of each individual course. Evaluation is conducted after each semester, and students have the opportunity to express their views on the content of the course, the load on the course, the quality of teaching and the organization of exams. The obtained results are analyzed and reports are submitted to teachers for each subject individually. Based on the obtained results, teachers perform the necessary corrective actions. The process of data collection and analysis, evaluation and implementation of corrective measures is coordinated by the Quality Assurance Committee of the Faculty of Science, University of Sarajevo,

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with the support of the Vice Dean for International Cooperation and Quality of the Faculty.

3. DESCRIPTION OF THE STUDY PROGRAM

3.1. LEARNING OUTCOMES AT THE STUDY PROGRAM LEVEL

Upon completion of the study program, students will be able to:

- understand and explain the basic terms, principles and concepts in the field of biomonitoring;
- understand the legal basis of European Union water legislation and critically discuss environmental policy issues;
- understand the main classes of toxic substances, including pollutants in aquatic bodies and the main effects of toxic agents in aquatic organisms;
- apply scientific and professional methods in research into the ecological status of aquatic ecosystems;
- use learned principles to solve real problems in the conservation or management of wetlands and coastal habitats;
- carry out field research using GIS and remote sensing technology;
- use spatial database models in spatial analysis and process modeling;
- apply RHS (River Habitat Survey) and SERCON (River Conservation Assessment System) methods for assessing the value of river conservation.

3.2. LIST OF COMPULSORY AND ELECTIVE COURSES

Study program	Study type (cycle)	Master study (II)
	Name of study program	Ecological monitoring of Freshwaters (EMAB)

Course title

Freshwater Ecology

Course code	Semester	Course status	ECTS	Contact hours (L+E+C+S+In)
	I	Obligatory	6	30+30+20+30+40
Course objectives	The course is designed to provide the essential knowledge of the chemical and physical properties of inland water, including lakes, wetlands, rivers and streams. Theoretical and applied concepts of ecosystem approach will be addressed through lectures, classroom exercises and labs with field trips.			
Student learning outcomes	Knowledge: Students will be able to understand elementary principles of chemical, biological, physical and geographical factors of inland waters and how they affect the distribution of aquatic organisms. The holistic approach of freshwater assessment will be employed. Skills: Application of limnological field and laboratory techniques; Identification of aquatic organisms and their interactions; Understanding of issues related to water resources on local, regional and global scale. Competencies: critical thinking, problem solving, managing information, communication and cooperation			

Class topics

1. Structure of freshwater ecosystems.
2. Lakes and water-retentions.
3. Running waters.
4. Movement of water – hydrology of the land.
5. Growth factors in freshwater ecosystems.
6. Physical factors in freshwater ecosystems. Light and temperature.
7. Chemical factors in freshwater ecosystems. Oxygen and carbon dioxide.
8. Nitrogen and Phosphorous. Other nutrients.
9. Structure and dynamics of biocoenoses in freshwater ecosystems.
10. Phytoplankton. Zooplankton.
11. Zoobenthos. Phytobenthos.
12. Ichthyofauna.
13. Food-webs and metabolism of freshwater ecosystems.
14. Integrated management of water resources.

Literature

Obligatory

Radulović, S., Teodorović, I. (2010): Ekologija i monitoring kopnenih voda. Metodološki priručnik. Novi Sad : Prirodno-matematički fakultet, Univerzitet.
Doods, K. W. (2002): Freshwater Ecology: Concepts and Environmental Applications. Mannhatan (Kansas) (etc.) : Division of Biology, Kansas State University ; Academic Press.
Whitton, B. A. (1975): River Ecology. Oxford (etc.) : Blackwell Scientific Publications.
Dukić, D. (1984): Hidrologija kopna. Beograd : Naučna knjiga.

Tests and evaluation - criteria

	Max points	Pass points		BiH	ECTS
Tests[2]	36	20	< 55,00	5	F
Seminar paper	19	10	55,00 – 64,99	6	E
Written final exam	45	25	65,00 – 74,99	7	D
Total	100	55	75,00 – 84,99	8	C
			85,00 – 94,99	9	B
			95,00 – 100,00	10	A

L-lectures, P-practical classes, C-consultations, S-seminar paper, Is-individual/independent study/work

Study program	Study type (cycle)	Master study (II)
	Name of study program	Ecological monitoring of Freshwaters (EMAB)

Course title

System for evaluating rivers for conservation

Course code	Semester	Course Status	ECTS	Contact hours (L+E+C+S+In)
	I	Obligatory	6	30+30+20+30+40

Course objectives	The aim of this course is to knowledge and skills in ecological and conservation assessment of rivers using a combination of scored and unscored elements, relate to a suite of conservation criteria and a range of human impacts, as well as unscored to set the context in which evaluations are mandatory, essential to a balanced interpretation of the conservation value of an ECS (Evaluated Corridor Section).
Student learning outcomes	Knowledge: Students will have an understanding of physical, chemical, and biological processes of streams and rivers, know important concepts that shaped the development and current state of stream ecology, and be familiar with the application/integration of stream ecological principles to environmental management. Skills: Students will be able to apply RHS (River Habitat Survey), and SERCON (System for Evaluating Rivers for Conservation) methods to evaluate conservation values of rivers, in all SERCON modules: River Rehabilitation, Environmental Impact Assessment, Site Assessments, Special Natural Characteristics, Flora and Fauna and Monitoring, as well as to use SERCON software tools and scoring systems evaluating habitat diversity and modification of SERCON software. Competencies: critical thinking, problem solving, managing information, communication and cooperation

Class topics

1. Conservation strategies for running waters
2. River Rehabilitation
3. Environmental Impact Assessment
4. Site Assessments
5. Special Natural Characteristics
6. Flora and Fauna and Monitoring
7. SERCON software tools and scoring systems evaluating habitat diversity and modification of SERCON software

Literature

Obligatory

Boon, P. J., Holmes, N. T. H., Maitland, P. S., Fozzard, L. (2004): Sercon Version 2 System For Evaluating Rivers For Conservation, User's Guide and Technical Guide, SNH UK.

Ovuka, M., Racković, M., Radulović, S., Cvijanović, D., Živković, M., Novković, M., Boon, P.: SERCON Software (System for Evaluating Rivers for Conservation), Version 3.1 (2012-2015): PMF UNS script and available from: http://sercon.pmf.uns.ac.rs/SerconWeb/ Supplemental Philip, J. Boon, P. J., Raven, P. J., eds. (2012): River Conservation and Management. John Wiley & Sons.

Tests and evaluation - criteria

	Max points	Pass points		BiH	ECTS
Tests[2]	36	20	< 55,00	5	F
Seminar paper	19	10	55,00 – 64,99	6	E
Written final exam	45	25	65,00 – 74,99	7	D
Total	100	55	75,00 – 84,99	8	C
			85,00 – 94,99	9	B
			95,00 – 100,00	10	A

L-lectures, P-practical classes, C-consultations, S-seminar paper, Is-individual/independent study/work

Study program	Study type (cycle)	Master study (II)
	Name of study program	Ecological monitoring of Freshwaters (EMAB)

Course title

GIS and Remote Sensing in Ecomonitoring

Course code	Semester	Course status	ECTS	Contact hours (L+E+C+S+In)
	I	Obligatory	6	30+30+20+30+40

Course objectives	Students will get knowledge on principles and methods used in Geographic information systems (GIS) and remote sensing and their application in ecological investigations. Students will be able to use application software and optional tools necessary for complex and component investigations in the field of ecology
Student learning outcomes	Knowledge: History of development of GIS and Remote Sensing, data types and structure, data quality, data analyses, how to create data and information in GIS and remote sensing, their interpretation and analyses, possibilities of use in nature resources investigations. Skills: Students will be able to carry out field investigations using basic and advanced GIS and Remote Sensing technologies - GPS and UAV (drones) and to process georeferenced data, to develop models of spatial data, to explore and prepare statistics of spatial data, to prepare distribution maps, to create basic predictive scenarios for environmental impacts using tools and resources of open access. Competencies: critical thinking, problem solving, managing information, communication and cooperation

Class topics

1. Introduction to Remote Sensing – definition and approach,
2. Tasks and objectives of the investigations.
3. Historical and geographical continuum and present state in the field of geospatial investigations
4. Spatial analyses in ecology. Spatial analyses of biodiversity.
5. Electromagnetic radiation
6. Data sources and sensors in remote sensing. Ecological variables in remote sensing.
7. Systems for observation of Earth's surface and their classification
8. Rectification and improvement of imagery
9. Improvement of satellite imagery
10. Statistics of digital imagery
11. Vegetation indices
12. Classification of satellite imagery
13. Sonar recording of aquatic vegetation
14. Types of GIS models. Preparation of maps. Data georeferencing
15. Databases (graphic and attribute).

Literature

Obligatory

Đug, S., Dreščović, N., Odžak, S. (2015): Daljinska istraživanja: principi i primjena u prirodnim naukama. Sarajevo : Univerzitet.
Horning, N., Robinson, J. A., Sterling, E. J., Turner, W., Spector, S. (2010): Remote Sensing for Ecology and Conservation: A Handbook of Techniques. New York : Oxford University Press.
Franklin, J., Miller, J. A. (2009): Mapping Species Distribution: Spatial Inference and Prediction. Cambridge : University Press.

Supplemental

Radulović, S., Teodorović, I. (2011): Ekologija i monitoring kopnenih voda: metodološki priručnik. Novi Sad : Prirodno-matematički fakultet.

Tests and evaluation - criteria

	Max points	Pass points		BiH	ECTS
Tests[2]	36	20	< 55,00	5	F
Seminar paper	19	10	55,00 – 64,99	6	E
Written final exam	45	25	65,00 – 74,99	7	D
Total	100	55	75,00 – 84,99	8	C
			85,00 – 94,99	9	B
			95,00 – 100,00	10	A

L-lectures, P-practical classes, C-consultations, S-seminar paper, Is-individual/independent study/work

Study program	Study type (cycle)	Master study (II)
	Name of study program	Ecological monitoring of Freshwaters (EMAB)

Course title

Wetland and riparian ecology

Course code	Semester	Course status	ECTS	Contact hours (L+E+C+S+In)
	I or II	Optional	6	30+30+20+30+40

Course objectives	The aim of this course is to provide students: with an understanding of the biological components (plants, animals and biodiversity) of wetlands and riparian habitats and their adaptations; with information on the diversity of different types of wetlands and riparian habitats including vegetation diversity (with special reference to the Balkan peninsula and the Danube basin); a conceptual understanding of wetland ecosystem functions & processes such as hydrology, productivity, soils and biogeochemical cycling; with the scientific background to evaluate wetland delineation and regulation.
Student learning outcomes	Knowledge: Students will be able to distinguish plant and animal species, plant communities and habitat types; critically discuss issues related to wetland and riparian habitat policies, conservation or management; use the learned principles for solving real-world problems in conservation or management of wetland and riparian habitats. Skills: Students will be able to apply scientific methods and use tools for data gathering and analyses in the field and laboratory Competencies: critical thinking, problem solving, managing information, communication and cooperation

Class topics

1. What is a Wetland.
2. Wetland Classification, & Function: an overview. 3. Hydrology: Surface water and hydrodynamics
4. Hydrology: Ground water and topographic convergence.
5. Wetland Functions: Hydrology.
6. Wetland Plants. 7. Wetland Soils.
8. Wetland Functions: Biogeochemistry, Productivity & Energy Flow.
9. Wetland Functions: Wetland Plant and Faunal support. 10. Wetland Federal, State, Local, and Tribal Regulation.
11. Intro to human interaction.
12. Ecological Assessment Overview.
13. Climate perspective.
14. Ecosystem Services.

Literature

Obligatory

Lovett, S., Price, P., Eds. (2007): Principles for riparian lands management. Canberra: Land & Water Australia. Keddy, P. A. (2010): Wetland ecology: principles and conservation. Cambridge: University Press.

Supplemental

Maitland, P. S., Morgan, N. C. (1997): Conservation management of freshwater habitats: lakes, rivers and wetlands. New York: Springer Science + Business Media.

Tests and evaluation - criteria

	Max points	Pass points		BiH	ECTS
Tests[2]	36	20	< 55,00	5	F
Seminar paper	19	10	55,00 – 64,99	6	E
Written final exam	45	25	65,00 – 74,99	7	D
Total	100	55	75,00 – 84,99	8	C
			85,00 – 94,99	9	B
			95,00 – 100,00	10	A

L-lectures, P-practical classes, C-consultations, S-seminar paper, Is-individual/independent study/work

Study program	Cycle	Master study (II)
	Name of Study Program	Ecological monitoring of Freshwaters (EMAB)

Course Name

Numerical Ecology

Course number	Semester	Type of course	Credits (ECTS)	Hours (L+E)
	I or II	Optional	6	45+45

Objectives	(1) data type and standardization (working with multivariate data); (2) classification and cluster analyses (working with groups); (3) ordination and related methods (working with gradients); (4) computer approaches to multivariate statistical analyses
Outcomes	Students should gain broad understanding of the various multivariate techniques with respect to the types of research and data sets appropriate for each technique in ecology. The course is strongly focused on project-based learning, group work, discussions and analysis of problem sets. This course aims to present students with a necessary background in various multivariate and spatial statistical techniques commonly used to analyze biological and environmental data. Topics covered include • basic data science and visualization, • vector and matrix operations, • multivariate techniques, • clustering techniques, • multivariate analysis • ecological modeling applications.

Description

1. An introduction to multivariate statistics.
2. Review of basics of vector and matrix algebra and applicability to multivariate analysis (MVA).
3. Ecological data sets (working with multivariate data).
4. Dimensional analysis in ecology.
5. Multidimensional quantitative data.
6. Multidimensional semiquantitative data and qualitative data.
7. The basic of clustering and ordination.
8. Q and R analysis; Q mode; R mode.
9. Cluster analysis (working with groups, finding groups, testing for differences among groups (e.g., multi-response permutation procedures, and describing group differences (e.g,. discriminant analysis, classification tree analysis)).
10. Multivariate analysis of variance (ANOVA-standard analysis of variance (ANOVA), ANCOVA (analysis of covariance).
11. MANOVA (Multivariate ANOVA) and MANCOVA (Multivariate ANCOVA).
12. Regression analysis.
13. Unconstrained ordination.
14. Canonoal ordination.
15. Spatial structures and spatial analysis.

Literature

Borcard, D., Gillet, F., Legendre, P. (2011): Numerical Ecology with R (use R!). Springer.
Carol, J. D., Green, O. E., Chaturvedi, A. (1997): Mathematical Tools for Applied Multivariate Analysis. Revised ed. Academic Press.
Karadžić, B., Marinković, S. (2009): Kvantitativna ekologija. Beograd : IBISS.
Legendre, P., Legendre, L. (2012): Numericall Ecology. 3rd English Ed. Elsevier.
McGarigal, K., Cushman, S., Stafford, S. (2000): Multivariate Statistics for Wildlife and Ecology Research. Springer.

Evaluation methods and grading					
	Maximum score	Minimum score to pass exam		BiH	ECTS
Exam	50	30	< 55,00	5	F
Project	50	25	55,00 – 64,99	6	E
Total	100	55	65,00 – 74,99	7	D
			75,00 – 84,99	8	C
			85,00 – 94,99	9	B

			95,00 – 100,00	10	A

L-lectures, P-practical classes, C-consultations, S-seminar paper, Is-individual/independent study/work

Study program	Type of study (cycle)	Master study (II)
	The name of the study program	Ecological monitoring of Freshwaters

Subject name/Module title

Ecotoxicology of aquatic ecosystems

Module code	Semester	Course status	ECTS (credits)	Contact hours (L+E+C+S+In)
	I or II	Optional	6	30+30+20+30+40

The aim of the module/subject	Provide knowledge of the interactions between anthropogenic chemicals and aquatic ecosystems as well as of methods employed in aquatic toxicity testing. The origin, toxicity, fate of pollutants and their impact at the molecular, biochemical, cellular, physiological, organismal, and community levels of organization will be presented. Students will also be exposed to some of the classical methodologies and understand basic concepts behind both in situ and in vitro aquatic toxicity testing with special attention given to biological markers in aquatic organisms. This module aims to develop awareness of the major current theories and concepts in field of aquatic ecotoxicology.
Learning outcome	Knowledge: knowledge about main classes of toxicants including emerging contaminants in water bodies and main effects of toxic agents in aquatic organisms; ability to think and work interdisciplinary. Skills: a good overview about the most important methods and study approaches used in studies and research of environmental pollutant chemicals; capacity for process analysis, systemic thinking as well as for a goal oriented, structured, efficient working method. Competencies: ability to do research in this area and expand and transfer further knowledge; abilities to know and understand the positions of different stakeholders in ecotoxicology; the ability to present the research results to an international audience and to discuss the results.

Course content with thematic units per week

1. Introduction to the module; Toxicology (toxin, toxicant, toxicity) – acute, chronic and life cycle toxicity
2. Pollutants - the production, use and effects of various classes of environmental pollutants and their pathways in different ecosystems; Characteristics of environmental chemicals
3. Ecosystems and their functioning (global pollution impacts)
4. Environmental Chemistry - use of chemicals, routes of entry in the environment and basic Lab Course Environmental Chemistry (fundamental chemical and physical water analysis)
5. Principles of ecotoxicology
6. Ecotoxicology of aquatic ecosystems
7. Bioindicators in aquatic ecotoxicology - bioaccumulation and biomagnification
8. Biomonitoring in aquatic ecotoxicology (*in situ* and *ex situ*)
9. Ecotoxicological tests (types, test organisms) and overview of the most used ecotoxicological tests
10. Macroinvertebrates in ecotoxicological studies of aquatic ecosystems; Ecotoxicological field studies;
11. Aquatic plants and ecotoxicological assessment in freshwater ecosystems
12. Plant species sensitivity and minimum data requirements for chemical risk assessments in aquatic ecosystems
13. Methods in ecotoxicology - selected examples of ecotoxicity tests (unicellular algae growth inhibition test, acute toxicity test on *Daphnia magna* and/or fish acute toxicity test)
14. Basics of environmental risk assessment and international strategies of addressing ecotoxicological problems in nature 15. Seminar on data handling, revision and exam preparation

Literature

Basic/required

Đug, S., Drešković, N., Trožić Borovac, S., Mušović, A., Vesnić, A., Trakić, S, Gajević, M., Bešta Gajević, R., Šljuka, S., Mirić, R., Korjenić, E., Škrijelj, R. (2020): Biomonitoring akvatičnih ekosistema. Sarajevo : Univerzitet.
Amiard-Triqut, C., Amiard, J.-C., Mouneyrac, C. (2015): Aquatic Ecotoxicology: Advancing Tools for Dealing with Emerging Risks. London : Academic Press ; Elsevier.
Calow, P. P., ed. (2009): Handbook of ecotoxicology. John Wiley & Sons.
Walker, C. H., Hopkin, S. P., Sibly, R. M., Peakall, D. B. (2006): Principles of Ecotoxicology. London : Taylor and Francis.

Advanced/additional

National Research Council (2014): A Framework to Guide Selection of Chemical Alternatives.
Nollet, M. L., Gelder, L. S. P. de (2014): Handbook of water analysis. Boca Raton : CRC Press.

Knowledge assessment and evaluation - criteria

	The maximum number of points	Pass points		BiH	ECTS
Written exam(s)	36	20	< 55,00	5	F
Seminar paper	19	10	55,00 – 64,99	6	E
Written final exam	45	25	65,00 – 74,99	7	D
Total points	100	55	75,00 – 84,99	8	C
			85,00 – 94,99	9	B
			95,00 – 100,00	10	A

L-lectures, P-practical classes, C-consultations, S-seminar paper, Is-individual/independent study/work

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Study program	Type of study (cycle)	Master study (II)
	Name of the study program	Ecological monitoring of Freshwaters (EMAB)

Subject name/Module title

Algology

Course code	Semester	Course status	ECTS	Contact hours (L+E+C+S+In)
	I or II	Optional	6	30+30+20+30+40

Course Objective	Course provides a comprehensive overview of classical and contemporary aspects of the freshwater algal ecology and takes full advantage of the excellent range of aquatic habitats to provide a sound introduction to community succession and species interactions in plankton and benthos.
Course Outcome	Students will develop knowledge of algal community monitoring methods at different spatial and temporal scales in a diversity of freshwater habitats. Students will be able to apply ecological principles in describing relationships between algal community and habitats and explain the environmental controls of the algal distribution in plankton and benthos. Students will acquire a foundation for understanding complex ecological processes in freshwaters and will be able to apply it in biomonitoring and next generation biomonitoring.

1. Introduction to Systematics. Systematics development. Systematics in the order of the natural sciences. Systematic categories. Basic principles of nomenclature. General characteristics of algae (cell structure, algae body structure, algae diet, algal propagation modes, and algae life cycle). Characteristics of algae with a prokaryotic type of cell organization. Algae characteristics with eukaryotic cell organization type.
2. Classification of algae A. (Division Cyanophyta - Class Cyanophyceae; Division Rhodophyta - Class Bangiophyceae, Class Florideophyceae).
3. Classification of algae B. (Division Heterokontophyta - Class Chrysophyceae, Class Parmophyceae, Class Sarcinochrysidophyceae, Class Xanthophyceae, Class Eustigmatophyceae, Class Bacillariophyceae Class raphidophyte, Class Dictyochophyceae, class Phaeophyceae; Division Haptophyta - Class Primnesiophyceae; Division Cryptophyta - Class Cryptophyceae; Division Dinophyta - Class Dinophyceae; Division Euglenophyta – Euglenophyceae).
4. Classification of algae C. (Division Chlorophyta - Class Prasinophyceae, Class Ulvophyceae, Class Chlorophyceae, Class Chlorophyceae).
5. Algae: the major microbial biomass in freshwater systems. Taxonomic and molecular characterization. Size, shape and surface mucilage. Activities within the freshwater environment. Strategies for survival. Biodiversity in the algal community.
6. Freshwater environments: the influence of physico-chemical conditions on algal communities.
7. Lakes. Lake morphology and hydrology. Lakes as isolated environments. Climatic influence on lakes.
8. Wetlands. General characteristics. Wetland habitats and communities.
9. Rivers. Comparison of lotic and lentic ecosystems. River flow and benthic community. River hydrology.
10. Adverse and extreme conditions in freshwater environments. Adverse conditions as part of the environmental continuum. The role of ecosystem assessment in environmental management.
11. Use of algae in ecological assessments. A framework for ecological assessment. Sampling algae in freshwater habitats. Sampling design.
    Sampling technique.
12. Attributes of algal assemblages – biomass, chemical composition, functional attributes, taxonomic composition.

Compulsory:
Barudanović, S., Mašić, E. (2015): Raznolikost i sistematika algi. Sarajevo : Univerzitet, Prirodno-matematički fakultet.
Dodds, W. K., While, M. R. (2010): Freshwater Ecology, Second Capacity Building in the field of Higher Education – Joint Projects Development of master curricula in ecological monitoring and aquatic bioassessment for Western Balkans HEIs / ECOBIAS Page 47 of 404 edition: Concepts and Environmental Applications of Limnology (Aquatic ecology), New York : Academic press.
Supplementary:
Wehr, J. D., Sheath, R. G., Kociolek, J. P., Eds. (2015): Freshwater algae of North America: ecology and classification. Elsevier.
Barudanović, S., Macanović, A., Topalić-Trivunović, Lj., Cero, M. (2015): Ekosistemi Bosne i Hercegovine u funkciji održivog razvoja. Sarajevo.
Hoek, C. van den, Mann, D. G., Jahns, H. M. (1995). Algae, an introduction to phycology. Cambridge : University Press. Lee, R. E. (1999): Phycology. 3 ed. Cambridge : University Press.

Knowledge verification and evaluation - criteria	

	Maximum number of points	Points for passing		BiH	ECTS
Tests[2]	36	20	< 55,00	5	F
Seminar paper	19	10	55,00 – 64,99	6	E
Written final exam	45	25	65,00 – 74,99	7	D
In total	100	55	75,00 – 84,99	8	C
			85,00 – 94,99	9	B
			95,00 – 100,00	10	A

L-lectures, P-practical classes, C-consultations, S-seminar paper, Is-individual/independent study/work

Study program	Type of study (cycle)	Master study (II)		
	Name of the study program	Ecological monitoring of Freshwaters (EMAB)		
Course				
Ecological projects				
Course code	Semester	Course status	ECTS	Contact hours (L+E+C+S+In)
	I or II	Optional	6	30+30+20+30+40
Course objective	The aim of this course is to explain how to recognize priorities for various conservation actions and how to build reliable, cost-effective and successful project proposals to realize it.			
Learning outcome	Knowledge: This course will provide training in writing conservation project proposals. Skills: The course teaches how to use specific protocols to identify priority areas and separate them from processes which threaten their persistence, and how networks of priority areas in particular region can form the framework for building other conservation actions. Competences: Through dynamic mixture of conservation theory and presentation of various case studies students will be encouraged to recognize hot topics in conservation and to apply that knowledge in their surrounding by learning how to make own conservation project proposal and apply for real funds.			

Course content with thematic units

1. The importance of conserving biodiversity
2. Major factors threatening biodiversity
3. Identifying conservation priorities
4. Concept of conservation-ecological project.1.
5. 6. Assessment of the state of protection.1.
6. Legal basis of environmental protection in Bosnia and Herzegovina
7. Legal basis of environmental protection in the European Union and the International Convention
8. Biological values of Bosnia and Herzegovina
9. Application of protection status assessment in environmental protection projects
10. Monitoring as the backbone of the conservation-environmental project
11. Species and community monitoring projects
12. Basics of conservation and development projects
13. Species conservation management projects
14. Protection management projects and sustainable exploitation projects
15. Projects of ecological education and ecological tourism

Literature

Mandatory

Pullin, A. S. (2002): Conservation Biology. Cambridge: University Press.
Sutherland, W. (2000): The Conservation Handbook: Research, Management and Policy. Wiley-Blackwell.

Knowledge assessment and evaluation - criteria

	Maximum number of points	Pass points		BiH	ECTS
Test[2]	36	20	< 55,00	5	F
Seminar paper	19	10	55,00 – 64,99	6	E
Written final exam	45	25	65,00 – 74,99	7	D
In total	100	55	75,00 – 84,99	8	C

			85,00 – 94,99	9	B
			95,00 – 100,00	10	A

L-lectures, P-practical classes, C-consultations, S-seminar paper, Is-individual/independent study/work

Study program	Type of study (cycle)	Master study (II)			
	Name of the study program	Ecological monitoring of Freshwaters (EMAB)			
Course					
Forensic essentials in aquatic insects ecology					
Course code	Semester	Course status	ECTS	Contact hours (L+E+C+S+In)	
	I or II	Optional	6	30+30+20+30+40	
Course Objective	The aim of this course is to provide broad knowledge about the use of aquatic insects in determining the post-mortem intervals of invertebrates and vertebrates found in water after environmental stress. The aim is also to present physical, chemical, geographical and biological parameters that influence the colonization speed of dead animals by insects and introduce students to different methods (traditional and modern) of insect identification.				
Course outcome	*Knowledge*: Students should gain broad understanding about aquatic ecology of biota relevant for forensic science and apply it to help solve litigation in civil and criminal cases. *Skills*: Students will learn about the techniques used to identify forensically important insects and the proper techniques for collecting and breeding forensically important insects. Students will acquire positive laboratory practice skills and learn the basics of biosecurity. Students will master methods of applying sequential data and bioinformatics databases and software for the purpose of identifying forensically important insects. *Competencies*: Students who successfully complete this course will be aware of the challenges and opportunities presented by this emerging discipline. This course is designed to provide students with a basic understanding of the interaction between the discipline of entomology and forensic science (the application of science during criminal investigation). Students will be taught the basic entomology concepts necessary to understand forensic entomology, using a blend of lecture, discussion, and active classroom work. Students will also learn how to apply modern genetic and bioinformatics methods in solving various forensic issues.				

Course content with thematic units

1. Introduction and history of forensic entomology
2. Introduction to insect anatomy. Biosystematic review. The role of aquatic insects in forensics.
3. Collection of entomological evidence. Laboratory insect breeding for forensic purposes.
4. Insect identification
5. Postmortem decomposition. Succession of insects in the natural environment.
6. Factors influencing insect succession. Estimation of postmortem interval (time of death)
7. Molecular methods in forensic entomology. DNA barcoding in forensic analysis of aquatic insects
8. Bioinformatics methods in sequence data analysis
9. Other applications of forensic entomology. Case studies.

Literature

Mandatory

Byrd, J. H., Tomberlin, J. K. (2010): Forensic Entomology: The Utility of Arthropods in Legal Investigations, 2nd ed. Boca Raton : CRC Press. Markquez-Grant, N., Roberts, J. (2012): Forensic Ecology Handbook: From Crime Scene to Court. Oxford : Wiley-Blackwell. Claverie, J.-M., Notredame, C. (2006): Bioinformatics for Dummies, 2nd ed. Oxford: Wiley-Blackwell.

Auxiliary

Wells, J. D., Stevens, J. R. (2008): Application of DNA-Based Methods in Forensic Entomology. Annual Review of Entomology, 53: 103–20.
Gemmellaro, M. D., Hamilton, G. C., Ware, J. L. (2019): Review of Molecular Identification Techniques for Forensically Important Diptera. Journal of Medical Entomology, 56 (4):887-902, doi: 10.1093/jme/tjz040.
Meng F., Ren, L., Wang, Z., Deng, J., Guo, Y., Chen, C., Finkelbergs, D., Cai, J. (2017): Identification of Forensically Important Blow Flies (Diptera: Calliphoridae) in China Based on COI. Journal of Medical Entomology, 54(5), 2017, 1193–1200.

Knowledge assessment and evaluation - criteria

*	Maximum number of points	Pass points		BiH	ECTS
Test[2]	36	20	< 55,00	5	F
Seminar paper	19	10	55,00 – 64,99	6	E

Written final exam	45	25	65,00 – 74,99	7	D
In total	100	55	75,00 – 84,99	8	C
			85,00 – 94,99	9	B
			95,00 – 100,00	10	A

L-lectures, P-practical classes, C-consultations, S-seminar paper, Is-individual/independent study/work

Study program	Type of study (cycle)	Master study (II)		
	Name of the study program	Ecological monitoring of Freshwaters (EMAB)		
Course/module title				
Freshwater microbiology				
Modul code	Semester	Modul	Credits	Contact hours (L+E+C+S+In)
	I or II	Optional	6	30+30+20+30+40
Learning goals	Freshwater microbiology Course Objective: To describe the role of microorganisms in the freshwater ecosystems and their importance in monitoring of water quality of different freshwater environments. Description of microbial loop and microbial diversity in in different environmental systems including lakes, rivers and wetlands. To describe microbial response to eutrophication. To introduce the fundamentals of water borne disease transmission and to describe agents of disease: bacterial pathogens, viral pathogens, protozoan pathogens, and other vectors of disease.			
Learning outcomes	Learning outcomes: after passing the module, students will be able to explain the role of microorganisms in aquatic ecosystems and the metabolic diversity of microorganisms in water. Students will know about infectious diseases that are transmitted by contaminated water and the causes of these diseases. Students will be able to assess and monitor the quality of surface waters based on the presence of indicator microorganisms. Students will know the role of microorganisms in the process of wastewater remediation and the impact of polluted water on aquatic organisms. Learning goals/competencies: after successfully completed pre-examination and examination obligations, the student will be able to sample water for microbiological analysis, detect and identify indicators of fecal origin using various methods. Students will be able to categorize surface waters based on the results of microbiological analyzes and assess the degree of contamination. Competencies: students will have the skills and be able to work in diverse teams in the field of freshwaters microbiology. Students will be able to coordinate complex tasks within their group and will be able to use relevant methods and results in identifying sources of pollution and preventing them. Students will know how to use their technical knowledge for solving problems.			

Module Content (Module Timetable)

1. Introduction in water microbiology
2. Microbial loop; Microbial diversity in aquatic ecosystem;
3. Microbial contamination of freshwaters environments
4. Waterborn diseases
5. Microbial indicators of water quality
6. Water quality classification
7. Water sampling for analysis
8. Methods for water microbiological quality assessment
9. Detection and identification of coliforms and *E. coli*
10. Detection and identification of fecal enterococci, *Clostridium perfrigens* and *Pseudomonas aeruginosa*
11. *Membrane filter* technique
12. Wastewater microbiology
13. Microbiology laboratory manual and analysis
14. *Bioremediacion* in fresh *water* bodies
15. Assessment of aquatic pollution using histopathology in fish

Literature

Basic/required literature

Đug, S., Drešković, N., Trožić-Borovac, S., Mušović, A., Vesnić, A., Trakić, S., Gajević, M., Bešta-Gajević, R., Šljuka, S., Mirić, R., Korjenić, E., Škrijelj, R. (2020): Biomonitoring akvatičnih ekosistema. Sarajevo : Univerzitet.

Markert, B. A., Breure, A. M., Zechmeister, H.G. (2003): Bioindicators & Biomonitors Principles, Concepts and Applications. Elsevier Science.

Petrović, O., Gajin, S., Matavulj, M., Radnović, D., Svirčev, Z. (1998): Microbiological investigation of surface water quality. Novi Sad : Institute of Biology, Faculty of Sciences, University.

Sigee, D. (2005): Freshwater Microbiology. John Wiley and Sons.

Additional literature

Chigbu, P., Sobolev, D. (2007): Bacteriological Analysis of Water. // Nollet, L. M. L. (2007): Handbook of water analysis. 2nd ed. Taylor & Francis Group.

Knowledge assessment and evaluation - criteria

	Maximal point number	Points for passing the exam		BiH	ECTS
Partial test exame[2]	36	20	< 55,00	5	F
Students' activity/seminar[1]	19	10	55,00 – 64,99	6	E
Final test exam	45	25	65,00 – 74,99	7	D
Total	100	55	75,00 – 84,99	8	C
			85,00 – 94,99	9	B
			95,00 – 100,00	10	A

L-lectures, P-practical classes, C-consultations, S-seminar paper, Is-individual/independent study/work

I certify herewith that this is a true and faithful rendering of the original text written in the official language of Bosnia and Herzegovina.

Register No.: 25/23

Sarajevo, February 28, 2023,

Delija Mensur, mr.sci.
Certified Court Interpreter for English

Address: Grbavička 61, 7100 Sarajevo, Phone: +387618902[illegible], E-mail: mensurdelija@gmail.com;

Stalni sudski tumač za [illegible] jezik
Стални судски тумач за [illegible] језик
MENSUR DELIJA
SARAJEVO
МЕНСУР ДЕЛИЈА
САРАЈЕВО
CERTIFIED COURT INTERPRETER FOR ENGLISH

Za: **UNIVERZITET U SARAJEVU PRIRODNO-MATEMATIČKI FAKULTET**

Sudski tumač za engleski jezik
Delija Mensur
Grbavička 61
71000 Sarajevo

TROŠKOVNIK broj: 25-1/23

Uplatu izvršiti na Žiro-račun
Bosna Bank International

Prezime i ime Delija Mensur

Broj računa 1413081310290804

Ovjera prijevoda na engleski jezik 35 stranica i to:

1. Ovjera prijevoda Elaborata **Ecological monitoring and biological assessment of water quality (EMAB)**.....160,00KM

UKUPNO:160,00KM

Sarajevo, 28.02.2023. godine

Stalni sudski tumač za engleski jezik
Delija Mensur, mr.sci.

Stalni sudski tumač za engleski jezik
Стални судски тумач за енглески језик
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МЕНСУР ДЕЛИЈА
САРАЈЕВО
CERTIFIED COURT INTERPRETER FOR ENGLISH