

ANALYSIS OF EXISTING CURRICULA RELATED TO EMAB IN BOTH PROGRAMME AND PARTNER COUNTRY PARTNERS

Task 1.3 - REPORT

Intact aquatic ecosystems are a prerequisite for sustainable development. In order to reliably assess the ecological state of freshwater ecosystems, robust bioassessment procedures and continuous biomonitoring data are important. Such assessments are legally binding as part of the European Water Framework Directive (WFD, 2000/60/EC) and established through all EU member states. Therefore, professionals in the field of ecological biomonitoring are needed that are also increasingly capable with new methods such as DNA-based bioassessments. The aim of this report is to identify the existing university teaching portfolio relevant for ecological monitoring and aquatic bioassessment (EMAB) at the Master level in Programme Countries (PgC) (Germany, Serbia, and Croatia) and Partner Countries (PC) (Montenegro, and Bosnia and Herzegovina). In addition to traditional assessment approaches, we also searched for modules training state-of-the-art genetic methods. These are cost-effective and fast in comparison to traditional assessment methods such as characterization of ecological state solely by morphology-based taxonomy. Modernization of master programs in the Balkan countries and therefore education of future professionals is an important step in the direction of efficient monitoring and possible restoration of key freshwater bodies in this region according to the WFD.

The analysis of the existing curricula reveals that while few universities in the PgC, PC systematically teach and train DNA-based methods for ecological monitoring, many courses exist with content related to EMAB using morphotaxonomic approaches. Also, in the area of ecotoxicology, many progressive modules are being taught as well as modules in systemic restoration ecology. The Balkan countries can profit from the experience of established Master programmes/modules running in European countries.

INTERNET SEARCH OF EXISTING EMAB MASTER PROGRAMMES

The internet search was restricted to PgCs and PCs. **Table 1** lists a summary of all keywords and their combinations used for the internet search:

Table 1. Search Parameters used to identify relevant master programs in EMAB in addition to the personal consultations and individual searchers at university module pages.

Search engine	Keywords	Relevant hits (e.g. data bases of master programs)
Google	master, curriculum, ecological monitoring	www.masterstudies.com 35 Master Programs University of Kiel (Environmental Management) University of Bremen (Ecology) University of Leipzig (International MSc in Biodiversity, Ecology and Evolution) University of Duisburg Essen (Biology, Biodiversity, Translational Water Management; Environmental Toxicology) University of Hohenheim (European Master in Env. Sciences) University of Koblenz-Landau (Ecotoxicology) University of Trier (Environmental Sciences) Technical University of Munich (Biology)
Google	master, curriculum, ecology, bio monitoring	University of Duisburg-Essen, Studies Program, Master Environmental Toxicology /MSC. University of Trier
Google	master, curriculum, ecology, water management	TH Köln, University of Duisburg-Essen, Studies Program: Transnational ecosystem-based Water Management
Google	master, curriculum, ecology, biodiversity	www.master-and-more.de
Google	master, curriculum, ecology, ecosystem	www.masterstudies.com Filter settings: name of all partner countries, Language: English, German, Serbian, Croatian, Bosnian

Retrieved data bases do not usually link directly to the curriculum of the master programs, therefore the web page of the universities were accessed individually and the documents were downloaded. The curricula are attached to this report in section „Curricula of Master Programs relevant to EMAB“.

Additionally, web pages of known Universities in PgC and PC were accessed directly in search for EMAB master programs.

UNIVERSITIES THAT OFFER MASTER STUDIES OR MODULES RELATED TO EMAB

All relevant results comprising master programs and specific modules offered by the retrieved Universities are summarized in **Table 2**.

A systematic internet search as well as personal inquiries with the professors/docents offering the courses resulted in the following list of modules as part of full Master Programmes or Modules relevant to EMAB. For Germany, we did not include university programs in general like ecology / biology (there are several hundred modules) but focused explicitly on biomonitoring or freshwater-specific ecological or ecotoxicological modules.

Table 2. Master programs and modules related to EMAB.

Country	Name of University	Name of Master Program	Name of Module/Specialty	Credit Points
Germany	University of Duisburg-Essen Faculty of Biology	Environmental Toxicology (EnviTox) https://www.uni-due.de/studienangebote/studiengang.php?id=40	Ecology and Protection of Freshwater Ecosystems and Aquatic Organisms	5
		https://www.uni-due.de/imperia/md/content/biologie/studium/masterenvitox_modulhandbuch1920.pdf	European Environmental Legislation	8
	Transnational ecosystem-based Water Management https://www.uni-due.de/studienangebote/studiengang.php?id=103	Basic Water Ecology (Hydroclimatology and Sustainable Water Management; Hydrogeology and Application; Water Quality Modelling)	10	
	https://www.uni-due.de/imperia/md/content/twm/module_handbook.pdf	Applied Water Ecology	9	
		Water Engineering (including Water Governance and Spatial Planning)	11	
		Water Basin Management	6	
		Sustainability/Wetland Management	6	
	Social Environmental Sciences (Principles of environmental Management, environmental economics etc.)	9		

		Project "Water Management" (different applied projects in the area of aquatic management, including bioassessment and -monitoring)	16-21
	Biodiversity (Together with Ruhr-University Bochum)	Aquatic Ecology (Gewässerökologie)	9
	http://www.biologie.ruhr-uni-bochum.de/studium/bm/msc_b/index.html.de	Molecular Ecology (focus on DNA-based methods for bioassessment and -monitoring)	9
University of Koblenz-Landau	Ecotoxicology	Principles of Ecotoxicology	6
		Methods in Ecotoxicology	9
Faculty 7: Natural and Environmental Sciences	https://www.uni-koblenz-landau.de/de/landau/fb7/studium-dokumente/modulhandbuecher/list-of-modules-mscecotox	Risk Assessment and Management	6
		Biogeochemical Interfaces	6
		Current Developments in Environmental Chemistry	6
		Process modelling	6
		Environmental physics II	6
		Green Chemistry	6
		Indicator Organisms	6
		Community Ecology	6

	Quantitative experimentelle Ökologie (English: Quantitative Experimental Ecology)	6
	Molecular Ecology II	6
	Land Use and Ecosystems	6
	Applied Geoecology I	6
	Applied Geoecology I	6
	Geosystems	6
	Environmental policy and law	6
	Environmental Life Cycle Assessment	6
	Environmental Cost-Benefit Analysis	6
	Advanced Data Science	6
Environmental Sciences	Sustainability and Global Change	4
https://www.uni-koblenz-landau.de/en/campus-landau/faculty7/study-documents/listofmodules/list-of-modules-mscenvsci.pdf	Tools for Complex Data Analysis	6
	Fate and Transport of Pollutants	6
	Land Use and Ecosystems	6
	Water Analysis	
	Basic Lab Course Environmental Chemistry	6

We refrained from listing twice the Specialty Areas that are identical between the two Master Studies at the University of Koblenz-Landau (Ecotoxicology and Environmental Sciences).

Advanced Lab Course Environmental Chemistry	6
Community Ecology	6
Quantitative Experimental Ecology	6
Molecular Ecology I	6
Molecular Ecology II	6
Conservation Biology	6
Human-Environment Systems	6
Applied Geoecology I	6
Applied Geoecology II	6
Sustainability and Society	6
Environmental Management	6
Business Administration for Environmental Scientists	6
Environmental Modelling	6
Models in Ecotoxicology	6



Technical University of Munich (TUM) Master Biosciences https://www.biowiss.wzw.tum.de/fileadmin/MHBs/MHBs_WS1920/Modulhandbuch_MSc_BIO_WS1920.pdf	Environmental Monitoring and Data Analysis	5
	Applied River Restoration	5
	Applied Limnology	5
	Aquatic Ecology and Conservation	5
	Ecosystem Management and Applied Restoration Ecology	5
	Molecular Ecology and Restoration Genetics	5
	Methods in Fish Biology and Aquatic Ecology	10
	Molecular biology and limnology	10
University of Cologne The International Master of Environmental Sciences (IMES) http://www.imes.uni-koeln.de/sites/imes/user_upload/Modulhandbuch_Websites.pdf	Introduction to Environmental Statistics	2
	Basic Module: Ecology (Biosphere)	6
	Hydrology: Lecture Physical Hydrology "[...] gain an understanding of hydrological methods used in water resources management"	3
	Hydrosphere: Seminar "Topics of Hydrology and Water Resources Management"	12
	Advanced module "Biosphere" (Applied Issues of Aquatic and Microbial Ecology)	12

		International Cooperation and Development	5
		Environmental Monitoring	5
		Environmental Assessment	5
		Water Resources Management	5
		Ecosystem Management and Conservation	5
University of Bremen	Master of Ecology	Experimental Design and Data Analysis	12
	https://www.uni-bremen.de/fileadmin/user_upload/fachbereiche/fb2/msc_ecol/MScEcologyCourseCatalogue_2017new.pdf	Molecular Ecology	9
Faculty 02 Biology/Chemistry		Basics in biodiversity	3
		Environmental Risks and Ecotoxicology	6
		Advances in biodiversity	6
University of Aachen	Ecotoxicology		
	Website of the Master Studies:		
	https://www.rwth-aachen.de/cms/root/Studium/Vordem-Studium/Studiengaenge/Liste-Aktuelle-Studiengaenge/Studiengangbeschreibung/~bnrm/Oekotoxikologie-M-Sc-/?lid=1		
		Mandatory Modules in the Course of Study:	
		<ul style="list-style-type: none"> • Ecological terrestrial or limnetic systems • Environmental analysis or environmental chemistry of pollutants • Ecotoxicology concepts • Practical methods in ecotoxicology • Regulatory ecotoxicology • Statistical and mechanical modelling in ecotoxicology or modelling of behavior and expansion of chemical materials in 	Total 120

organisms and the environment or statistics
in ecotoxicology

Elective Modules:

- Ecology of Terrestrial Systems
- Ecology of Limnetic Systems
- Environmental Analysis of Pollutants
- Environmental Chemistry of Pollutants
- Statistic and Mechanical Modelling of Ecotoxicology
- Modelling of Behavior and the Expansion of Chemical Materials in Organisms and the Environment
- Statistics in Ecotoxicology
- Plant Ecology 1 or 2
- Toxicology
- Residential Water Management and Water Engineering
- Applied Geography
- Microorganisms 1 or 2
- Phytopathology
- Climatology and Hydrology

**University of
Stuttgart**

Water Resources Engineering and Management (WAREM)

Integrated River Management and Engineering, 6
Lecture: "River Engineering and Sediment
Management"



	https://campus.uni-stuttgart.de/cusonline/wbModhbReport.downloadPublicMHBVersion?pOrgNr=3&pStpStpNr=979&pDocNr=5559343	Chemistry and Biology for Environmental Engineers, Lecture: "Biology and ecology of water, soil and air systems"	6
		Water Quality and Treatment	6
		Limnic Ecology	6
Freie Universität Berlin	Biodiversity, Evolution, Ecology	Advances in Water Ecology: Structure, Function and Dynamics (Aktuelle Themen der Gewässerökologie: Struktur, Funktion und Dynamik)	5
Faculty of Biology, Chemistry and Pharmacy	https://www.fu-berlin.de/vv/de/modul?id=480774&sm=528624	Advanced Biodiversity, Evolution and Ecology (Vertiefte Biodiversität, Evolution und Ökologie)	10
		Computational Biology	10
		Research Project: Biodiversity, Evolution and Ecology (Forschungsprojekt: Biodiversität, Evolution und Ökologie)	15
University of Trier	Environmental Sciences	Environmental Monitoring Strategies	5
		Environmental Chemistry and Risk Assessment	5
	https://www.uni-trier.de/fileadmin/fb6/fb6/studium/Modulhandbuecher/4_UNI_TR_FB_6_Modulhandbuch_MSC_ES_Reakkred_final_Mai_2013.pdf	Aquatic Pollution Assessment	5
Faculty VI Raum- und Umweltwissenschaften		Regional Biomonitoring Project	5
		Ecotoxicological Effects of Environmental Pollutants	5

		Advanced Remote Sensing Data Processing & Analysis	5
		European Environmental Law	5
University of Bayreuth	Biodiversity and Ecology (page only in German)	Molecular Biodiversity Research	5
		Statistical Modelling in R	5
	https://www.masterstudium-biologie.uni-bayreuth.de/pool/dokumente/Modulhandbuecher/MHB_BOEK.pdf	Biodiversity and Ecosystem Functioning	5
		Basics of aquatic Ecology	9
	Molecular Ecology (page only in German)	Methods for Analyzing Nucleic acid	9
	https://www.masterstudium-biologie.uni-bayreuth.de/pool/dokumente/Modulhandbuecher/MHB_MOE.pdf	Molecular Environmental Aquatic Microbiology	9
Christian-Alberts-Universität zu Kiel	Sustainability, Society and the Environment	B3 - Environmental Management – focus more on political and economic aspects	120
Kiel School of Sustainability	https://www.sustainability.uni-kiel.de/en/taught-masters/master-of-science-sustainability-society-and-the-environment-1/modules		
University of Leipzig	International Master of Science in Biodiversity, Ecology and Evolution	Specialty Areas:	120
Faculty of Biology		<ul style="list-style-type: none"> • advanced biostatistics • experimental design • bioinformatics • Modelling • molecular biology 	

		https://biologie.lw.uni-leipzig.de/studium-lehre/msc-in-biodiversity-ecology-and-evolution/	<ul style="list-style-type: none"> • chemical analysis • single cell analysis • field experiments, monitoring, sensor-based methods 	
Bosnia & Herzegovina	University of Sarajevo Faculty of Sciences	No EMAB program At the Biology department http://www.pmf.unsa.ba/biologija/index.php/studijski-programi/ii-ciklus-studija/ekologija#i-semestar	Hydrobiology curricula on undergraduate study VI semester	5
		No EMAB program At the Biology department http://www.pmf.unsa.ba/biologija/index.php/studijski-programi/ii-ciklus-studija/ekologija#i-semestar	Freshwater ecology on master study II semester	2
	University of Bihac Biotechnology Faculty	No EMAB program At the Department of Nutrition, study group Habitat Conservation https://btf.unbi.ba/?page_id=1227 https://btf.unbi.ba/?page_id=1122	Upravljanje i sistemi zaštite voda (Water management and systems) is curricula on undergraduate study VI semester.	6
			Tehnologija vode i obrada otpadnih voda (Water technology and sewage treatment) is curricula on undergraduate study VI semester.	6
			Analitika prirodnih i otpadnih voda (Water technology and sewage treatment) is curricula on undergraduate study VII semester. On master study II semester.	6
			Hydrobiology is curricula on undergraduate study VII semester.	5

		Hydrobiology is curricula on undergraduate study VII semester.	5
		Biološki postupci obrade otpadnih voda (Biological treatment of wastewater) on undergraduate study VIII semester.	4
		Upravljanje zrakom, vodom i tlom (Air, water and soil management) On master study III semester.	6
University of Tuzla	No EMAB program	Ekologija ekosistema (Ecology of ecosystems)	6
Faculty of Natural Sciences and Mathematics, Department of Biology	Applied biology, orientation: Ecology and nature protection http://www.untz.ba/index.php?page=studij http://pmf.untz.ba/wp-content/uploads/2017/04/Primijenjena_biologija.pdf	Odabrana poglavlja iz ekologije biljaka I ekologije životinja (Selected chapters of plant ecology and animal ecology)	6
		Sistemi i modeli u ekologiji (Systems and models in ecology)	6
		Zaštita ekoloških sistema (Protecting ecosystems)	6
		Zaštita prirode Bosne i Hercegovine (Nature protection of Bosnia and Herzegovina)	6
University of Banja Luka	No EMAB program	Populaciona ekologija životinja (Population ecology of animals)	8
	Study program: Ecology and environmental protection	Zoocenologija (Zoocenology)	8
		Zaštita biodiverziteta (Protection of biodiversity)	6

Faculty of Natural Sciences and Mathematics, Department of Biology	Orientation: Animal ecology https://pmf.unibl.org/wp-content/uploads/2019/05/2-ciklus-ekologija-zivotinja.pdf https://pmf.unibl.org/ekologija-npp/	Fauna balkanskog poluostrva (Fauna of the Balkan Peninsula)	8
		Zoekološke i zoogeografske analize (Zooecological and zoogeographic analyzes)	
		Ekologija i sistematika odabranog taksona – beskičmenjaka (Ecology and systematics of a selected taxon – Invertebrates)	
		Ekologija i sistematika odabranog taksona – kičmenjaka (Ecology and systematics of a selected taxon – vertebrates)	5
		Principi zoološke taksonomije (Principles of zoological taxonomy)	
	Study program: Ecology and environmental protection	Idioekologija biljaka (Plant idioecology)	8
	Orientation: Plant ecology https://pmf.unibl.org/wp-content/uploads/2016/04/2_ciklus_ekologija_biljaka.pdf https://pmf.unibl.org/ekologija-npp/	Ekološke i fitogeografske analize (Ecological and phytogeographic analyzes)	8
		Zaštita biodiverziteta (Protection of biodiversity)	6
	Populaciona ekologija biljaka (Population ecology of plants)	8	
	Flora i vegetacija balkanskog poluostrva (Flora and vegetation of the Balkan Peninsula)		

			Ekologija i horologija odabrane grupe biljaka (Ecology and horology of a selected group of plants)	5
	University of Mostar	No EMAB program		No data
	Faculty of Science and Education	Diplomski studij biologije, ekologije i zaštite prirode (Graduate study of biology, ecology and nature protection) https://fpmoz.sum.ba/index.php?option=com_content&view=category&layout=blog&id=18&Itemid=126&lang=hr		
Serbia	University of Belgrade	No EMAB program https://www.bio.bg.ac.rs/master-akademske-studije	Makroinvertebrate kao pokazatelji kvaliteta vode (Macroinvertebrates as indicators of water quality)	6
	Faculty of Biology	No EMAB program https://www.bio.bg.ac.rs/master-akademske-studije	Monitoring površinskih voda na osnovu algi (Algae-based surface water monitoring) master study II semester	5
	University of Novi Sad	Master of Science in Ecology (1 year, 60 ECTS) https://www.pmf.uns.ac.rs/en/studies/study-programs/master-of-science-in-ecology-2018/	Nature conservation and sustainable development, hydrobiology	60
	Faculty of Science		Ecological Risk Assessment Applied Botany	
	University of Niš	Master studies	Abiotic characteristics of aquatic ecosystems	5

Faculty of Science and Mathematics	Ecology and nature protection https://www.ni.ac.rs/en/studies-and-admission/studies/course-catalogue/courses/category/250-ecology-and-nature-conservation	Animal ecology	8
		Biodiversity conservation	5
		Bioindication and monitoring	6
		Conservation Biology	7
		Ecology of microorganisms	5
		Ecotoxicology	6
		Genotoxicology	6
		Global ecology	6
		Hydrobiology	6
		Limnology	6
		Phytogeography	5
		Plant Ecology	7
		Protected natural areas and species of Serbia	5
		Urban ecology	6
	Vegetation of the World	6	
	Zoogeography	5	

	University of Kragujevac Faculty of Science and Mathematics	Institute of biology and ecology Master academic studies https://www.pmf.kg.ac.rs/pub/f66d3f360ce511625c5af47154a042d8_04252017_023500/mas%20ekologija%202016.pdf	Master of ecology – General ecology Master of ecology – Applied ecology	No data
Croatia	University of Zagreb Biology Department	No EMAB program Ecology and nature conservation https://www.pmf.unizg.hr/download/repository/lspitni_r okovi_DS-Ekologija_i_zastita_prirode%5B2%5D.pdf	Ecology of freshwater Biology of polluted water Bacteriology of polluted water Ichthyology and fishery of freshwater	No data
		https://www.pmf.unizg.hr/download/repository/lspitni_r okovi_DS-Znanosti_o_okolisu%5B2%5D.pdf	Aquaculture and fishery	No data
	University of Josip Juraj Strossmayer Osijek Biology Department	Graduate study program: Ecology and environmental protection http://www.biologija.unios.hr/nastava/izvedbeni-diplomski-zastita-prirode-i-okolisa/		No data
Montenegro	University of Donja Gorica	No EMAB program Graduate and postgraduate studies in food technology, food safety and ecology https://fptbhe.udg.edu.me/	Food processing, food safety, environmental impacts of food production	Not applicable

University Mediteran	No EMAB program http://unimediteran.net/index.php/mne/	No environment-related programs	
University of Montenegro	No EMAB program https://www.ucg.ac.me/programi/pmf	Ecological Microbiology	6
Faculty of Biology	Masters programs in Biodiversity, Ecology and Environmental Protection, Biology-Ecology, Experimental Biology and Biotechnology, Teaching Biology, Environmental Protection	Crenobiology and Ecology of Underground Waters	6
		Basics of Ichthyology	6
University of Montenegro	No EMAB program https://www.ucg.ac.me/programi/mtf	Water protection engineering course (undergraduate, covers monitoring of physical and chemical parameters)	8
Faculty of Metallurgy and Technology	Undergraduate degree in Environmental Protection Master's program in Environmental Protection starting in 2020/2021.		

SUMMARY

In PgCs and PCs no explicit MSc study programme for EMAB exists. However, as part of several other Master study programmes, several modules (or parts of modules) exist that are closely related to content relevant to EMAB. In Serbia, several modules related to EMAB are taught as part of MSc programmes at University of Novi Sad and University of Nis. In Germany, the three most relevant Universities in this respect seem to be University of Duisburg-Essen (where also a specialised MSc “Aquatic Biology” has been accredited and will start in 2022), University of Koblenz-Landau, where several Master programmes related to EMAB are established, and Technical University of Munich (TUM). Knowledge transfer and skill training within the training programmes spans from environmental legislation, chemical assessment, GIS-based skills and toxicology over core disciplines such as taxonomic identification, bioindication, ecotoxicology, environmental assessment, DNA-based monitoring, remote sensing data analysis to environmental decision making. The Master curricula to be developed for the Balkan countries can rest to a large extent on the content of such courses. It will be important, to clearly distinguish the study programme from the biological and ecological master programmes. This needs to be done by putting more emphasis on the inter- and transdisciplinary aspects required for EMAB, e.g. by including environmental legislation, GIS, ecotoxicology, environmental planning, engineering aspects to the biological core aspects.

ESTIMATE OPTIMAL PRIOR KNOWLEDGE

Suggestions only.

Based on the analysis of existing MSc curricula we propose the following set of criteria as relevant to the acceptance of prospective MSc in EMAB.

- A University degree (typically BSc) in Biology, Microbiology, Biochemistry, Water Science or Environmental Sciences in the Natural Science domain
- A Bachelor thesis relevant for EMAB (e.g. Zoology, Botany, Ecology, Evolution, Hydrobiology)
- Documented skills in statistics (e.g. at least 5 ECTS)
- Documented skills in taxonomic training (e.g. at least 5 ECTS)
- Documented skills in basic chemistry (e.g. at least 5 ECTS)
- English language test (level B2)

CURRICULA OF MASTER PROGRAMMES RELEVANT TO EMAB

Relevant master curricula are attached as separate pdf files.