HOCHSCHULE
RHEIN-WAAL
Rhine-Waal University
of Applied Sciences

Handbook of Modules for the Degree Programme

Environment and Energy, B.Sc.

Faculty of Communication and Environment

Version 1.40

17.03.2023

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Rhine-Waal University of Applied Sciences

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Curriculum of the Bachelor Degree Programme Environment and Energy, B.Sc.

Code No (Kennnr.)	Module	CH (SWS)	Type (Veranstaltungsart)						Te (Prü)	CP	WS1	SS2	WS3	SS4	WS5	SS6	WS7
			L (V)	SL (SL)	S (S)	Ex (Ü)	PT (Pra)	Pro (Pro)									
8111	Fundamentals of Energy Management and Technology Grundlagen des Energiemanagements und der Energietechnik	5	3			2			E (P)	5	5					8161 Internship or semester abroad (Praxis- oder Auslandsstudiensemester (30 CP; TE: C (T))	8171 Workshop 1: Research Methods (Forschungsmethoden) (4 SW; 5 CP; type: S; TE: C (T)) 8172 Workshop 2: Scientific Writing (Wissenschaftliches Schreiben) (4 SW; 5 CP; type: S; TE: C (T)) 8173 Workshop 3: Advanced Seminar (Hauptseminar) (4 SW; 5 CP; type: S; TE: C (T)) 8101 Bachelor Thesis (Bachelorarbeit) (12 CP) and 8102 Colloquium (Kolloquium) (3 CP)
8112	Mathematics: Analysis and Discrete Mathematics Mathematik: Analysis und diskrete Mathematik	4	2			2			E (P)	5	4						
8113	Introduction to Ecology and Environmental Sciences Einführung in die Ökologie und Umweltwissenschaften	5	3			2			E (P)	5	5						
8114	Fundamentals of Biology and Natural Cycles of Matter Grundlagen der Biologie und der natürlichen Stoffkreisläufe	5	3			2			E (P)	5	5						
8115	Physics: Mechanics, Electricity and Magenetism Physik: Mechanik, Elektrizität und Magnetismus	8	4			4			E (P)	10	8						
8121	General and Inorganic Chemistry Allgemeine und anorganische Chemie	5	2			1	2		E/C (P/T)	5		5					
8122	Evaluation of Ecosystems and Environmental Assessment Ökosystem- und Umweltbewertung	5	2				3		E/C (P/T)	5		5					
8123	Physics: Thermodynamics, Radiation and Heat Transfer Physik: Thermodynamik, Strahlung und Wärmeübertragung	4	2			2			E (P)	5		4					
8124	Linear Algebra and Graph Theory Lineare Algebra und Grafentheorie	4	2			2			E (P)	5		4					
8125	Fundamentals of Scientific Programming Grundlagen des wissenschaftlichen Programmierens	4	3			1			E (P)	5		4					
8126	Statistics and Data Processing Statistik und Datenverarbeitung	5	3			2			E (P)	5		5					
8131	Organic Chemistry and Analytical Chemistry Organische Chemie und analytische Chemie	5	2				3		E/C (P/T)	5			5				
8132	Energy Technology Energietechnik	4	2			2			E (P)	5			4				
8133	Fundamentals of Business Administration Grundlagen der Betriebswirtschaftslehre	4	2			2			E (P)	5			4				
8134	Project Management and Intercultural Competence Projektmanagement und interkulturelle Kompetenz	4	2			2			C (T)	5			4				
8135	Microbiology Mikrobiologie	4	2				2		E/C (P/T)	5			4				
8136	Fundamentals of Geodata Management Systems Grundlagen der Geoinformationssysteme	4	2			2			E (P)	5			4				
8141	Resource Management and Environmental Health Ressourcenmanagement und Umwelthygiene	6	4			2			E (P)	5				6			
8142	Applied Measurement and Control Angewandte Verfahren der Mess- und Regelungstechnik	4	2			2			E (P)	5				4			
8143	Legal Fundamentals Rechtliche Grundlagen	4	4						E (P)	5				4			
8144	Entrepreneurship Unternehmensgründung	4	3			1			E (P)	5				4			
8151	Remediation and Redevelopment Sanierung und Standortentwicklung	5	4			1			E (P)	5					5		
8152	Process Engineering Verfahrenstechnik	5	5						E (P)	5					5		
8009	Interdisciplinary Project Interdisziplinäres Projekt	6						6	E (P)	10					6		
	Elective courses * Wahlpflichtkurse *	16								20				8	8		
	Total weekly semester hours Gesamt-Semesterwochenstunden	129									27	27	25	26	24	30	30

Code No (Kennnr.)	Elective Courses (Wahlpflichtkurse)	CH (SWS)	CP	Te (Prü)
8175	Advanced Simulation and Modelling Simulation und Modellierung	4	5	E (P)
8176	Innovative Solutions in Environment and Energy Innovative Lösungen in Umwelt- und Energietechnik	4	5	E (P)
8177	Advanced Environmental analytical chemistry Chemische Umweltanalytik	4	5	E (P)
8178	Electromobility Elektromobilität	4	5	E (P)
8179	Advanced auditing and certification procedures Auditierungs- und Zertifizierungsprozesse für Fortgeschrittene	4	5	E (P)
8180	Environmental Monitoring Umweltmonitoring	4	5	E (P)
8181	Environmental Economics Umweltökonomie	4	5	E (P)
8182	Energy Economics Energieökonomie	4	5	E (P)

List of Abbreviations:	
CH	Semesterwochenstunden,credit *hours per week*
V	Vorlesung, *lecture*
SL	seminaristischer Unterricht, *seminar-like lecture*
S	Seminar, *seminar*
Ü	Übung, *exercise*
Pra	Praktikum, *practical course*
Pro	Projekt, *project*
Ex	Art der Prüfung, *type of examination*
CP	credit points (= ECTS-points); (1ECTS/30h workload)
WS	Wintersemester, *winter semester*
SS	Sommersemester, *summer semester*
P	Prüfung, *examination*
T	Testat, *certificate*
SWS	Semesterwochenstunden, *contact hours per week*

8111 Fundamentals of Energy Management and Technology

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8111	150 h	5 CP	1st semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 45 TU/ 3 SWS Exercises with excursion: 30 TU/ 2 SWS	75 TU / 5 SWS	93.75 h	50 students

Learning outcomes / Competences and qualifications profile

Upon completion of this course, the student will be able to:

- relate renewable and non-renewable energy carriers to their corresponding range of coverage, environmental impact, and their characteristics in the energy chain.
- understand and analyse abstract concepts (e.g. sustainability, carbon or ecological footprint) and contemporary developments in global change (e.g. UNFCCC policies).
- explain basic concepts of thermodynamics
- describe the technology of energy conversion for renewable and non-renewable energy carriers.
- describe environmental impacts of different energy conversion technologies.

Content

This module intends to increase students´ awareness and interest in the field of energy management and technology.
Based on the introduction of key concepts in the energy chain and thermodynamics, the course analyses trends and drivers in energy supply.
The need for reducing greenhouse gas emissions, in particular carbon dioxide emissions caused by incineration of fossil fuels, to limit temperature increase is explained.
An overview of conventional and renewable energy resources and their applications is provided. Different kinds of energy conversion processes are explained and their efficiency is discussed.
The vast impact of conventional and renewable energy resources on the environment is illustrated and discussed using different concepts like e.g. “sustainability” or “carbon footprint”.
National, European and international policy approaches to reduce the missions of climate gases are presented and discussed.

Teaching methods

Lectures and practical trainings with workgroup exercises, excursions

Entry requirements

None

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points Module examination grade 4.0 or better, successful participation in practical training
Use of module (in other study programs)
Weight towards final grade 3,125%
Person in charge of module Prof. Dr. Irmgard Buder
Additional information Literature: Cengel, Y. A.; Boles, M. A. (2010): Thermodynamics - An Engineering Approach. Boston: McGraw-Hill. Boeker, E.; Grondelle, R. (2011): Environmental Physics - Sustainable Energy and Climate Change. Chichester: Wiley. Sorensen, B. (2004): Renewable Energy - its physics, engineering, use, environmental impacts, economy, and planning aspects. Amsterdam: Elsevier. Gevorkian, P. (2007): Sustainable Energy Systems Engineering. New York: McGraw-Hill. Quaschning, V. (2010) Renewable Energy and Climate Change Chichester John Wiley Sons LTD Quaschning, V. (2016) Understanding Renewable Energy Systems, London Washington DC Sec. Ed. Earthscan, Nelson, V. (2011): Introduction to Renewable Energy. Boca Raton: CRC Press.

8112 Mathematics: Analysis and Discrete Mathematics

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8112	150 h	5 CP	1st semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 30 TU / 2 SWS Excercise: 30 TU / 2 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

This lecture has introduced students to the basics of Discrete Mathematics and fundamental topics of Analysis and has therefore enabled them to solve technical and operational problems.
With the knowledge of these mathematical methods and formulas students can solve analytical problems based on discrete or continuous functions and are able to apply their knowledge to their professional context as analysts, planners or engineers.
Students will be able to turn scientific issues especially from chemistry and physics into a mathematical expression using functional relationships between scientific parameters.

Content

- Fundamentals of logic, sets and numerative systems
- Fundamentals of relations and functions
- Elementary functions like rational-, potential-, exponential- and logarithm-functions
- Trigonometric functions like sinus, cosinus, tangens, cotangens
- Fundamentals of differential calculus: functional limits, continuity, derivations and rules of derivations
- Fundamentals of integral calculus: anti derivations, integration and rules of integration
- Application of the gained knowledge to solve problems in chemistry and physics

Teaching methods

Tuition in lectures and practical classes

Entry requirements

None

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)

Same module in "Environment and Energy, B.Sc.", "Communication and Information Engineering, B.Sc./Infotronic Systems Engineering B.Sc." and "Mobility and Logistics, B.Sc."

Weight towards final grade

3,125 %
Person in charge of module Prof. Dr. Petra Blitgen-Heinecke
Additional information Literature: Stewart J. (2008): Calculus, Early Transcendentals, International Metric Edition, 6th Edition, BrooksCole, ISBN-13: 9780495382737.

8113 Introduction to Ecology and Environmental Sciences

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8113	150 h	5 CP	1st semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture „Introduction to Ecology": 30 TU / 2 SWS Exercises / excursions "Introduction to Ecology ": 15 TU / 1 SWS Lecture "Environmental Science" 15 TU / 1 SWS Exercises / Excursions "Environmental Science" 15 TU / 1 SWS	75 TU / 5 SWS	93.75 h	50 students

Learning outcomes / Competences and qualifications profile

Upon completion of this course, students will be able to:

- demonstrate their understanding of structural and functional relationships in organisms of the same species as well as their interactions with other species and their environment at various levels of integration.
- appreciate biodiversity at all levels, investigate its ecological, economical and social impact and advocate the need for its protection.
- master core concepts and methods of ecological and physical sciences and their application in environmental problem solving.
- apply the theoretical knowledge in a simple practical assignment of digital manufacturing.
- demonstrate their understanding of the complex interactions of humans and ecological systems in the natural world.
- interpret the impact and necessity for environmental engineering, resource management, and sustainability conflicts from multiple perspectives.
- effectively analyze and integrate the social and natural sciences to understand diverse environmental and sustainability challenges ranging from local issues to global environments.
- demonstrate their proficiency in quantitative methods, qualitative analysis, critical thinking, and written and oral communication needed to conduct interdisciplinary work.

Content

The course "Introduction to Ecology" gives an overview and fundamental knowledge of ecology and the functioning of ecosystems and conveys an ecological perspective to sustainability. Principal concepts of ecology such as population growth, species interaction, biogeography, succession, natural cycles of matter, and biodiversity are discussed with regard to their relationship to the growth of human population, human impact on ecosystems and (un)sustainable use of resources. At the threshold between natural sciences and engineering, the complementary course part “Environmental Sciences” highlights ecological and technical solutions to human impact on the three environmental compartments: water, soil and air. The theoretical concepts are transferred into simple practical applications by introducing the students to the fundamentals of digital manufacturing with a focus on 3D printing, and the programming of sensors and actuators.

Teaching methods Lectures, seminaristic exercises and practical training with excursions
Entry requirements None
Types of assessment Graded examination, usually an examination with several components (written examination 70 points and assignment 30 points), details to be announced at the beginning of the semester by the Examination Board.
Requirements for the award of credit points Module examination grade 4.0 or better, successful participation in practical training
Use of module (in other study programs)
Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Kai J. Tiedemann
Additional information Literature: Reece, J.B. et al. (2008): Campbell Biology. 8th ed., San Francisco: Pearson. Boeker, E.; vanGrondelle, R. (2001): Environmental Science, Physical Principles and Applications. Chichester: Wiley. Gray, N.F. (2010): Water Technology: an Introduction for Environmental Scientists and Engineers. 3rd ed., Oxford: Elsevier. Grotzinger, J.; Jordan, T. (2010): Understanding Earth; Sixth Edition, W.H. Freeman and Company. McKinney, M. L.; Schoch, R. M.; Yonavjak, L. (2007): Environmental Science: Systems and Solutions. London: Jones and Bartlett. Raven, P.H.; Hassenzahl, D.M.; Berg, L.R. (2013): Environment. International Student Version, 8th ed., Singapore: Wiley. Townsend, C.R. (2008): Ecological Applications Towards a Sustainable World. Oxford: Blackwell. Townsend, C. R.; Begon, M.; Harper, J. L. (2008): Essentials of Ecology. Oxford: Wiley-Blackwell Publishing. Weathers, K.C.; Strayer, D.L.; Likens, G.E. (2013): Fundamentals of Ecosystem Science. London: Elsevier.

8114 Fundamentals of Biology and Natural Cycles of Matter

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8114	150 h	5 CP	1st semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture "Fundamentals of Biology": 30 TU / 2 SWS Exercises / Excursions "Fundamentals of Biology": 15 TU / 1 SWS Lecture "Geology and Natural Cycles of Matter": 15 TU / 1 SWS Exercises / Excursions "Geology and Natural Cycles of Matter": 15 TU / 1 SWS	75 TU / 5 SWS	93.75 h	50 students

Learning outcomes / Competences and qualifications profile

The module has provided an introduction to fundamentals of Biology and Earth's Sciences. Students have gained the ability to understand the scientific basics behind actual topics related to food- and environmental technology, the sustainable use of resources, gene technology and agriculture. In addition they have gained an understanding of both, basic properties of life such as energy processing, evolution and regulation, and the physical and chemical environment of organisms due to climate conditions and soil characteristics. Furthermore, the module has provided insight into important biogeochemical cycles such as the natural cycles of carbon and nitrogen.

Content

- Basics of bio-catalysis and regulation of enzyme activity
- Response to the environment: signal transduction and hormonal regulation
- Growth and development, reproduction, genetics and evolution
- Regulation of gene expression
- Photosynthesis, cellular respiration and the chemistry of life
- Carbon, N and P budgets of the ecosystem- and on a global scale
- Climate, climate zones and climate change
- Weathering and basics of soil science
- The geology of fossil fuels
- The internal structure of the earth and plate tectonics

Teaching methods

Lectures and practical training, excursions

Entry requirements

None

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.
Requirements for the award of credit points Module examination grade 4.0 or better
Use of module (in other study programs)
Weight towards final grade 3,125 %
Person in charge of module PD Prof. Dr. Ute Hansen
Additional information Literature: Campbell, Reece, Urry, Wassermann, Minorsky and Jackson, Biology, 11th edition, Pearson Lutgens, Tarbuck and Tasa, Essentials of Geology, 12th edition, Pearson Schlesinger and Bernhardt Biogeochemistry - An Analysis of Global Change, 3rd Edition, Academic Press (Elsevier) Schultz, Handbuch der Ökozonen, 1st edition, Ulmer Verlag, Stuttgart

8115 Physics: Mechanics, Electricity and Magnetism

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8115	300 h	10 CP	1st semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 60 TU / 4 SWS Exercise: 60 TU / 4 SWS	120 TU / 8 SWS	210 h	Exercises: 50 students

Learning outcomes / Competences and qualifications profile

This module has introduced students to key principles of Physics. Successful students are able to apply and use the physical concepts, laws and equations they have learned in advanced modules and their professional life. After passing this module students are able to describe simple motion mathematically, can decompose forces, and have a sound understanding of the physical concepts work, energy and power. Students have understood the principal of energy conservation and are able to solve given tasks concerning the topics mentioned above. They are also able to describe simple harmonic oscillation/waves, calculate the natural frequency of simple oscillating systems, have a sound understanding of period and wave length and are able to solve basic tasks including superpositioning of waves. Furthermore students know fundamental principles in the field of electricity and magnetism and understand simple electric circuits with passive components such as resistors, capacitors and inductors. They are also familiar with alternating current and have understood the principles of induction.

Content

- Physical quantities and units
- 1 D and 3D Motion
- Newton's laws ands forces
- Friction and drag forces
- Work, energy and power
- Linear momentum and collsisions
- Circular motion and angular momentum
- Oscillations and waves
- Electrical charges and Coulomb's law
- Electrostatic field, electrical flux and Gauss's law
- Electrostatic potential energy and electric potential
- Capacitance
- Electrical current, Ohm's law, resistance, electrical power
- Kirchhoff's laws
- Magnetism and sources of the magnetic field
- Magnetic circuits
- Induction
- Electrical RC and RL DC-Circuits
- AC Currents
- Power in AC systems and power adjustment
- Transformer

Teaching methods

Lectures and practical classes

Entry requirements None
Types of assessment Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.
Requirements for the award of credit points Module examination grade 4.0 or better
Use of module (in other study programs) Same module in "Environment and Energy, B.Sc." and "Communication and Information Engineering, B.Sc."
Weight towards final grade 6,25 %
Person in charge of module Prof. Dr. –Ing. Rolf Becker, Prof. Dr. Irmgard Buder
Additional information Literature: Tipler P.A.; Mosca G.: Physics for Scientists and Engineers. enlarged 6th edition; W.H. Freeman. Halliday D.; Resnick R.; Walker J.: Fundamentals of Physics. 9th Edition; Wiley, John & Sons. W.D. Stanley, J.R. Hackworth, R.L. Jones: Fundamentals of electrical engineering and technology", Delmar Cangage Learning, New York, 2007. Hambley, A.R.;Electrical Engineering: Principles and Applications; 5th Edition, Pearson. R. Kories, H. Schmidt-Walter: Electrical Engineering - A pocket reference, Springer, Berlin, 2003

8121 General and Inorganic Chemistry

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8121	150 h	5 CP	2nd semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture "Fundamentals of Chemistry": 30 TU / 2 SWS Exercises "Fundamentals of Chemistry": 15 TU / 1 SWS Practical Training "Introduction to Chemical Practice": 30 TU / 2 SWS	75 TU / 5 SWS	93.75 h	Lecture: open practical training: 2 x 25 students

Learning outcomes / Competences and qualifications profile

Upon completion of this course, students will be able to:

- describe an atom and atomic bonds according to contemporary models.
- predict the characteristics of a chemical reaction from the reactants' positions in the periodic table of elements.
- identify fundamental chemistry concepts (e.g. redox reactions, acid-base reactions) as driving forces in chemical reactions.
- master basic laboratory tools and procedures.
- know and apply safety rules relevant for chemical labs.
- write scientific reports including their experimental results.

Content

Lecture " Fundamentals of Chemistry":

- Atomic theory, atomic structure, types of bonds and stoichiometry
- Thermochemistry
- Ions and solutions
- Reaction kinetics and equilibria
- Acids and bases
- Electrochmistry

The practical course provides an introduction to basic lab techniques

- setting up a lab experiment
- application of different measurement techniques
- qualitative and quantitative analytics
- evaluation of the results gained by the performed experiments and writing lab protocols

Teaching methods

Lecture with exercises and practical lab trainings

Entry requirements

None

Types of assessment

Split exam according to examination rules: Certificate (Testat) and graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module exam grade 4.0 or better, successful participation in practical training

Use of module (in other study programs)

Weight towards final grade

3,125 %

Person in charge of module

Prof. Dr. Irmgard Buder

Additional information

Literature:
Housecroft, C. E.; Constable, E. C. (2009): Chemistry - an introduction to organic, inorganic and physical chemistry. Harlow: Pearson Prentice Hall.
Corwin, C. H. (2010): Introductory Chemistry: Concepts and Critical Thinking. Boston: Mass., Prentice Hall.
Mortimer, C. E.; Müller, U. (2010): Chemie - das Basiswissen der Chemie. Stuttgart: Thieme.
Corwin, C. H. (2009): Introductory Chemistry Laboratory Manual: Concepts & Connections. Upper Saddle River, NJ: Pearson Education.

8122 Evaluation of Ecosystems and Environmental Assessment

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8122	150 h	5 CP	2nd Semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 30 TU / 2 SWS Practicals: 45 TU / 3 SWS	75 TU / 5 SWS	93.75 h	Lecture: open Field- and laboratory practicals: 2 x 25 students

Learning outcomes / Competences and qualifications profile

Students have been introduced to fundamental methods of ecosystem evaluation and environmental assessment. They know methods to determine selected groups of species and relations between species composition of an ecosystem and abiotic factors including contaminants. Students are familiar with common assessment methods e.g. for terrestrial and/or aquatic ecosystems. Based on ecological field data, students can categorize the status of ecosystems and are able to make decisions taking site-specific or ecosystem-specific parameters into account. They have practiced sampling and analytical techniques, the writing of scientific protocols, the interpretation of ecological field data and the use of assessment criteria.

Content

The lecture will provide an introduction to fundamentals of evaluation of ecosystems:

- Components of ecosystems, value of ecosystem services e.g. in soil, assessment of biodiversity
- Concepts for the evaluation of ecosystems and environmental assessment, assessment criteria and indicators
- Case examples of evaluation of ecosystems and environmental assessment
- Decision making based on both scientific data and consensus-driven assessment criteria

Field- and laboratory practicals will impart practical knowledge on taxonomical and analytical methods as well as methods of data interpretation like:

- Methods of ecological assessment and assessment of anthropogenic impact
- Indicator species in assessing ecosystem status
- Tools for environmental assessment (such as diversity-based indices; spreadsheet/program tools linking frequency and indicator values)

Teaching methods

Lectures, field- and laboratory practicals

Entry requirements

Completion of the following modules is recommended:
“EE_1.06 Introduction to Ecology and Environmental Sciences”
“EE_1.07 Fundamentals of Biology and Natural Cycles of Matter”

Types of assessment Split exam according to examination rules: Certificate (Testat) and graded examination, usually an examination with several components (written examination 45 points and term paper 45 points), details to be announced at the beginning of the semester by the Examination Board.
Requirements for the award of credit points Protocols and or poster presentation of practical results, module examination grade 4.0 or better
Use of module (in other study programs)
Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Daniela Lud
Additional information Literature: Chapin F.S.III, Matson P.A., Vitousek P.M. (2011) Principles of Terrestrial Ecosystem Ecology. Springer K. Grunewald, O. Bastian (2015), Ecosystem Services – Concept, Methods and Case Studies. Springer Reid W.V.; Berkes F.; Wilbanks T., Capistrano D. eds. (2006): Bridging scales and knowledge systems. Concepts and applications in ecosystem assessment. Island Press. Rutgers M. & Jensen J. (2011) Site specific ecological risk assessment in F.A. Swartjes (ed.), Dealing with Contaminated Sites From Theory towards Practical Application. Springer Suter, G.W. (2006): Ecological risk assessment. CRC Press Wildi, O. (2013): Data analysis in vegetation ecology. Wiley-Blackwell

8123 Physics: Thermodynamics, Radiation and Heat Transfer

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8123	150 h	5 CP	2nd semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 30 TU / 2 SWS Exercise: 30 TU / 2 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

After having passed this module, students understand the potential of solar irradiance as a source of renewable energy systems. They know about heat transfer in various forms and are able to quantify heat conductance through construction elements of buildings. They are familiar with basic thermodynamic principles and their applications in thermal machines related to energy generation and conversion.

Content

- Solar spectral irradiance and radiation laws
- Atmospheric window and absorption, introduction to molecular spectra (vs. atomic spectra)
- Radiation budget and greenhouse effects
- Heat transfer by radiation, conduction and convection
- Thermal condutance in composit construction elements such as walls
- Thermodynamics of ideal gas
- Phase changes and latent heat with real gas and vapour
- Fundamental laws of thermodynamics
- Thermodynamic cycles: Carnot, Stirling, Rankine, Otto
- Thermodynamics and efficiency of tech. systems: heat pump, refrigerator, steam turbine, combustion engine

Teaching methods

Dialog oriented, seminaristic lectures with exercises
Students´ presentations

Entry requirements

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)

Weight towards final grade 3,125 %
Person in charge of module Prof. Dr.-Ing. Rolf Becker
Additional information Literature:Çengel, Y. A.; Boles, M.A.: Thermodynamics - an engineering approach

8124 Linear Algebra und Graph Theory

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8124	150 h	5 CP	2nd semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 30 TU / 2 SWS Excercise: 30 TU / 2 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

This lecture has introduced students to mathematical methods of linear algebra and the basics of graph theory needed to solve technical and operational problems.
Based on selected examples out of sciences and engineering, students will are able to solve technical problems applying mathematical tools.

Content

- Introduction of vectors, simple vector operations
- Scalar product, vector product
- Linear dependence of vectors, linear combinations of vectors
- Vector spaces and subspaces
- Matrices and matrix operations (addition, multiplication, matrix product, determinant of a matrix)
- Inverse of a matrix and procedures to find it
- Linear equation systems
- Procedures to solve linear equation systems (Gauss algorithm, adjoin method, Cramer rule)
- Applications in Chemistry and Physics

Teaching methods

Tuition in seminars, lectures and practical classes

Entry requirements

None

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)

Same module in "Environment and Energy, B.Sc.", "Communication and Information Engineering, B.Sc./Infotronic Systems Engineering B.Sc." and "Mobility and Logistics, B.Sc."

Weight towards final grade

3,125 %
Person in charge of module Prof. Dr. Petra Blitgen-Heinecke
Additional information Literature: Horst Chmiel (2011) Bioprozesstechnik, Heidelberg, Spektrum Akademischer Verlag, Ricardo Simpson, Sudhir K. Sastry (2013) Chemical and Bioprocess Engineering, NY, Springer Verlag, Behr, D.W. Agar, J. Jörissen (2010) Einführung in die Technische Chemie, Heidelberg, Spektrum Akademischer Verlag.

8125 Fundamentals of Scientific Programming

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8125	150 h	5 CP	2nd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 45 TU / 3 SWS Excercise: 15 TU / 1 SWS	60 TU / 4 SWS	105 h	45 students

Learning outcomes / Competences and qualifications profile

This module has introduced students to key principles of scientific programming. Successful students have understood the importance of programming in environmental sciences. They are familiar with the fundamental principles and different programming paradigms. They show proficiency in identifying and formulating problems and are able to solve them by developing their own software. They are able to solve simple data conversion, analysis and modeling problems. They know about the basic principles of digital data processing and show basic knowledge of how hardware and software are related.

Content

- Examples for today's use of computers and embedded systems in environmental sciences
- Introduction to pure imperative as well as object oriented programming
- Basic principles: numeral systems, representation of numbers and text, Boolean algebra
- Solving simple numerical problems (e.g. integration, differentiation, interpolation)
- Linking software and hardware for environmental science applications

Teaching methods

Tuition in seminars, lectures and practical classes

Entry requirements

None

Types of assessment

Graded examination, usually an examination with several components (written examination 70 points and project work 30 points), details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)

None

Weight towards final grade

3,125 %

Person in charge of module

Prof. Dr.-Ing. Rolf Becker
Additional information Literature: Langtangen, H.P. (2016) A Primer on Scientific Programming with Python. Heidelberg, Berlin, Springer, 10.1007/978-3-662-49887-3 Billo, E. J. (2007) Excel for Scientists and Engineers, Hoboken, New Jersey, John Wiley Sons Inc.

8126 Statistics and Data Processing

Code	Workload	Credits	Level of module	Frequency of offer	Duration
EE_3.03	150 h	5 CP	2nd semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture "Statistics": 45 TU / 3 SWS Exercises "Statistics": 30 TU / 2 SWS	75 TU / 5 SWS	93.75 h	Lecture: open Practical training: 2 x 25 students

Learning outcomes / Competences and qualifications profile

This module has provided an introduction to descriptive statistics and statistical inference. Students who have completed this module successfully have gained a good grounding in practical data analysis. They are able to explain and apply the basic concepts and techniques in descriptive statistics as well as of statistical testing and estimation. Students are skilled in interpreting and communicating the results of a statistical analysis in the context of an environmental or technical problem.

Content

Probability:

- Random phenomena (Probability experiments and events)
- Probability rules
- Conditional probabilities (Bayes-Theorem)
- Combinatorics (Counting techniques)
- Random variables (Discrete und continuous)
- Expected value and variance
- Discrete and continuous probability distributions

Statistics :

- Descriptive statistics and correlation analysis:
  - Basic concepts (Levels of measurement, univariate data, bivariate data)
  - Sampling and data collection
  - Graphical and numerical summaries
  - Frequency distributions
  - Measures of central tendency, measures of position, measures of dispersion
  - Grouped data
  - Covariance, correlation, regression
- Inferential statistics:
  - Sampling distribution of a sample mean
  - Sampling distribution of a sample proportion
  - Point estimates, interval estimates, confidence intervals
  - Hypothesis tests

Teaching methods

Lecture and Exercises. The course will be carried out in a seminar-like, interactive manner. The impartation of statistical concepts will be supported by the integration of relevant applied examples.

Entry requirements

Completion of the following modules is recommended:

- "Mathematics: Analysis and Discrete Mathematics"
- "Linear Algebra and Graph Theory"

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)

Lecture and exercises are open to students of "Environment and Energy", "International Business Administration" and "Mobility and Logistics".

Weight towards final grade

3,125 %

Person in charge of module

Dipl.-Biol. Ralf Darius

Additional information

Literature:
Johnson R.; Kuby P. (2008): Elementary Statistics. Tenth Edition, Brooks/Cole.
Michael S. (2005): Fundamentals of Statistics. 3rd Edition, San Francisco: Pearson Education

8131 Organic Chemistry and Analytical Chemistry

8131	**Workload** 150 h	**Credits** 5 CP	**Level of module** 3rd semester	**Frequency of offer** Winter semester	**Duration** 1 semester
Courses Lecture "Fundamentals of Organic Chemistry": 30 TU / 2 SWS Practicals "Applied Organic Chemistry" and "Environmental Analytical Chemistry": 45 TU / 3 SWS		**Teaching time** 75 TU / 5 SWS	**Self-study** 93.75 h		**Planned group size** Lecture: open Practicals: 2 x 25 students

Learning outcomes / Competences and qualifications profile

Students have acquired a basic understanding of the structure of organic molecules and the relation between structural properties and physical-chemical properties. They know and can apply basic equations of environmental partitioning and transport as well as basic rules on how physical-chemical properties influence the environmental fate of organic chemicals. Students know and can describe the most important groups of organic contaminants.
They got an insight into symbols and applicable safety rules for hazardous substances which are used during the experiments. Students have learned to work safely in a laboratory. They have developed skills to set up and conduct simple chemical experiments and are skilled in applying analytical techniques such as chromatography and photometry. They have also practised scientific documentation, evaluation of analytical results and the interpretation of experiments and analytical results.

Content

Lecture " Fundamentals of Organic Chemistry":

- General properties of organic chemicals (structure, formula, bonding, functional groups, nomenclature)
- Fundamentals of environmental fate of organic chemicals (partitioning, transport, transformation)
- Environmental fate of selected organic chemicals (petroleum hydrocarbons, benzene and related compounds, polycyclic aromatic hydrocarbons, organohalogens, persistent organic pollutants)

Practicals "Applied Organic Chemistry" and "Environmental Analytical Chemistry":

- Physical chemical properties of organic chemicals e.g. flashpoint of petroleum hydrocarbons, reactions and properties of polymers
- Basic sampling techniques of environmental samples (e.g. air, soil, water)
- Extraction of chemicals from environmental samples and analysis
- Fundamentals of analytical methods applied (e.g. bioassays, chromatography, photometry)

Teaching methods

Lectures, laboratory practicals

Entry requirements

Completion of the module "General and Inorganic Chemistry" is recommended

Types of assessment Split exam according to examination rules: Certificate (Testat) and graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.
Requirements for the award of credit points Protocols and or posters of practical experiments; Module examination grade 4.0 or better
Use of module (in other study programs)
Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Daniela Lud
Additional information Literature: Manahan, S. E. (2010): Environmental Chemistry. Boca Raton: CRC Press. Mortimer, C. E. (1986): Chemistry. Belmont, California: Wadsworth Publishing. Mortimer, C. E.; Müller, U. (2010): Das Basiswissen der Chemie. Stuttgart: Thieme. Schwarzbauer, J., Jovančićević, B. (2018) Fate and Assessment Organic Pollutants in the Geosphere, Fundamentals in Organic Geochemistry, Cham: Springer. Schwarzenbach, R. P.; Gschwend, P. M.; ImbodenD. M. (2003): Environmental Organic Chemistry. Hoboken, New Jersey: Wiley. Housecroft, C. E.; Constable, E. C. (2009): Chemistry - an introduction to organic, inorganic and physical chemistry. Harlow: Pearson Prentice Hall.

8132 Energy Technology

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8132	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 30 TU/ 2 SWS Exercises: 30 TU/2 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

Having passed this module, students have gained a sound technical knowledge and critical thinking about energy technology with emphasis on renewable energy systems. They are able to assess the environmental and economic impact of different approaches. They understand the basic physical principles and overall technical design of energy systems. This encompasses electrical energy generation as well as distribution. Students are able to discuss the assets and drawbacks of alternative technologies and consider scalability and transferability to other use cases and regional conditions.

Content

Lecture with exercises

- Energy sources for Germany and worldwide
- Photovoltaic (PV) energy systems
- Solar thermal collectors
- Concentrated solar power plants
- Wind turbines, physical fundamentals
- Hydro power turbines, physical fundamentals
- Heat pumps
- Alternating and direct current
- Power grids, high voltage DC transmission
- Electrical generators
- Energy storage and their application for grid stabilization, load shift and peak leveling

Teaching methods

Dialog oriented, seminaristic lectures with exercises

Entry requirements

Completion of EE_1.02 “Fundamentals of Energy Management and Technology” and EE_1.08 Physics: “Mechanics, Electricity and Magnetism” is recommended.

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)
Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Irmgard Buder
Additional information Literature: Volker Quaschning (2010) Understanding renewable energy systems. Earthscan J. Twidell, T. Weir (2006) Renewable Energy Resources, Second Ed. Taylor & Francis London and New York Robert Gasch, Jochen Twele (Eds.), (2012) Wind Power Plants - Fundamentals, Design, Construction and Operation, Springer Heidelberg, London, Dordrecht and New York

8133 Fundamentals of Business Administration

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8133	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 30 TU / 2 SWS Exercise: 30 TU / 2 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

Students are introduced to the fundamental market forces, to the calculatory approach in profit maximization and to welfare theory. They have gained an understanding of the fundamental concepts of strategic management, investment and finance, to decision, utility and game theory. They have a good grasp of important terms, concepts, and methods and are able to apply them to real-life problems from a micro- and macroeconomic perspective. They have discussed the impacts of globalization and can describe its influence on business processes.

Content

- FORMIntroduction to key concepts in economics and business administration
- How markets work
- Cost of production
- Utility and game theory
- Investment and finance
- Strategic management
- Gross Domestic Product, inflation and Consumer Price Index

Teaching methods

FORMTEXT Lectures, accompanied by exercises with case studies and problems

Entry requirements

None

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)

Weight towards final grade

3,125 %

Person in charge of module

Prof. Dr. Kai J. Tiedemann

Additional information

Literature:

Mankiw, N.G. (2011): Essentials of economics. 6th ed., Mason (Ohio): South-Western.
Gamble, J.E.; Thompson, A. A. (2011): Essentials of Strategic Management. The Quest for Competitive Advantage. 2nd edition. New York: McGraw-Hill.
Hill, C. W. L. (2009): International Business. Competing in the Global Marketplace. 7th edition. New York: McGraw-Hill.
Kotler, P.; Armstrong, G. (2010): Principles of Marketing. 13th edition. Upper Saddle River: Pearson Prentice Hall.
Luthans, F.; Doh, J. P. (2009): International Management. Culture, Strategy, and Behavior. 7th edition. New York: McGraw-Hill.
Robbins, S. P.; DeCenzo, D. A.; Coulter, M. (2011): Fundamentals of Management. Essential Concepts and Applications. 7th edition. Upper Saddle River: Pearson Prentice Hall.
Slack, N.; Chambers, S.; Johnston, R. (2010): Operations Management. 6th edition. Harlow: Pearson Prentice Hall.

8134 Project Management and Intercultural Competence

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8134	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 30 TU / 2 SWS Exercise: 30 TU / 2 SWS	60 TU / 4 SWS	105 h	Lecture: 50 Exercise: 2x25 students

Learning outcomes / Competences and qualifications profile

Upon successful completion of the course students have gained insight into key principles of project management and the importance of related skills in today´s world. They are able to apply the specific terminology and to plan, schedule, control and conduct projects. Participants have improved their skills related to the development of project proposals. They further have experienced the dynamics of team work in projects and have gained some routine in presenting and communicating results. They have also gained valuable knowledge of the advantages and challenges of working in a multicultural environment.

Content

- Terminology of project management and project management methodology
- Definition of a project, discussion of the scope document
- Development of a project flow chart and network plan
- Scheduling of a project
- Principles of creating, leading, and managing a project team, managing resources, monitoring the project performance and managing risks
- Alternative methodologies of project management and specifics of international projects
- The challenge of working in a multicultural environment
- Presentation of a project proposal developed by the project team (use of presentation software, gaining experience in organizing the work within the team)

Teaching methods

Lectures, accompanied by exercises in which students develop their own project proposals.

Entry requirements

None

Types of assessment

Certificate (Testat)

Requirements for the award of credit points

Development of a project plan, final presentation and report

Use of module (in other study programs)

Same module in "Environment and Energy, B.Sc.", "Communication and Information Engineering, B.Sc." and "Mobility and Logistics, B.Sc."
Weight towards final grade None (ungraded)
Person in charge of module PD Prof. Dr. Ute Hansen, Prof. Dr. Petra Blitgen-Heinecke
Additional information Literature: Larson, E.W., Gray, C.F. (2011) Project Management. The Managerial Process. 5th edition. New York: McGraw-Hill. Hillson, D. (2009): Managing Risk in Projects. Farnham; Burlington: Gower.

8135 Microbiology

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8135	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture "Introduction to Microbiology": 30 TU / 2 SWS Practical training "Applied Environmental Microbiology": 30 TU / 2 SWS	60 TU / 4 SWS	105 h	50 students Practicals: 2 x 25 students

Learning outcomes / Competences and qualifications profile

Upon completion of this module students will have gained basic knowledge of
- the anatomy, the metabolism and the physiology of various types of microorganisms.
- microbial growth and the control of microbial growth.
- the methods used to classify and identify microorganisms using microscopy and differential staining.
- the qualitative and quantitative determination of various microorganisms in fresh water samples.

They will have applied their knowledge on all these topics in practical lab work.
Students will have gained knowledge on scientific basics and techniques in biotechnology and microbial genetics. They will be able to understand the important roles microorganisms play in ecosystems where they act as destruents, symbionts and pathogens, and their important role in environmental remediation.
Students will have performed lab work, and will have a good knowledge of basic laboratory methods, the writing of scientific protocols and the interpretation of experimental results.

Content

Lecture:
- Prokaryotic and eukaryotic cells
- Microbial metabolism, growth and control of microbial growth
- The classification of microorganisms
- Environmental microbiology
- Applied and industrial microbiology
- Biotechnology and recombinant DNA
- Microbial mechanism of pathogenicity and host defence

Practical lab training:
- Laboratory safety and basic laboratory techniques
- Isolation and cultivation of microorganisms
- Nutritional requirements, physical factors and chemical control agents
- Methods to determine the amount of bacteria in a culture, bacterial growth
- Microscopy and bacterial staining
- Microbiology of soil and water
- Introduction to molecular genetics

Teaching methods

Lecture; Laboratory practicals

Entry requirements

None

Types of assessment Split exam according to examination rules: Certificate (Testat) and graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.
Requirements for the award of credit points Group protocols of laboratory practicals; Module examination grade 4.0 or better
Use of module (in other study programs)
Weight towards final grade 3,125 %
Person in charge of module PD Prof. Dr. Ute Hansen
Additional information Literature: Tortora G.J., Funke B.R., Case C.L. (2010): Microbiology An Introduction. 10th Edition. San Francisco: Pearson Education, INC., publishing as Pearson Benjamin Cummings. Campell, N.A. et al. (2008): Biology. 8th Edition. San Francisco: Pearson Education, INC., publishing as Pearson Benjamin Cummings. Cappuccino, J.G., Sherman N. (2011): Microbiology A Laboratory Manual. 9th Edition. San Francisco: Pearson Education, INC., publishing as Pearson Benjamin Cummings. Fuchs G. (2007): Allgemeine Mikrobiologie. 8. Auflage.Stuttgart: Thieme.

8136 Fundamentals of Geodata Management Systems

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8136	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 30 TU/ 2 SWS Exercises: 30 TU/ 2 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

Having passed this course students are able to describe the fundamental concepts of Geographic Information Science and Technology. Students have demonstrated proficiency in the basic functions of geospatial software including map creation, map projection and spatial analysis. They understand the potential of geospatial data related web services. They know the concept of geospatial databases and have gained experience in using relational databases for storing attribute data. Students are able to create own spatial data and to integrate real-time sensor data. They are aware of fundamental remote sensing and related spatial analysis techniques and can create scripts to automate geospatial data processing.

Content

- Motivation for Geographic Information Systems (GIS)
- Data types
- Layers and mapping
- Spatial analysis
- Coordinate systems and geo-rectification
- Geodatabases
- Web services
- Real-time sensor data integration
- Simple processing of remote sensing data
- Scripting for automated processing

Teaching methods

Dialog oriented, seminaristic lectures with exercises
Hands-on training in computer lab
Students' presentations

Entry requirements

None

Types of assessment

Graded examination, usually a project work, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)

Weight towards final grade 3,125 %
Person in charge of module Prof. Dr.-Ing. Rolf Becker
Additional information

8141 Resource Management and Environmental Health

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8141	150 h	5 CP	4th semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture "Water Cycle and Water Management": 30 TU / 2 SWS Exercises with field practical "Water Cycle and Water Management": 15 TU / 1 SWS Lecture "Toxicology and Environmental Health": 30 TU / 2 SWS Exercise "Resource and Risk Management": 15 TU / 1 SWS	90 TU / 6 SWS	82.50 h	Lectures: open Exercises: 2 x 25 students

Learning outcomes / Competences and qualifications profile

Upon completion of this course, students will be able to:

- explain the elements of the water cycle and water catchment management.
- value water as a scarce resource and improve community understanding of the importance of conserving water resources.
- master fundamental laws and equations in hydrology and their application in typical water management situations.
- outline and compute the key elements of irrigation and drainage systems.
- identify the most important procedures of water treatment and purification and appreciate their importance with regard to possible toxicological impacts on human population.
- know and understand basic concepts of toxicology, environmental health and risk management.
- describe anthropogenic impacts on natural resources and environmental health.
- describe and apply selected risk assessment methods.
- use conceptional site models as a tool in risk management to evaluate and manage potential environmental hazards from the exposure to toxic substances.
- understand the interactions of chemical, biological, technical and socioeconomic factors of environmental health.
- evaluate and manage potential environmental hazards caused by the exposure to toxic substances.

Content

This module explains relevant background information for the management of environmental resources and the implications for environmental health. Based on the fundamental knowledge about the properties of water and hydrological concepts, the lecture introduces key technologies for water production, purification and treatment as well as the use of water for irrigation and integrated management concepts for river basins. The scope of water management cannot be fully appreciated without further insights into the complexity of other resources' management and the potential risks that arise for water quality.
For the evaluation of risks for environmental resources, the module outlines processes and methods in toxicology, epidemiology and environmental health. Major global and regional environmental health issues will

be introduced covering biological, chemical and physical agents and their effects on health. Based on fundamental concepts of toxicology and dose-response mechanisms, current methods of risk assessment will be introduced. The use of conceptual models based on the source-receptor-pathway concept will be explained. The lecture will highlight the use of conceptual models for stakeholder participation in risk assessment and risk management processes with a special focus on the consequences of climate change.

Teaching methods

Lectures and practical trainings with workgroup exercises, field practical

Entry requirements

None

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better, successful participation in exercises

Use of module (in other study programs)

Weight towards final grade

3,125 %

Person in charge of module

Prof. Dr. Daniela Lud, PD Prof. Dr. Ute Hansen, Prof. Dr. Kai J. Tiedemann

Additional information

Literature:

Asano, T. (2007): Water Reuse: Issues, Technologies, and Applications. New York: McGraw-Hill.
Brutsaert, W. (2005): Hydrology - an Introduction. Cambridge: Cambridge University Press.
Davis, M. L.; Cornwell, D. A. (2008): Introduction to Environmental Engineering. Boston: McGraw-Hill.
Hornberger, G. M. (1998): Elements of Physical Hydrology. Baltimore, Md.: Johns Hopkins Univ. Press.
Friis, R.H. (2012): Essentials of Environmental Health. London: Jones and Bartlett Publishers.
Frumkin, H. (2010): Environmental Health: From Global to Local. San Francisco: Jossey-Bass.
Gray, N. F. (2010): Water Technology - an Introduction for Environmental Scientists and Engineers. Oxford: Elsevier Butterworth-Heinemann.
Plant, J. A. et al (2013) Pollutants, Human Health and the Environment A Risk Based Approach. Chichester: Wiley-Blackwell.
Selinus, O. (2013): Essentials of Medical Geology: Revised Edition. Dordrecht: Springer
Smith, S. W. (1997): Landscape Irrigation - Design and Management. New York: Wiley.
Reece, J.B. et al. (2011) Campbell Biology, 9th ed., Pearson
Botkin, D.B., Keller, E.A. (2012) Environmental Science, 8th ed., John Wiley & Sons Inc.
Schlesinger, W. H. Bernhardt E. S. (2013) Biogeochemistry, Elsevier.

8142 Applied Measurement and Control

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8142	150 h	5 CP	4th semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 30 TU / 2 SWS Exercise: 30 TU /2 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

- This course follows an application based approach for measurement and control systems in the field of environment and energy. Having completed this course, students are able to programme simple embedded systems with sensors and actuators and to build their own environmental monitoring systems (hard- and software). They understand fundamental physical measuring principles of different sensors and are able to consider spatiotemporal scales of environmental processes.

Content

- Programming embedded systems for environmental sciences
- Fundamentals of embedded systems and their peripherals
- Linking software and hardware
- Analog and digital signals and interfaces
- Serial communication
- Basic principles of sensors and transducers and their application
- Fundamentals of signal conditioning and processing
- Sampling, transmission and storage of data
- Realizing data loggers with external sensors
- Environmental variables and the spatiotemporal characteristics of the underlying processes
- Simple control systems with sensors and actuators

Teaching methods

Dialog oriented, seminaristic lectures with exercises, project work

Entry requirements

None

Types of assessment

Graded examination, usually a project work, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)

Weight towards final grade 3,125 %
Person in charge of module Prof. Dr.-Ing. Rolf Becker
Additional information

8143 Legal Fundamentals

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8143	150 h	5 CP	4th semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture with exercises "Civil Law": 30 TU / 2 SWS Lecture "Environmental Law and Regulations": 15 TU / 1 SWS Lecture "Audits and Certification": 15 TU / 1 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

Upon completion of this course, students will be able to:

- demonstrate current and integrated knowledge and understanding of key concepts in civil and environmental law (with a strong focus on environmental law) and its development in Germany and the EU, the nature of the legal controls over environmental pollution, the operation of environmental regulation and various enforcement mechanisms.
- recognise the issues involved in the implementation and enforcement of environmental law.
- analyse and apply such knowledge to identify and critically evaluate appropriate regulatory and enforcement strategies.
- identify, research (from a variety of sources) and analyse issues in environmental law, producing a persuasive, coherent and critical evaluation.
- understand the application of the principles, procedures and techniques of auditing and certification in the environmental field.

Content

Companies in European countries such as Germany are faced with numerous environmental laws and regulations, which can affect the company's core activities, materials flows, planning processes and environmental policy. Compliance and auditing procedures for the certification of environmental and quality standards continuously grow in importance even for small and medium-sized companies and can be a tool to enhance the sustainability of the company's processes. This development not only invites our graduates to understand the meaning of these certifications but may also provide employment opportunities. In an ambience of strong dynamics such as environmental and energy engineering, however, it does not suffice to merely receive a list of relevant procedures and regulations to consider. This module therefore intends to give students a general understanding of the process of legislation and its corresponding implications with particular focus on environmental law in Germany and the European Union.

Teaching methods

Lecture with exercises in workgroups

Entry requirements

None

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.
Requirements for the award of credit points Module examination grade 4.0 or better
Use of module (in other study programs)
Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Daniela Lud; PD Prof. Dr. Ute Hansen
Additional information Literature: Camilleri, M.A. (2017) Corporate Sustainability, Social Responsibility and Environmental Management. Cham: Springer . Center for Chemical Process Safety (2011) Guidelines for Auditing Process Safety Management Systems. Hoboken, NJ: Wiley. Förtsch G.; Meinholz H. (2018) Handbuch Betriebliches Umweltmanagement. Cham: Springer. Makuch K. Pereira R. (2012) Environmental and Energy Law. Wiley-Blackwell. Nakanishi, Y. (2018). Environmental Law. In: Brinkmann, R., Garren, S. (eds) The Palgrave Handbook of Sustainability. Cham: Palgrave Macmillan. Thumann, A.; Younger, W. J.; Niehus, T. (2010): Handbook of Energy Audits. Lilburn, GA: Fairmont Press. Selected legal texts, selected texts of standards related to environment and energy

8144 Entrepreneurship

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8144	150 h	5 CP	4th semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 45 TU / 3 SWS Exercises: 15 TU / 1 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

Upon completion of this course, students will.

- be able to assess the commercial viability of a product and the feasibility of a business idea.
- be prepared to manage people, processes and resources within a start-up enterprise.
- be able to formulate an effective business plan.
- understand the potential pitfalls within the process of setting up a business and will be able to avoid them.
- be prepared to communicate a business idea convincingly and time-efficiently.
- be able to develop strategies for lasting success of their business and for their success as entrepreneurs.

Content

The main focus of the module is on the process of transforming the idea of a new development or the concept of a business into viable products and services on commercial markets. In order to do so, participants will have developed an understanding of the various functional domains of this process. They will have learned how to identify and the assess business opportunities and will have been introduced to the steps which are necessary to successfully start a business and operat it in the long run - such as a market analysis, aquisition of human and financial resources, and the formulation of an effective business plan. The course will have also given an insight into the options regarding the legal form of a business, their respective consequences and some guidelines towards lasting success and exit strategies for entrepreneurs.

Teaching methods

The course is mainly tought in seminaristic lectures. These will be accompanied by group works, student presentations and, if possible, also PC sessions to demonstrate business planning in excel.

Entry requirements

Completion of the module "Fundamentals of Business Administration" is recommended.

Types of assessment

Graded examination, usually a project work, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)

Same module in "Environment and Energy, B.Sc." and "Information and Communication Design, B.A."

Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Kai J. Tiedemann
Additional information Literature: Baron, R. A. & Shane, S. A. (2008): Entrepreneurship - A Process Perspective. International student edition, 2nd ed., Mason OH: Cengage (Primary Text). Bragg, S. M. (2011): Bookkeeping Essentials. Hoboken NJ: Wiley & Sons. Bygrave, W. & Zacharakis, A. (2011): Entrepreneurship. 2nd ed., Hoboken NJ: Wiley & Sons. Harvard Business School Press (ed. 2007): Creating a Business Plan: Expert Solutions to Everyday Challenges. Boston MA: Harvard Business School Press. Morris, M. (2008): Starting a Successful Business: Start Up and Grow Your Own Company (Starting a Successful Business: Start Up & Grow Your Own Company). London: Kogan Page. Powers, M.; Needles, B. E. & Crosson, S. V. (2010): Financial and Managerial Accounting Principles. 9th ed. Andover: Cengage Learning EMEA.

8151 Remediation and Redevelopment

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8151	150 h	5 CP	5th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture "Remediation Procedures and Techniques": 30 TU / 2 SWS Exercises "Remediation Procedures and Techniques": 15 TU / 1 SWS Lecture "Sustainable Architecture and Redevelopment": 30 TU / 2 SWS	75 TU / 5 SWS	93.75 h	Lecture: open Exercises: 2 x 25 students

Learning outcomes / Competences and qualifications profile

Upon completion of the course students will be able to:

- explain typical combinations of anthropogenic activities and soil and groundwater contaminations.
- apply fundamental equations concerning contaminant transport in soil and groundwater to typical groundwater contamination situations.
- conceptualize and calculate the basic elements of simple groundwater remediation systems.
- describe and categorize the basic approaches of groundwater remediation and name basic advantages and disadvantages with regard to cost, risk-reduction and environmental footprint of these basic approaches.
- understand the role of remediation in redevelopment processes of contaminated land management.
- understand current global and European developments with regard to urbanization and sustainable cities.
- understand current municipal climate adaptation processes (urban form, community design, economic viability, energy, mobility).
- understand concepts of smart cities and built environments of the future.

Content

This module provides relevant background information for a basic understanding of remediation and mitigation of the human impact on the environment with a special focus on soil and groundwater remediation and the design of sustainable solutions for redevelopment of contaminated sites. Based on the knowledge about the fundamental processes of contaminant behavior and transport in soil and groundwater, the lecture provides an insight into basic remediation concepts. The lecture introduces key technologies for containment or in-situ or ex-situ treatment and provides an insight into the advantages and disadvantages of the technical approaches. Methods for the valuation of different approaches are introduced. The lecture on sustainable architecture and redevelopment provides relevant background information on sustainable built environments (design of healthy and sustainable communities, urban concepts for energy, viability and mobility, municipal climate change adaptation).

Teaching methods

Lectures and practical training with practical cases and exercises

Entry requirements

None

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better, successful participation in exercises

Use of module (in other study programs)

Weight towards final grade

3,125 %

Person in charge of module

Prof. Dr. Daniela Lud

Additional information

Literature:

Blum, W.E.H. (2016). Role of Soils for Satisfying Global Demands for Food, Water, and Bioenergy. In: Hettiarachchi, H., Ardakanian, R. (eds) Environmental Resource Management and the Nexus Approach. Springer.
Dannenberg, A.L.; Frumkin, H.; Jackson R. J. (2011) Making Healthy Places Designing and Building for Health, Well-being, and Sustainability. Island Press
Dixon, T.; Raco, M.; Catney, P.; Lerner, D.N. (2007): Sustainable Brownfield Regeneration: Liveable Places from Problem Spaces. Blackwell Publishing.
Heilmann, A.; Pundt H. (2016) Kommunale Anpassung an die Folgen des Klimawandels als Komponente einer Nachhaltigen Entwicklung. In Walter Leal Filho (ed.) Forschung für Nachhaltigkeit an deutschen Hochschulen pp 223-244. Springer
Keijzer, Th. J. S.; Pijls, C.; Marnette, E.; Sumann, M.; Volkering, F.; van Zutphen, M. (2006): In-situ soil and groundwater remediation: theory and practice. Deventer: Tauw bv.
Kitanidis, P.K. and McCarty P.L. (2012) Delivery and Mixing in the Subsurface Processes and Design Principles for In Situ Remediation. Springer
Swartjes, F.A. (2011): Dealing with Contaminated Sites: From Theory Towards Practical Application. Springer.
Wilke F. (2012) Planning. In: Kresse, W. and Dank D. M. (eds.) Springer Handbook of Geographic Information. Springer

8152 Process Engineering

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8152	150 h	5 CP	5th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture with exercises “Chemical engineering, Bioengineering, Local feedstocks” 75 TU / 5 SWS	75 h / 5 SWS	93.75 h	50 students

Learning outcomes / Competences and qualifications profile

Upon successful participation, students will be familiar with the basics of chemical and bioprocess engineering. They will have got an insight into different challenges in the fields of chemical and bioengineering and will have gained an overview of the most important chemical and biochemical processes in industry. They will be able to solve simple problems of mass and energy transfer in chemical and biochemical plants. Based upon that knowledge, they will be able to estimate the sustainability of processes.

Content

- Introduction to chemical engineering, important chemical processes
- Introduction to bioengineering: brief history of biotechnology
- Chemical and biocatalysis (enzyme kinetics, enantioselectivity)
- Reactor types in chemical and bioengineering
- Process design
- Immobilization of microorganisms and enzymes
- Mass conservation
- Energy conservation
- Separation and purification
- Downstreaming, examples
- New developments in biotechnology (solvents, biphasic reactors)

Teaching methods

Dialog oriented, seminaristic lectures with exercises

Students´ presentations

Entry requirements

None

Types of assessment

Graded examination, usually a written examination, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)
Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Blitgen-Heinecke
Additional information Literature: Horst Chmiel, Bioprozesstechnik, Spektrum Akademischer Verlag, 3. Auflage, 2011. Ricardo Simpson, Sudhir K. Sastry, Chemical and Bioprocess Engineering, Springer Verlag, NY, 2013. Behr, D.W. Agar, J. Jörissen, Einführung in die Technische Chemie, Spektrum Akademischer Verlag, Heidelberg 2010.

8009 Interdisciplinary Project

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8009	300 h	10 CP	5th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Project	90 TU / 6 SWS	232.50 h	open

Learning outcomes / Competences and qualifications profile

In this module students have expanded and deepened the knowledge and skills they have acquired in previous projects and modules. The interdisciplinary character of the project encourages students to discover new topics and gather practical experiences in different fields. Completing this course students have developed the following competencies:

- work scientifically and independently in a team
- manage complex projects
- apply multidisciplinary approaches to develop convincing solutions
- present their results in a scientific way, for example in an oral presentation, poster session or a report

Content

The content in the fields of environment, energy and sustainable development differs between projects, depending on the degree programmes which are involved and the teaching staff's background. Students with different backgrounds work together in a joint project and apply their specific skills to achieve the project goals. To be successful they need to apply technics of professional project management. Depending on students' knowledge, lectures and workshops on different topics are included which means that students have got the opportunity to attend different lectures of other degree programmes for example.

Teaching methods

Sessions for basic information about the project options; project coordination; project counseling provided by teaching staff or project partners from a company; accompanying lectures depending on the topics of the projects and demand; presentation of results to an interested audience consisting of university staff and students as well as external project partners.

Entry requirements

To be specified by project supervisor

Types of assessment

Graded examination, usually a project work, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)

Same module for all Bachelor study programs of the faculty

Weight towards final grade 6,25%
Person in charge of module All professors of the faculty
Additional information

8161 Internship / Semester Abroad

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8161	900 h	30 CP	6th semester	Summer or winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
		900 h	Open

Learning outcomes / Competences and qualifications profile

The internship has been done in a company, an agency or a research institute in a field related to the degree programme. Students have applied their classroom knowledge in a real world professional environment. They have gained insights into a company and into specific practical fields. During their stays as interns they have worked on different tasks in the companies and have taken on responsibility for certain topics. A descriptions of the projects and of the lessons learned in the internship has been presented in form of a scientific report. The internship has helped to increase knowledge, to specialise in a certain field, to gain additional qualifications, to network, and to improve students' career management.

Students who opted for a semester abroad have gained intercultural competencies. They have improved their foreign language skills or have even studied a new foreign language, have learned how to get along in a foreign educational system and have worked with other students and teaching staff of different nationalities. Students' semester abroad reports have met the criteria of scientific reports. This means that the reports also included a reflection on a topic related to the degree programme with a special focus on country-specific features. The topic had to be arranged in advanced and needed to be approved by the supervisor.

Content

Depending on the company the internship is done at or the university abroad. Topics will be discussed with teaching staff of Rhine-Waal University of Applied Sciences in advance.

Teaching methods

Entry requirements

90 credit points achieved

Types of assessment

Certificate (Testat)

Requirements for the award of credit points

The required 20 weeks of internship have to be completed as a whole. An interruption is not allowed. Students have to hand in an internship report which meets scientific quality criteria.

In case of a semester abroad at least 15 ECTS have to be earned at the foreign university which is located in a non-German speaking country. Exceptions can be made in cases in which the success of the semester abroad is defined differently.

Use of module (in other study programs) Same module in "International Business Administration, B.A.", "Communication and Information Engineering, B.Sc.", "Information and Communication Design, B.A.", and "Mobility and Logistics, B.Sc."
Weight towards final grade None (ungraded)
Person in charge of module All professors of the faculty
Additional information

8171 Bachelor Workshop I: Research Methods

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8171	150 h	5 CP	7th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminaristic lectures: 60 TU / 4 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

Having completed this course, students are able to decide which research method is suitable to answer the research question they have chosen for their thesis. Regarding the specific requirements of scientific work, students have gained the competence to develop a hypothesis, to use an appropriate study setup for the verification or falsification of the hypothesis, to collect and evaluate data, to consider data quality, to discuss their own work in the context of other findings and to present results in articles and contributions to conferences.

Content

Lectures and exercises on

- the challenge of finding the appropriate research question.
- observational versus experimental methods.
- objectivity and repeatability.
- hypotheses and theories.
- correlation versus causality.
- the experimental setup suitable to verify or falsify a hypothesis.
- evaluation of nominal, ordinal, interval and ratio data.
- descriptive statistics, algorithms and models.
- presentation of data in tables and figures.
- developing and validating models.
- writing an extended abstract.
- oral presentations at conferences.
- the sources of information (scientific papers, norms, legislation).

Teaching methods

Seminaristic lectures which will include discussions as well as student tasks.

Entry requirements

175 credits points achieved (including internship or semester abroad)

Types of assessment

Certificate (Testat) usually an assignment

Requirements for the award of credit points

Successful participation reflected by the total of submitted assignments

Use of module (in other study programs) Same module in "Environment and Energy, B.Sc.", "Communication and Information Engineering, B.Sc." and "Mobility and Logistics, B.Sc."
Weight towards final grade None (ungraded)
Person in charge of module All professors of the faculty
Additional information Literature: Field, A., Hole, G. (2003): How to Design and Report Experiments, SAGE Publications Sullivan, M. (2014) Fundamentals of Statistics, Pearson

8172 Bachelor Workshop II: Scientific Writing

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8172	150 h	5 CP	7th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminaristic lectures: 60 TU / 4 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

The workshop in scientific writing is set at the end of the bachelor degree program with the purpose of providing a structural and stylistic toolbox for students near the end of their studies, particularly in preparation of their thesis. As such, the workshop offers training in

- the logical and formal structuring of the thesis,
- the expansion of English vocabulary with a focus on scientific language,
- the use of a toolbox for paraphrasing other authors' knowledge,
- visualization of scientific information,
- the design of a scientific poster, and
- the personal appearance in front of a professional auditorium.

Content

- Introduction, plagiarism, definition of a personal research topic
- Literature research, citation rules, basics of scientific style
- Basic structure of a scientific manuscript, exercises on excerpting, summarizing and paraphrasing
- Visualization of scientific data and information
- Analysis of scientific manuscripts, exercises on abstract writing and introduction writing
- The word field of quantitative language, exercises on methodology and discussion writing
- Poster design
- Elevator pitch of personal research topic
-

Teaching methods

Workshop including seminaristic lectures and many writing exercises. Students discuss their results and support each other.

Entry requirements

175 credits points achieved (including internship or semester abroad)

Types of assessment

Certificate (Testat) usually an assignment

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

Same module in "Environment and Energy, B.Sc.", "Communication and Information Engineering, B.Sc." and "Mobility and Logistics, B.Sc."
Weight towards final grade None (ungraded)
Person in charge of module Prof. Dr. Kai J. Tiedemann
Additional information Literature: Cargill, M.; O'Connor, P. (2009): Writing Scientific Research Articles. Strategy and Steps. Chichester: Wiley-Blackwell. Glasman-Deal, H. (2010): Science Research Writing for Non-Native Speakers of English. A Guide for Non-Native Speakers of English. London: Imperial College Press. Hofmann, A. H. (2010): Scientific Writing and Communication: Papers, Proposals, and Presentations. Oxford: Oxford University Press. Russey, W. E.; Ebel, H. F.; Bliefert, C. (2006): How to Write a Successful Science Thesis. The Concise Guide for Students. Weinheim: Wiley-VCH.

8173 Bachelor Workshop III: Advanced Seminar

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8173	150 h	5 CP	7th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminaristic lectures: 60 TU / 4 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

Students have received feedback, advice and guidance for their bachelor thesis. Each student has presented his or her own research findings in a short presentation (20-30 minutes). Together with two other students, who had received the respective presentation earlier, he/she has discussed the current state of research findings, methodology etc. In that way students have learned to present their research in a convincing way, to professionally defend their research and to accept feedback or criticism from their peers. At the same time students have learned to give feedback, provide ideas and advice for the work of others and formulate criticism in a fair way.

Content

- How to present research findings in a professional way
- How to comment and criticize the research of others
- How to moderate a group discussion
- Students´ presentations of their own findings followed by two discussant contributions and an open group discussion

Teaching methods

Students present their own research. Group discussions about the findings and methods applied.

Entry requirements

175 credits points achieved (including internship or semester abroad)

Types of assessment

Certificate (Testat) usually an assignment

Requirements for the award of credit points

Individual student´s presentation of his/her own research findings. Contribution to the discussion of two other students' researches.

Use of module (in other study programs)

Same module in "Environment and Energy, B.Sc.", "Communication and Information Engineering, B.Sc." and "Mobility and Logistics, B.Sc."

Weight towards final grade

None (ungraded)

Person in charge of module All professors of the faculty
Additional information

8101 Bachelor Thesis and Disputation

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8101	450 h	15 CP	7th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Bachelor Thesis: 12 CP Disputation: 3 CP	Depends on need and demand		

Learning outcomes / Competences and qualifications profile

Students have conducted their own studies examining a research question from their scientific discipline, developing an appropriate methodological approach, and reflecting their research design and findings critically.
During the disputation students have proven their competencies in evaluating the topic and reflecting on its impact on real-life problems.

Content

- Depends on the topic; inter alia:
- Researching and evaluating literature
- Developing a research question and deriving hypotheses
- Operationalizing constructs
- Analyzing methodological strengths and weaknesses of different research approaches
- Developing research designs
- Conducting the studies
- Evaluating the results
- Writing the thesis
- Presenting and defending the findings

Teaching methods

Individual supervision and support

Entry requirements

175 credits points achieved (including internship or semester abroad)

Types of assessment

Graded Bachelor thesis and oral disputation

Requirements for the award of credit points

Passed Bachelor thesis and disputation as well as successful completion of all other modules of the curriculum

Use of module (in other study programs)

Weight towards final grade

9,375 %
Person in charge of module All professors of the faculty
Additional information

8175 Advanced Simulation and Modelling

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8175	150 h	5 CP	4th or 5th semester	Winter semester or summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture (seminaristic style): 30 TU / 2 SWS Excercises: 30 TU / 2 SWS	60 TU / 4 SWS	105 h	25 students

Learning outcomes / Competences and qualifications profile

Students are able to model systems of the real world and analyze them via simulations, particularly in the context of environmental studies. In detail, students can model problems of the real world, describe them mathematically and find solutions. They know the appropriate use of models and simulations and their limits and understand the steps of the simulation process. Students are familiar with modern modelling and simulation techniques as well as common tools. They understand the modelling and simulation technology as a useful tool to understand real world systems and they can apply them in different contexts.

Content

Introduction: Meaning of modelling and simulation in the context of environmental studies, simulation chain
Continuous simulations, e.g. predator-prey relationships, intraspecific competition, various predators or prey species, fishing dynamics (optimal fishing quotas, Maltus model, Verhulst model), dimensionless variables, implementation with Octave, Matlab, Scilab, R, Python, transfer to other situations and systems as, e.g. epidemiology, numerical fundamentals
Introduction to partial differential equations (e.g. diffusion equation describing the spread of pollutants in the aquatic environment using FEM or FDM, groundwater modelling, implementation e.g. in Octave/Matlab, Python, R, FEFLOW, Comsol)
Stochastic simulations (Monte Carlo simulations, Forest-fire simulations, implementation in R, …)
Advanced data processing (multivariate statistics, cluster analysis and data mining in environmental studies, simulations in data science, implementation e.g. in R, Python)

Teaching methods

Lectures and trainings with workgroup exercises (using e.g. GNU Octave/Matlab, Scilab, Excel, R, Python, FEFLOW, Comsol).

Guest lectures planned (e.g. Applied Groundwater Modelling)

Entry requirements

Successful completion of the module "Statistics and Data Processing" is recommended

Types of assessment

Graded examination, usually a project work, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better, successful participation in exercises

Use of module (in other study programs)

Open to students of other study programs upon successful participation in "Statistics and Data Processing" (or equivalent statistics or mathematics module of other programs)

Weight towards final grade

3,125 %

Person in charge of module

Prof. Dr. Frank Zimmer

Additional information

Literature:

- Acevedo, M. F. (2013): Data Analysis and Statistics for Geography, Environmental Science, and Engineering, Boca Raton, London, New York CRC Press, Taylor & Francis Group,
- Acevedo, M. F. (2013): Simulation of Ecological and Environmental Models, Boca Raton, London, New York CRC Press, Taylor & Francis Group,
- Anderson, M.P.; Woessner, W. W.; Hunt, R. J. (2015): Applied Groundwater Modeling: Simulation of Flow and Advective Transport, Academic Pr Inc,
- Bitelli, M.; Tomei, F.; Campbell G.S. (2015): Soil Physics with Python: Transport in the Soil-Plant-Atmosphere System, Oxford, Oxford University Press, Oxford,
- Borcard, D.; Gillet, F.; Legendre, P. (2011): Numerical Ecology with R, New York, Springer,
- Diersch, H.-J. (2013): FEFLOW: Finite Element Modeling of Flow, Mass and Heat Transport in Porous and Fractured Media, Berlin Heidelberg, Springer-Verlag
- Gilat, Amos ; Subramaniam, Vish (2011): Numerical Methods - An introduction with Applications Using MATLAB. SI Version, Asia, John Wiley & Sons
- Imboden, D.M.; Pfenninger, S. (2015): Introduction to Systems Analysis: Mathematically Modeling Natural Systems, Berlin Heidelberg, Springer-Verlag,
- Jones, Owen ; Maillardet, Robert ; Robinson, Andrew (2014): Introduction to Scientific Programming and Simulation Using R., Boca Raton, FL, CRC Press, Taylor & Francis Group,
- Hill, C. (2016): Learning Scientific Programming with Python, Cambridge University Press, 2016
- Pryor, R. W. (2015): Multiphysics Modeling Using Comsol5 and MATLAB, Dulles, Mercury Learning and Information LLC,
- Quarteroni, A. M. ; Saleri, F. ; Gervasio, P. (2014): Scientific Computing with MATLAB and Octave, Berlin, Springer,
- Soetart, K.; Cash, J.; Mazzia, F. (2012): Solving Differential Equation in R (Use R!), Berlin Heidelberg, Springer-Verlag,
- Stevens, M.H.H. (2009): A Primer of Ecology with R. corrected at 2nd printing 2010, Springer Science + Business Media, LLC,
- Temple, M. (2016): Simulation for Data Science with R, Packt Publishing.

8176 Innovative Solutions in Environment and Energy

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8176	150 h	5 CP	4th or 5th semester	Winter semester or summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture 30 TU / 2 SWS Seminar 30 TU / 2 SWS	60 TU / 4 SWS	105 h	25 students

Learning outcomes / Competences and qualifications profile

The module provides basic knowledge on innovation, inventions, patents and knowledge management in companies. Students have gained an overview of the various techniques of environmental technology and renewable energy. They are able to assess the benefits advantages, risks and limitations of the different techniques and can discuss and analyse current developments in environmental technologies and renewable energy. Students have deepened their understanding of the demand for environmental technology and renewable energy upon state-of-the-art publications. They have discussed possible solutions to current questions and problems and presented a corresponding concept.

Content

- Innovation, inventions and patents
- Knowledge management
- Innovative solutions in environmental technology (case examples)
- Innovative solutions in (renewable) energy and energy storage (case examples)
- Putting energy and environmental Research into practice

Teaching methods

Lectures; Tuition in seminars

Entry requirements

Completion of the following modules is recommended:

- "Introduction to Ecology and Environmental Sciences"
- "Fundamentals of Biology and Natural Cycles of Matter"
- "Fundamentals of Energy Management"
- "Energy Technology"

Types of assessment

Graded examination, usually an examination with several components (term paper 60 points and two assignment (each 20 points)), details to be announced at the beginning of the semester by the the Examination Board.

Requirements for the award of credit points

Presentation of results, grade 4.0 or better for the seminar paper

Use of module (in other study programs) Open to students of other study programs
Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Daniela Lud; Prof. Dr. Irmgard Buder
Additional information Literature: Meusburger P., Glückler J., el Meskioui M. (2013) Knowledge and the Economy. Springer Pimentel D. (Editor) (2008): Biofuels, Solar and Wind as Renewable Energy Systems, Benefits and Risks. Springer Recent scientific journal articles from e.g.: Energy, Sustainability and Society Environmental and Resource Economics Environmental Science and Pollution Research

8177 Advanced Environmental Analytical Chemistry

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8177	150 h	5 CP	4th or 5th semester	Winter semester or summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminar "Advanced topics in Environmental Analytical Chemistry": 30 TU / 2 SWS Exercises with excursions and practical training "Advanced Environmental Analytical Chemistry": 30 TU / 2 SWS	60 TU / 4 SWS	105 h	25 students

Learning outcomes / Competences and qualifications profile

Upon completion of this course, students will be able to describe the principle analytical techniques and methods for detecting and quantifying contaminants in environmental samples. They will be able to explain the significance of sampling methods and sample preparation for the quality of analytical data. The can describe and value external and internal sources of errors in the sampling and analysis chain, outline and apply an analytical approach for a practical analytical problem and use, evaluate and present analytical data from primary literature e.g. in a protocol or scientific paper.

Content

- Sampling methods and preparation of samples for analysis
- Principles of analytical techniques for detecting and quantifying environmental contaminants as for example chromatographic techniques, atom absorption spectroscopy, bio-essays

In recent years there has been a considerable increase in analytical techniques that are available for the chemical analysis of environmental samples. The number of less invasive, faster measurement techniques including on-site measurement techniques has also increased. There is growing attention for emerging contaminants and the principles of green chemistry are integrated in analytical chemistry. This module explains the principles and the use of general and advanced analytical techniques for detecting and quantifying environmental contaminants and gives insight into current developments of analytical chemistry. The lecture also provides insight into the significance of sampling methods and sample preparation for the quality of analytical data and addresses sources of errors. Based on the fundamental knowledge about analytical techniques, the practical deepens laboratory skills of environmental analytical chemistry and provides insight intp methods like GC or HPLC, AAS, bioassays and electrochemical methods.

Teaching methods

Seminar-like teaching and trainings with workgroup exercises, practicals and/or excursions

Entry requirements

Completion of the module "General and Inorganic Chemistry" and "Organic and Analytical Chemistry" is recommended

Types of assessment Graded examination, usually an examination with several components (two assignments, each 45 points), details to be announced at the beginning of the semester by the Examination Board.
Requirements for the award of credit points Module examination grade 4.0 or better, successful participation in exercises
Use of module (in other study programs) Open to students of other study programs upon successful participation in "Organic and Analytical Chemistry" (or equivalent Chemistry module)
Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Daniela Lud; Prof. Dr. Irmgard Buder
Additional information Literature: Cammann K. (2010) Instrumentelle Analytische Chemie Verfahren, Anwendungen, Qualitätssicherung. Spektrum Danzer, K. (2007) Analytical Chemistry Theoretical and Metrological Fundamentals Springer Kellner, R., Mermet, J.-M., Otto, M., Valcárel, M. Widmer, H. M. (2004): Analytical Chemistry, 2 Ed. Wiley VCH Weinheim Vaz Jr., S. (2018) Analytical Chemistry Applied to Emerging Pollutants . Springer, Cham. And selected scientific publications

8178 Electromobility

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8178	150 h	5 CP	4th or 5th semester	Winter semester or summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture with exercises "Electromobility": 60 TU / 4 SWS	60 TU / 4 SWS	105 h	25 students

Learning outcomes / Competences and qualifications profile

Upon completion of this course, the student will be able to:

- understand and evaluate different concepts of drive systems including motors.
- understand fundamental principles in vehicle technology.
- understand the basics of accumulators and fuel cells (electrochemistry).
- define and apply the term „sustainability“ on mobility with passenger cars.
- evaluate mobility under sustainability aspects in a scientific manner.

Content

- Impact of traffic on the environment, criteria for sustainable transportation
- Can electric vehicles contribute to sustainable transportation?
- Comparison of electric engines and internal combustion engines (ICE)
- Mobile storage of electricity (accumulators)
- Mobile production of electricity (electro generator, fuel cell)
- Challenges and requirements for vehicle construction of electric cars
- Will cars become “smart”? New concepts of mobility
- Stabilization of the electric power supply by car batteries?

Teaching methods

Lecture with exercises in workgroups

Entry requirements

None

Types of assessment

Graded examination, usually an examination with several components (oral examination 50 points and term paper 50 points), details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module examination grade 4.0 or better

Use of module (in other study programs)

Open to students of other study programs

Weight towards final grade

3,125 %
Person in charge of module Prof. Dr. Irmgard Buder
Additional information Literature: Pistoia, G. (2010): Electric and Hybrid Vehicles: Power Sources, Models, Sustainability. Amsterdam: Elsevier. Wallentowitz, H.; Freialdenhoven, A. (2011): Strategien zur Elektrifizierung des Antriebsstranges. Wiesbaden: Vieweg und Teubner. Hüttl, R. F.; Pischetsrieder, B.; Spath, D. (eds.) (2010): Elektromobilität - Potenziale und wissenschaftlich-technische Herausforderungen. Berlin: Springer. Reddy T. B. (2011): Linden's Handbook of Batteries fourth Ed. Mac Graw Hill New York Chau, K. T. (2015) Electric Vehicles Machines and Drives Design, Analysis and Application John VWiley and Sons LTD Singapore

8179 Advanced Auditing and Certification Procedures

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8179	150 h	5 CP	4th or 5th semester	Winter semester or summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminar "Advanced auditing procedures": 30 TU / 2 SWS Exercises "Advanced auditing procedures": 30 TU / 2 SWS	60 TU / 4 SWS	105 h	25 students

Learning outcomes / Competences and qualifications profile

Upon completion of this course, the student will be able to:

- define the terms "audit" and "certification" and explain the role of auditing (regarding quality, safety, environment and energy) in the assessment and improvement of environmental performance of companies and organizations.
- explain different types e.g. of environmental audits and energy audits.
- describe the general timeline of audits, identify the elements of this timeline (planning, commitment, goals, protocols and checklists, auditing process, evaluation, reporting, planned actions, further steps) and apply these in basic practical cases.

Students have also acquired an understanding of the role of e.g. Environmental Audit and e.g. Environmental Management Systems for the ongoing improvement of environmental performance of organizations and know how sustainability concepts can be linked with Environmental Auditing.
Students have gained

- a basic understanding of how auditing data are collected in a systematic way.
- a basic understanding of assessment and evaluation of performance of the data collected.
- practise in the use of limit values and assessment criteria during the evaluation process and in general technical reporting skills.

Content

This module provides relevant background information for a more advanced understanding of auditing and certification procedures as tools to evaluate environmental performance of companies and organizations, to clarify undesired environmental effects of current activities and to identify possibilities for changes of current practice. The lecture will introduce different types of environmental audit such as compliance audit, health and safety audit, site audit, energy audit and due diligence audit. The lecture will provide insight into the timeline and elements of environmental audits (planning, commitment, goals, protocols and checklists, auditing process, evaluation, reporting, planned actions, further steps). Based on the knowledge about the different types of environmental audits and their general timeline and elements, the role of auditing in Environmental Management Systems will be explained. Students will also be introduced to current developments e.g. integrating sustainability concepts and auditing. During the exercises the contents of the lecture will be applied using online tools and practical cases.

Teaching methods

Seminar-like teaching and training/field practicals with case examples

Entry requirements Completion of the module "Legal Fundamentals" is recommended
Types of assessment Graded examination, usually an examination with several components (project work 45 points and three assignments, each 15 points), details to be announced at the beginning of the semester by the Examination Board.
Requirements for the award of credit points Module examination grade 4.0 or better, successful participation in exercises
Use of module (in other study programs) Open to students of other programs upon successful participation in "Legal Fundamentals" (or equivalent)
Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Daniela Lud
Additional information Literature: Azapagic, A. and Perdan, S. (2011) Sustainable Development in Practice Case studies for engineers and scientists. Chichester: Wiley-Blackwell Castelo B.M. (2013) Sustainability Reporting Guidelines. In: Idowu S.O., Capaldi N., Zu L., Gupta A.D. (eds) Encyclopedia of Corporate Social Responsibility. Berlin: Springer Morvay, Z. K. and Gvozdenac, D.D. (2008) Applied Industrial Energy and Environmental Management Chichester: Wiley IEEE Press Poltronieri, C.F., Leite, L.R., Sousa, S.R. (2021). Environmental Management Systems and Performance Measurement. In: de Oliveira, J.A. et al. (eds) Life Cycle Engineering and Management of Products. Cham: Springer. Reich S. (2018) Technical Due Diligence. In: Just T., Stapenhorst H. (eds) Real Estate Due Diligence. Management for Professionals. Cham: Springer And selected scientific publications from scientific journals

8180 Environmental Monitoring

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8180	150 h	5 CP	4th or 5th semester	Winter semester or summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture "Environmental Monitoring": 30 TU / 2 SWS Exercises with excursions and practical training: 30 TU / 2 SWS	60 TU / 4 SWS	105 h	25 students

Learning outcomes / Competences and qualifications profile

Upon completion of the course students will have gained theoretical and practical experience on environmental monitoring methodologies, the processing and aggregation of environmental data, the organizations responsible for monitoring activities and common ways of making monitoring data available to the public. They will be familiar with data quality assurance and quality control. Students will have gained an overview of relevant regional, national and EU-legislation. They will be able to use the appropriate terms and nomenclature and they will have acquired an understanding of monitoring methods and how environmental monitoring is organized and performed in the real world. The participants will have discussed actual problems of water management, air pollution and related health effects.

Content

- Lecture addressing approaches of environmental monitoring, the legal background, parameters monitored and their value as indicators for environmental pressures
- Collection of particulate matter as an example for an important air pollutant
- Acquisition, processing and evaluation of meteorological data
- Application of microbiological methods to investigate the safety and quality of drinking water and surface water bodies
- Deepening of the understanding of analytical techniques to determine pollutant concentrations in drinking water, surface water, ground water and waste water
- Excursions to actors in water management and environmental protection in order to provide insight into current activities of authorities responsible for the protection of the environment
- Exercises with the objective to deepen the understanding of the scientific background of environmental monitoring
- Discussion of benefits, risks and limitations of monitoring techniques

Teaching methods

Lectures, trainings, excursions, exercises and experimental work

Entry requirements

None

Types of assessment

Graded examination, usually a term paper, details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points Module examination grade 4.0 or better, successful participation in exercises
Use of module (in other study programs) Open to students of other study programs
Weight towards final grade 3,125 %
Person in charge of module PD Prof. Dr. Ute Hansen
Additional information Literatur: Schlesinger & Bernhardt (2013) Biogeochemistry, Elsevier Wiersma, G.B. (2004) Environmental Monitoring, CRC Press Botkin & Keller (2012) Environmental Science, John Wiley & Sons Artiola, Pepper & Brusseau (eds.) Environmental Monitoring and Characterization, Elsevier 2004

8181 Environmental Economics

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8181	150 h	5 CP	4th or 5th semester	Winter semester or summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Environmental Economics Lecture: 30 TU / 2 SWS Seminaristic exercises with excursions: 30 TU/ 2 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

Upon completion of this course, students will be able to:
- relate the concept of allocation of scarce resources to economics as well as to environmental problems.
- appreciate alternative perspectives on the nature of environmental problems.
- use various methods for the monetary evaluation of environmental goods and services.
- transfer the concept of sustainability into practical applications.
- demonstrate how various market based options for environmental policy work.
- apply the theoretical knowledge in a practical case study.

Content

At the example of brown coal or gravel mining we learned all too well, how the use of natural resources leads to conflicts between industry and society. Typically, enterprises argue with economic benefits, while environmentalists have little more than an ethical stance. In response to this dilemma, the course provides an introduction to methods for the economic valuation of natural resources (minerals, species, healthy living conditions etc.) to achieve comparability for a sustainable form of economic activity. In this context, Environmental Economics is the application of the principles of economics to the study of how environmental and natural resources are developed and managed. It addresses the economic implications of environmental impacts caused by human activity and introduces some concepts of economical appreciation of ecosystem services. It combines theoretical analysis with discussions on specific environmental policies as applied to water management, air pollution, the energy sector, and climate change. Within these examples, particular topics like the microeconomic analysis of environmental regulations, the problem of social cost, the policy instrument choice, and the evaluation of environmental improvements will be covered.

Teaching methods

Lecture with exercises in workgroups

Entry requirements

None

Types of assessment

Graded examination, usually an examination with several components (written exam 40 points, project work 60 points), details to be announced at the beginning of the semester by the Examination Board.
Requirements for the award of credit points Module exam grade 4.0 or better
Use of module (in other study programs)
Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Kai J. Tiedemann
Additional information Literature: Tietenberg, T.; Lewis, L. (2011): Environmental & Natural Resources Economics, International Edition. Upper Saddle River, NJ: Pearson Education. Mäler, K.-G.; Vincent, J. R. (eds.) (2003): Handbook of Environmental Economics. Amsterdam: Elsevier. Perman, R. (2003): Natural Resource and Environmental Economics. Harlow: Pearson Addison Wesley.

8182 Energy Economics

Code	Workload	Credits	Level of module	Frequency of offer	Duration
8182	150 h	5 CP	4th or 5th semester	Winter semester or summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Energy Economics Lectures: 30 TU / 2 SWS Exercises: 30 TU / 2 SWS	60 TU / 4 SWS	105 h	50 students

Learning outcomes / Competences and qualifications profile

Upon completion of this course students will be able to

- understand basic economic concepts that influence energy production, energy distribution and end-use.
- understand how local, regional, and global institutions affect energy markets and prices.
- relate historical and contemporary public policy issues to energy management in the EU and globally.
- apply this knowledge to analyze specific energy industries and policy questions.
- evaluate the sustainability of different forms of fuel and energy production.

Content

The lecture “Energy Economic” has the objective to apply economics to particular issues of energy markets, issues of energy distribution, investment in conventional and renewable energy, and energy storage. It gives an overview of key economic concepts which are applied to energy markets and highlights special conditions of these markets, such as the extraction of fossil fuels and the exploitation of renewable energy.
As in the complementary course “Environmental Economics”, the lecture highlights energy related externalities e.g. pollution by mining and extraction of fossil fuels, climate change due to increased CO2 emissions and other negative impacts of energy use. Concepts to regulate pollutants by economic incentives as cap and trade and concepts of support for energy saving measures and more sustainable technologies are discussed and valuated.

Teaching methods

Lecture with exercises in workgroups

Entry requirements

None

Types of assessment

Graded examination, usually an examination with several components (oral examination 45 points, term paper 40 points, assignments 15 points) details to be announced at the beginning of the semester by the Examination Board.

Requirements for the award of credit points

Module exam grade 4.0 or better;

Use of module (in other study programs) Open to students of other study programs
Weight towards final grade 3,125 %
Person in charge of module Prof. Dr. Irmgard Buder
Additional information Literature: Subhes C. Bhattacharyya (2011): Energy Economics -Concepts, Issues, Markets and Governance, Springer London Dordrecht Heidelberg New York Dahl, C. A. (2004): International Energy Markets: Understanding Pricing, Policies and Profits, PennWell Tulsa, OK. Tietenberg, T.; Lewis, L. (2011): Environmental & Natural Resources Economics, Pearson Education International Edition, Upper Saddle River, NJ David A. Anderson (2014): Environmental Economics and Natural Resource Management, Routledge 4th edition, 2 Park Square, Milton Park Abingdon, Oxon, OX 14 RN