Manual of Modules

Water Science

Water: Chemistry, Analytics, Microbiology

Master of Science (M.Sc.)

4. Inhaltsverzeichnis /Module – Master

Master – Programme: Water Science

Module	Module Tutor	Sem.	Total Number of Credits of Modules	Course	HPW			HPW	Credits	Category	Requirements	Exam
					L	S	P	Sum				

Required Modules

Applied Analytical Chemistry	Hirner	2	5	Applied Analytical Chemistry	2	1		3	5	Advanced	none	Written exam
Applied Microbiology	Sand	3	6	Geomicrobiology	2			2	3	Advanced	none	Written exam of module
				Microbial Physiology	2			2	3			
Biofouling, Biocorrosion	Sand	2	5	Biofouling, Biocorrosion	2	1		3	5	Advanced	None	Written exam
Chemometrics and Statistics	Molt	1	5	Chemometrics and Statistiks	2	1		3	5	Advanced	None	Written exam
Environmental Microbiology	Flemming	1 2	12	Environmental Microbiology	2	1		3	5	Advanced	none	
				Practical Course Environmental Microbiology		1	8	9	7		Lecture: Environmental Microbiology	Written exam of module
Practical Analytical Chemistry	Hirner	3	10	Practical Course Analytical Chemistry		1	14	15	10	Advanced	Module: Applied Analytical Chemistry	
Research Practical	All	3	10	Research Practical Course		1	14	15	10	Advanced	Practical Courses in Analy.Chem. + Invironmental Microbiology	
Water Chemistry	Schmidt	1	5	Water Chemistry	2	1		3	5	Advanced	none	Written exam

Master – Programme: Water Science

Module	Module Tutor	Sem.	Total Number of Credits of Modules	Course	HPW			HPW	Credits	Category	Requirements	Exam
					L	S	P	Sum				

Optional Modules

Ecology	Hering	2 2	4	Environmental Management	2			2	2	Interdisciplinary	none	Written exam of module
				Ecology and Protection of Water	2			2	2			
Electrochemistry and Electrochemical Analysis	Schmidt	1od. 3	5	Electrochemistry and Electrochemical Analysis	2	1		3	5	Advanced	none	Written exam
Environmental Chemistry: Air	Zellner	2	5	Environmental Chemistry: Air	2	1		3	5	Advanced	none	Written exam
Environmental Chemistry: Pollutants	Hirner	1 od. 3	5	Environmental Chemistry: Pollutants	2	1		3	5	Advanced	none	Written exam
Environmental Chemistry: Soil / Waste	Hirner	1 od. 3	5	Environmental Chemistry: Soil / Waste	2	1		3	5	Advanced	none	Written exam
Excursions	All	1,2 od.3	2	Excursions		2		2	2	Interdisciplinary	none	
Hydrochemical System Modelling	Molt	1 od.3	5	Hydrochemical System Modelling	2	1		3	5	Interdisciplinary	none	Oral exam
Management	Molt	2 3	6	Quality Management	1	1		2	3	Interdisciplinary	none	Written exam of Module
				Project Management	2			2	3			
Membrane Technologies	Ulbricht	1 od. 3	3	Membrane Technologies	1	1		2	3	Interdisciplinary	none	Written exam

Master – Programme: Water Science

Module	Module Tutor	Sem.	Total Number of Credits of Modules	Course	HPW			HPW	Credits	Category	Requirements	Exam
					L	S	P	Sum				

(Fortsetzung Optional Modules)

Stable Isotope Analysis	Schmidt	1od.3	5	Stable Isotope Analysis	2	1		3	5	Advanced	none	Written exam
Technical Engineering Water	Gimbel	2 3	9	Technical Engineering Water	2	1		3	5	Interdisciplinary	none	Written or oral exam of Module
				Practical Course Technical Engineering Water			3	3	4		Lecture: Technical Engineering Water	
Water Pollution / Water Pollution Monitoring	Bester	1,2 od.3	5	Water Pollution / Water Pollution Monitoring	2		1	3	5	Advanced	none	Written or oral exam
Water: Rules, Norms, Laws	Herbell	1 od. 3	3	Water: Rules, Norms, Laws	2			2	3	Interdisciplinary	none	Written exam
Waste Water	Denecke	2	7	Microbiology of Waste Water	1	1		2	2	Interdisciplinary	none	Written exam or oral exam of Module
				Proteins in Activated Sludges/Sandfiltration		1		4	5			

Master – Programme: Water Science

Module	Module Tutor	Sem.	Total Number of Credits of Modules	Course	HPW			HPW	Credits	Category	Requirements	Exam
					L	S	P	Sum				

Master – Thesis

Master - Thesis	Dean of Studies	4	Master - Thesis						30	Advanced	90	Thesis

Compulsory Courses				Analytical Chemistry Biosciences Research Practical					**25** **23** **10**			
Optional Courses									**32**			
Master Thesis									**30**			
Sum									**120**			

Module	Course	HPW	Cr.	Exam
	1. Semester			
Chemometrics and Statistics	Chemometrics and Statistics	3	5	Written exam
Environmental Microbiology	Environmental Microbiology	3	5	Written exam
Water Chemistry	Water Chemistry	3	5	Written exam
	Optional Courses		15	2 exams or colloq.
	Sum		**30**	**5 Exams**
	2. Semester			
Applied Analytical Chemistry	Applied Analytical Chemistry	3	5	Written exam
Biofouling, Biocorrosion	Biofouling, Biocorrosion	3	5	Written exam
Environmental Microbiology	Practical Course Environmental Microbiology	9	7	
	Optional Courses		12	2 exams or colloq.
	Sum		**29**	**4 Exams**
	3. Semester			
Applied Microbiology	Geomicrobiology	2	3	
Applied Microbiology	Microbial Physiology	2	3	Written exam of the module
Practical Analytical Chemistry	Practical Course Analytical Chemistry	15	10	
Research Practical	Research Practical Course	15	10	
	Optional Courses		5	1 exam or colloq.
	Sum		**31**	**2 Exams**
	4. Semester			
Master Thesis	Master Thesis		30	written exam
	Sum		**30**	**1 Exam**
	Total Sum		**120**	**12 Exams**

Module	**Applied Analytical Chemistry**
Person in Charge	Prof. Dr. A. Hirner
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional/Compulsory Course	Requirements
1	1 Semester	Compulsory	none

Courses	HPW	Workload in h	Credits
Applied Analytical Chemistry	3	150	5
Sum	3	150	5

Proficiency Certificate	Written exam

Module	**Applied Analytical Chemistry**
Course	Applied Analytical Chemistry
Lecturer	Prof. Dr. A. Hirner

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
2	SS	M.Sc. Water Science M.Sc. Chemie	none	5

Learning target	Acquisition of basic theoretical and practical knowledge in applied analytical chemistry. The handling and preparation of samples and the reduction of matrix effects through application of appropriate analytical methods will be addressed. Target analytical niveau: Eurocurriculum
Kind of teaching	Lecture (2 HPW) and Seminar (1 HPW)
Literature	Kellner, Mermet, Otto, Widmer: Analytical Chemistry, Wiley-VCH 1998

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	3	39	61	50	150

Content oft teaching	• Concrete knowledge transfer with regard to the chemical and analytical preparation of samples (material and environmental samples, biological samples): Handling of samples and analytical methodology with respect to the most important instrumental techniques of atomic, isotopic and molecular analysis. • Sampling, sample storage and sample preparation. • X-ray analyses (powder diffractometry, fluorescence), chroma-tography (GC, LC, IC), mass spectrometry (EI, CI, ICP) and hyphenated methods (GC/MS, LC/AFS, etc.) • Qualitative and quantitative determination of main, trace and • ultratrace components as well as the ratio of stable and unstable isotopes. • Sample fractionation, determination of total content and relevant parameters, mass balance

Module	**Applied Microbiology**
Person in charge	Prof.Dr. W. Sand
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional/Compulsory Course	Requirements
2	1 Semester	Compulsory	none

Courses	HPW	Workload in h	Credits
Geomicrobiology	2	90	3
Microbial Physiology	2	90	3
Sum	4	180	6

Proficiency Certificate	Written exam

Modul	**Applied Microbiology**
Course	Geomicrobiology
Lecturer	Prof. Dr. W. Sand

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
3	WS	M.Sc. Water Science	none	3

Learning targets	The students will learn how deeply microorganisms are involved in geochemical cycles and often are the responsible driving agents. They will understand that microbial ecology, geochemistry and geology are closely connected. The students will acquire knowledge of the physiology and biochemistry of the microorganisms involved is of utmost importance for the understanding of geochemical processes and will be intensified where necessary.It shall become obvious to them that Earth as a habitat has been largely created by microorganisms. Processes in this habitat are cyclic processes -Earth as a batch culture- and will be discussed in detail.
Kind of teaching	Lecture course (1 HPW) and Seminar (1 HPW)
Literature	a) Geomicrobiology, 4 th edition, 2002, Henry Lutz Ehrlich, Marcel Dekker New York, ISBN 0-8247-0764-8;b) Geomikrobiologie, 1998, Manfred Köhler und Fernando Völgsen, Wiley-VCH Weinheim, ISBN 3-527-30083-x; c) Brock Biology of Microorganisms, 2006, Michael T. Madigan, John M. Martinko, Pearson Education Prentice Hall Upper Saddle River, ISBN 0-13-196893-9

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	2	26	34	30	90

Content of teaching	1) Earth as a microbial habitat, microbial growth, environment, lithosphere, hydrosphere, atmosphere, geomicrobiological processes and methods 2) Formation and degradation of carbonates, interactions with Si 3) Interactions with P and N 4) Interactions with As, Sb, Hg, and Cr 5) Geomicrobiology of Fe 6) Geomicrobiology of Mn 7) Geomicrobiology of S incl. formation and degradation of metal sulfides 8) Interactions with Se and Te 9) Fossil energy sources

Module	**Applied Microbiology**
Course	Microbial Physiology
Lecturer	Prof. Dr. W. Sand

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
3	WS	M.Sc. Water Science	none	3

Learning target	The students will learn how deeply microorganisms are involved in geochemical cycles and often are the responsible driving agents. They will understand that microbial ecology, geochemistry and geology are closely connected. The students will acquire knowledge of the physiology and biochemistry of the microorganisms involved is of utmost importance for the understanding of geochemical processes and will be intensified where necessary.It shall become obvious to them that Earth as a habitat has been largely created by microorganisms. Processes in this habitat are cyclic processes -Earth as a batch culture- and will be discussed in detail.
Kind of teaching	Lecture course (1 HPW) and Seminar (1 HPW)
Literature	a) Brock, Biology of Microorganisms, 2006, Michael T. Madigan, John M. Martinko, Pearson Education Prentice Hall Upper Saddle River, ISBN 0-13-196893-9. b) Stryer, Biochemistry. c) K. Munk, Einführung in die Mikrobiologie

Workload	Hours per week (HPW)	Time of attendance in h	Time for prepartion and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	2	26	34	30	90

Content of teaching	1) Basic metabolism – glycolysis, TCC, respiratory chain, ATP- ase, membrane potential etc. 2) Anabolism – amino acid synthesis, sugar synthesis, fatty acid synthesis, nucleic acid synthesis, anaplerotic sequences 3) Photosynthesis – cyclic, non-cyclic, oxygenic 4) Fermentations of organic compounds – sugars, proteins, fatty acids and alcohols 5) Iron oxidation and reduction 6) Nitrogen oxidation and reduction 7) Sulfur oxidation and reduction 8) Carbon dioxide reduction – methanogenesis and methylotrophix bacteria (C-1-metabolism)

Module	**Biofouling, Biocorrosion**
Person in charge	Prof. Dr. W. Sand
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional / Compulsory Course	Requirements
1	1 Semester	Compulsory	none

Courses	HPW	Workload in h	Credits
Course: Biofouling, Biokorrosion	3	150	5
Sum	3	150	5

Proficiency Certificate	Written Exam

Module	**Biofouling Biocorrosion**
Course	Biofouling, Biocorrosion
Lecturer	Prof. Dr. W. Sand

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
2	SS	M.Sc. Water Science	none	5

Learning targets	The students will learn about biofilms as the dominant form of microbial life on earth, the occurrence, the development, structure, function and analysis of biofilms. Then, they will learn about undesirable biofilm effects such as biofouling in the natural environment and in man-made niches such as industrial production, everyday life and medicine. Furthermore, the students will understand the participation of biofilms in corrosion processes of mineral material, metals and synthetic polymers. They will learn the basic mechanisms of biocorrosion (microbially influenced corrosion, MIC), and how to recognize in actual case histories. The course will enable them to diagnose MIC and to basically develop concepts for sanitation and prevention of MIC with special concern to environmentally acceptable strategies.
Kind of teaching	Lecture course (2 HPW) and Seminar (1 HPW)
Literature	a) Heitz, E., Sand, W. and Flemming, H.C. (eds.): Microbially influenced corrosion of materials - scientific and technological aspects. Springer, Heidelberg; 1996; b) Flemming, H.C., Griebe, T. and Szewzyk, U. (eds.): Biofilms. Investigative methods and applications. Technomics Publishers, Lancaster, PA; 2000; c) Videla, H.A.: Manual of Biocorrosion. Lewis Publishers, Boca Raton, 1996 d) Ghannoum, M., O´Toole, G.A.: Microbial Biofilms. ASM Press, 2004 e) W. Sand, Microbial Corrosion and its inhibition; In: Biotechnology, 2nd edition, H.J. Rehm, G. Reed, A. Pühler, P.J.W. Stadler (eds.), Vol. 10, Wiley-VCH, Weinheim, Seite 265-318

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	3	39	61	50	150

Content of teaching	1) Biofilms – Structure, function, growth, analysis, interactions with interfaces 2) Biofilm monitoring in technical systems, pathogenic bacteria in biofilms, resistance 3) Biofouling in water systems 4) Detection of biofouling, counterstrategies 5) HACCP-concept in anti-fouling 6) Biocorrosion, history and case studies, MIC, microbial growth requirements 7) Detection of biocorrosion, physical, chemical and biological countermeasures 8) Biocorrosion of mineral materials 9) Biocorrosion of metallic materials 10) Biodegradation (“biodeterioration”) of organic materials

Module	**Chemometrics and Statistics**
Person in charge	Prof. Dr. K. Molt
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional/Compulsory	Requirements
1	1 Semester	Compulsory	none

Courses	HPW	Workload	Credits
Chemometrics and Statistics	3	150	5
Sum	3	150	5

Proficiency	Written exam

Module	**Chemometrics and Statistics**
Course	Chemometrics and Statistics
Lecturer	Prof. Dr. K. Molt

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1. Sem.	WS	M.Sc. Water Science	none	5

Learning target	After a repetition of classical statistics the students get acquainted with modern multivariate chemometric methods including factor analysis. Students will learn to grasp the underlying concepts by solving problems with the programming environment „R“ (R is a statistical computer program similar to Matlab made available through the Internet under the GNU General Public Licence).
Kind of teaching	Lecture (2 HPW) and Seminar (1 HPW)
Literature	a) Peter Dalgaard, Introductory Statistics with R, Springer 2002; b) William N. Venables, Brian D. Ripley, Modern Applied Statistics with S, Springer 2003; c) John Fox, An R and S-Plus Companion to Applied Regression, Sage Publications 2002; d) Brian Everitt, An R and S-Plus Companion to Multivariate Analysis, Springer 2004; e) J.W. Einax et al., Chemometrics in Environmental Analysis, VCH (Wiley) 1997

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	3	39	61	50	150

Content of teaching	1. Introduction: Probability, special discrete and continous distributions, limit theorems, confidence intervals, statistical tests, correlation and regression, variance analysis 2. Multivariate methods: Linear statistical models, factor analysis, cluster and discriminant analysis 3. Basic methods of time series analysis 4. Case studies

Module	**Environmental Microbiology**
Person in Charge	Prof. Dr. H.-C. Flemming
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional/Compulsory Course	Requirements
1	1 Semester	Compulsory	none

Courses	HPW	Workload in h	Credits
Environmental Microbiology	3	150	5
Practical Course Environmental Microbiologie	9	210	7
Sum	12	360	12

Proficiency Certificate	Written exam

Module	**Environmental Microbiology**
Course	Environmental Microbiology
Lecturer	Prof. Dr. H.-C. Flemming

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1	WS	M.Sc. Water Science M.Sc. TWM	none	5

Learning target	The students will understand the processes underlying drinking water and waste water purification by biological filtration. They will obtain knowledge about the basics of sediment microbiology and bio-remediation and get access to the basics of biotechnology
Kind of teaching	Lecture (2 HPW) and Seminar (1 HPW)
Literature	Brock: Biology of Microorganisms 10 th Edition 2002. Prentice Hall, ISBN 0-13-081922-0 Doods, W.K.: Freshwater Ecology. Academic Press, San Diego, 2002, ISBN 0-12-219135-8 Maier, Pepper, Gerba: Environmental Microbiology, Academic Press, 2000, ISBN 0-12-49750-4

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	3	39	61	50	150

Content oft teaching	- Drinking water microbiology: bank filtration, groundwater - Microbiology of drinking water treatment - Microbiology of waste and waste water treatment - Sediment – microbiology - Bioremediation - Introduction to biotechnology

Module	**Environmental Microbiology**
Course	Practical Course - Environmental Microbiology
Lecturer	Prof. Dr. H. C. Flemming

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
2	SS	M.Sc. Water Science M.Sc. TWM	Course Environmental Microbiology	7

Learning target	The students shall - get used to work with environmental microorganisms, - will apply biomolecular methods like FISH, to determine species, activity and number of microorganisms in water samples
Kind of teaching	Laboratory exercises (8 HPW) and Seminar (1 HPW)
Literature	Script for practical

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	9	117	47	46	210

Content oft teaching	- Microscopy of microorganisms - Analysis of aerobic and anaerobic sediments through biomolecular methods (PCR methods) - Fluorescence-in-situ-hybridisation (FISH) - Different cultivation methods for water and sediment microorganisms

Module	**Practical Analytical Chemistry**
Person in Charge	Prof. Dr. A. Hirner
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional/Compulsory Course	Requirements
2	1 Semester		none

Courses	HPW	Workload in h	Credits
Practical Analytical Course Chemistry	15	300	10
Sum	15	300	10

Proficiency Certificate	Colloquium

Module	**Practical Course Analytical Chemistry**
Course	Practical Course Analytical Chemistry
Lecturer	Prof. Dr. A. Hirner

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
3	WS	M.Sc. Water Science M.Sc. Chemie	None	10

Learning target	Acquisition of basic theoretical and practical knowledge in applied analytical chemistry. The most common analytical methods in practice will be used for the analysis of real samples. Participants will receive both a characteristic and active view into the everyday practices of an analytical laboratory.
Kind of teaching	Practical (14 HPW) and Seminar (1 HPW)
Literature	Kellner, Mermet, Otto, Widmer: Analytical Chemistry, Wiley-VCH 1998

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	15	195	65	40	300

Content of teaching	Performance of analytical methods with modern instrumental techniques; selected liquid and solid samples,sample preparation; qualitative analysis, screening, quantitative determinations, theory of errors; X-ray analysis (XRF, diffractometry); chromatographic methods (GC, HPLC); hyphenated methods (GC-MS, LC-AFS, LA-ICP-MS); methods of evaluation: special analytical parameters

Module	**Research Practical**
Person in charge	All
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional / Compulsory	Requirements
2	2 months	compulsory	Master-lectures and Master-practical course of the relevant department

Courses	HPW	Workload in h	Credits
Research Practical Course	15	300	10
Sum	15	300	10

Proficiency Certificate	Report and final colloquium

Module	**Research Practical**
Course	Research Practical Course
Lecturer	All lecturers of Master Programme

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
3	WS	M.Sc. Water Science	Practical courses in Analytical Chemistry and Environmental Microbiology	10

Learning targets	Provide deeper knowledge in different scientific subjects
Kind of teaching	Practical course (14 HPW) and Seminar (1 HPW)
Literature	Depending on the specific subject; literature will be made available

Workload	Hours per week (HPW)	Time of attendance in h	Time for Preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	15	195	65	40	300

Content of teaching	For a limited period a defined research project in one of the research groups. IT-supported literature searching, learning of typical experimental laboratory work, oral presentation, written reports

Module	**Water Chemistry**
Person in charge	Prof. Dr. T. Schmidt
Internet	http://www.chemie.uni-essen.de

Years of study	Duration	Optional / Compulsory Course	Requirements
1	1 Semester	Compulsory	none

Courses	HPW	Workload in h	Credits
Water Chemistry	3	150	5
Sum	3	150	5

Proficiency Certificate	Written exam

Module	**Water Chemistry**
Course	Water Chemistry
Lecturer	Prof. Dr. T. Schmidt

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1	WS	M.Sc. Water Science M. Sc. Chemie	none	5

Learning targets	Students should acquire an advanced understanding of chemical processes relevant in natural and technical aqueous systems, and of conceptual models and quantitative approaches to describe these. Controls of behavior and fate of organic and inorganic contaminants will be emphasized.
Kind of teaching	Lecture (2 HPW) and Seminar (1 HPW)
Literature	a) Benjamin, M. M. *Water Chemistry*, McGrawHill: New York, 2002. b) Jensen, J. N. *A Problem-Solving Approach to Aquatic Chemistry*, Wiley: New York, 2003. c) Schwarzenbach, R. P., Gschwend, P. M., Imboden, D. M. *Environmental Organic Chemistry*, 2nd ed., Wiley: Ney York, 2003.

Workload-	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	3	39	61	50	150

Content of teaching	**Sorption processes:** partitioning, adsorption, ion exchange, surface complexation; sorption coefficients, linear and nonlinear sorption, sorption isotherms, dual mode theory, role of colloids/DOM, role of inorganic surfaces, mass transfer limitations, experimental methods and predictive tools. **Non-aqueous phase liquids**: characterization, dissolution, mass transfer coefficients, interfacial films. **Reaction kinetics:** zero-order, first-order and pseudo-first-order reactions, kinetics and thermodynamics. **Transformations:** nucleophilic substitution including hydrolysis, elimination, redox reactions, introduction to photolysis.

Module	**Ecology**
Person in charge	PD Dr. D. Hering
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional / Compulsory Course	Requirements
1	1 Semester	Optional	none

Courses	HPW	Workload in h	Credits
Environmental Management	2	60	2
Ecology and Protection of Waters	2	60	2
Sum	4	120	4

Proficiency Certificate	Written examination

Module	**Ecology**
Course	Environmental Management
Lecturer	Dr. A. v. Ahsen

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
2	SS	M. Sc. Water Science	none	2

Learning target	The Students shall - understand the economic principles for environmental management - be able of economical evaluation
Kind of teaching	Lecture (1 HPW) and Seminar (1 HPW)
Literature	• Culley, C. William (1998): Environmental and Quality Systems Integration; • Boca Raton et al. (1992): Environmental Life Cycle Assessment of Products, ed. by Centrum voor Milieukunde Leiden (CML), Leiden Ecological economics • Jasch, C. (2001): Environmental Management Accounting. Procedures and Principles, http:/www.un.org/esa/sustdev/proceduresandprinciples.pdf. • Edwards-Jones. G., Davies. B., Hussain. S.: Ecological economics: An introduction

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	2	26	17	17	60

Content of teaching	Environmental management systems in companies, environmental management instruments, such as Material- and Energy-Flow Analysis, Life Cycle Assessment, monetary (willing to pay, WTP) and nonmonetary forms, methods for integrated monetary (CBA) and nonmonetary decision making (MCA)

Module	**Ecology**
Course	Ecology and Protection of Waters
Lecturer	Prof. Dr. H. Schuhmacher

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
2	SS	M. Sc. Water Science	none	2

Learning target	The Students shall - be capable of transferring theoretical knowledge in aquatic ecology into practical application - know how to use different means to acquire information - be able to present a topic in context using modern means of presentation
Kind of teaching	Lecture (1 HPW) and Seminar (1HPW)
Literature	To be annouced in the course.

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	2	26	17	17	60

Content of teaching	A-priori and a-posteriori typology of freshwater ecosystems (rivers, lakes, groundwater, transitional waters), impacts of different perturbations (pollution, eutrophication, acidification, pesticides, hydromorphological alteration, waterpower) on aquatic ecosystems, river and lake assessment according to national and international regulations, the organism groups addressed by the EU Water Framework Directive and how to use them in biomonitoring, transferring monitoring results into restoration measures, lake and river restoration.

Module	**Electrochemistry and electrochemical analysis**
Person in charge	Prof. Dr. T. Schmidt
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional/Compulsory Course	Requirements
1 or 2	1 Semester	Optional	none

Courses	HPW	Workload in h	Credits
Electrochemistry and electrochemical analysis	3	150	5
Sum	3	150	5

Proficiency Certificate	Written exam

Module	**Electrochemistry and electrochemical analysis**
Course	Electrochemistry and electrochemical analysis
Lecturer	Dr. H. Krohn, Dr. B. Wermeckes

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1 or 3	WS	M.Sc. Water Science	none	5

Learning target	On the basis of fundamentals of electrochemistry students should be able to understand and to apply electrochemical methods and techniques in analytical chemistry, water treatment, corrosion and its protection.
Kind of teaching	Lecture (2 HPW) and Seminar (1 HPW)
Literature	a) C.H. Hamann, A. Hamnett, W. Vielstich, Electrochemistry, Weinheim 1998 (Wiley-VCH); b) P.W. Atkins, J. de Paula, Physical Chemistry, Seventh Edition, Oxford 2003; c) A.J. Bard, L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications, Second Edition, J. Wiley & Sons 2000; d) P. Monk, Fundamentals of Electroanalytical Chemistry, J. Wiley & Sons 2001; e) F. Scholz (Ed.), Electroanalytical Methods, Springer Verlag 2002; f) H. Kaesche, Corrosion of Metals, Springer Verlag 2003

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	3	39	61	50	150

Content of teaching	Fundamentals of electrochemistry (electrolytes, thermodynamics, kinetics, transport); Electrochemical methods and techniques (control of potential or current, conductivity, impedance, coulometry, cell design, rotating electrodes); errors of measurements (diffusion potential, Ohmic drop etc.); Corrosion and corrosion protection; Water treatment (waste water and drinking water); Electrometric end point detection of titrations (potentiometric, amperometric, conductivity); Ion specific electrodes and electrochemical sensors Voltammetric methods (cyclovoltammetry, polarography, stripping (invers) voltammetry); Detectors for liquid chromatography (conductivity, amperometry) Electrophoresis (capillary)

Module	**Environmental Chemistry: Air**
Person in charge	**Prof. Dr. R. Zellner**
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional/Compulsory Course	Requirements
1	1 Semester	optional	none

Courses	HPW	Workload in h	Credits
Environmental Chemistry: Air	3	150	5
Sum	3	150	5

Proficiency Certificate	Written exam or colloquium

Module	**Environmental Chemistry: Air**
Course	Environmental Chemistry: Air
Lecturer	Prof. Dr. R. Zellner

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
2	SS	M.Sc. Water Science M.Sc. Chemie	none	5

Learning target	The objectives are to convey fundamental aspects of environmental chemistry in the air and water compartments. The focus is on chemistry, radiation and transport in the natural environment and its perturbation by anthropogenic activities.
Kind of teaching	Lecture (2 HPW) and Seminar (1 HPW)
Literature	Finlayson-Pitts, Pitts: Atmospheric Chemistry Seinfeld, Pandis: Atmospheric Chemistry and Physics Stumm, Morgan: Aquatic Chemistry

	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparatio of exam in h	Total workload in h
Workload	3	39	61	50	150

Content of teaching	The composition of the atmosphere; temperature profile and vertical structure; global circulation, Eddy-diffusion, long-range transport; atmospheric radiation, photochemistry of trace gases; atmospheric chemical cycles, radical chemistry; global CO_2 cycle; ozone depletion in the stratosphere, CFCs and CFC-substitutes; climate effect of trace gases and greenhouse effect; climate history and climate change; photochemical smog; aerosols and multiphase chemistry; Chemistry of aqueous systems in the environment; solubility of gases, octanol/water partition coefficients; chemistry of surface waters; the water cycle and fresh water supply; eutrophication of lakes and oceans; photochemistry in aqueous systems, redox processes, kinetics and phase transition, the role of metal ion chemistry; solid/liquid phase boundaries.

Module	**Environmental Chemistry : Pollutants**
Person in charge	**Prof. Dr. A. Hirner**
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional/Compulsory Course	Requirements
1 or 2	1 Semester	Optional	none

Course	HPW	Workload in h	Credits
Environmental Chemistry Pollutants	3	150	5
Sum	3	150	5

Proficiency Certificate	Written exam or colloquium

Module	**Environmental Chemistry Pollutants**
Course	Environmental Chemistry Pollutants
Lecturer	Prof. Dr. A. Hirner

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1 or 3	WS	M.Sc. Water Science M.Sc. Chemie	none	5

Learning target	Overview of environmental contamination and associated processes as well as insight into risk assessment of relevant scenarios. Establishment of foundations for subject related open discussion.
Kind of teaching	Lecture (2 HPW) and Seminar (1HPW)
Literature	Manahan: Environmental Chemistry, Lewis Publ. 2004; Hirner, Rehage, Sulkowski: Umweltgeochemie, Steinkopff 2000

Workload	Hours per week in HPW	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	3	39	61	50	150

Content of teaching	Introduction to environmental medicine and human toxicology: asbestos, environmentally relevant particles and fine particles, diesel soot, heavy metals (introduction, speciation), mercury, lead, cadmium, arsenic, zinc, selenium, antimony, tin, thallium, beryllium, organics (introduction), PAK, bioaccumulation, DDT, PCB, dioxin, biocide (degradation, metabolite) radioactive materials (differentiation of geo- and anthropogenic sources, contamination scenarios, Chernobyl, radon), contaminant-fingerprinting

Module	**Environmental Chemistry: Soil/Waste**
Person in charge	Prof. Dr. A. Hirner
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional/Compulsory Course	Requirements
1 or 2	1 Semester	Optional	none

Courses	HPW	Workload in h	Credits
Environmental Chemistry: Soil / Waste	3	150	5
Sum	3	150	5

Proficiency Certificate	Written exam or colloquium

Module	**Environmental Chemistry: Soil/Waste**
Courses	Environmental Chemistry: Soil / Waste
Lecturer	Prof. Dr. A. Hirner

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1 or 3	WS	M.Sc. Water Science M.Sc. Chemie	none	5

Learning target	Acquisition of basic knowledge of environmental chemistry of soils and sediments. Insight into relevant environmental scenarios with regard to geogenic and anthropogenic impact; introduction of concepts of toxicological assessment
Kind of Teaching	Lecture (2 HPW) and Seminar (1 HPW)
Literature	Heintz, Reinhardt: Chemie und Umwelt, Vieweg 1996; Bliefert: Umweltchemie, Wiley-VCH 2002; Hirner, Rehage, Sulkowski: Umweltgeochemie, Steinkopff 2000

	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
Workload	3	39	61	50	150

Content of teaching	Environmental chemistry Soil / Waste Overview of contamination of environmentally relevant solid samples. Explanation of transformation and transport processes affecting the mobility and toxicological relevance of pollutants - Soils and sediments (genesis, components, clay minerals, humic material, interaction, pollutant-chronology) - Pollutant mobility (sequential extraction, elution tests, speciation, solvent extraction) - Rubbish and waste (geochemical background contamination, stabilisation and storage, compilation and appraisal) - Dust (external and internal areas, diesel soot, toxicology of fine particulates)

Module	**Excursions**
Person in charge	All
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional / Compulsory Course	Requirements
1 or 2	1 Semester	Optional	none

Courses	HPW	Workload in h	Credits
Excursions	2	60	2
Sum	2	60	2

Proficiency Certificate	Written Report

Module	**Excursions**
Course	Excursions
Lecturer	All lecturers of Master Programme Water Science

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1,2 or 3	SS or WS	M.Sc. Water Science	none	2

Learning target	Students should become familiar with the industrial site of water treatment
Kind of teaching	Excursions
Literature	Scripts

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	-	24	18	18	60

Content of teaching	Selected topics out of - Drinking water production - Waste water treatment - Water supply

Module	**Hydrochemical System Modelling**
Person in charge	Prof. Dr. K. Molt
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional / Compulsory Course	Requirements
1 or 2	1 Semester	Optional	none

Courses	HPW	Workload in h	Credits
Hydrochemical System Modelling	3	150	5
Sum	3	150	5

Proficiency Certificate	Computer homework (solution to exercises) and final oral examination

Module	**Hydrochemical System Modelling**
Course	Hydrochemical System Modelling
Lecturer	Prof. Dr. K. Molt

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1 or 3	WS	M.Sc. Water Science	none	5

Learning target	Understanding aquatic chemistry by treating chemical equilibria in aqueous solutions quantitatively. Students will learn how to solve corresponding problems with the programming environment „R“ (R is a statistical computer program similar to Matlab made available through the Internet under the GNU General Public Licence).
Kind of teaching	Lecture (2 HPW) and Seminar (1 HPW)
Literature	a) Robert De Levie, How to Use Excel in Analytical Chemistry and in General Scientific Data Analysis, Cambridge University Press (2001); b) Werner Stumm, James J. Morgan, Aquatic Chemistry, John Wiley & Sons Inc (1995) c) Richard E. Zeebe, Dieter A. Wolf-Gladrow, CO2 in Seawater: Equilibrium, Kinetics, Isotopes (Elsevier Oceanography Series, 65)(2001); d) An Introduction to R (Notes on R: A Programming Environment for Data Analysis and Graphics, Version 1.8.0/2003-10-08), www.r-project.org

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	3	39	61	50	150

Content of teaching	Acid-base-systems, pH-dependency of dissociation equilibria, simulation of titrations and calculation of pH values, Stick Diagrams, Schwartz and Gran-Plots, buffer und buffer capacity, isoelectric point, precipitation and dissolution equilibria, equilibrium properties of the carbonate system.

Module	**Management**
Person in charge	Prof. Dr. K. Molt
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional / Compulsory Course	Requirements
1 and 2	2	Optional	none

Courses	HPW	Workload in h	Credits
Quality Management	2	90	3
Project Management	2	90	3
Sum	4	180	6

Proficiency Certificate	Written exam of module

Module	**Management**
Course	Quality Management
Lecturer	Prof. Dr. Karl Molt

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
2	WS	M. Sc. Water Science M.Sc. TWM	None	3

Learning target	The application of Quality Assurance techniques has led to major improvements in the quality of many products and services. In this course the international guides and concepts regarding quality management are imparted and the essential points elaborated. At special examples students learn dealing with international norms. After the course students should be able to establish and validate quality management and assurance systems.
Kind of teaching	Lecture (1 HPW) and Seminar (1 HPW)
Literature	a) Neidhart, B.; Wegscheider, W.: Quality in Chemical Measurements, Springer-Verlag Berlin Heidelberg New York 2001, ISBN 3-540-65994-32; b) ISO Standards Compendium ISO 9000 – Quality management, 10th edition 2003, ISBN 92-67-10381-43; c) ISO Survey of ISO 9000 and ISO 14001 certificates, 12th circle 2002, ISBN 92-67-10377-64. ISO Management System The International Review of ISO 9000 and ISO 14000, International Organisation for Standardisation

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	2	26	32	32	90

Content of teaching	Quality assurance in analytics and production; Introduction into the terms Good Laboratory Practice, Accreditation, Certification and the corresponding guides like GLP, GMP, EN 45001 und ISO 9000 ff; Requirements concerning a quality management system, e.g. standard operating standard procedures (SOPs), manuals, test devices, validation of methods; Quality Control Charts; Metrology; Documentation and archiving of data; Software Applications

Module	**Management**
Course	Project Management
Lecturer	Prof. Dr. Griebler

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
3	WS	M.Sc. Water Science	None	3

Learning targets	Students learn the basic knowledge of Project Management and the application of its fundamental rules to structure, organize and execute common projects with success. Case studies are used for demonstration and training purposes.
Kind of teaching	Lecture (2 HPW)
Literature	a) Smith, K.A., 2000, Project Management and Teamwork, Boston: McGraw-Hill's BEST; b) Verzuh, E., 1999, The Fast Foreward MBA in Project Management, New York: John Wiley & Sons, Inc.; c) PMBOK ® Guide, 2000 Edition to the Project Management Body of Knowledge, Newton Square, Pensylvania: Project Management Institute; d) Cleland, D.I., 2000, Ireland, L.R., Project Manager's Portable Handbook, New York: McGraw-Hill; e) Schelle, H.,1999, Projekte zum Erfolg führen, München: C.H. Beck; f) Ackoff, R.L.,1994, The Democratic Corporation, Oxford/New York: Oxford University Press

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	2	26	32	32	90

Content of teaching	1. Project characteristics and success factors 2. Stakeholder Concept 3. Project Life Cycle Concept 4. Project Initiation and Planning 5. Project Organization 6. Project Execution and Controlling 7. Costs and Budgeting 8. Role of Project Manager and work in Project Teams 9. Risk- and Conflict Management 10. Documentation and Communication.

Modul	**Membrane Technologies**
Person in charge	Prof. Dr. M. Ulbricht
Internet	http://www.chemie.uni-essen.de/Module

Years of study	Duration	Optional / Compulsory Course	Requirements
1 oder 2	1 Semester	optional	none

Courses	HPW	Workload in h	Credits
Membrane Technologies	2	90	3
Sum	2	90	3

Proficiency Certificate	Written exam

Modul	**Membrane Technologies**
Course	Membrane technologies
Lecturer	Prof. Dr. M. Ulbricht

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1 or 3	WS	M.Sc. Water Science	none	3

Learning target	On the basis of fundamental knowledge in physical chemistry and (chemical) process engineering, the students will gain detailed insights into the fundamentals of membranes and membrane separations as well as the most important membrane technologies which are applied to water treatment and/or purification.
Kind of teaching	Lecture (1 HPW) and Seminar (1 HPW)
Literature	a) M. Mulder, Basic principles of membrane technology, 2nd Ed., Dordrecht: Kluwer Academic Publishers, 1996. b) R. W. Baker, Membrane technology and applications, 2nd Ed. Chichester: John Wiley and Sons, 2004.

Workload	Präsentation (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload ín h
	2	26	34	30	90

Content of teaching	Membranes: – Types (non-porous vs. porous, ion-exchange, affinity) – Processes by type and driving force (gas separation, reverse osmosis, nanofiltration, ultrafiltration, microfiltration, dialysis, electrodialysis, pervaporation, specials) – Materials and preparation / manufacturing – Shape (flat-sheet, hollow fibre) and morphology Membrane fouling and scaling Membrane modules and principles of membrane separation engineering Membrane adsorbers Membrane reactor concepts Examples (case studies) with particular relevance to water technologies: - Desalination by reverse osmosis, nanofiltration and electrodialysis Purification and ultrapurification by reverse osmosis, nano-, ultra- and microfiltration as well as combined processes - Membrane bioreactors

Module	**Stable Isotope Analysis**
Person in charge	Prof. Dr. T. Schmidt
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional / Compulsory Course	Requirements
1 or 2	1 Semester	optional	none

Courses	HPW	Workload in h	Credits
Stable Isotope Analysis	3	150	5
Sum	3	150	5

Proficiency Certificate	Exam

Module	**Isotope Analysis**
Course	Stable Isotope Analysis
Lecturer	Prof. Dr. T. Schmidt

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1 or 3	WS	M.Sc. Water Science	none	5

Learning target	Students should get to know the principles and instrumentation in modern stable isotope analysis with emphasis on light elements. By studying exemplary applications and case studies they will learn for which problems in environmental science isotope analysis might provide solutions.
Kind of teaching	Lecture (1 HPW) and Seminar (1 HPW)
Literature	a) Clark, I.; Fritz, P. *Environmental Isotopes in Hydrogeology*; CRC Press: Boca Raton, 1997. b) Kendall, C.; McDonnell, J. J., Eds. *Isotope Tracers in Catchment Hydrology*; Elsevier: Amsterdam, 1998.

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	3	39	61	50	150

Content of teaching	Isotope fundamentals, isotope fractionation, referencing and calibration; Instrumentation, principles of isotope analysis; Gas source isotope ratio mass spectrometry (C, H, N, and O), bulk techniques: dual inlet, continuous flow, compound specific isotope analysis, position-specific isotope analysis; Isotope analysis of heavy elements: multicollector-ICP-MS, thermal ionization MS (e.g., Fe, Ca, Sr, Pb, (U)); Applications of stable isotope analysis in environmental science: Source apportionment, transformation (extent and pathways)

Module	**Technical Engineering Water**
Person in charge	Prof. Dr. R. Gimbel
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional / Compulsory Course	Requirements
1 and 2	2 Semester	Optional	none

Courses	HPW	Workload in h	Credits
Technical Engineering Water	3	150	5
Practical Course Technical Engineering Water	3	120	4
Sum	6	270	9

Proficiency Certificate	Oral/written examination and report of the practical courses

Module	**Technical Engineering Water**
Lecture	Technical Engineering Water
Lecturer	Prof. Dr. R. Gimbel, Dr. R. Hobby

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
2	SS	M. Sc. Water Science	none	5

Learning targets	Theoretical basics of different processes in drinking water treatment, and basic knowledge for the practical design.
Kind of teaching	Lecture (2 HPW) and Seminar (1 HPW)
Literature	a) Sontheimer et. al., Activated Carbon for Water Treatment, DVGW-Forschungsstelle am Engler-Bunte Institut der Universität Karlsruhe (TH) 1988; b) Tien, C., Granular Filtration of Aerosols and Hydrosols, Butterworth Publishers 1989, ISBN 0-409-90043-5; c) Filters and Filtration Handbook, 3rd Edition Elsevier Science Publishers LTD, 1996, ISBN 1-85617-078-0

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload In h
	3	39	61	50	150

Content of teaching	Basics knowledge and practical orientated knowledge for the following water treatment processes: • Overview • Oxidation Processes • Decarbonisation • Ion Exchange • Gas Exchange • Flocculation • Sedimentation • Sludge Treatment • Filtration • Adsorption • Membrane Processes

Module	**Technical Engineering Water**
Course	Practical Technical Engineering Water
Lecturer	Prof. Dr. R. Gimbel

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
3	WS	M. Sc. Water Science	Lecture Technical Engineering Water (Master)	4

Learning targets	Students have to enhance their theoretical knowledge from the lecture Practical Engineering Water. They have to carry out practical orientated experiments with different pilot plants.
Kind of teaching	Practical course with pilot pants
Literature	a) Sontheimer et. al., Activated Carbon for Water Treatment, DVGW-Forschungsstelle am Engler-Bunte Institut der Universität Karlsruhe (TH) 1988; b) Tien, C., Granular Filtration of Aerosols and Hydrosols, Butterworth Publishers 1989, ISBN 0-409-90043-5; c) Filters and Filtration Handbook, 3rd Edition Elsevier Science Publishers LTD, 1996, ISBN 1-85617-078-0

	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Preparation of exam in h	Total workload in h
Workload	3	39	41	40	120

Content of teaching	1. Filtration 2. Deacidification Membrane Filtration

Module	**Water Pollution/Water Pollution Monitoring**
Person in charge	PD Dr. K. Bester
Internet	http://www.chemie.uni-essen.de

Years of study	Duration	Optional / Compulsory Course	Requirements
1-3	1 Semester	Optional	none

Courses	HPW	Workload in h	Credits
Water Pollution/Water Pollution Monitoring	3	150	5
Sum	3	150	5

Proficiency Certificate	Written or oral exam

Module	**Water Pollution/Water Pollution Monitoring**
Course	Water Pollution/Water Pollution Monitoring
Lecturer	PD Dr. K. Bester

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1-3	SS or WS	M.Sc. Water Science	Water Chemistrry, Analytical Chemistry	5

Learning targets	The students will be able to develop and assess sampling strategies under the diverse rationales. They will be able to realistically assess field and monitoring data.
Kind of teaching	Seminar (2 HPW) and Practical Course (1 HPW)
Literature	FENT, K.: Ökotoxikologie, Georg Thieme Verlag, Stuttgart (1998)

	Hours per week (HPW)	Time of attendance in	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
Workload	3	39	61	50	150

Content of teaching	**Pollution of surface waters** with organic contaminants such as pesticides, detergents, plasticisers, and endocrine disruptors. **Sources of pollution**: Point sources like sewage treatment plants, diffuse sources like agriculture, air-water gas exchange (PAHs, PCBs) **Fate of contaminants in surface waters**: Hydrolysis, metabolisation, sediment interaction. **Fate of contaminants in** wastewater treatment, as well as drinking water. **Effects**: biomagnification, acute toxicity, chronic toxicity **Differences in highly used and remote water bodies** (urban waters, remote areas like Arctic Seas) **Legal issues**: Water Framework Directive. Complyment with target concentration. **Sampling strategies:** Why is sampling performed-diverse targets: pollution control, safeguard drinking water production, healthy ecosystems, fish production / bio-accumulating compounds **Sampling techniques** **Analytical techniques**: Internal standards, recovery rates, method validation. **Extraction techniques**: SPE, LLE, Clean-ups, **Drafting and experimentally testing** an own sampling strategy, performing the sampling and analysis of own field samples, interpretation of results

Module	**Water: Rules, Norms, and Laws**
Person in charge	Prof. Dr. J.-D. Herbell
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional / Compulsory Course	Requirements
1 or 2	1 Semester	Optional	none

Courses	HPW	Workload in h	Credits
Water: Rules, Norms, and Laws	2	90	3
Sum	2	90	3

Proficiency Certificate	Written exam

Module	**Water Rules, Norms, and Laws**
Course	Water Rules, Norms, and Laws
Lecturer	Prof. Dr. J.-D. Herbell

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
1 or 3	WS	M.Sc. Water Science	none	3

Learning target	Students will be enabled to read and understand basics in environmental protection laws and regulations. The general principles, such as prevention, polluter pays, community task, and integration should be understood and transferred into practice. Starting from German regulations, actual trends in european and internatinal legislation are discussed. The overall goal of this lecture is to encourage students in natural sciences and engineering to make use of juridical matters in practice, and to overcome their usual reserve against such kind of materials. Students will be enabled to take over responsibility and to transfer environmental protection into global economy.
Kind of teaching	Lecture (2 HPW)
Literature	Scripts, Wasserhaushaltsgesetz, Bundesimmissionsschutzgesetz, Kreislaufwirtschafts-/und Abfallgesetz, EMAS, ISO 14000 ff

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	2	26	34	30	90

Content of teaching	Selected topics out of - Wasserhaushaltsgesetz: Apprehension principle; § 7a - Bundesimmissionsschutzgesetz: How to apply for and get admission to set up and operate technical plants - Kreislaufwirtschafts-/Abfallgesetz: Avoid, recycle, product reponsibility, life cycle analysis - Umweltmanagement: Overview on EMAS, ISO 14000 ff.

Module	**Waste Water**
Person in Charge	Dr. M. Denecke
Internet	http://www.chemie.uni-essen.de/Module

Year of study	Duration	Optional/Compulsory Course	Requirements
1	1 Semester	Optional	none

Courses	HPW	Workload in h	Credits
Microbiology of Waste Water Treatment	2	60	2
Proteins in Activated Sludges/Sandfiltration	5	150	5
Sum	7	210	7

Proficiency Certificate	Written exam

Module	**Waste Water**
Course	Microbiology of Waste Water Treatment
Lecturer	Dr. M. Denecke

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
2	SS	M.Sc. Water Science	none	3

Learning target	The student shall: • gain knowledge of wastewater biology and chemistry • gain understanding the fundamentals in the field of Urban Water Management • master the design of individual facility components of wastewater treatment plants
Kind of teaching	Lecture (1 HPW) and Seminar (1 HPW)
Literature	to be announced in the course.

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	2	26	32	32	90

Content oft teaching	Sources and composition of waste water, basic biological processes, activated sludge plants, trickling filters, nitrification, denitrification, P-elimination, anaerobic processes, sludges treatment, mass balances

Module	**Waste Water**
Course	Proteins in activated sludge/sandfiltration
Lecturer	Dr. M. Denecke

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
3	Winter	M.Sc. Water Science	none	5

Learning target	The students will gain theoretical and practical knowledge in wastewater treatment; basics of protein extraction from environmental samples; protein measurement (Bradford and Lowry), gelelectrophoresis (PAGE); participants will receive a characteristic and active view into the everyday practices of activated sludge analysis.
Kind of teaching	Seminar (1HPW) and Practical Course (4 HPW)
Literature	Henze, Mogens; Harremoes, Poul; LaCour Jansen, Jes; Arvin, Erik; Wastewater Treatment, Biological and Chemical Processes

Workload	Hours per week (HPW)	Time of attendance in h	Time for preparation and postprocessing in h	Time for Preparation of exam in h	Total workload in h
	5	65	50	35	150

Content of teaching	The wastewater treatment process and basics of the design, and the operation of sandfiltration, basic of the microbiology of activated sludge, role of proteins in activated sludge, handling of activated sludge - sampling, sample storage and sample preparation - protein extraction, separation (PAGE), quantification

Module	**Master-Thesis**
Person in Charge	Dean of Studies
Internet	http://www.chemie.uni-essen.de/Module

Course	Workload in h	Credits
Master-Thesis	900	30

Proficiency Certificate	Marking of the thesis

Semester	Frequency	Relevant for Study Programme	Requirements	Credits
4	At any time	M.Sc. Water Science M.S. Chemie	80 Credits in M.Sc.-Water Science	30

Learning target	The Master Thesis is an experimental or theoretical work presented in written form showing that the students can perform and evaluate a scientific topic within 6 months time. The students will gain experiences with modern scientific methods.
Kind of teaching	Experimental and theoretical work and evaluation and written documentation

Content of teaching	The projects will be provided by the lecturers. The students are free to choose the supervisor by themselves.