UNIVERSITÄT
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University of Duisburg-Essen

Module Handbook

Water Science

Master of Science (M.Sc.)

(Draft 29-09-2011)

Contents

First Term	HPW	Cr	Exam
Chemometrics and Statistics	3	5	1
Environmental Microbiology	3	5	1
Water Chemistry	3	5	1
Optional Courses		**15**	**2-3**
Electrochemistry and Electrochemical Analysis	3	5	1
Environmental Chemistry: Pollutants	3	5	1
Environmental Chemistry: Soil/Waste	3	5	1
Membrane Technologies	2	3	1
Wastewater Treatment	3	5	1
Water Pollution/ Water Pollution Monitoring	3	5	1
Excursions	1-5	1-5	
Sum		30	5-6

Second Term	HPW	Cr	Exam
Applied AnaC	3	5	1
Env-MiBi-P	9	7	
Applied Microbiology	4	6	1
Optional Courses		**12**	**2-3**
Advanced Mass Spectrometry	2	3	1
Ecology and Protection of Freshwater Ecosystems	4	5	1
Environmental Chemistry: Air	3	5	1
Quality Management	2	3	
Metrology in Chemistry	1	2	1
Microbial Physiology	2	3	1
Oxidative Processes	3	5	1
Stable Isotope Analysis	6	9	1
Technical Engineering Water	3	5	1
Water Pollution/ Water Pollution Monitoring	3	5	1
Excursions	1-5	1-5	
Sum		30	4-5

Third Term	HPW	Cr	Exam
Biofouling, Biocorrosion	3	5	1
AnaC-P	15	10	
Research-P	15	10	
Optional Courses		**5**	**1**
Electrochemistry and Electrochemical Analysis	3	5	1

Environmental Chemistry: Pollutants	3	5	1
Environmental Chemistry: Soil/Waste	3	5	1
Project Management	2	3	1
Membrane Technologies	2	3	1
Technical Engineering Water-Practical Course	3	4	
Wastewater Treatment	3	5	1
Water Pollution/ Water Pollution Monitoring	3	5	1
Excursions	1-5	1-5	
Sum		30	2
Fourth Term	**HPW**	**Cr**	**Exam**
Master-Arbeit		30	1
Sum		30	1
Total Sum		120	11-12

Module Descriptions

Module Name	Abbreviation Module
Applied Analytical Chemistry	Appl AnaC
Responsible for the Module	Faculty
Prof. Dr. Alfred Hirner	Chemistry

Relevance for following study programmes:	Module Level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	C	5

Prerequisites	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Applied Analytical Chemistry	C	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
Students will understand the opportunities and limitations of instrumental analytical methods to obtain information on environmental systems.
Associated Key Qualifications
Basic knowledge, systemic thinking, scientific thinking, structural ability, switching ability, - Ability to choose appropriate analytical methods for their own research questions based on the acquired theoretical and practical knowledge - Ability to evaluate the quality of reported or achieved analytical data

Module examinations to gain grades
Written exam
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Applied Analytical Chemistry	Appl AnaC	
Course Name	Abbreviation Course	
Applied Analytical Chemistry		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Alfred Hirner	Chemistry	C

Designated Semester	Frequency	Language	No. students
2	SS	english	

SWS	Presence[1]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
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
Contents
• 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), chromatography (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
Examination
Written exam
Literature

[1] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Kellner, Mermet, Otto, Widmer: Analytical Chemistry, Wiley-VCH 1998
Further Information on the course

Module name	Abbreviation Module
Applied Microbiology	Appl MiBi
Responsible for the Module	Faculty
Prof. Dr. Wolfgang Sand	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	C	6

Prerequisites according to examination regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Geomicrobiology	C	2	90 h
II	Hygiene	C	2	90 h
Sum (Compulsory and Supplementary Courses)			4	180 h

Learning Outcomes of the Module
The students have knowledge how deeply microorganisms are involved in geochemical cycles. They are able to understand that microbial ecology, geochemistry and geology are closely connected. They obtain knowledge of the physiology and biochemistry of the microorganisms for the understanding of geochemical processes.
Associated Key Qualifications
Knowledge of geochemical processes, physiology and biochemistry of the microorganism.

Module examinations to gain grades
Written exam for module
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Applied Microbiology	Appl MiBi	
Course Name	Abbreviation Course	
Geomicrobiology		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Wolfgang Sand	Chemistry	C

Designated Semester	Frequency	Language	No. students
2	SS	English	

SWS	Presence[2]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (2 SWS)
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.
Contents

[2] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

1) Earth as a microbial habitat, growth conditions of microorganisms, Environment, Lithosphere, Hydrosphere, Atmosphere, geomicobiological processes and methods

2) Formation and degradation of carbonates

3) Interactions with Si

4) Interactions with P and N

5) Interactions with As, Sb, Hg, and Cr

6) Geomicrobiology of Fe

7) Geomicrobiology of Mn

8) Interactions with Se and Te

9) Geomicrobiology of S

10) Formation and degradation of metal sulfides (bioleaching)

11) Fossil fuels

Examination
Written exam
Literature
a) Geomicrobiology, 5th edition, 2009, Henry Lutz Ehrlich, Marcel Dekker New York, ISBN 978-0-8493-7906-2 b) Geomikrobiologie, 1998, Manfred Köhler und Fernando Völsgen, Wiley-VCH Weinheim, ISBN 3-527-30083-x; c) Brock Biology of Microorganisms, 2003, Michael T. Madigan, John M. Martinko, Jack Parker, Pearson Education Prentice Hall Upper Saddle River, ISBN 0-13-049147-0
Further Information on the course

Module name	Abbreviation Module	
Applied Microbiology	Appl MiBi	
Course Name	Abbreviation Course	
Hygiene		
Lecturer	Faculty	Module Type (C/S)
Dr. Jost Wingender	Chemistry	C

Designated Semester	Frequency	Language	No. students
2	SS	English	Ca. 20

SWS	Presence[3]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (2 SWS)
Learning Targets
The students will have an overview of the characteristics and epidemiology of water-related infectious diseases. They will learn the relationships between water, sanitation and health. They will acquire basic knowledge on the relevant microbial, human and environmental factors which determine the hygienic status of water and its impact on public health. They will be able to evaluate the role of water-related pathogens for human health and learn approaches to prevent or control water-related infectious diseases.
Contents
1) Water, sanitation and health – global situation 2) Transmission routes and reservoirs of water-related pathogens 3) Classical and emerging waterborne pathogens – bacteria 4) Waterborne pathogens – viruses 5) Waterborne pathogens – protozoa 6) Vector-borne diseases associated with water 7) Water-related disease caused by cyanobacteria and algae 8) Hygienic aspects of catchment and source water quality 9) Hygienic aspects of water treatment, disinfection and water distribution 10) The indicator concept 11) Risk assessment

[3] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Examination
Written exam
Literature
Brock Biology of Microorganisms. Madigan, M., Martinko, J., Dunlap, P. (2008) 12th Edition, Addison Wesley Pub Co Inc.
Further Information on the course
Homepage der World Health Organization (WHO), Water, sanitation and health: http://www.who.int/water_sanitation_health

Module name	Abbreviation Module
Biofouling, Biocorrosion	Biof
Responsible for the Module	Faculty
Prof. Dr. Hans-Curt Flemming & Prof. Dr. Wolfgang Sand	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
3	1 Semester	C	5

Prerequisites according to examination regulations	Recommended Prerequisites
none	Environmental Microbiology, Microbial Physiology, Geomicrobiology, Hygiene

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Biofouling, Biocorrosion	C	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
Increased understanding of biofilms as the dominant life form, introduction to the most frequent microbially influenced problems in technical systems, guidance for analyses and problem solving approaches incl. integrated countermeasures
Associated Key Qualifications
Knowledge of biofilms, problems encountered and applicable solutions

Module examinations to gain grades
Written exam
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Biofouling, Biocorrosion	Biof	
Course Name	Abbreviation Course	
Biofouling, Biocorrosion		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Hans-Curt Flemming & Prof. Dr. Wolfgang Sand	Chemistry	C

Designated Semester	Frequency	Language	No. students
3	SS	English	

SWS	Presence[4]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
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.
Contents

[4] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

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

Examination

Written exam

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

Further Information on the course

Module name	Abbreviation Module
Chemometrics and Statistics	Chemo
Responsible for the Module	Faculty
Dr. Maik Jochmann, Prof. Dr. Torsten Schmidt	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1	1 Semester	C	5

Prerequisites according to examination regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Chemometrics and Statistics	C	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
The students get knowledge about statistics including probability calculus, random variables, interval estimates and regression analysis. They are able to use these in modern chemometric data evaluation methods. They can solve problems within a programming environment.
Associated Key Qualifications
Basic knowledge, problem solving strategies, computing skills, structured working

Module examinations to gain grades
Written exam
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Chemometrics and Statistics	Chemo	
Course Name	Abbreviation Course	
Chemometrics and Statistics		
Lecturer	Faculty	Module Type (C/S)
Dr. Maik Jochmann, Prof. Dr. Torsten Schmidt	Chemistry	C

Designated Semester	Frequency	Language	No. students
1	WS	English	

SWS	Presence[5]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 HPW) and Seminar (1 HPW)
Learning Targets
After a brief 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 in a computer-based environment.
Contents
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
Examination
Written exam
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

[5] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Further Information on the course

Module name	Abbreviation Module
Environmental Microbiology	Envi MiBi
Responsible for the Module	Faculty
Prof. Dr. Wolfgang Sand & Prof. Dr. Bettina Siebers & Prof. Dr. Hans-Curt Flemming	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1-2	2 Semester	C	12

Prerequisites according to examination regulations	Recommended Prerequisites
	Biochemistry, molecular biology

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Environmental Microbiology	C	3	150 h
II	Practical Course Environmental Microbiology	C	9	210 h
Sum (Compulsory and Supplementary Courses)			3	360 h

Learning Outcomes of the Module
The students get knowledge about drinking water microbiology, microbiology of waste and waste water treatment. They have basic information about biotechnology.
Associated Key Qualifications
Application of the molecular biological approaches to microbial diversity. Knowledge of environmental microorganisms and biotechnological processes.

Module examinations to gain grades
Written exam
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Environmental Microbiology	Envi MiBi	
Course Name	Abbreviation Course	
Environmental Microbiology		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Bettina Siebers & Prof. Dr. Hans-Curt Flemming	Chemistry	C

Designated Semester	Frequency	Language	No. students
1	WS	English	

SWS	Presence[6]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
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 bioremediation and get access to the basics of biotechnology.
Contents
- Drinking water microbiology: bank filtration, groundwater - Microbiology of drinking water treatment - Microbiology of waste and waste water treatment - Sediment – microbiology - Bioremediation - Introduction to biotechnology - Extremophiles (Microorganisms in extreme habitats) - Molecular ecology: - Population analysis by classical and molecular approaches - Gene transfer and gene regulation during biofilm formation
Examination
Written exam

[6] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
Brock: Biology of Microorganisms 12 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
Further Information on the course

Module name	Abbreviation Module	
Environmental Microbiology	Envi MiBi	
Course Name	Abbreviation Course	
Practical Course Environmental Microbiology		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Wolfgang Sand & Prof. Dr. Bettina Siebers	Chemistry	C

Designated Semester	Frequency	Language	No. students
2	SS	English	

SWS	Presence[7]	preparation, self tutoring, preparation for exam (h)	Workload
9	135 h	75 h	210 h

Education Methodology
Practical (8 SWS) & Seminare (1 SWS)
Learning Targets
The students shall get trained in - handling environmental microorganisms - analyses of environmental samples incl. enrichment of relevant metabolic types - staining methods - geomicrobiological cycles and microorganisms - simple biotechnological processes like fermentation - application of molecular biological approaches to address microbial diversity
Contents
- Microscopy of microorganisms - Analysis of microbial communities through biomolecular methods (PCR methods) - Different cultivation methods for water and sediment microorganisms
Examination
Written/oral exam & protocol
Literature
Special script for practical course

[7] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Further Information on the course

Module name	Abbreviation Module
Practical Analytical Chemistry	PracAnalChem
Responsible for the Module	Faculty
Prof. Dr. Torsten Schmidt	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
3	1 Semester	C	10

Prerequisites according to examination regulations	Recommended Prerequisites
none	Applied Analytical Chemistry

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Practical Course Analytical Chemistry	C	15	300 h
Sum (Compulsory and Supplementary Courses)			15	300 h

Learning Outcomes of the Module
The students learn different modern methods and special work techniques of analytical chemistry and their applications. They can estimate and evaluate the advantages and disadvantages of these methods critically. They learn how to present their work in a written report.
Associated Key Qualifications
Basic knowledge, systemic thinking, scientific thinking and functions, structural ability, planning, switching ability, realistic time and work planning

Module examinations to gain grades
Colloquia and report in the practical course (study achievements); conclusion colloquium with an university teacher (test achievement)
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Practical Analytical Chemistry	PracAnalChem	
Course Name	Abbreviation Course	
Practical Course Analytical Chemistry		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Torsten Schmidt	Chemistry	C

Designated Semester	Frequency	Language	No. students
3	WS	english	

SWS	Presence[8]	preparation, self tutoring, preparation for exam (h)	Workload
15	225 h	75 h	300 h

Education Methodology
Experimental project work (14 SWS) & Seminar (1 SWS)
Learning Targets
The students acquire advanced theoretical and practical basic knowledge in applied analytical chemistry. By direct integration into a project-oriented research topic they learn how to set-up and validate analytical methods aiming at answering research questions. The students receive thus also an active insight into the everyday life in a modern analytical laboratory.
Contents
Rather than carrying out pre-set identical experiments on a lab course level as on the Bachelor level, in the Master practical course analytical chemistry students select topics suggested by all research groups involved in analytical chemistry training, covering topics from advanced spectrometry via hyphenation techniques to sophisticated mass spectrometry. Although only a limited and individually selected number of analytical techniques will thus be learned hands-on, this procedure contributes to the development of an individual study profile and due to the research orientation is much more motivating for the students than carrying out pre-selected experiments with known results.
Examination
Colloquia and report in the practical course (study achievements); conclusion colloquium with an university teacher (test achievement)
Literature
Research-related primary literature will be distributed at the beginning of the practical

[8] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Further Information on the course

Module name	Abbreviation Module
Research Practical	Res Pract
Responsible for the Module	Faculty
Lecturers of the selected subject	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
3	1 Semester	C	10

Prerequisites according to examination regulations	Recommended Prerequisites
Practical Course AnaC + Envi Mibi	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Research Practical	C	15	300 h
Sum (Compulsory and Supplementary Courses)			15	300 h

Learning Outcomes of the Module
Students learn how to set-up a small-scale research project, to carry out the required experimental work independently in a limited period of time and to present their results in a written report and/or an oral presentation.
Associated Key Qualifications
Presentations skills, teamwork, project management skills, problem solving capabilities, organizational skills, structured working

Module examinations to gain grades
Written report
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Research Practical	Res Pract	
Course Name	Abbreviation Course	
Research Practical		
Lecturer	Faculty	Module Type (C/S)
Lecturers of the selected subject	Chemistry	C

Designated Semester	Frequency	Language	No. students
3	WS	english	

SWS	Presence[9]	preparation, self tutoring, preparation for exam (h)	Workload
15	225 h	75 h	300 h

Education Methodology
Experimental project work (14 SWS) & Seminar (1 SWS)
Learning Targets
Provide deeper knowledge and experimental skills in a chosen scientific subject, developments of skills required in the Master thesis
Contents
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 presentations, written reports
Examination
Written report
Literature
Depending on the chosen subject; initial literature will be made available
Further Information on the course

[9] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Water Chemistry	WatChem
Responsible for the Module	Faculty
Prof. Dr. Torsten Schmidt	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science, M.Sc. Environmental Toxicology	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1	1 Semester	C	5

Prerequisites according to examination regulations	Recommended Prerequisites
none	Basic knowledge in physical, organic and aqueous chemistry

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Water Chemistry	C	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
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. Students will know how to apply the acquired knowledge by carrying out case studies on the behavior of chemicals in aqueous systems.
Associated Key Qualifications
Presentations skills, teamwork, project management skills, problem solving capabilities

Module examinations to gain grades
Written exam, case study and presentation
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Water Chemistry	WatChem	
Course Name	Abbreviation Course	
Water Chemistry		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Torsten Schmidt	Chemistry	C

Designated Semester	Frequency	Language	No. students
1	WS	english	

SWS	Presence[10]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture and Seminar (2 HPW) and Case Study (1 HPW)
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. Students will know how to apply the acquired knowledge by carrying out case studies on the behavior of chemicals in aqueous systems.
Contents
Sorption processes and surfaces in aquatic systems: 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, experimental methods and predictive tools. **Tools in aquatic chemistry:** Linear free energy relationships, mass balances, thermodynamic cycles **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.
Examination
Written exam, case study and presentation
Literature

[10] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

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.
Further Information on the course

Module name	Abbreviation Module
Advanced Mass Spectrometry	Adv MS
Responsible for the Module	Faculty
PD Dr. Wolfgang Schrader	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	10

Prerequisites according to examination regulations	Recommended Prerequisites
none	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Advanced Mass Spectrometry and hyphenated techniques	S	2	90 h
Sum (Compulsory and Supplementary Courses)			2	90 h

Learning Outcomes of the Module
Understanding of the use of mass spectrometric methods, technical understanding of fundamental issues, learning to solve problems in analytical chemistry, technical understanding of fundamental issues
Associated Key Qualifications
Learning to solve problems in analytical chemistry

Module examinations to gain grades
Written or oral exam
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Advanced Mass Spectrometry	Adv MS	
Course Name	Abbreviation Course	
Advanced Mass Spectrometry		
Lecturer	Faculty	Module Type (C/S)
PD Dr. Wolfgang Schrader	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SS	english	

SWS	Presence[11]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (1 SWS) & Seminar (1 SWS)
Learning Targets
Understanding of the use of mass spectrometric methods, technical understanding of fundamental issues, learning to solve problems in analytical chemistry, technical understanding of fundamental issues
Contents
Fundamentals of mass spectrometry, understanding of ionization, ion selection and detection, mass analyzers, fragmentation of ions in MS, compound characterization from spectra, understanding of hyphenated techniques, advantages and disadvantages of different analytical instruments, usability in regard to problem solving.
Examination
Written or oral exam
Literature
i.e. Mass Spectrometry - A Textbook, Jürgen Gross
Further Information on the course

[11] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Ecology and Protection of Freshwater Ecosystems	Ecol
Responsible for the Module	Faculty
Prof. Dr. D. Hering	Biology

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	5

Prerequisites according to examination regulations	Recommended Prerequisites
none	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Ecology and Protection of Freshwater Ecosystems	S	4	150 h
Sum (Compulsory and Supplementary Courses)			4	150 h

Learning Outcomes of the Module
Analysis and restoration of freshwater ecosystems
Associated Key Qualifications
Ability to analyse and assess the effects of different stressors (ranging from contamination with chemicals to intense land use) on aquatic ecosystems Presentation techniques. Ability to perform advanced data analysis techniques

Module examinations to gain grades
Written exam, homework, oral presentation
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Ecology and Protection of Freshwater Ecosystems	Ecol	
Course Name	Abbreviation Course	
Ecology and Protection of Freshwater Ecosystems		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. D. Hering	Biology	S

Designated Semester	Frequency	Language	No. students
2	SS	english	

SWS	Presence[12]	preparation, self tutoring, preparation for exam (h)	Workload
4	60 h	90 h	150 h

Education Methodology
Combination of lecture and exercise: general lectures introduce to the topic, the student partly prepares a topic based on background materials; presentations of students and discussions.
Learning Targets
The student: - Gains knowledge of different freshwater ecosystem and classifications - Gains knowledge of related environmental impacts and stressors - Gains knowledge of and practice with freshwater ecological assessment and monitoring - Gains a basic understanding of applied water management - Gains knowledge of basic multivariate tools to analyse ecological data - Is able to transfer freshwater ecology into actual policies (e.g. the Water Framework Directive) - Is able to gain and filter information to understand and explain water-related problems - Is able to derive measures to protect freshwater ecosystems
Contents

[12] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

A-priori and a-posteriori typology of freshwater ecosystems, 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 Water Framework Directive and how to use them in biomonitoring, transferring monitoring results into restoration measures, lake and river restoration, impact of global climate change

Examination

Written exam, homework, oral presentation

Literature

- Rosenberg, D.M. & V.H. Resh (ed.) (1992): Freshwater Biomonitoring and Benthic
- Macroinvertebrates. Springer, Chapman & Hall, New-York, 504pp.
- Davis, W.S. & T.P. Simon (1995): Biological Assessment and Criteria. Boca Raton, Lewis Publishers.
- Cooke, D., E.B. Welch, S.A. Peterson & S.A. Nichols (2005): Restoration and Management of Lakes and
- Reservoirs. 3rd edition. CRC Press, Boca Raton.
- Naiman, R.J., R.E. Bilby (ed.) (2001): River Ecology and Management. New-York, Springer.
- Firth, P. & S.G. Fisher (1992): Global Climate Change and Freshwater Ecosystems. New-York, Springer.

Further Information on the course

Module name	Abbreviation Module
Electrochemistry and Electrochemical Analysis	Electro
Responsible for the Module	Faculty
Dr. Holger Krohn, Dr. Bernd Wermeckes	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1 or 3	1 Semester	S	5

Prerequisites according to examination Regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Electrochemistry and Electrochemical Analysis	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
The Students are able to understand and to apply electrochemical methods and techniques in analytical chemistry, water treatment, corrosion and its protection.
Associated Key Qualifications
Student will learn methods and techniques in analytical chemistry. Ability to use these methods for research.

Module examinations to gain grades
Written Exam
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Electrochemistry and Electrochemical Analysis	Electro	
Course Name	Abbreviation Course	
Electrochemistry and Electrochemical Analysis		
Lecturer	Faculty	Module Type (C/S)
Dr. Holger Krohn, Dr. Bernd Wermeckes	Chemistry	S

Designated Semester	Frequency	Language	No. students
1 or 3	WS	english	

SWS	Presence[13]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
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.
Contents
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)
Examination
Written exam
Literature

[13] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

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

Further Information on the course

Module name	Abbreviation Module
Environmental Chemistry: Air	Envi Air
Responsible for the Module	Faculty
Prof. Dr. Reinhard Zellner	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	5

Prerequisites according to examination Regulations	Recommended Prerequisites
none	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Environmental Chemistry: Air	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
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.
Associated Key Qualifications
Ability to different of environmental chemistry in the air and water.

Module examinations to gain grades
Written exam or colloquium
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Environmental Chemistry: Air	Envi Air	
Course Name	Abbreviation Course	
Environmental Chemistry: Air		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Reinhard Zellner	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SS	english	

SWS	Presence[14]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
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.
Contents
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.
Examination
Written exam or colloquium
Literature

[14] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

- Finlayson-Pitts, Pitts: Atmospheric Chemistry
- Seinfeld, Pandis: Atmospheric Chemistry and Physics
- Stumm, Morgan: Aquatic Chemistry

Further Information on the course

Module name	Abbreviation Module
Environmental Chemistry: Pollutants	Envi Poll
Responsible for the Module	Faculty
Prof. Dr. Alfred Hirner	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1 or 3	1 Semester	S	5

Prerequisites according to examination Regulations	Recommended Prerequisites
none	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Environmental Chemistry: Pollutants	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
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.
Associated Key Qualifications
strengthen presentations skills, working in teams, project management skills

Module examinations to gain grades
Written exam or colloquium
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Environmental Chemistry: Pollutants	Envi Poll	
Course Name	Abbreviation Course	
Environmental Chemistry: Pollutants		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Alfred Hirner	Chemistry	S

Designated Semester	Frequency	Language	No. students
1 or 3	WS	english	

SWS	Presence[15]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
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.
Contents
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 geoand anthropogenic sources, contamination scenarios, Chernobyl, radon), contaminant-fingerprinting
Examination
Written exam or colloquium
Literature
• Manahan: Environmental Chemistry, Lewis Publ. 2004; Hirner, Rehage, • Sulkowski: Umweltgeochemie, Steinkopff 2000
Further Information on the course

[15] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Environmental Chemistry: Soil/Waste	Envi Soil
Responsible for the Module	Faculty
Prof. Dr. Alfred Hirner	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1 or 3	1 Semester	S	5

Prerequisites according to examination Regulations	Recommended Prerequisites
none	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Environmental Chemistry: Soil/Waste	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
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.
Associated Key Qualifications
strengthen presentations skills, working in teams, project management, skills

Module examinations to gain grades
Written exam or colloquium
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Environmental Chemistry: Soil/Waste	Envi Soil	
Course Name	Abbreviation Course	
Environmental Chemistry: Soil/Waste		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Alfred Hirner	Chemistry	S

Designated Semester	Frequency	Language	No. students
1 or 3	WS	english	

SWS	Presence[16]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
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
Contents
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)
Examination
Written exam or colloquium
Literature

[16] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

- Heintz, Reinhardt: Chemie und Umwelt, Vieweg 1996; Bliefert:
- Umweltchemie, Wiley-VCH 2002; Hirner, Rehage, Sulkowski:
- Umweltgeochemie, Steinkopff 2000

Further Information on the course

Module name	Abbreviation Module
Excursions	Excursions
Responsible for the Module	Faculty
All lecturers of Master Programme Water Science	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1, 2 or 3	1 Semester	S	1-5

Prerequisites according to examination regulations	Recommended Prerequisites
None	None

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Excursions	S	1-5	30-150 h
Sum (Compulsory and Supplementary Courses)			1-5	30-150 h

Learning Outcomes of the Module
Students get to know how large scale research facilities, advanced water works or wastewater treatment plants work
Associated Key Qualifications
Writing skills

Module examinations to gain grades
Written report (no grades)
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Excursions	Excursions	
Course Name	Abbreviation Course	
Excursions		
Lecturer	Faculty	Module Type (C/S)
All lecturers of Master Programme Water Science	Chemistry	S

Designated Semester	Frequency	Language	No. students
1,2 or 3	WS/SS	english	

SWS	Presence[17]	preparation, self tutoring, preparation for exam (h)	Workload
1-5	15-75 h	15-75 h	30-150 h

Education Methodology
Excursion
Learning Targets
Students get to know how large scale research facilities, advanced water works or wastewater treatment plants work
Contents
Excursion options may change according to willingness and ability of companies/operators to host student groups. Regular excursions are currently offered to an ultrafiltration plant for drinking water production in Roetgen, the Alfred-Wegener-Institute in Bremerhaven and the IRMM in Geel/Belgium.
Examination
Written report (no grades)
Literature
Provided on-site of necessary
Further Information on the course

[17] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Management	Manage
Responsible for the Module	Faculty
PD Dr. Ursula Telgheder	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2-3	2 Semester	S	6

Prerequisites according to examination regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Quality Management	S	2	90 h
II	Project Management	S	2	90 h
Sum (Compulsory and Supplementary Courses)			4	180 h

Learning Outcomes of the Module
Students get an inside about the application of Quality Assurance techniques. Students learn dealing with international norms at special examples. After the course students should be able to establish and validate quality management and assurance systems.
Associated Key Qualifications
Validate quality management, quality assurance techniques

Module examinations to gain grades
Written exam of module
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Management	Manage	
Course Name	Abbreviation Course	
Quality Management	QM	
Lecturer	Faculty	Module Type (C/S)
PD Dr. Ursula Telgheder	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SS	english	

SWS	Presence[18]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (1 SWS) & Seminar (1 SWS)
Learning Targets
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.
Contents
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
Examination
Written exam
Literature

[18] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

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
Further Information on the course

Module name		Abbreviation Module	
Management		Manage	
Course Name		Abbreviation Course	
Project Management		PM	
Lecturer		Faculty	Module Type (C/S)
Prof. Dr. Wolf-Dieter Griebler		Chemistry	S

Designated Semester	Frequency	Language	No. students
3	WS	english	

SWS	Presence[19]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (2 SWS)
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.
Contents
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
Examination
Written exam of module
Literature

[19] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

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 Willey&Sohns, Inc.;

c) PMBOK®Guide, 2000 Edition to the Project Management Body of Knowledge, Newton Square, Pennsylvania: Project Management Institute;

d) Cleland, D. I., 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

Further Information on the course

Module name	Abbreviation Module
Membrane Technologies	Mem Tech
Responsible for the Module	Faculty
Prof. Dr. Mathias Ulbricht	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1 or 3	1 Semester	S	3

Prerequisites according to examination regulations	Recommended Prerequisites
none	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Membrane Technologies	S	2	90 h
Sum (Compulsory and Supplementary Courses)			2	90 h

Learning Outcomes of the Module
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.
Associated Key Qualifications
Ability to use membrane technologies in the water treatment and/or purification.

Module examinations to gain grades
Written Exam
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Membrane Technologies	Mem Tech	
Course Name	Abbreviation Course	
Membrane Technologies		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Mathias Ulbricht	Chemistry	S

Designated Semester	Frequency	Language	No. students
1 or 3	WS	english	

SWS	Presence[20]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (1 SWS) & Seminar (1 SWS)
Learning Targets
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.
Contents

[20] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

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

Examination

Written exam

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.

Further Information on the course

Module name	Abbreviation Module
Metrology in Chemistry	Metrol
Responsible for the Module	Faculty
Prof. Dr. Hendrik Emons	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	2 Semester	S	2

Prerequisites according to examination regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Metrology in Chemistry	S	1	60 h
Sum (Compulsory and Supplementary Courses)			1	60 h

Learning Outcomes of the Module
Students shall realize the importance of traceability and other concepts in metrology for the evaluation of analytical results. They shall also obtain fundamental knowledge of the international systems in metrology.
Associated Key Qualifications
Quality management, insight into international regulations in metrology, critical data evaluation

Module examinations to gain grades
Written or oral exam
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Metrology in Chemistry	Metrol	
Course Name	Abbreviation Course	
Metrology in Chemistry		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Hendrik Emons	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SS	english	

SWS	Presence[21]	preparation, self tutoring, preparation for exam (h)	Workload
1	20 h	40 h	60 h

Education Methodology
Lecture (4x 5 h)
Learning Targets
Obtain knowledge and understanding on the fundamental concepts of metrology and their application in chemical analysis, on principles and instruments of analytical quality assurance, and on the international measurement infrastructure
Contents
Metrology and the analytical process, metrological traceability, measurement uncertainty, analytical quality assurance, ISO 17025, method validation, reference materials, international standardisation, European measurement infrastructure
Examination
Written or oral exam
Literature
i.e. K. Danzer 'Analytical Chemistry', Springer Verlag; B. Hibbert 'Quality Assurance for the Analytical Chemistry Laboratory', Oxford University Press
Further Information on the course

[21] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Microbial Physiology	Microb Phys
Responsible for the Module	Faculty
Prof. Dr. Wolfgang Sand	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	3

Prerequisites according to examination regulations	Recommended Prerequisites
	Environmental Microbiology, Biochemistry

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Microbial Physiology	S	2	90 h
Sum (Compulsory and Supplementary Courses)			2	90 h

Learning Outcomes of the Module
The students will get an overview of all relevant metabolic types of microorganisms: from the basic metabolic cycles to the metabolism of special bacteria effecting the cycling of elements on Earth. Starting with a repeat of biochemistry detailed physiology incl. specialized reactions and components will be discussed and linked with the responsible microorganisms.
Associated Key Qualifications
Ability to analyse of different metabolic types of microorganisms. Basics in microbial physiology.

Module examinations to gain grades
Written exam
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Microbial Physiology	Microb Phys	
Course Name	Abbreviation Course	
Microbial Physiology		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Wolfgang Sand	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SS	English	

SWS	Presence[22]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (2 SWS)
Learning Targets
The students will get an overview of all relevant metabolic types of microorganisms: from the basic metabolic cycles to the metabolism of special bacteria effecting the cycling of elements on Earth. Starting with a repeat of biochemistry detailed physiology incl. specialized reactions and components will be discussed and linked with the responsible microorganisms.
Contents
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 methylotrophic bacteria (C-1-metabolism)
Examination
Written exam
Literature

[22] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

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
Further Information on the course

Modulname	Modulcode
Nanopartikel und Kolloide	Nano
Modulverantwortliche/r	Fachbereich
Prof. Dr. S. Barcikowski	Chemie

Zuordnung zum Studiengang	Modulniveau: Ba/Ma
Chemie	MA

Vorgesehenes Studiensemester	Dauer des Moduls	Modultyp (P/WP/W)	Credits
1 oder 3	1 Semester	WP	5

Voraussetzungen laut Prüfungsordnung	Empfohlene Voraussetzungen
keine	

Zugehörige Lehrveranstaltungen:

Nr.	Veranstaltungsname	Belegungstyp	SWS	Workload
I	Master-Vorlesung Nanopartikel und Kolloide	W	3	150 h
Summe (Pflicht und Wahlpflicht)			3	150 h

Lernergebnisse / Kompetenzen
davon Schlüsselqualifikationen

Prüfungsleistungen im Modul
Klausur oder Kolloquium (Prüfungsleistung)
Stellenwert der Modulnote in der Fachnote

Modulname	Modulcode	
Nanopartikel und Kolloide	Nano	
Veranstaltungsname	Veranstaltungscode	
Nanopartikel und Kolloide		
Lehrende/r	Lehreinheit	Belegungstyp (P/WP/W)
Prof. Dr. S. Barcikowski, Dr. P. Wagener	Chemie	WP

Vorgesehenes Studiensemester	Angebotshäufigkeit	Sprache	Gruppengröße
1 oder 3	WS	deutsch	

SWS	Präsenzstudium[23]	Selbststudium	Workload in Summe
3	39 h	111 h	150 h

Lehrform
Vorlesung (2 SWS) & Seminar (1 SWS)
Lernergebnisse / Kompetenzen
Vermittlung der Grundlagen und vertiefter Kenntnisse der Kolloidchemie und der Eigenschaften von Nanopartikeln. Den Studierenden wird anhand von Fallbeispielen aus der Nanotechnologie die Vermittlung von funktionalen Eigenschaften durch Nanopartikel erläutert.
Inhalte

[23] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Grundlagen der Kolloidchemie

- Historische Entwicklung

- Oberflächeneffekte, Elektrochem. Doppelschicht (Helmholtz, Gouy-Chapman) Stern-Potential, Debye-Länge

- Nanopartikel-Stabilisierung (Ostwald-Reifung, LSW-Theorie, sterische/elektrosterische Stabilisierung, DLVO-Theorie)

Spezielle Eigenschaften von Nanopartikeln

-Materialklassen (Metalle, Oxide, Halbleiter, Legierungen) Thermodynamische und mechanische Eigenschaften

-Optische Nanopartikeleigenschaften (Plasmonenresonanz, Größen- und Morphologieabhängigkeiten, Streuung)

-Magnetische Nanopartikeleigenschaften (Magnetismus von Nanopartikeln, Superparamagnetismus, Ferrofluide)

Synthese von Nanopartikeln

-Top-down Methoden (Mechanische Zerkleinerung, Plasmasynthese, Laserablation etc.)

-Bottom-up Methoden (Nasschemische Synthese, Gasphasensynthese, Form-in-place etc.)

Anwendung von Nanopartikeln und –materialien

Funktionale Nanopartikel, Nanokomposite, Technische Applikation, Nanopartikel im Alltag, biomedizinische Anwendung,

Charakterisierung von Nanopartikeln

Elektronenmikroskopische Methoden, Spektroskopische Methoden, Lichtstreuung

Prüfungsleistung

Klausur oder Kolloquium

Literatur

z.B.

D. Vollath: Nanomaterials, Wiley-VCH, Weinheim

L. Cademartiri, G. Ozin: Concepts of Nanochemistry, Wiley-VCH, Weinheim

C. N. R. Rao, A. Müller, A. K. Cheetham: The Chemistry of Nanomaterials, Wiley-VCH, Weinheim

Weitere Informationen zur Veranstaltung

Module name	Abbreviation Module
Oxidative Processes in Water Technology	Ox Process
Responsible for the Module	Faculty
Prof. Dr. Torsten Schmidt	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	5

Prerequisites according to examination regulations	Recommended Prerequisites
none	Basic knowledge in physical, organic and aqueous chemistry

Associated Courses:

Nr.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Oxidative Processes	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
Students should obtain an overview of routine and state-of-the-art oxidative processes used in water and wastewater treatment. They should acquire an advanced understanding of the fundamental transformation processes involved. By studying exemplary applications they will learn the advantages and drawbacks of oxidative processes. This will aid them in a selection of appropriate technological solutions.
Associated Key Qualifications
Presentations skills, teamwork, problem solving capabilities, scientific method

Module examinations to gain grades
Written or oral exam and presentation
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Oxidative Processes in Water Technology	Ox Process	
Course Name	Abbreviation Course	
Oxidative Processes		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Torsten Schmidt, Prof. Dr. Clemens von Sonntag, Dr. Jochen Türk	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SS	english	

SWS	Presence[24]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 HPW) and Seminar (1 HPW)
Learning Targets
Students should obtain an overview of routine and state-of-the-art oxidative processes used in water and wastewater treatment. They should acquire an advanced understanding of the fundamental transformation processes involved. By studying exemplary applications they will learn the advantages and drawbacks of oxidative processes. This will aid them in a selection of appropriate technological solutions.
Contents
Oxidative species/processes of interest: Chlorine, Chlorine dioxide, Ozone, Fenton, UV, Permanganate, Hydroxyl radicals, Other radicals, Ferrate, others Transformation reactions: electron transfer, H-abstraction, electrophilic addition Kinetics of transformation reactions Applications in water treatment (including disinfection) Applications in wastewater treatment Disinfection/transformation by-products: (Eco)toxicological evaluation Economical considerations
Examination
Written or oral exam and presentation

[24] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
Will be announced in the course
Further Information on the course

Module name	Abbreviation Module
Stable Isotope Analysis	SIA
Responsible for the Module	Faculty
Dr. Maik Jochmann, Prof. Dr. Torsten Schmidt	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1	1 Semester	S	9

Prerequisites according to examination regulations	Recommended Prerequisites
none	Basic knowledge in physical, organic and analytical chemistry

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Stable Isotope Analysis	S	3	150 h
II	Practical Course Stable Isotope Analysis	S	3	120 h
Sum (Compulsory and Supplementary Courses)			6	270 h

Learning Outcomes of the Module
Students should get to know the principles and instrumentation in modern stable isotope analysis with emphasis on light elements and will acquire hands-on experience on how to perform stable isotope analysis.
Associated Key Qualifications
Presentations skills, teamwork, problem solving capabilities, scientific method

Module examinations to gain grades
Written exam, presentation and lab course reports
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Stable Isotope Analysis	SIA	
Course Name	Abbreviation Course	
Stable Isotope Analysis	SIA_1	
Lecturer	Faculty	Module Type (C/S)
Dr. Maik Jochmann, Prof. Dr. Torsten Schmidt	Chemistry	S

Designated Semester	Frequency	Language	No. students
1	SS	english	

SWS	Presence[25]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 HPW) and Seminar (1 HPW)
Learning Targets
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.
Contents
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); Applications of stable isotope analysis in environmental science (source apportionment, transformation (extent and pathways), food sciences (food adulteration, food origin), geosciences (tracing of geochemical pathways by stable isotopes), forensic sciences (doping analysis).
Examination
Written exam and presentation (poster or oral)
Literature

[25] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

a) Clark, I.; Fritz, P. Environmental Isotopes in Hydrogeology; CRC Press: Boca Raton,1997.

b) b) Kendall, C.; McDonnell, J. J., Eds. Isotope Tracers in Catchment Hydrology; Elsevier: Amsterdam, 1998.

c) Frey, B.;Stable Isotope Ecology; Springer: Berlin, 2008.

d) Sharp, Z.; Principles of Stable Isotope Geochemistry; Prentice Hall: Upper Saddle River, New Jersey, 2006.

Further Information on the course

Module name	Abbreviation Module	
Stable Isotope Analysis	SIA	
Course Name	Abbreviation Course	
Practical Course Stable Isotope Analysis	SIA_2	
Lecturer	Faculty	Module Type (C/S)
Dr. Maik Jochmann, Prof. Dr. Torsten Schmidt	Chemistry	S

Designated Semester	Frequency	Language	No. students
1	SS	english	

SWS	Presence[26]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	75 h	120 h

Education Methodology
Lab Course (3 HPW)
Learning Targets
Acquisition of practical knowledge and hands-on experience in stable isotope analysis. By own measurements students shall realize experimental pitfalls in stable isotope analysis and be able to evaluate isotope data including precision and accuracy.
Contents
Performing stable isotope analyses using modern GC-IRMS instrumentation for selected experiments on: 1. vanillin authentification 2. origin of alcoholic beverages 3. practical isotope mass balance
Examination
Written reports
Literature
Handouts and literature listed therein
Further Information on the course

[26] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Technical Engineering Water	TechEng Water
Responsible for the Module	Faculty
Prof. Dr. Rolf Gimbel, Dr. Ralph Hobby	Engineering

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2-3	2 Semester	S	9

Prerequisites according to examination regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Technical Engineering Water	S	3	150 h
II	Practical Course Technical Engineering Water	S	3	120 h
Sum (Compulsory and Supplementary Courses)			6	270 h

Learning Outcomes of the Module
Students have theoretical and practical knowledge for different water treatment processes.
Associated Key Qualifications
Basic knowledge, systemic thinking, scientific thinking. The possibility to use these knowledge in the praxis.

Module examinations to gain grades
Written or oral exam
Contribution of the Module Grade for the Final Grade

Module name		Abbreviation Module	
Technical Engineering Water		TechEng Water	
Course Name		Abbreviation Course	
Technical Engineering Water			
Lecturer		Faculty	Module Type (C/S)
Prof. Dr. Rolf Gimbel, Dr. Ralph Hobby		Engineering	S

Designated Semester	Frequency	Language	No. students
2	SS	english	

SWS	Presence[27]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
Theoretical basics of different processes in drinking water treatment, and basic knowledge for the practical design.
Contents
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
Examination
Written or oral exam

[27] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

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
Further Information on the course

Module name	Abbreviation Module	
Technical Engineering Water	TechEng Water	
Course Name	Abbreviation Course	
Practical CourseTechnical Engineering Water		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Rolf Gimbel, Dr. Ralph Hobby	Engineering	S

Designated Semester	Frequency	Language	No. students
3	SS	english	

SWS	Presence[28]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	75 h	120 h

Education Methodology
Practical Course (3 SWS)
Learning Targets
Students have to enhance their theoretical knowledge from the lecture Practical Engineering Water. They have to carry out practical oriented experiments with different pilot plants.
Contents
1. Filtration 2. Deacidification Membrane Filtration
Examination
Written exam
Literature
a) Sontheimer et. al., Activated Carbon for Water Treatment, DVGWForschungsstelle 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
Further Information on the course

[28] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Wastewater Treatment	WWT
Responsible for the Module	Faculty
Prof. Dr. Rolf Gimbel, Dr. Ralph Hobby	Engineering

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1 or 3	1 Semester	S	5

Prerequisites according to examination regulations	Recommended Prerequisites
None	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Wastewater Treatment	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
The students know the sources a composition of wastewater, their biological processes.
Associated Key Qualifications
Students have knowledge about wastewater biology and chemistry. They understand the fundamentals in the field of Urban Water Management.

Module examinations to gain grades
Written exam
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Wastewater Treatment	WWT	
Course Name	Abbreviation Course	
Wastewater Treatment		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Rolf Gimbel, Dr. Ralph Hobby	Engineering	S

Designated Semester	Frequency	Language	No. students
1 or 3	WS	english	

SWS	Presence[29]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
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
Contents
Sources and composition of wastewater, basic biological processes, activated sludge plants, trickling filters, nitrification, denitrification, P-elimination, anaerobic processes, sludge treatment, mass balances
Examination
Written examination (50 %), laboratory report (50 %)
Literature
Henze, M., Harremoes, P., Jansen, J. la Cour, Arvin, E. (1996): Wastewater Treatment, Biological and Chemical Processes, Springer Verlag; Vesilind, A., Rooke, R.L., (2003): Wastewater Treatment Plant Design, IWA Publishing; Bitton, G., (1990): Wastewater Microbiology, Wiley-Liss Verlag, DWA Dictionary; The Microbiology of Activated Sludge Second Edition Author(s): Robert Seviour, Linda Blackall NYP ISBN: 1843390329; ATV Dictionary; Principles of Water and Wastewater Treatment Processes Editor(s): R Stuetz ISBN: 1843390264; Hosang, W., Bischof, W. (1998): Abwassertechnik, Teubner Verlag
Further Information on the course

[29] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Water Pollution/ Water Treatment	Wat Poll
Responsible for the Module	Faculty
PD Dr. Kai Bester	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	Master

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1,2 or 3	1 Semester	S	5

Prerequisites according to examination regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Water Pollution/ Water Treatment	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
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.
Associated Key Qualifications
The students - know different sources of surface water pollution - get to know and apply methods to take water samples as well as means to determine pollutants in surface waters - are able to interpret results of chemical analyses in the context of European legislation

Module examinations to gain grades
Oral exam (30–45 min/group) 50 %, report of the experiments 50 %
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Water Pollution/ Water Treatment	Wat Poll	
Course Name	Abbreviation Course	
Water Pollution/ Water Treatment		
Lecturer	Faculty	Module Type (C/S)
PD Dr. Kai Bester	Chemistry	S

Designated Semester	Frequency	Language	No. students
1,2 or 3	WS/SS	english	

SWS	Presence[30]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Practical Course (1 SWS)
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.
Contents
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
Examination
Written exam and presentation
Literature

[30] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

FENT, K.: Ökotoxikologie, Georg Thieme Verlag, Stuttgart (1998)
Further Information on the course

Module name	Abbreviation Module
Master Thesis	Master
Responsible for the Module	Faculty
Dean	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	Master

Designated Semester	Duration of Module	Module Type (C/S)	Credits
4	1 Semester	C	30

Prerequisites according to examination regulations	Recommended Prerequisites
80 Credits	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Master Thesis	S		900 h
Sum (Compulsory and Supplementary Courses)				900 h

Learning Outcomes of the Module
The students have the ability - to apply biological and or chemical principles to current fields related to Water Science - to comprehensively deal with a given topic within a limited timeframe, - to cooperate with professionals in the practice, - to collect topic-related information by means of modern information technology.
Associated Key Qualifications
time management, project management, team work, presentation skills

Module examinations to gain grades
Master thesis
Contribution of the Module Grade for the Final Grade

Module name	Abbreviation Module	
Master Thesis	Master	
Course Name	Abbreviation Course	
Master Thesis		
Lecturer	Faculty	Module Type (C/S)
Coordinator of the Master project	Chemistry	C

Designated Semester	Frequency	Language	No. students
4	SS	english	

SWS	Presence[31]	preparation, self tutoring, preparation for exam (h)	Workload
			900 h

Education Methodology
Experimental and theoretical work and evaluation and written documentation
Learning Targets
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.
Contents
The projects will be provided by the lecturers. The students are free to choose the supervisor by themselves.
Examination
Master Thesis
Literature
Depending on the topic of the master thesis
Further Information on the course

[31] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.