Master of Science Tropical Hydrogeology and Environmental Engineering

Module Handbook PO 2021

TECHNISCHE UNIVERSITÄT DARMSTADT

Content

Abbreviations

Abbr.	German terminology	English translation/explanation
WiSe	Wintersemester	Winter term
SoSe	Sommersemester	Summer term
CP	Kreditpunkte	Credits (ECTS)
SWS	Semesterwochenstunde	Contact hours per week
VL	Vorlesung	Lecture
Ü	Übung	Exercise
VÜ	Vorlesung und Übung	Lecture and exercise
PR	Praktikum	Practical course (lab or field)
EK	Exkursion	Excursion, field trip
S	Seminar	Seminar
FP	Fachprüfung	'technical examination' = exam with only three attempts
SL	Studienleistung	'study examination' = exam without limitation on number of attempts
St	Standardbewertungssystem	standard grading system with range from 1 (very good) to 5 (fail)
bnb	bestanden/nicht bestanden	pass/no pass (no pass = fail)

Module descriptions for M.Sc. Tropical Hydrogeology and Environmental Engineering

Compulsory Modules

Module name Scientific Methods					
Module no. 11-02-3402	**Credits** 6 CP	**Workload** 180 h	**Self-study** 150 h	**Duration** 1 semester	**Cycle** Yearly in the SoSe
Language of instruction English			**Person responsible for the module** Hinderer		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Project Seminar	6 CP	S	2

2 Course contents

Questions and problems related to geosciences, water management and environmental technologies are addressed in small student teams, if possible in cooperation with students from other departments or other degree programmes. While the project seminar has a strong scientific focus and may even involve lab or field work, it contains significant skills-oriented elements such as intercultural team building, project management, and presentations training (posters and oral presentations). The results of the teamwork are presented in the seminar. Presentation of the results may include both, talks and posters.

3 Qualification and learning goals

The students will be able to employ team-oriented and interdisciplinary approaches for solving questions and problems related to geosciences, water management and environmental technologies, against the background of geological and technical factors as well as infrastructural and ecological/economic conditions. Moreover, geoscientific solutions will be evaluated with respect to globalisation and ethical standards. The students will be able to describe and present the results of their work in a scientifically adequate form (presentation skills).

4 Prerequisites for attending

none

5 Type of exam

Presentation (*SL*)

6 Criteria for obtaining the credits

Passing the exam

7 Grading

Graded (*St*)

8 Curricula where the module is used

M.Sc. TropHEE, Compulsory Modules

9 Literature

Dependent of contents to be addressed in the project seminar

10 Comments

Module name Semiarid Field Hydrogeology					
Module no. 11-02-3431	**Credits** 6 CP	**Workload** 180 h	**Self-study** 90 h	**Duration** 1 semester	**Cycle** Yearly in the WiSe
Language of instruction English			**Person responsible for the module** Schüth		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Field Trip to a Semiarid Region	6 CP	EK	6

2 Course contents

Excursion to a semiarid area to study urban and rural water supply, irrigation, well types, regional groundwater balance and flow, water reservoirs, water quality, fossil waters, salt water intrusion in coastal areas, salinization. Visit of water supply companies, drinking water and wastewater treatment plants. Visits are accompanied by seminars in the evening reflecting on the daily activities with special focus on the technical, economical, and social aspects of water pricing, water supply, and water treatment.

3 Qualification and learning goals

Field work is an essential part of geoscientific work. In this module the students develop an understanding of how problems in geosciences and related scientific areas are practically solved in semi-arid countries where water resources are scarce. The students acquire theoretical and practical knowledge of geoscientific fundamentals and methods with focus on water and environmental management. They acquire skills to understand regional and global water and environmental problems - which often require interdisciplinary cooperation - and to develop approaches to solve them. They will also get an insight into water pricing from the point of cost recovery, but also as an effective policy instrument to signal scarcity and to encourage water conservation. As a usually multinational group during the field trip, the students improve their intercultural competence. They also improve other soft skills such as team working skills and communication skills.

4 Prerequisites for attending

none

5 Type of exam

Report (*SL*)

6 Criteria for obtaining the credits

Passing the exam

7 Grading

Not graded (*bnb*)

8 Curricula where the module is used

M.Sc. TropHEE, Compulsory Modules

9 Literature

Dependent of destination of field trip

10 Comments

Module name Scientific Training					
Module no. 11-02-3400	**Credits** 6 CP	**Workload** 180 h	**Self-study** 180 h	**Duration** 1 semester	**Cycle** Each semester
Language of instruction English			**Person responsible for the module** Dean of Study Affairs		

1	**Course(s)**				
	Course no.	**Course title**	**Workload (CP)**	**Teaching method**	**SWS**
	1	Scientific Training	6 CP	PR	-
2	**Course contents** Main focus of the Scientific Training is the development of a research concept and a research plan for a specific scientific question from geosciences or environmental engineering, usually related to a possible topic for a master's thesis. Based on the research question, a sound methodological concept, a realistic timing, and a feasible organization of the work are developed based on existing experience and appropriate literature. This may also be accompanied by familiarizing the student with a certain software program or by conveying specific analytical skills in the laboratory. The Scientific Training may take place at TU Darmstadt, at other scientific institutions, or as an internship in the industry. It may be carried out directly in a target region for field work, e.g. in the home country of the student, to (re)establish contacts, to collect samples for a proof of concept, or to check the general feasibility of the proposed concept and field work. The results are compiled into a report to be submitted before start of the master's thesis work.				
3	**Qualification and learning goals** The Scientific Training allows the student to conduct introductory studies on a given scientific subject by means of practical lab and field methods or acquisition and organisation of external data. It is a step towards disciplinary specialisation, usually in the forerun of the master's thesis. The students improve their methodical knowledge and skills and are enabled to assess and use different technical and/or analytical methods, including data evaluation. The students acquire skills to understand scientific problems in the field of water and environment and to develop approaches to solve them. They are able to independently create a research plan for future research work/projects. Moreover, they will be trained to understand global challenges in the water sector and their technical, socio-economic, and socio-ecologic relevance.				
4	**Prerequisites for attending** none				
5	**Type of exam** Report (*SL*)				
6	**Criteria for obtaining the credits** Passing the exam				
7	**Grading** Graded (*St*)				
8	**Curricula where the module is used** M.Sc. TropHEE, Compulsory Modules				
9	**Literature**				

	Dependent of contents to be addressed in the Scientific Training
10	**Comments**

Elective Modules

Module name Applied (Environmental) Microbiology for Engineers					
Module no. 13-K6-M001	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 Semester	**Cycle** Yearly in the SoSe
Language of instruction English			**Person responsible for the module** Lackner		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Applied (Environmental) Microbiology for Engineers	6 CP	VÜ	4

2 Course contents

This seminar conveys basic knowledge of applied environmental microbiology and principals that are relevant and applicable in the context of civil and environmental engineering. The Seminar covers (i) an introduction to the basic principles of microbiology (cell structure and growth, metabolic pathways and detection methods); (ii) the role of microorganisms for humans and their interactions in the global nutrient cycles (iii) examples of microbial processes in technical systems esp. relevant for civil and environmental engineers.

Examples for such topics are: microorganisms and energy, production of valuable products, bio-corrosion and material science, biofilms in technical systems (e.g. wastewater treatment), microorganisms and hygienic aspects. The knowledge provided in this seminar intends to help with understanding technically relevant bio-chemical and molecular biological aspects and specifications that can be advantageous or disadvantageous for environmental engineering systems and processes.

3 Qualification and learning goals

The students have a basic understanding of applied environmental microbiology and its relevance in the technical context for the examples covered in class. The students are able to solve problems related to these topics. Additionally, the students are able to apply their fundamental knowledge to evaluate microbiological aspects (esp. within technical systems).

4 Prerequisites for attending

none

5 Type of exam

Oral exam, 15 minutes, or written exam, 60 minutes (*FP*) (as a rule, the examination takes the form of an oral examination, or a written examination if there are more participants); plus home work (term paper) or report and presentation (*SL*) (the study achievements are announced at the beginning of the course and will be adjusted to the topics chosen by the students, the maximum number of submissions is three, and they are spread evenly over the course of the semester)

6	**Criteria for obtaining the credits** Passing both exams (*FP* and *SL*)
7	**Grading** Oral or written exam: graded (*St*); home work/report and colloquium/presentation: graded (*St*); total module grade average from both exams, with oral or written exam weighting 60% and home work/report and presentation weighting 40%.
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Bauingenieurwesen, Forschungsfach Gewässerbewirtschaftung M.Sc. Umweltingenieurwissenschaften, Fachlicher Wahlbereich
9	**Literature** Literature will be announced at the beginning of the course.
10	**Comments**

Module name Clay Mineralogy					
Module no. 11-02-2238	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 2 semesters	**Cycle** Yearly, starting in SoSe
Language of instruction English			**Person responsible for the module** Ferreiro Mählmann		

1	**Course(s)**				
	Course no.	**Course title**	**Workload (CP)**	**Teaching method**	**SWS**
	1	Clay Mineralogy	3 CP	VL	2
	2	Applied Clay Mineralogy	3 CP	VL	2
2	**Course contents** Structure of the phyllosilicates. Mineralogy, crystallography and geochemistry of clay minerals. Physical properties of clay minerals. Clay minerals in soil science, for soil improvement in land use, and their distribution in the soils. Diagenesis and low-temperature petrology of clay minerals, paleogeothermometry. Clay minerals and clays in construction, in the production of ceramic materials, and in various other geological, technical, medical. and pharmaceutical areas of use. In addition, a reference is made to climate research and soil formation (with a focus on the tropics), to groundwater protection, to the prospecting of clay deposits, and to the exploration of hydrocarbons.				
3	**Qualification and learning goals** The students have a sound understanding of the specific role of clays and clay minerals in different fields of geosciences and their use in geotechnical and environmental engineering.				
4	**Prerequisites for attending** none				

5	**Type of exam** Written exam, 90 minutes (*FP*)
6	**Criteria for obtaining the credits** Passing the exam
7	**Grading** Graded (*St*)
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Angewandte Geowissenschaften: Vertiefungsrichtung "Umweltgeowissenschaften": Kernbereich, 2. und 3. Fachsemester Vertiefungsrichtung "Angewandte Geologie": Vertiefungsspezifischer Wahlpflichtbereich, 2. und 3. Fachsemester
9	**Literature** Velde, B. (1992): Introduction to Clay Minerals.- 159 p.; Chapman & Hall. Velde, B. (1995): Origin and Mineralogy of Clays. Clays and the Environment.- 356 p.; Springer. Rule, A.C. & Guggenheim, S. (2002): Teaching Clay Science.- CMS Workshop Lectures, 11, 223 p.; Aurora, CO (The Clay Minerals Society).
10	**Comments**

Module name Drinking Water					
Module no. 13-K6-M006	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 Semester	**Cycle** Yearly in the WiSe
Language of instruction English			**Person responsible for the module** Lackner		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Drinking Water	3 CP	2 VL	2
2	Drinking Water - Exercise	3 CP	2 Ü	2

2 Course contents

- Legal framework (water quality): national (German, Vietnamese), international (WHO, EU)
- Water quality parameters: hygienic, physical, chemical, sensory
- Water quantity: consumption per capita, water fees, water saving strategies (reuse)
- Water resources: ground water, surface water (sea, lake, river), rain water, grey water, wastewater
- Water treatment technologies: disinfection, chlorination, RO, filtration, ion exchange, softening (cf. water treatment processes) with specific focus on drinking water production

	- Water distribution and networks: pipelines, pumps, valves, flow meters - Storage: bulk and small scale / household level - Decentralized water supply - Planning, construction, operation and maintenance of water supply systems
3	**Qualification and learning goals** - The students will have an understanding of legal frameworks concerning drinking water. - The students will be able to assess the need of water quality and quantity. - The students will be able to assess (drinking) water resources. - The students will be able to design water works. - The students will be able to design drinking water storage facilities and networks. - The students will have basic knowledge of planning, construction, operation and maintenance of water supply systems.
4	**Prerequisites for attending** Recommended: Water Treatment Processes (13-K0-M008)
5	**Type of exam** Oral exam, 15 minutes, or written exam, 60 minutes (*FP*) (as a rule, the examination takes the form of a written exam, or an oral exam if the number of participants is low); plus home work (assignments) (*SL*) (details of the home assignment will be announced at the beginning of the course)
6	**Criteria for obtaining the credits** Passing both exams (*FP* and *SL*)
7	**Grading** Oral exam or written exam, graded (*St*) = total grade for the module; home work, not graded (*bnb*)
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Bauingenieurwesen, Forschungsfach Siedlungswasserwirtschaft M.Sc. Umweltingenieurwissenschaften, Fachlicher Wahlbereich
9	**Literature** Literature will be announced at the beginning of the course.
10	**Comments**

Module name Fundamentals of Geosciences					
Module no. 11-02-3401	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 semester	**Cycle** Yearly in the WiSe
Language of instruction English			**Person responsible for the module** Hinderer		

1	**Course(s)**				
	Course no.	**Course title**	**Workload (CP)**	**Teaching method**	**SWS**
	1	Geological Methods	3 CP	VÜ	2
	2	Practical Mineralogy and Petrology	3 CP	VÜ	2
2	**Course contents** Geological Methods: Development of the earth, geological mapping, working with maps, cross section drawing, soil and rock description, stratigraphic sections, field and laboratory methods. Practical Mineralogy and Petrology: Crystallography, crystal morphology, basics of mineralogy, rock forming minerals and how to identify them. Introduction to magmatic and metamorphic petrology. Textural and structural characteristics of magmatic and metamorphic rocks. Metamorphic pathways.				
3	**Qualification and learning goals** The courses of this module aim at bringing the students - who often have different academic backgrounds - to an equal level of fundamental geological and mineralogical knowledge. The students improve or refresh their previous knowledge of geological basics and methodical skills, and of mineralogical basics. The students acquire methodical skills on how to identify important rock forming minerals and rocks in the field and by laboratory methods.				
4	**Prerequisites for attending** none				
5	**Type of exam** Written exam, 90 minutes (*FP*)				
6	**Criteria for obtaining the credits** Passing the exam				
7	**Grading** Graded (*St*)				
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules				
9	**Literature** McCann, T. (Ed., 2008): The Geology of Central Europe.- 2 Vols.; London (Geological Society). Maltman, A. (1990): Geological maps - an introduction.- New York (Wiley & Sons). Skinner, B.J., Porter, S.C. & Park, J. (2003): The Dynamic Earth: An Introduction to Physical Geology.- 5. Ed., 648 p.; Wiley. Bloss, F.D. (1994): Crystallography and Crystal Chemistry - An Introduction.- The Mineralogical Society of America, Washington D.C., USA; ISBN 0-939950-37-5. Nesse, W.D. (2000): Introduction to Mineralogy.- Oxford University Press; ISBN 13-978-0-19-510691-6.				
10	**Comments**				

Module name Geohydraulics and Well Construction					
Module no. 11-02-2310	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 Semester	**Cycle** Yearly in the Wise
Language of instruction English			**Person responsible for the module** Sass		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Geohydraulics and Well Construction	6 CP	4 VÜ	4

2 Course contents

Basics of soils, water, and fluid flow; aquifer types and their parameters; Darcy's law and permeability; soil physics; pumping tests. Well types and well construction methods; well design; drilling techniques; long term assessment.

3 Qualification and learning goals

The module aims at bringing students with different academic backgrounds (geosciences or engineering) to an equal level of fundamental knowledge in geohydraulics as well as well design and construction topics. The students acquire solid knowledge of geohydraulics and quantitative geohydraulic methods in hard rock. They are able to apply the methods they have learned and to assess their results. They are also able to design groundwater wells and plan their construction.

4 Prerequisites for attending

none

5 Type of exam

Written exam, 90 minutes (*FP*)

6 Criteria for obtaining the credits

Passing the exam

7 Grading

Written exam, graded (*St*)

8 Curricula where the module is used

M.Sc. TropHEE, Elective Modules

M.Sc. Angewandte Geowissenschaften:

Vertiefungsrichtung "Angewandte Geologie": Vertiefungsspezifischer Wahlpflichtbereich, 3. Fachsemester

Vertiefungsrichtung "Umweltgeowissenschaften": Erweiterter geowissenschaftlicher Wahlpflichtbereich, 3. Fachsemester

9 Literature

Cushman, J.H. & Tartakovsky, D.M. (2017): Handbook of Groundwater Engineering, 3rd ed.

Krusemann, G.P. & De Ridder, N.A. (1990): Analysis and evaluation of pumping test data.- 2nd ed., 377 p.; Wageningen (International Inst. for Land Reclamation and Improvement).

10 Comments

Module name Geoinformation Systems					
Module no. 11-02-3462	**Credits** 6 CP	**Workload** 180 h	**Self-study** 90 h	**Duration** 2 semesters	**Cycle** Yearly, starting in SoSe
Language of instruction English			**Person responsible for the module** Studiendekan/in		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Geoinformation Systems I (GIS I)	3 CP	PR	3
2	Geoinformation Systems II (GIS II)	3 CP	VL + Ü	3

2 Course contents

Geoinformation Systems I (GIS I): Focus on techniques. Concepts of Geoinformation Systems, special features of Geoinformation Systems, software components of ArcGIS, data types, georeferencing, editing and manipulating spatial data, spatial queries, interpolation techniques, thematic mapping and map layout, use of ArcGIS extensions (Spatial Analyst, 3D Anaylst).

Geoinformation Systems II (GIS II): In-depth knowledge of the most relevant functions of the ArcGIS software, and their application in GIS-based multicriteria analyses and GIS-based geostatistical analyses using exemplary data sets. Furthermore, mobile GIS functionalities will be introduced, like well databases (GeODin). GIS functionalities regarding geological 3D modelling will be addressed. In particular the class comprises the following aspects:

- Database structures
- Spatial Analyst
- 3D Analyst
- Geostatistical Analyst
- Multicriteria Analyses
- Automation of workflows, model builder, batch processing annotation
- Web publishing with the ArcGIS Publisher & ArcReader
- Introduction to well databases
- Introduction to mobile GIS solutions (GIS-based field work)

3 Qualification and learning goals

The students understand the concepts and theory of Geoinformation Systems and are able to apply them on an advanced level - beyond the basic functions - for processing complex geoscientific questions and problems. In addition, the students acquire knowledge on the functionality of well databases (GeODin), how to query well information, and how to migrate the queried data to a GIS project. Through case studies and hands-on exercises, the students get significant practical training that enables them to improve soft skills such as organisational skills, team working skills, communication skills, and presentation skills.

4 Prerequisites for attending

none

5 Type of exam

Geoinformation Systems I (GIS I): home work (term paper) (*FP*)

Geoinformation Systems II (GIS II): written exam, 90 Minutes (*FP*)

6 Criteria for obtaining the credits

Passing both exams

7	**Grading** Geoinformation Systems I (GIS I): graded (*St*); Geoinformation Systems II (GIS II): graded (*St*); total module grade weighted by CP shares of the two courses
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules
9	**Literature** Environmental Research Systems Institute Inc. (2002): ArcGIS manuals.- ESRI, Redlands, California. Greene, R.W. (2000): GIS in Public Policy - Using Geographic Information for More Effective Government.- 100 p.; Redlands, CA. (ESRI Press). Maidment, D.R. (ed., 2002): Arc Hydro - GIS for Water Resources. - 203 p.; Redlands, CA (ESRI Press). www.esri.com
10	**Comments**

Module name Geophysical Methods					
Module no. 11-02-3413	**Credits** 6 CP	**Workload** 180 h	**Self-study** 105 h	**Duration** 1 semester	**Cycle** Yearly in the SoSe
Language of instruction English			**Person responsible for the module** Hinderer		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Geophysical Field Methods	3 CP	VL + PR	3
2	Ground Penetrating Radar (GPR)	3 CP	PR	2

2 Course contents

Geophysical Field Methods: Introduction into various methods of applied engineering geophysics: seismics, geoelectrics, electromagnetics, ground penetrating radar, geomagnetics.

Ground Penetrating Radar (GPR): Practical, advanced application of a GPR system including processing and geological interpretation of data. 3D surveys, CMP analysis (velocity-depth profiles), monitoring, and local moisture sounding.

3 Qualification and learning goals

In the two field courses, the students are enabled to understand and use the most important geophysical field methods, including their data evaluation, and acquire knowledge and methodical skills on the near-surface method of Ground Penetrating Radar (GPR). As a usually multinational group, during the field course the students improve their intercultural competence. They also gain other soft skills such as organisational skills, team working skills, communication skills, and data presentation skills.

4 Prerequisites for attending

none

5	**Type of exam** Geophysical Field Methods: written exam, 90 minutes (*SL*) Ground Penetrating Radar (GPR): written exam, 90 minutes, or report (*SL*)
6	**Criteria for obtaining the credits** Passing both exams
7	**Grading** Geophysical Field Methods: graded (*St*); Ground Penetrating Radar (GPR): graded (*St*); total module grade weighted by CP shares of the two courses
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules
9	**Literature** Telford, W.M. (1990): Applied Geophysics.- Cambridge.
10	**Comments**

Module name Geothermal Engineering					
Module no. 11-02-3460	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 Semester	**Cycle** Yearly in the WiSe
Language of instruction English			**Person responsible for the module** Sass		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Geothermal Engineering	6 CP	2 VÜ	4

2 Course contents

- Introduction to Geothermal Energy
- Thermal Regime of the Earth
- Fundamentals of Thermodynamics
- Introduction to Heat Pumps
- Design and Application of Shallow Geothermal Systems (Guidelines)
- Open Shallow Geothermal Systems
- Closed Shallow Geothermal Systems
- Seasonal Heat Storage
- Installation of Borehole Heat Exchangers
- Geothermal Power Plants
- District Heating
- Geothermal Response Test
- Introduction to Numerical Simulation Concepts
- Numerical Modeling of Geothermal Reservoirs
- Advanced Geothermal Reservoir Simulation

3	**Qualification and learning goals** Global warming potential as a result of using fossil fuels for energy supply has been increasing rapidly. The students have fundamental knowledge on geothermal energy as a sustainable energy source for heating, cooling and thermal underground storage with an interdisciplinary approach, including geothermal power plant systems. They are familiar with heat pump technologies, fundamentals of district heating grids, basic engineering of power plant technologies, design guidelines and technical requisites for practical utilization of geothermal energy for future energy provision.
4	**Prerequisites for attending** Recommended: fundamental knowledge of applied geoscience and a basic background in engineering.
5	**Type of exam** Written exam, 90 minutes (*FP*)
6	**Criteria for obtaining the credits** Passing the exam
7	**Grading** Graded (*St*)
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules
9	**Literature** Deutsche Gesellschaft für Geotechnik e.V. / Deutsche Gesellschaft für Geowissenschaften e.V. (eds., 2016): Shallow Geothermal Systems - Recommendations on Design, Construction, Operation and Monitoring. - 312 p.; Wilhelm Ernst & Sohn, Berlin. DiPippo, R. (2015): Geothermal Power Plants - Principles, Applications, Case Studies and Environmental Impact. - 4. ed., 800 p.; Butterworth-Heinemann. Borgnakke, C. & Sonntag, R.E. (2020): Fundamentals of Thermodynamics. - 10. ed., 592 p.; Wiley. Bergman, T.L., Lavine, A.S., Incropera, F.P. & DeWitt, D.P. (2018): Fundamentals of Heat and Mass Transfer. - 8. ed., 992 p.; Wiley.
10	**Comments**

Module name Groundwater Modelling					
Module no. 11-02-2219	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 2 semesters	**Cycle** Yearly, starting in SoSe
Language of instruction English			**Person responsible for the module** Schüth		
1	**Course(s)**				

	Course no.	Course title	Workload (CP)	Teaching method	SWS
	1	Introduction to Groundwater Modelling	3 CP	VÜ	2
	2	Advanced Groundwater Modelling	3 CP	VÜ	2

2 Course contents

Introduction to Groundwater Modelling introduces basic theoretical principles of groundwater modelling. It will be discussed (i) what kind of groundwater models exist and what they are needed for, (ii) which mathematical concepts they are based on, (iii) what boundary and initial conditions are and (iv) which numerical solution methods exist. This will be accompanied by practical exercises on groundwater flow (MODFLOW), visualization and particle tracking (PMPATH), and solute transport (MT3D).

Advanced Groundwater Modelling expands the basic knowledge, and model calibration (inverse modelling) using PEST is introduced. Afterwards there is an extensive group work in which a practical case is dealt with. Data pre- and post-processing for the case study is performed with ArcGIS.

3 Qualification and learning goals

The students are able to independently develop a groundwater flow and transport model and to critically analyse it through implementation of a model calibration and sensitivity analysis. They are able to assess data needs for improving the model performance and therefore to suggest how to efficiently collect new field data. As groundwater models are powerful decision support systems, which constitute a nexus between human demand and sustainable resources management, in addition to the technical aspects of flow modeling the students will be sensitized for a responsible use of natural resources.

4 Prerequisites for attending

none

5 Type of exam

Introduction to Groundwater Modelling: written exam, 90 minutes (*FP*)

Advanced Groundwater Modelling: home work (case study) (*SL*)

6 Criteria for obtaining the credits

Passing both exams

7 Grading

Introduction to Groundwater Modelling: graded (*St*); Advanced Groundwater Modelling: graded (*St*); total module grade weighted by CP shares of the two courses

8 Curricula where the module is used

M.Sc. TropHEE, Elective Modules

M.Sc. Angewandte Geowissenschaften:

Vertiefungsrichtung "Angewandte Geologie": Vertiefungsspezifischer Wahlpflichtbereich, 2. und 3. Fachsemester

Vertiefungsrichtung "Umweltgeowissenschaften": Vertiefungsspezifischer Wahlpflichtbereich, 2. und 3. Fachsemester

9 Literature

Wang, H. & Anderson, M.P. (1995): Introduction to Groundwater Modeling – Finite Differences and Finite Element Methods.- San Diego (Elsevier Academic Press).

	Rausch, R., Schäfer, W., Therrien, R. & Wagner, C. (2005): Solute Transport Modelling – An Introduction to Models and Solution Strategies.- Stuttgart (Borntraeger). Hill, M. & Tiedeman, C. (2007): Effective Groundwater Model Calibration.- Wiley Interscience.
10	**Comments**

Module name Hydrochemistry I					
Module no. 11-02-3466	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 semester	**Cycle** Yearly in the WiSe
Language of instruction English			**Person responsible for the module** Schüth		

1	**Course(s)**				
	Course no.	**Course title**	**Workload (CP)**	**Teaching method**	**SWS**
	1	Hydrochemistry	3 CP	VL	2
	2	Water Analysis	3 CP	VL + PR	3
2	**Course contents** Hydrochemistry: Ionic species in groundwater; ion balance; activity; solubility product; dissolution of gases in waters; the carbonate system; redox reactions; classification of waters; water chemistry and geological formations; evolution of water chemistry; presentation and interpretation of groundwater analyses; Schoeller and Piper diagram; hydrochemical calculations using PHREEQC. Water Analysis: Surface water sampling in the field, determination of field parameters, quantitative analysis of major anions and cations as well as organic compounds in the laboratory (IC, AAS), calculation of ion balance, evaluation of plausibility and quality of water analyses, typing due to classification schemes.				
3	**Qualification and learning goals** The students understand the chemical processes occurring in groundwater and are enabled to interpret and present groundwater chemistry data. They understand that natural waters are in constant interaction with the solid materials of the soils and aquifers. They acquire methodical skills to use standard laboratory equipment to analyse water samples and to evaluate the results. Through the hands-on laboratory work they gain soft skills such as organizational skills, team working skills, communication skills, and data presentation skills.				
4	**Prerequisites for attending** none				
5	**Type of exam** Hydrochemistry: written exam, 90 minutes (*FP*) Water Analysis: report (*SL*)				
6	**Criteria for obtaining the credits** Passing both exams				

7	**Grading** Hydrochemistry: graded (*St*); Water Analysis: graded (*St*); total module grade weighted by CP shares of the two courses
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Angewandte Geowissenschaften: Vertiefungsrichtung "Umweltgeowissenschaften": Kernbereich, 1. Fachsemester Vertiefungsrichtung "Angewandte Geologie": Vertiefungsspezifischer Wahlpflichtbereich, 1. Fachsemester
9	**Literature** Deutsch, W.J. (2003): Groundwater Geochemistry.- Boca Raton. Fetter, C.W. (1999): Contaminant Hydrogeology.- 500 p.; New Jersey (Prentice Hall). Stumm, W. & Morgan, J.J. (1995): Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters.- John Wiley & Sons. Nollet, L.M.L. (2007): Handbook of Water Analyses.- 784 p.; CRC Press Int.
10	**Comments**

Module name
Hydrochemistry II

Module no.	Credits	Workload	Self-study	Duration	Cycle
11-02-6023	6 CP	180 h	120 h	1 semester	Yearly in SoSe

Language of instruction	Person responsible for the module
English	Schüth

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Hydrogeochemistry	6 CP	VÜ	4

2 Course contents

Organic contaminants: occurrence and classification in soil and groundwater; physicochemical parameters; distribution equilibria (Henry, K_{ow}, K_d, K_{oc} concepts); sorption isotherms; sorption kinetics; diffusion; contaminant transport in groundwater; non-aqueous phase liquids; inorganic contaminants: occurrence and classification in soil and groundwater; speciation, complex formation, stability diagrams; mobility; background values.

3 Qualification and learning goals

The students acquire in-depth knowledge on the behaviour of contaminants in different environmental compartments, how to assess and evaluate environmental contaminations, and how to remove or reduce such contaminations. In particular, the students are able to evaluate the behaviour of inorganic and organic contaminants in groundwater as well as their transformation processes and to conclude on appropriate site investigation and remediation methods. They understand the impact of human activities on the environment, particularly the soil and water ecosystems, and evaluate socio-economic consequences (such as loss of soil function and water use, and costs of risk assessment and remediation activities).

4	**Prerequisites for attending** none
5	**Type of exam** Written exam, 90 minutes (*FP*)
6	**Criteria for obtaining the credits** Passing the exam
7	**Grading** Graded (*St*)
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Angewandte Geowissenschaften: Vertiefungsrichtung "Angewandte Geologie": Vertiefungsspezifischer Wahlpflichtbereich, 2. Fachsemester Vertiefungsrichtung "Umweltgeowissenschaften": Vertiefungsspezifischer Wahlpflicht-bereich, 2. Fachsemester
9	**Literature** Schwarzenbach, R.P., Gschwend, P. & Imboden, D.M. (1996): Environmental organic chemistry.- Wiley, VCH. Fetter, C.W. (1999): Contaminant Hydrogeology.- 500 p.; New Jersey (Prentice Hall). Appelo, C.A.J. & Postma, D. (2005): Geochemistry, Groundwater and Pollution.- Taylor and Francis.
10	**Comments**

Module name Hydrogeology I					
Module no. 11-02-3406	**Credits** 6 CP	**Workload** 180 h	**Self-study** 75 h	**Duration** 1 semester	**Cycle** Yearly in the WiSe
Language of instruction English			**Person responsible for the module** Schüth		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Hydrogeology I	4 CP	VÜ	3
2	Hydrogeological Field Trips	2 CP	EK	2

2 Course contents

Hydrogeology I: Water cycle, precipitation, evapotranspiration, runoff, recharge, water balance, methods for data regionalization, aquifer types, Darcy's Law, aquifer parameters, (regional) groundwater flow, pumping tests (steady state and transient conditions), slug tests, water sampling techniques, field parameters, basics of augering and drilling, selected case studies.

	Hydrogeological Field Trips: Day trips to places of hydrogeological interest including water works, waste water treatment plants, contaminated sites, landfill sites etc.
3	**Qualification and learning goals** The students acquire fundamental knowledge of the hydrological cycle and groundwater hydraulics with respect to various climatic zones, and the capability to apply related quantitative methods to actual hydrogeological problems. They acquire skills to understand local, regional and global water and environmental problems, and to develop approaches and solve them using hydrogeological methods. Their knowledge will enable them to realize, understand and address future water related challenges in light of the millennium goals of which several are related to an efficient water management. As a usually multinational group, during the field trips the students improve their intercultural competence. They also improve other soft skills such as team working skills and communication skills.
4	**Prerequisites for attending** none
5	**Type of exam** Hydrogeology I: written exam, 90 minutes (*FP*) Hydrogeological Field Trips: report (*SL*)
6	**Criteria for obtaining the credits** Passing both exams
7	**Grading** Hydrogeology I: graded exam (*St*) = total grade for the module; Hydrogeological Field Trips: not graded (*bnb*)
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules
9	**Literature** Brassington, R. (2017): Field Hydrogeology.- Wiley Blackwell. Fetter, C.W. (2000): Applied Hydrogeology.- Prentice Hall. Hiscock, K.M. & Bense, V.F. (2014): Hydrogeology Principles and Practice.- Wiley Blackwell. Hölting, B. & Coldewey, W.G. (2019): Hydrogeology.- Springer.
10	**Comments**

Module name Hydrogeology II					
Module no. 11-02-3468	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 semester	**Cycle** Yearly in the SoSe
Language of instruction English			**Person responsible for the module** Schüth		

1	**Course(s)**				
	Course no.	**Course title**	**Workload (CP)**	**Teaching method**	**SWS**

	1	Hydrogeology II	3 CP	VL + Ü	2
	2	Hydrogeological Field Course	3 CP	PR	2

2 Course contents

Hydrogeology II: Groundwater systems (groundwater landscapes, karst aquifers, fractured rock aquifers), use of tracers in hydrogeology (conservative tracers, reactive tracers, evaluation of breakthrough curves), isotopes in hydrogeology (characterization of the water cycle, dating), groundwater development (average demand/peak demand, well construction, borehole measurements, pumping tests), groundwater monitoring (water framework directive, monitoring strategies, measuring networks), computer programs in hydrogeology (Surfer, Aqtesolv, Aquachem).

Hydrogeological Field Course: Stream discharge measurement techniques, groundwater level measurements, pumping tests, field parameters, groundwater sampling, levelling of observation wells, generation of groundwater contour and depth to water maps.

3 Qualification and learning goals

The students have in-depth knowledge in hydrogeology, in particular to understand groundwater systems. They are able to plan groundwater developments and develop monitoring concepts and classify them in the context of current legislation. They are aware of the regional aspects of groundwater management and potential geopolitical conflicts related to, e.g., transboundary aquifer systems with different stakeholder interests. In addition, the use of standard software in hydrogeology is learned and critically questioned. The students are able to apply basic field techniques to characterize groundwater levels, groundwater flow fields, and to characterize aquifers in terms of hydraulic properties. Through the hands-on fieldwork, they gain soft skills such as organizational skills, team working skills, communication skills, and data presentation skills.

4 Prerequisites for attending

none

5 Type of exam

Hydrogeology II: written exam, 90 minutes (*FP*)

Hydrogeological Field Course: report (*SL*)

6 Criteria for obtaining the credits

Passing both exams

7 Grading

Hydrogeology II: graded exam (*St*); Hydrogeological Field Course: graded (*St*); total module grade weighted by CP shares of the two courses

8 Curricula where the module is used

M.Sc. TropHEE, Elective Modules

M.Sc. Angewandte Geowissenschaften:

Vertiefungsrichtung "Angewandte Geologie": Kernbereich, 2. Fachsemester

Vertiefungsrichtung "Umweltgeowissenschaften": Vertiefungsspezifischer Wahlpflichtbereich, 2. Fachsemester

9 Literature

Domenico, P.A. & Schwartz, F.W. (1998): Physical and Chemical Hydrogeology.- 2nd ed., 506 p.; New York (Wiley & Sons).

Hiscock, K.M. & Bense, V.F. (2014): Hydrogeology: Principles and Practice.- 2nd ed., 544 p.; Wiley.

	Hölting B. & Coldewey, W.G. (2019): Hydrogeology.- Springer. Brassington, F.C. (2006): Field Hydrogeology.- 276 p.; John Wiley & Sons.
10	**Comments**

Module name Integrated Water Management					
Module no. 13-L1-M007	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 Semester	**Cycle** Yearly in the WiSe
Language of instruction English			**Person responsible for the module** Schmalz		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Integrated Water Management	6 CP	VÜ	4

2 Course contents

- Water availability and water demand
- Aims of sustainable integrated water resources management (IWRM)
- Definitions and principles of IWRM, technical, economic, social, ecological and legal aspects of integrated water management, IWRM planning and implementation
- Data and models for IWRM
- Water management under global change, ecosystem-based adaptation
- Exercises on case studies
- Presentations and discussions of water management systems

3 Qualification and learning goals

By passing the module examinations, students are able to understand the goals and principles of sustainable integrated water management, to carry out exercises on case studies, and to present and discuss different water management systems. Students have the ability to weigh different solutions against each other, to explain them objectively and comprehensibly.

4 Prerequisites for attending

Recommended: Fundamentals of Hydrology

5 Type of exam

Oral exam, 15 minutes (*FP*); plus home work (*SL*)

6 Criteria for obtaining the credits

Passing both exams (*FP* and *SL*)

7 Grading

Oral exam, graded (*St*) = total grade for the module; home work: not graded (*bnb*)

8 Curricula where the module is used

M.Sc. TropHEE, Elective Modules

M.Sc. Bauingenieurwesen, Fachlicher Wahlbereich

M.Sc. Umweltingenieurwissenschaften, Fachlicher Wahlbereich

9	**Literature** Will be announced in the course.
10	**Comments**

Module name Isotope Hydrology and Dating					
Module No. 11-02-2229	**Credits** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Duration** 1 Semester	**Cycle** Yearly in the WiSe
Language of instruction English			**Person responsible for the module** Schüth		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Isotope Hydrology and Dating	3 CP	1 VL + 1 Ü	2

2 Course contents

Natural and artificial isotopes, stable isotopes, radiogenic isotopes; isotopes in rivers, soils and groundwater; groundwater dating techniques; field sampling and laboratory methods; introduction to modeling of isotope signals.

3 Qualification and learning goals

The students have in-depth knowledge on isotopes methods and their use in solving hydrological and hydrogeological questions. They are also able to assess results acquired by these methods for their plausibility, reproducibility and error margins. Through the hands-on exercises they gain soft skills such as team working skills, communication skills, and data presentation skills.

4 Prerequisites for attending

none

5 Type of exam

Written exam, 60 minutes (*FP*)

6 Criteria for obtaining the credits

Passing the exam

7 Grading

Graded (*St*)

8 Curricula where the module is used

M.Sc. TropHEE, Elective Modules

M.Sc. Angewandte Geowissenschaften:

Vertiefungsrichtung "Angewandte Geologie": Vertiefungsspezifischer Wahlpflichtbereich, 3. Fachsemester

Vertiefungsrichtung "Umweltgeowissenschaften": Vertiefungsspezifischer Wahlpflichtbereich, 3. Fachsemester

9	**Literature** Fritz, P. (1080): Handbook of Environmental Isotope Geochemistry.- New York.
10	**Comments**

Module name Mathematical Simulation in Wastewater Treatment					
Module no. 13-K6-M002	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 Semester	**Cycle** Yearly in the SoSe
Language of instruction English			**Person responsible for the module** Lackner		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Mathematical Simulation in Wastewater Treatment	6 CP	VÜ	4

2 Course contents

The seminar covers theoretical and practical knowledge to enable the students to carry out mathematical simulations of wastewater treatment plants. The course introduces the fundamentals of mathematical modelling and modelling of the biochemical processes. We will implement simple models for carbon and nitrogen removal in different reactor types. Based on that, the students will get hands-on experience with software tools to simulated the complete wastewater treatment plant. Content:

- introduction to simulation
- introduction to the software tools (e.g. Aquasim, BioWin, Simba, Sumo)
- influent fractionation
- activated sludge models (ASM)
- biofilm models
- problem oriented approach with mathematical modelling

3 Qualification and learning goals

The students have a deepened basic knowledge in the mathematical simulation of biochemical processes in simple reactor systems with the application to biological wastewater treatment (Software Tool, Aquasim). The students are able to model simple wastewater treatment plants in BioWin/Simba/Sumo and apply the software tool to solve problems. They can solve tasks from these areas independently. In addition to the well-founded basic knowledge, they have the ability to apply their knowledge to the assessment of different scenarios in wastewater treatment.

4 Prerequisites for attending

Recommended: 'Siedlungswasserwirtschaft I/II' (13-K0-M001/13-K2-M001/3) or 'Kommunale Abwassertechnik' (13-K2-M002)

5 Type of exam

Oral exam, 15 minutes, or written exam, 90 minutes (*FP*) (as a rule, the examination takes the form of an oral examination, or a written examination if there are more participants); plus home work (assignments)/report/presentation (*SL*) (the students will solve 3-5 short basic

	modeling assignments during the first half of the semester to evaluate their understanding of the tools and methods; during the second half of the semester the students will work on a specific modeling task which will be presented at the end of the semester)
6	**Criteria for obtaining the credits** Passing both exams (*FP* and *SL*)
7	**Grading** Oral or written exam: graded (*St*); home work/report/presentation: graded (*St*); total module grade average from both exams, with oral or written exam weighting 60% and home work/report/presentation weighting 40%.
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Bauingenieurwesen, Fachlicher Wahlbereich M.Sc. Umweltingenieurwissenschaften, Fachlicher Wahlbereich
9	**Literature** Literature will be announced at the beginning of the course.
10	**Comments**

Module name Oxidative Processes in Water Treatment					
Module no. 13-K8-M002	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 Semester	**Cycle** Yearly in the SoSe
Language of instruction English			**Person responsible for the module** Lutze		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Oxidative Processes in Water Treatment	6 CP	VÜ	4

2 Course contents

Oxidation processes are a success story in water treatment as they are the first treatment step applied in the early 20th century to provide hygienically safe water. However, ongoing research continuously discovers new important insights which can lead to improvement (e.g., degradation of persistent pollutants) but also limitations of oxidation processes (e.g., emerging toxic by-products). To cope with the rapid knowledge gain and to meet the current state of the art, the content of the course will be continuously updated on basis of the latest literature. In brief the course provides:

- A decent insight in the complex processes happening in oxidative water treatment
- skills to choose individual treatment options for a specific water resources
- Experimental tools for investigation of oxidation processes (efficiency, by-product formation, reaction kinetics)
- Options for simulating pollutant degradation and disinfection in real water applications
- Insights in reaction kinetics and mechanisms of oxidants used in water treatment

	- Influence of water matrix constituents such as organic matter and halides and carbonates - Integration of oxidation processes in the water treatment chain - Mechanisms of pollutant degradation and disinfection processes - Skills to assess the quality of current literature and strategies to evaluate literature as a scientific reviewer For fostering the learning effect, the course is divided in lecture and tutorial.
3	**Qualification and learning goals** The students will learn how to treat individual source waters (e.g., surface water, wastewater or groundwater) on basis of the source water quality (content of organic matter, halides etc.). Furthermore experimental setups will be explained to briefly characterise water oxidative processes in bench scale experiments to determine the optimal oxidant dose. The students will be able to plan all important experiments to investigate oxidation processes in terms of pollutant degradation, disinfection, product formation and energy demand and how to develop strategies for polishing water treatment steps (e.g., strategies for minimizing by-product formation). The students will learn to assess the quality of research papers and the limitations of the peer-review process.
4	**Prerequisites for attending** All knowledge needed to understand the course content will be provided. However, it is recommended to have basic knowledge in water chemistry, kinetics, speciation, intermolecular interactions and red/ox processes.
5	**Type of exam** Open book written exam, 90 minutes (*FP*); plus report and presentation (*SL*) (report and presentation approx. 6 weeks after start of the course, group work)
6	**Criteria for obtaining the credits** Passing both exams (*FP* and *SL*)
7	**Grading** Oral or written exam: graded (*St*); report and presentation: graded (*St*); total module grade average from both exams, with oral or written exam weighting 60% and report and presentation weighting 40%.
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Bauingenieurwesen, Fachlicher Wahlbereich M.Sc. Umweltingenieurwissenschaften, Fachlicher Wahlbereich
9	**Literature** Lutze, H.V., Brekenfeld, J., Naumov, S., von Sonntag, C. & Schmidt, T.C. (2018): Degradation of perfluorinated compounds by sulfate radicals – New mechanistic aspects and economical considerations.- Water Research, 129, 509-519. Lutze, H.V. (2016): Treatment by oxidation processes.- Ullmann's Encyclopaedia of Industrial Chemistry, Wiley-VCH. Tentscher, P.R., Lee, M. & Von Gunten, U. (2019): Micropollutant Oxidation Studied by Quantum Chemical Computations: Methodology and Applications to Thermodynamics, Kinetics, and Reaction Mechanisms.- Accounts of Chemical Research, 52(3), 605-614. Terhalle, J., Kaiser, P., Jütte, M., Buss, J., Yasar, S., Marks, R., Uhlmann, H., Schmidt, T.C. & Lutze, H.V. (2018): Chlorine dioxide – Pollutant transformation and formation of hypochlorous acid as a secondary oxidant.- Environmental Science & Technology, 52(17), 9964-9971.

	von Gunten, U. (2018): Oxidation Processes in Water Treatment: Are We on Track? - Environmental Science & Technology, 52(9), 5062-5075. von Sonntag, C. & von Gunten, U. (eds., 2012): Chemistry of ozone in water and wastewater treatment.- IWA Publishing.
10	**Comments**

Module name Pollutants in the Water Cycle					
Module no. 13-K8-M001	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 Semester	**Cycle** Yearly in the WiSe
Language of instruction English			**Person responsible for the module** Lutze		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Pollutants in the Water Cycle: Sources and Fate in the Aquatic Environment	6 CP	VÜ	4

2 Course contents

Sources of pollutants such as wastewater, agriculture, architecture, natural sources (water born). Transformation of pollutants in aquatic systems (e.g., photo-oxidation, reactive species such as free radicals). Mobility of pollutants: Sorption and desorption processes. Control strategies: e.g., water treatment, soil and engineered surfaces. Critical use of literature; options and limitations of scientific literature.

3 Qualification and learning goals

Students learn fundamentals of the fate and reactions of pollutants in the aquatic environment regarding transformation and mobility. Students will learn how molecules behave on basis of their molecular structure. Principles of technical purification processes for elimination of pollutants and prevention of their spread into the environment. Fundamental aspects in water chemistry and water/surface interface reactions (e.g., buildings, soil) will be learned. Students will practice to evaluate current papers, find major flaws and thus, sharpen their critical few on published data.

4 Prerequisites for attending

Recommended: Knowledge in basic chemistry, reaction kinetics, acid/base speciation, inter-molecular interactions, red/ox processes.

5 Type of exam

Open book written exam, 90 minutes (*FP*); plus report and presentation (*SL*) (report and presentation approx. 6 weeks after start of the course, group work)

6 Criteria for obtaining the credits

Passing both exams (*FP* and *SL*)

7	**Grading** Oral or written exam: graded (*St*) = total grade for the module; report and presentation: not graded (*bnb*)
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Bauingenieurwesen, Forschungsfach Gewässerbewirtschaftung M.Sc. Umweltingenieurwissenschaften, Fachlicher Wahlbereich
9	**Literature** Schwarzenbach, R.P., Gschwend, P.M. & Imboden, D.M. (eds., 2016): Environmental organic chemistry.- Wiley, VCH. von Sonntag, C. & von Gunten, U. (eds., 2012): Chemistry of ozone in water and wastewater treatment.- IWA Publishing. Weingärtner, H., Teermann, I., Borchers, U., Balsaa, P., Lutze, H.V., Schmidt, T.C., Franck, E.U., Wiegand, G., Dahmen, N., Schwedt, G., Frimmel, F.H. & Gordalla, B.C. (2016): Water, 1. Properties, Analysis, and Hydrological Cycle.- Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH. Lutze, H.V. (2016): Treatment by oxidation processes.- Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH.
10	**Comments**

Module name Remote Sensing and Statistics					
Module no. 11-02-3416	**Credits** 6 CP	**Workload** 180 h	**Self-study** 105 h	**Duration** 2 semesters	**Cycle** Yearly, starting in SoSe
Language of instruction English			**Person responsible for the module** Hinderer		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Statistics	3 CP	VÜ	2
2	Remote Sensing in Geology	3 CP	VÜ	2

2 Course contents

Statistics: Introduction on statistical methods; data presentation; elementary statistics, e.g. t-tests, F-tests, chi-square tests, analysis of variance, non-parametric tests; analysis of multi-variate data, e.g. cluster analysis, PCA, CA, DCA; time series analysis, e.g. analysis of stationary and non-stationary data; PC-based exercises.

Remote Sensing in Geology: Introduction to remote sensing techniques. Exercises with aerial photographs within a stereoscopic model by drawing and interpreting valley systems and geology; determination of quantitative data (e.g., difference in elevation, thickness of bed and strike and slip).

3	**Qualification and learning goals** The students have in-depth knowledge on isotopes and tracer methods and their use in solving hydrological and hydrogeological questions. They are also able to assess results acquired by these methods for their plausibility, reproducibility and error margins. Through the hands-on exercises, they gain soft skills such as team working skills, communication skills, and data presentation skills.
4	**Prerequisites for attending** none
5	**Type of exam** Statistics: written exam, 60 Minutes (*FP*) Remote Sensing in Geology: home work (case study) (*SL*)
6	**Criteria for obtaining the credits** Passing both exams
7	**Grading** Statistics: graded (*St*); Remote Sensing in Geology: graded (*St*); total module grade weighted by CP shares of the two courses
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules
9	**Literature** Drury, S.A. (1997): Image Interpretation in Geology.- 2nd ed., 283 p.; Allen & Unwin, London. Miller, V.C. & Miller, F. (1961): Photogeology.- 248 p., McGraw-Hill, New York. Ray, R.G. (1960): Aerial photographs in geologic interpretation and mapping.- Prof. Paper U.S. Geol. Survey, 373: 230 p., Washington. Chilès, J.-P. & Delfiner, P. (1999): Geostatistics.- 720 p.; New York (Wiley & Sons). Davis, J.C. (2003): Statistics and Data Analysis in Geology.- 638 p.; New York (Wiley & Sons). Isaaks, E.H. (1989): Applied Geostatistics.- New York. Goovaerts, P. (1999): Geostatistics for Natural Resources Evaluation.- Oxford. Townend, J. (2002): Practical statistics for environmental and biological scientists.- 276 p.; New York (Wiley & Sons). Webster, R. & Oliver M.A. (2007): Geostatistics for Environmental Scientists.- 336 p.; New York (Wiley & Sons).
10	**Comments**

Module name Sedimentology II					
Module no. 11-02-2336	**Credits** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Duration** 1 semester	**Cycle** Yearly in the SoSe
Language of instruction English			**Person responsible for the module** Hinderer		

1	**Course(s)**				
	Course no.	**Course title**	**Workload (CP)**	**Teaching method**	**SWS**
	1	Basin Analysis	3 CP	2 VL	2
	2	Sequence Stratigraphy Field Course	2 CP	2 PR	2
2	**Course contents** Basin Analysis: Concepts of sequence stratigraphy, required data sets, seismic stratigraphy, classification of sedimentary basins, plate tectonic framework, subsidence, thermic evolution, filling pattern, diagenesis and evolution of porosity-permeability. Selected case studies with focus on reservoir geology, e.g. oil, gas, groundwater and geothermal energy. Sequence Stratigraphy Field Course: Training of sedimentary outcrop analysis by visiting outcrops on a three days field course. The data will be integrated into a sequence stratigraphic basin model. Field methods are: logging of sediment facies, outcrop sketches, measurement of natural gamma radiation and magnetic susceptibility. All data and observations will be documented and interpreted in a report. The students will use the data to qualitatively evaluate reservoir quality. The practical work is done in small groups. The case studies are from the epicontinental basin of the Germanic Triassic and the Cenozoic Northalpine Foreland Basin (Molasse).				
3	**Qualification and learning goals** The students know about modern concepts in basin analysis, with focus on sequence stratigraphy and cyclo-stratigraphy. They recognize sedimentary cycles in outcrops and are able to describe and interpret them genetically. They are able to integrate different hierarchies and couple observations to basin evolution for siliciclastic as well as for carbonate sedimentary rocks. They learn to handle geophysical field instruments for sediment logging. They decide upon data to assess reservoir models for groundwater, petroleum, and geothermal energy. They are able to document field data in a scientific report.				
4	**Prerequisites for attending** none				
5	**Type of exam** Basin Analysis: written exam, 90 minutes (*FP*) Sequence Stratigraphy Field Course: report (*SL*)				
6	**Criteria for obtaining the credits** Passing both exams				
7	**Grading** Basin Analysis: graded (*St*); Sequence Stratigraphy Field Course: graded (*St*); total module grade weighted by CP shares of the two courses				
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Angewandte Geowissenschaften: Vertiefungsrichtung "Angewandte Geologie": Vertiefungsspezifischer Wahlpflichtbereich, 2. Fachsemester Vertiefungsrichtung "Umweltgeowissenschaften": Erweiterter geowissenschaftlicher Wahlpflichtbereich, 2. Fachsemester				
9	**Literature**				

	Catuneanu, O. (2006): Principles of sequence stratigraphy.- 375 p.; Elsevier. Einsele, G. (2000): Sedimentary Basins.- 792 p.; Springer. Nichols, G. (2009): Sedimentology and Stratigraphy.- 2nd ed., 432 p.; Oxford (Blackwell). Miall, A.D. (2000): Principles of Sedimentary Basin Analysis.- Heidelberg (Springer). Miall, A.D. (2016): Stratigraphy: A modern synthesis.- 471 p.; Springer. Allen, P.A. & Allen, J.R. (2013): Basin Analysis - Principles and applications.- 3rd ed., 632 p.; London (Blackwell).
10	**Comments**

Module name Sedimentology III					
Module no. 11-02-2337	**Credits** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Duration** 1 semester	**Cycle** Yearly in the SoSe
Language of instruction English			**Person responsible for the module** Hinderer		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Sedimentary Petrology and Provenance Analysis	2 CP	1 VL	1
2	Microscopy of Sandstones	3 CP	2 Ü	2

2 Course contents

Sedimentary Petrology and Provenance Analysis: Source-to-sink-concept; sediment generation (climate, tectonics, source rocks); sediment dispersal (hydraulic considerations, sorting, maturity); diagenesis (compaction, porosity, cements); sandstone classification; provenance concepts and classifications; overview of methods (image analysis, point counting, heavy mineral analysis, single-grain geochemistry) as well as relevant statistics and software.

Microscopy of Sandstones: Practical exercises; polarisation microscopy of quartz, feldspar, various lithic fragments, matrix and cement in thin sections; polarisation microscopy of the most common heavy minerals in strewn slides.

3 Qualification and learning goals

The students know how to describe the genesis and composition of siliciclastic sediments and sedimentary rocks (especially of sands and sandstones) and their interpretation in the context of provenance, tectonics, climate and reservoir characteristics. They are able to identify various constituents of sediments or sedimentary rocks as well as their diagenetic modifications using the polarization microscope. The acquired knowledge is fundamental for various applications in reservoir geology, environmental analysis and geological research.

4 Prerequisites for attending

Recommended: fundamentals of polarisation microscopy

5 Type of exam

Written exam, 90 minutes (*FP*)

6	**Criteria for obtaining the credits** Passing the exam
7	**Grading** Graded (*St*)
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Angewandte Geowissenschaften: Vertiefungsrichtung "Angewandte Geologie": Vertiefungsspezifischer Wahlpflichtbereich, 2. Fachsemester Vertiefungsrichtung "Umweltgeowissenschaften": Erweiterter geowissenschaftlicher Wahlpflichtbereich, 2. Fachsemester
9	**Literature** Mange, M. & Maurer, H.F.W. (1992): Heavy minerals in color.- 147 p.; Chapman & Hall. Pettijohn, F.J., Potter, P.E. & Siever, R. (1987): Sand and Sandstones.- 553 p.; Springer. Ulmer-Scholle, D., Scholle, P.A., Schieber, J. & Raine, R.J. (2015): A color guide to the petrography of sandstones, siltstones, shales and associated rocks.- AAPG memoir 109, 526 p.
10	**Comments**

Module name Sedimentology IV					
Module no. 11-02-2338	**Credits** 5 CP	**Workload** 150 h	**Self-study** 120 h	**Duration** 1 semester	**Cycle** Yearly in the SoSe
Language of instruction English			**Person responsible for the module** Hinderer		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Sedimentological Field Course	5 CP	2 PR	2

2 Course contents

The field course introduces into the outcrop-analogue concept and reservoir geology using outcrops and sediment cores. This comprises:
- Sediment logging of siliciclastic and carbonate rocks and applying the lithofacies concept
- Measurements with handheld instruments: spectral gamma-ray, magnetic susceptibility, and pXRF.
- Mapping of outcrop walls and identification of architectural elements
- Drilling of plugs for petrophysical analysis
- Sample preparation with a rock saw
- Measurement of plugs in the lab on porosity and permeability
- Identification of sedimentary cycles

3 Qualification and learning goals

The field course introduces into common methods of field observations and field measurements of sedimentary rocks, which are required for scientific work and/or in the industry. The

	students are able to present field data using standard and special software (e.g., drawing, calculation, sediment logging software) and to write a scientific report. Specific focus is put on drawing publication-ready graphs and on a precise data handling.
4	**Prerequisites for attending** Recommended: *Sedimentary Geology II*
5	**Type of exam** Report (*SL*)
6	**Criteria for obtaining the credits** Passing the exam
7	**Grading** Graded (*St*)
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Angewandte Geowissenschaften: Vertiefungsrichtung "Angewandte Geologie": Vertiefungsspezifischer Wahlpflichtbereich, 2. Fachsemester Vertiefungsrichtung "Umweltgeowissenschaften": Erweiterter geowissenschaftlicher Wahlpflichtbereich, 2. Fachsemester
9	**Literature** Stow, D.A.V. (2008): Sedimentary rocks in the field – a color guide.- 320 p.; Manson Publishing. Nichols, G. (2009): Sedimentology and Stratigraphy.- 2. ed., 432 p.; Oxford (Blackwell). Miall, A.D. (2016): Stratigraphy: A modern synthesis.- 471 p.; Springer.
10	**Comments**

Module name Sedimentology V					
Module no. 11-02-2339	**Credits** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Duration** 1 semester	**Cycle** Yearly in the SoSe
Language of instruction English			**Person responsible for the module** Hinderer		

1	**Course(s)**				
	Course no.	**Course title**	**Workload (CP)**	**Teaching method**	**SWS**
	1	Erosion: Processes and Methods	5 CP	2 VL + 1 Ü	3
2	**Course contents** Repetition and consolidation of knowledge of basic earth surface processes (weathering, erosion, transport, deposition); description and quantification of erosion parameters with a focus on water erosion; methods for measurements of erosion and sediment fluxes at various spatial and temporal scales (e.g. sediment traps, tracers, cosmogenic nuclides, sedimentary				

	fingerprinting); erosion models on various scales (e.g., USLE, BQART); global importance of the sediment loads of fluvial systems; quantification of sediment budgets.
3	**Qualification and learning goals** Students understand natural and anthropogenically amplified erosional processes and erosion rates at various temporal and spatial scales. They are familiar with relevant measurement and modelling techniques to quantify erosion. They are aware of the social, economic and ecologic consequences of erosional processes and are able to recommend and apply appropriate state-of-the-art techniques to case studies.
4	**Prerequisites for attending** none
5	**Type of exam** Written exam, 90 minutes (*FP*)
6	**Criteria for obtaining the credits** Passing the exam
7	**Grading** Graded (*St*)
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Angewandte Geowissenschaften: Vertiefungsrichtung "Angewandte Geologie": Vertiefungsspezifischer Wahlpflichtbereich, 2. Fachsemester Vertiefungsrichtung "Umweltgeowissenschaften": Vertiefungsspezifischer Wahlpflicht-bereich, 2. Fachsemester
9	**Literature** Allen, P.A. (1997): Earth surface processes.- 404 p.; Blackwell Science. Burbank, D.W. & Anderson, R.S. (2011): Tectonic geomorphology.- 2nd ed., 472 p.; Wiley-Blackwell. Hinderer, M. (2012): From gullies to mountain belts: a review of sediment budgets at various scales.- Sedimentary Geology, 280: 21-59. Morgan, R.P.C. (2005): Soil erosion and conservation.- 3rd ed., 316 p.; Wiley-Blackwell.
10	**Comments**

Module name Soil and Groundwater Physics					
Module no. 11-02-3464	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 2 semesters	**Cycle** Yearly, starting in WiSe
Language of instruction English			**Person responsible for the module** Schüth		
1	**Course(s)**				

	Course no.	Course title	Workload (CP)	Teaching method	SWS
	1	Physical Hydrogeology	3 CP	VL	2
	2	Unsaturated Zone Processes/ Groundwater Recharge	3 CP	VÜ	2
2	**Course contents** Physical Hydrogeology: Factors and processes influencing the quantity and quality of water discussion all compartments of the hydrosphere, such as atmospheric water (rain, snow, hail), river water, lake water and their interactions; vulnerability of groundwater, water protection; case studies and methods are presented which give hints on how to evaluate and deal with groundwater vulnerability. Unsaturated Zone Processes/Groundwater Recharge: The course starts with an introduction to soil physics, i.e. physical properties, water content, hydraulic potential, and unsaturated flow. Furthermore, it deals with the soil water balance and in particular with the two components groundwater recharge and evapotranspiration. At the end of the course an introduction to the modeling software HYDRUS with practical applications is given.				
3	**Qualification and learning goals** The students understand that water, particularly groundwater, is a vulnerable resource and acquire in-depth on the factors and processes governing groundwater vulnerability. The students are sensitized for the protective function of soils and their vulnerability. They understand the physical characteristics of soils as a crucial factor for water distribution/percolation in the unsaturated zone and for groundwater recharge, which constitutes the key figure for sustainable groundwater management.				
4	**Prerequisites for attending** none				
5	**Type of exam** Physical Hydrogeology: written exam, 60 minutes (*FP*) Unsaturated Zone Processes: written exam, 90 minutes, or home work (term paper) (*FP*)				
6	**Criteria for obtaining the credits** Passing both exams				
7	**Grading** Physical Hydrogeology: graded (*St*); Unsaturated Zone Processes: graded (*St*); total module grade weighted by CP shares of the two courses				
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules				
9	**Literature** Domenico, P.A. & Schwartz, F.W. (1998): Physical and Chemical Hydrogeology.- 2nd ed., 506 p.; New York (Wiley & Sons). Stephens, D.B. (1995): Vadose Zone Hydrology.- 347 p.; CRC Press Inc. Tindal, J.A. & Kunkel, J.R. (1998): Unsaturated Zone Hydrology for Scientists and Engineers.- 624 p.; Pretence Hall. White, R.E. (1987): Introduction to the Principles and Practice of Soil Science.- Oxford.				
10	**Comments**				

Module name Sustainable Waste Management and Life Cycle Assessment Application					
Module no. 13-K3-J021	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 Semester	**Cycle** Yearly in the SoSe
Language of instruction English			**Person responsible for the module** Lutze		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Sustainable Waste Management and LCA Application	3 CP	VL	2
2	Sustainable Waste Management and LCA Application - Exercise	3 CP	Ü	2

2 Course contents

This module combines the topics sustainable waste management and life cycle assessment (LCA).

In the first part of the lecture, principles of the development of circular economy and waste management concepts in an international context will be taught. The concept of Integrated Sustainable Waste Management, which is particularly relevant to design sustainable waste management in urban contexts and in countries in transitions, is presented. Relevant actors of the waste management chain, collection and treatment practices as well as approaches for the evaluation and design of waste management systems (for example benchmarking, LCA) will be addressed.

In the second part of the lecture, a practical introduction to the LCA-method will be given. Concerning the content, a special emphasis is put on the LCA application in the field of circular economy and waste management: the assessment of waste streams and waste management systems is explained, typical LCA applications and lessons learnt from the current research are presented and, thus, the role of LCA for sustainable waste management is demonstrated. Methodologically, the focus is on the presentation of specific LCA software and databases as well as the communication of the results for practical decision support for planners, developers and companies. In this respect, the module is an extended course for students with basic knowledge of the LCA method, but it can also be used by students without previous LCA experience.

The accompanying exercise includes a case study analysis to identify waste flows and relevant actors of the waste management chain and applies basic approaches for the evaluation the city´s waste management system. Methodological aspects of LCA will be demonstrated based on a literature analysis. A practical exercise is given to introduce an LCA software and its application to model certain aspects for the specific case study. By evaluating the presented case study, knowledge about the environmental impacts of waste collection and treatment from a life cycle perspective is conveyed and decision-making contexts of waste management are clarified.

Within the scope of the study achievement, a waste management system (case study from the accompanying exercise) is assessed environmentally using the LCA approach and the LCA software openLCA. The results of the stakeholder and waste stream analysis for the specific case study are also part of the study achievement.

3 Qualification and learning goals

On successful completion of this module, students are able to:

	1. Identify and assess relevant elements, aspects and stakeholders of waste management systems and to evaluate them from different perspectives; 2. Apply methodological concepts for the evaluation of waste management systems; 3. Understand the concept of life cycle thinking and implementation steps of an LCA; 4. Implement a basic LCA model using an LCA software and databases 5. Interpret LCA results in a practice-oriented way and communicate them to decision-makers; 6. Develop measures for sustainable waste management; 7. Understand the role of life cycle thinking for the evaluation and optimization of waste management systems.
4	**Prerequisites for attending** none
5	**Type of exam** Written exam, 90 minutes (*FP*); plus presentation (*SL*) (preparation of a group presentation; during the course, the presenting groups are selected by the lecturers. All student groups who wish to present their work voluntarily may do so with prior communication of the lecturers)
6	**Criteria for obtaining the credits** Passing both exams (*FP* and *SL*)
7	**Grading** Written exam: graded (St) = total grade for the module; presentation: not graded (*bnb*)
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Bauingenieurwesen, Fachlicher Wahlbereich M.Sc. Umweltingenieurwissenschaften, Fachlicher Wahlbereich
9	**Literature** Baumann, H. & Tillman, A.-M. (2004): The hitch hiker's guide to LCA. An orientation in life cycle assessment methodology and application.- Lund: Studentlitteratur. Bilitewski, B., Wagner, J. & Reichenbach, J. (2018): Best Practice Municipal Waste Management. Information pool on approaches towards a sustainable design of municipal waste management and supporting technologies and equipment.- Texte 40/2018, Umweltbundesamt (UBA), zuletzt geprüft am 30.08.2018. Hauschild, M., Rosenbaum, R. & Olsen, S.I. (eds., 2018): Life Cycle Assessment: Theory and Practice.- 1st ed. Cham: Springer International Publishing. Kaza, S., Yao, L., Bhada-Tata, P. & van Woerden, F. (2018): What a waste 2.0. A Global Snapshot of Solid Waste Management to 2050.- World Bank Group, zuletzt geprüft am 21.09.2018. Wilson, D.C., Rodic, L., Cowing, M.J., Velis, C.A., Whiteman, A.D., Scheinberg, A. et al. (2015): 'Wasteaware' benchmark indicators for integrated sustainable waste management in cities.- In: Waste management (New York, N.Y.), 35, 329-342. DOI: 10.1016/j.wasman.2014.10.006.
10	**Comments**

Module name Tracer Techniques					
Module No. 11-02-2239	**Credits** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Duration** 1 Semester	**Cycle** Jährlich zum WiSe
Language of instruction English			**Person responsible for the module** Schüth		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Tracer Techniques	3 CP	1 VL + 1 Ü	2

2 Course contents

Types of tracers (isotopes tracer, chemical tracer, microbiological tracer, fluorescence dyes), application of artificial tracers in field tests, analysis of tracer breakthrough curves, tracer mixing models; measurement of tracer concentrations in the lab and in the field; transport modelling; technical aspects and examples of applications of tracer studies; planning of environmental tracer campaigns.

3 Qualification and learning goals

The students have in-depth knowledge on tracer techniques and their use in solving hydrological and hydrogeological questions. They are also able to assess results acquired by these methods for their plausibility, reproducibility and error margins. They are able to plan and organize a tracer test, including preparation of a permit application for a tracer test. Through the hands-on exercises they gain soft skills such as team working skills, communication skills, and data presentation skills.

4 Prerequisites for attending

none

5 Type of exam

Home work (term paper) (SL)

6 Criteria for obtaining the credits

Passing the exam

7 Grading

Graded (*St*)

8 Curricula where the module is used

M.Sc. TropHEE, Elective Modules

M.Sc. Angewandte Geowissenschaften:

Vertiefungsrichtung "Angewandte Geologie": Vertiefungsspezifischer Wahlpflichtbereich, 3. Fachsemester

Vertiefungsrichtung "Umweltgeowissenschaften": Vertiefungsspezifischer Wahlpflichtbereich, 3. Fachsemester

9 Literature

Käss, W. (1998): Tracing Technique in Geohydrology.- Balkema, Rotterdam.

10 Comments

Module name Water Supply Systems					
Module no. 13-K5-M009	**Credits** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Duration** 1 Semester	**Cycle** Yearly in the WiSe
Language of instruction English			**Person responsible for the module** Urban		

1	**Course(s)**				
	Course no.	**Course title**	**Workload (CP)**	**Teaching method**	**SWS**
	1	Water Supply Systems	3 CP	VL	2
2	**Course contents** Current state of the German water sector. Water supply in urban and rural areas in industrial and developing countries: Surface water storage, artificial groundwater recharge, rainwater harvesting, purification techniques, groundwater pollution, groundwater extraction.				
3	**Qualification and learning goals** Students understand the basic structure, organisation and essential professional contents of German water management. Students are able to identify, evaluate and select appropriate water supply techniques for urban and rural areas.				
4	**Prerequisites for attending** none				
5	**Type of exam** Oral exam, 15 minutes (*FP*); plus home work (term paper) and presentation (*SL*)				
6	**Criteria for obtaining the credits** Passing both exams (*FP* and *SL*)				
7	**Grading** Oral exam, graded (*St*) = total grade for the module; home work and presentation: not graded (*bnb*)				
8	**Curricula where the module is used** M.Sc. TropHEE, Elective Modules M.Sc. Bauingenieurwesen, Fachlicher Wahlbereich M.Sc. Umweltingenieurwissenschaften, Fachlicher Wahlbereich				
9	**Literature** Will be announced in the course.				
10	**Comments**				

Module name Water Treatment Processes					
Module no. 13-K0-M008	**Credits** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Duration** 1 Semester	**Cycle** Yearly in the WiSe
Language of instruction English			**Person responsible for the module** Lackner		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Water Treatment Processes	3 CP	VL	2
2	Water Treatment Processes - Exercise	3 CP	Ü	2

2 Course contents

The understanding of physical (adsorption, filtration, membrane processes, UV treatment, flocculation, reverse osmosis, ion exchange, softening, decarbonisation, etc.), chemical (precipitation, chlorination, oxidation, neutralisation, AOP, etc.) and biological (aerobic / anaerobic, denitrification, nitrification, etc.) processes are the basis of water treatment engineering. The content of the course therefore deals with the basic processes, the underlying mechanisms of action and their transfer to technical applications. It is intended to provide both an expanded knowledge and a deeper understanding of the universal treatment principles. In addition, scientific methods are taught to analyse, optimize and question complex processes and their combinations.

3 Qualification and learning goals

On successful competition of this module, students are able to understand and explain principles of treatment processes. They are capable to evaluate and select basic physical, chemical and biological processes in order to achieve defined water quality objectives. They are also able to assess and design process combinations for water treatment.

4 Prerequisites for attending

Recommended: Fundamentals of Hydrology

5 Type of exam

Oral exam, 15 minutes, or written exam, 90 minutes (*FP*); plus home work (*SL*)

6 Criteria for obtaining the credits

Passing both exams (*FP* and *SL*)

7 Grading

Oral exam or written exam, graded (*St*) = total grade for the module; home work: not graded (*bnb*)

8 Curricula where the module is used

M.Sc. TropHEE, Elective Modules

M.Sc. Bauingenieurwesen, Forschungsfach Siedlungswasserwirtschaft

M.Sc. Umweltingenieurwissenschaften, Fachlicher Wahlbereich

9 Literature

Literature will be announced at the beginning of the course.

10	Comments

Master Thesis

Module name Master Thesis					
Module no. 11-02-5001	**Credits** 30 CP	**Workload** 900 h	**Self-study** 900 h	**Duration** 1 semester	**Cycle** Every semester
Language of instruction English			**Person responsible for the module** Dean of Study Affairs		

1 Course(s)

Course no.	Course title	Workload (CP)	Teaching method	SWS
1	Master Thesis	30 CP	Thesis	-

2 Course contents

In the Master thesis, students apply and intensify their knowledge and skills acquired in the preceding courses. Under individual guidance, students will actively, and with increasing independence, work on a specific problem which is part of a scientific research project. The topic of the Master Thesis will usually be defined by the supervisor in response to a suggestion by the candidate. The topic will usually reflect the chosen specialisation of the student as documented by the choice of elective modules.

3 Qualification and learning goals

The students acquire in-depth knowledge on a specific, usually research-oriented topic in the field of geosciences, especially in the field of water-related issues and/or environmental management and engineering. They are able to apply knowledge and methodical skills acquired during participation in the TropHEE programme in order to independently work on given scientific questions, recognise new problems, find new solutions, and discover the limits of knowledge pertaining to a specific research area. The students are able to document, present and discuss the scientific results of their work and their evaluation in a coherent and scientifically adequate form.

4 Prerequisites for attending

Formal preconditions as laid out in the examination regulations

5 Type of exam

Written thesis set up in accordance with the examination regulations (*Ausführungsbestimmungen*)

6 Criteria for obtaining the credits

Acceptance of the thesis by the supervisors

7 Grading

Graded (*St*)

8 Curricula where the module is used

M.Sc. TropHEE, Master Thesis

9 Literature

Dependent of contents to be addressed in the thesis

10 Comments