TUHH
Hamburg
University of
Technology

Module Manual

Master of Science (M.Sc.)

Water and Environmental Engineering

Cohort: Winter Term 2021

Updated: 31st May 2023

Table of Contents

Program description

Content

Master of Science in ‘Water and Environmental Engineering’

The Master of Science in Water and Environmental Engineering gives students a choice of three areas of specialization - Water, Environment and City. Graduates of the Master in Water and Environmental Engineering are able to translate the engineering, mathematical and scientific knowledge gained on the course into practice in order to analyze problems scientifically and solve them even when they are unusually or incompletely defined and have complex specifications. Graduates have the ability to work independently, to apply the methods and processes required to solve technical and planning problems, and to apply, critically scrutinize, and further develop new findings. They are also qualified to plan exacting (household) water management projects and projects geared to environmental protection and to plan them paying due attention to the necessary clarifications and examination of existing information and resources. They can

- Collaborate successfully with professional and non-professional players in public administration, industry, and academia
- Independently define research tasks for theoretical and experimental exploration of environmental and water management issues and plan and execute projects in those areas
- Responsibly assess and take into account the concerns of those affected by planning and implementation and of society in general
- work together in international teams on international subjects with cross-cultural competence.

Core Qualification

Module M0523: Business & Management

Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way around selected special areas of management within the scope of business management. • Students are able to explain basic theories, categories, and models in selected special areas of business management. • Students are able to interrelate technical and management knowledge.
Skills	• Students are able to apply basic methods in selected areas of business management. • Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.
Personal Competence	
Social Competence	• Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems
Autonomy	• Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.
Workload in Hours	Depends on choice of courses
Credit points	6

Courses
Information regarding lectures and courses can be found in the corresponding module handbook published separately.

Module M0524: Non-technical Courses for Master

Module Responsible	Dagmar Richter
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	**The Nontechnical Academic Programms (NTA)** imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its **teaching architecture**, in its **teaching and learning arrangements**, in **teaching areas** and by means of teaching offerings in which students can qualify by opting for **specific competences** and a **competence level** at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses. **The Learning Architecture** consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling of TUHH degree courses. The learning architecture demands and trains independent educational planning as regards the individual development of competences. It also provides orientation knowledge in the form of "profiles". The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters during the course of studies. **Teaching and Learning Arrangements** provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in specific courses. **Fields of Teaching** are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way. The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal-oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations. **The Competence Level** of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc. This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life. **Specialized Competence (Knowledge)** Students can • explain specialized areas in context of the relevant non-technical disciplines, • outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area, • different specialist disciplines relate to their own discipline and differentiate it as well as make connections, • sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity, • Can communicate in a foreign language in a manner appropriate to the subject.
Skills	**Professional Competence (Skills)** In selected sub-areas students can • apply basic and specific methods of the said scientific disciplines, • aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline, • to handle simple and advanced questions in aforementioned scientific disciplines in a sucsessful manner, • justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.

Personal Competence	
Social Competence	**Personal Competences (Social Skills)** Students will be able • to learn to collaborate in different manner, • to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees, • to express themselves competently, in a culturally appropriate and gender-sensitive manner in the language of the country (as far as this study-focus would be chosen), • to explain nontechnical items to auditorium with technical background knowledge.
Autonomy	**Personal Competences (Self-reliance)** Students are able in selected areas • to reflect on their own profession and professionalism in the context of real-life fields of application • to organize themselves and their own learning processes • to reflect and decide questions in front of a broad education background • to communicate a nontechnical item in a competent way in writen form or verbaly • to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)
Workload in Hours	Depends on choice of courses
Credit points	6

Courses
Information regarding lectures and courses can be found in the corresponding module handbook published separately.

Module M0826: Biology, Geology and Chemistry

Courses

Title	Typ	Hrs/wk	CP
Biology (L1428)	Lecture	2	2
Geology and Soil Science (L0903)	Lecture	2	1
Environmental Analysis (L0354)	Lecture	2	3

Module Responsible	Dr. Dorothea Rechtenbach
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of inorganic/organic chemistry and biology (knowledge acquired at school)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	With the completion of this module students acquire profound knowledge of the geo- and pedosphere, biogeochemical processes and the fate of migrating compounds in soil and groundwater. They learn about methods to investigate sites for different use.
Skills	With the completion of this module students can apply the acquired theoretical knowledge to model sites and assess the situation technically and conceptually. They are able to draw comparisons on different investigation strategies and techniques. Model projects can be devised and treated.
Personal Competence	
Social Competence	Students can discuss technical and scientific tasks within a seminar subject specific and interdisciplinary .
Autonomy	Students can independently exploit sources , acquire the particular knowledge of the subject and apply it to new problems.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2 Std. 15 Min.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Core Qualification: Compulsory

Course L1428: Biology

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Johannes Gescher
Language	EN
Cycle	WiSe
Content	
Literature	Umweltmikrobiologie, Reineke, W. und Schlömann, M. (2015) 2. Aufl., Springer Spektrum Verlag

Course L0903: Geology and Soil Science

Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Joachim Gerth, Sonja Götz
Language	DE
Cycle	WiSe
Content	Geology: formation of the Earth, plate tectonics, macroscopic rock identification, introduction to Earth history, introduction to halokinesis. Soil science: soil use and function in ecosystems, faktors and processes of soil formation, mineral and organic components, surface types and properties, retention of nutrients and pollutants, hazards from faulty land use, erosion, salinization, and contamination, measures to preserve soils
Literature	R. Vinx (2011): "Gesteinsbestimmung im Gelände" H. Bahlburg & C. Breitkreutz (2012): "Grundlagen der Geologie", TUB Signatur GWB-318 R. Walter (2003): "Ergeschichte" TUB Signatur: 2816-1769 F.Scheffer und P. Schachtschabel (2002): "Lehrbuch der Bodenkunde" TUB Signatur AGG-308 W.E.H. Blum (2007): "Bodenkunde in Stichworten" TUB Signatur AGG-317

Course L0354: Environmental Analysis	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Dorothea Rechtenbach, Dr. Henning Mangels
Language	EN
Cycle	WiSe
Content	Introduction Sampling in different environmental compartments, sample transportation, sample storage Sample preparation Photometry Wastewater analysis Introduction into chromatography Gas chromatography HPLC Mass spectrometry Optical emission spectrometry Atom absorption spectrometry Quality assurance in environmental analysis
Literature	Roger Reeve, Introduction to Environmental Analysis, John Wiley & Sons Ltd., 2002 (TUB: USD-728) Pradyot Patnaik, Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes, CRC Press, Boca Raton, 2010 (TUB: USD-716) Chunlong Zhang, Fundamentals of Environmental Sampling and Analysis, John Wiley & Sons Ltd., Hoboken, New Jersey, 2007 (TUB: USD-741) Miroslav Radojević, Vladimir N. Bashkin, Practical Environmental Analysis RSC Publ., Cambridge, 2006 (TUB: USD-720) Werner Funk, Vera Dammann, Gerhild Donnevert, Sarah Iannelli (Translator), Eric Iannelli (Translator), Quality Assurance in Analytical Chemistry: Applications in Environmental, Food and Materials Analysis, Biotechnology, and Medical Engineering, 2nd Edition, WILEY-VCH Verlag GmbH & Co. KGaA,Weinheim, 2007 (TUB: CHF-350) STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, 21st Edition, Andrew D. Eaton, Leonore S. Clesceri, Eugene W. Rice, and Arnold E. Greenberg, editors, 2005 (TUB:CHF-428) K. Robards, P. R. Haddad, P. E. Jackson, Principles and Practice of Modern Chromatographic Methods, Academic Press G. Schwedt, Chromatographische Trennmethoden, Thieme Verlag H. M. McNair, J. M. Miller, Basic Gas Chromatography, Wiley W. Gottwald, GC für Anwender, VCH B. A. Bidlingmeyer, Practical HPLC Methodology and Applications, Wiley K. K. Unger, Handbuch der HPLC, GIT Verlag G. Aced, H. J. Möckel, Liquidchromatographie, VCH Charles B. Boss and Kenneth J. Fredeen, Concepts, Instrumentation and Techniques in Inductively Coupled Plasma Optical Emission Spectrometry Perkin-Elmer Corporation 1997, On-line available at: http://files.instrument.com.cn/bbs/upfile/2006291448.pdf Atomic absorption spectrometry: theory, design and applications, ed. by S. J. Haswell 1991 (TUB: 2727-5614) Royal Society of Chemistry, Atomic absorption spectometry (http://www.kau.edu.sa/Files/130002/Files/6785_AAs.pdf)

Module M0962: Sustainability and Risk Management

Courses

Title	Typ	Hrs/wk	CP
Safety, Reliability and Risk Assessment (L1145)	Seminar	2	3
Environment and Sustainability (L0319)	Lecture	2	3

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to describe single techniques and to give an overview for the field of safety and risk assessment as well as environmental and sustainable engineering, in detail: • basics in safety and reliability of technical facilities • safety and reliability analysis methods • risk assessment • Production and usage of bio-char • energy production and supply • sustainable product design
Skills	Students are able apply interdisciplinary system-oriented methods for risk assessment and sustainability reporting. They can evaluate the effort and costs for processes and select economically feasible treatment concepts.
Personal Competence	
Social Competence	
Autonomy	Students can gain knowledge of the subject area from given sources and transform it to new questions. Furthermore, they can define targets for new application or research-oriented duties in for risk management and sustainability concepts accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Elaboration and presentation (45 minutes in groups)
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Management and Controlling: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Water and Environmental Engineering: Core Qualification: Compulsory

Course L1145: Safety, Reliability and Risk Assessment

Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Marco Ritzkowski
Language	DE
Cycle	WiSe
Content	An introduction in safety and risk assessment is given and some typical problems of structural and environmental engineering are treated: • basics in safety and reliability of technical facilities • safety and reliability analysis methods • risk assessment • practical examples and excursions • discussions and presentations
Literature	- Vorlesungsunterlagen - Schneider, J., Schlatter, H.P.: Sicherheit und Zuverlässigkeit im Bauwesen. www.risksafety.ch/files/**sicherheit**_und_zuverlaessigkeit.pdf

Course L0319: Environment and Sustainability	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	This course presents actual methodologies and examples of environmental relevant, sustainable technologies, concepts and strategies in the field of energy supply, product design, water supply, waste water treatment or mobility. The following list show examples. Production and Usage of Bio-char Engergy production with algae Environmental product design Clean Development mechanism (CDM) Democracy and Energy New Concepts for a sustainable Energy Supply Recycling of Wind Turbines Alternative Mobility Disposal of Nuclear Wastes Waste2Energy Offshore Wind energy
Literature	Wird in der Veranstaltung bekannt gegeben.

Specialization Cities

Module M0830: Environmental Protection and Management

Courses

Title	Typ	Hrs/wk	CP
Integrated Pollution Control (L0502)	Lecture	2	2
Health, Safety and Environmental Management (L0387)	Lecture	2	3
Health, Safety and Environmental Management (L0388)	Recitation Section (small)	1	1

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	• Good knowledge in Technologies for Environmental Protection (end-of-pipe, integrated solutions) • Good knowledge of the relevant Environmental Legislation • Basic knowledge of instruments for Environmental Assessment
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the basics of regulations, economic instruments, voluntary initiatives, fundamentals of HSE legislation ISO 14001, EMAS and Responsible Care ISO 14001 requirements. They can analyse and discuss industrial processes, substance cycles and approaches from end-of-pipe technology to eco-efficiency and eco-effectiveness, showing their sound knowledge of complex industry related problems. They are able to judge environmental issues and to widely consider, apply or carry out innovative technical solutions, remediation measures and further interventions as well as conceptual problem solving approaches in the full range of problems in different industrial sectors.
Skills	Students are able to assess current problems and situations in the field of environmental protection. They can consider the best available techniques and to plan and suggest concrete actions in a company- or branch-specific context. By this means they can solve problems on a technical, administrative and legislative level.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare themselves for presentations and contributions to the discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Management and Controlling: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0502: Integrated Pollution Control	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	The lecture focusses on: • The Regulatory Framework • Pollution & Impacts, Characteristics of Pollutants • Approaches of Integrated Pollution Control • Sevilla Process, Best Available Technologies & BREF Documents • Case Studies: paper industry, cement industry, automotive industry • Field Trip
Literature	**Förstner**, Ulrich (1998): Integrated Pollution Control, Springer-Verlag Berlin Heidelberg, ISBN 978-3-642-80313-0 **Shen**, Thomas T. (1999): Industrial Pollution Prevention, Springer-Verlag Berlin Heidelberg, ISBN 978-3-540-65208-3

Course L0387: Health, Safety and Environmental Management	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Hans-Joachim Nau
Language	EN
Cycle	WiSe
Content	• Objectives of and benefit from HSE management • From dilution and end-of-pipe technology to eco-efficiency and eco-effectiveness Behaviour control: regulations, economic instruments and voluntary initiatives • Fundamentals of HSE legislation ISO 14001, EMAS and Responsible Care ISO 14001 requirements Environmental performance evaluation Risk management: hazard, risk and safety Health and safety at the workplace • Crisis management
Literature	C. Stephan: Industrial Health, Safety and Environmental Management, MV-Verlag, Münster, 2007/2012 (can be found in the library under GTG 315) Exercises can be downloaded from StudIP

Course L0388: Health, Safety and Environmental Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hans-Joachim Nau
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0902: Wastewater Treatment and Air Pollution Abatement

Courses

Title	Typ	Hrs/wk	CP
Biological Wastewater Treatment (L0517)	Lecture	2	3
Air Pollution Abatement (L0203)	Lecture	2	3

Module Responsible	Dr. Swantje Pietsch-Braune
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of biology and chemistry Basic knowledge of solids process engineering and separation technology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of the module students are able to • name and explain biological processes for waste water treatment, • characterize waste water and sewage sludge, • discuss legal regulations in the area of emissions and air quality • explain the effects of air pollutants on the environment, • name and explan off gas tretament processes and to define their area of application
Skills	Students are able to • choose and design processs steps for the biological waste water treatment • combine processes for cleaning of off-gases depending on the pollutants contained in the gases
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0517: Biological Wastewater Treatment

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	WiSe
Content	Charaterisation of Wastewater Metobolism of Microorganisms Kinetic of mirobiotic processes Calculation of bioreactor for wastewater treatment Concepts of Wastewater treatment Design of WWTP Excursion to a WWTP Biofilms Biofim Reactors Anaerobic Wastewater and sldge treatment resources oriented sanitation technology Future challenges of wastewater treatment

Literature	**Gujer, Willi** Siedlungswasserwirtschaft : mit 84 Tabellen ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?id=2842122&prov=M&dok_var=1&dok_ext=htm Berlin [u.a.] : Springer, 2007 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Imhoff, Karl** (Imhoff, Klaus R.;) Taschenbuch der Stadtentwässerung : mit 10 Tafeln ISBN: 3486263331 ((Gb.)) München [u.a.] : Oldenbourg, 1999 TUB_HH_Katalog **Lange, Jörg** (Otterpohl, Ralf; Steger-Hartmann, Thomas;) Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334 Donaueschingen-Pfohren : Mall-Beton-Verl., 2000 TUB_HH_Katalog **Mudrack, Klaus** (Kunst, Sabine;) Biologie der Abwasserreinigung : 18 Tabellen ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903 Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003 TUB_HH_Katalog **Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Kunz, Peter** Umwelt-Bioverfahrenstechnik Vieweg, 1992 **Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt** (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, ;) Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe aus der Abwasserbehandlung, Kleinkläranlagen ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL: http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf Weimar : Universitätsverl, 2006 TUB_HH_Katalog **Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall** DWA-Regelwerk Hennef : DWA, 2004 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 TUB_HH_Katalog

Course L0203: Air Pollution Abatement	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Swantje Pietsch-Braune, Christian Eichler
Language	EN
Cycle	WiSe
Content	In the lecture methods for the reduction of emissions from industrial plants are treated. At the beginning a short survey of the different forms of air pollutants is given. In the second part physical principals for the removal of particulate and gaseous pollutants form flue gases are treated. Industrial applications of these principles are demonstrated with examples showing the removal of specific compounds, e.g. sulfur or mercury from flue gases of incinerators.
Literature	Handbook of air pollution prevention and control, Nicholas P. Cheremisinoff. - Amsterdam [u.a.] : Butterworth-Heinemann, 2002 Atmospheric pollution : history, science, and regulation, Mark Zachary Jacobson. - Cambridge [u.a.] : Cambridge Univ. Press, 2002 Air pollution control technology handbook, Karl B. Schnelle. - Boca Raton [u.a.] : CRC Press, c 2002 Air pollution, Jeremy Colls. - 2. ed. - London [u.a.] : Spon, 2002

Module M0923: Integrated Transportation Planning

Courses

Title	Typ	Hrs/wk	CP
Integrated Transportation Planning (L1068)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineerin
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe interdependencies between land-use/location choice and transportation/mobility behaviour • explain and evaluate the social, ecological and economic effects of transport and land-use policy measures. • relate current issues in the area of integrated transport planning and formulate an opinion on them.
Skills	Students are able to: • quantify important parameters, which influence travel demand or are influenced by it. • comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document the results in accordance with scientific conventions.
Personal Competence	
Social Competence	Students are able to: • provide feedback on topical contents and their teaching. • constructively handle feedback on their own work. • produce results in group work and document these.
Autonomy	Students are able to: • assess potential consequences of their future professional activities • independently plan working on a pre-defined project topic, acquire the necessary knowledge and use appropriate means for its execution.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment with presentation during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1068: Integrated Transportation Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz, Dr. Philine Gaffron, Jacqueline Bianca Maaß
Language	DE
Cycle	WiSe
Content	The course will provide students with an understanding of interdependencies between land-use and transportation. Specific topics include a.o.: • interactions between transport and the environment and consequent limitations • characteristics of integrated planning • complex planning processes • interdependencies of location choice and mobility behaviour • transport and land-use policies • project on current issues in transportation studies
Literature	Kutter, Eckhard (2005) Entwicklung innovativer Verkehrsstrategien für die mobile Gesellschaft. Erich Schmidt Verlag. Berlin. Bracher, Tilman u. a. (Hrsg.) (68. Ergänzung 2013) Handbuch der kommunalen Verkehrsplanung. Herbert Wichmann Verlag. Berlin, Offenbach. (Loseblattsammlung mit kontinuierlichen Ergänzungen)

Module M0511: Electrical Energy from Solar Radiation and Wind Power

Courses

Title	Typ	Hrs/wk	CP
Sustainability Management (L0007)	Lecture	2	1
Hydro Power Use (L0013)	Lecture	1	1
Wind Turbine Plants (L0011)	Lecture	2	3
Wind Energy Use - Focus Offshore (L0012)	Lecture	1	1

Module Responsible	Dr. Isabel Höfer
Admission Requirements	None
Recommended Previous Knowledge	Module: Technical Thermodynamics I, Module: Technical Thermodynamics II, Module: Fundamentals of Fluid Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe. Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice.
Skills	Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects.
Personal Competence	
Social Competence	Students can discuss scientific tasks subjet-specificly and multidisciplinary within a seminar.
Autonomy	Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2.5 hours written exam + written elaboration (incl. presentation) in sustainability management
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0007: Sustainability Management	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Anne Rödl
Language	DE
Cycle	SoSe
Content	The lecture "Sustainability Management" gives an insight into the different aspects and dimensions of sustainability. First, essential terms and definitions, significant developments of the last years, and legal framework conditions are explained. The various aspects of sustainability are then presented and discussed in detail. The lecture mainly focuses on concepts for the implementation of the topic sustainability in companies: • What is "sustainability"? • Why is this concept an important topic for companies? • What opportunities and business risks are addressed or are associated with it? • How can the often mentioned three pillars of sustainability - economy, ecology, and social- be meaningfully integrated into corporate management despite their sometimes contradictory tendencies, and how a corresponding compromise can be found? • What concepts or frameworks exist for the implementation of sustainability management in companies? • Which sustainability labels exist for products or companies? What do they have in common, and where do they differ? Furthermore, the lecture is intended to provide insights into the concrete implementation of sustainability aspects into business practice. External lecturers from companies will be invited to report on how sustainability is integrated into their daily processes. In the course of an independently carried out group work, the students will analyze and discuss the implementation of sustainability aspects based on short case studies. By studying and comparing best practice examples, the students will learn about corporate decisions' effects and implications. It should become clear which risks or opportunities are associated if sustainability aspects are taken into account in management decisions.
Literature	Die folgenden Bücher bieten einen Überblick: Engelfried, J. (2011) Nachhaltiges Umweltmanagement. München: Oldenbourg Verlag. 2. Auflage Corsten H., Roth S. (Hrsg.) (2011) Nachhaltigkeit - Unternehmerisches Handeln in globaler Verantwortung. Wiesbaden: Gabler Verlag.

Course L0013: Hydro Power Use	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Stefan Achleitner
Language	DE
Cycle	SoSe
Content	• Introduction, importance of water power in the national and global context • Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies • Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems • Construction of hydroelectric power plants: description of the individual components and their technical system interaction • Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc. • Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection • Hydropower and the Environment • Examples from practice
Literature	• Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage • Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage • Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage • von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage • Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006

Course L0011: Wind Turbine Plants	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rudolf Zellermann
Language	DE
Cycle	SoSe
Content	• Historical development • Wind: origins, geographic and temporal distribution, locations • Power coefficient, rotor thrust • Aerodynamics of the rotor • Operating performance • Power limitation, partial load, pitch and stall control • Plant selection, yield prediction, economy • Excursion
Literature	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005

Course L0012: Wind Energy Use - Focus Offshore	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Skiba
Language	DE
Cycle	SoSe
Content	• Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering • Physical fundamentals for utilization of wind energy • Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships • Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures • Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection • Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics • Development and planning of offshore wind farms • Operation and optimization of offshore wind farms • Day excursion
Literature	• Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage • Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidel-berg, 1997, 3. Auflage • Hau, E.: Windkraftanalagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage • Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage • Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage

Module M0827: Modeling in Water Management

Courses

Title	Typ	Hrs/wk	CP
Groundwater Modeling using Modflow (L0543)	Lecture	1	1
Groundwater Modeling using Modflow (L0544)	Recitation Section (small)	2	2
Modeling of Water Supply and Sewer Network (L0875)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Groundwater • groundwater hydraulics and transport of substances Pipe Systems • Knowledge on urban water infrastructures, in particular drinking water systemsand urban drainage systems including special structures • Hydraulics of drinking water supply systems and sewer systems • Basic knowledge on water management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.
Skills	The students are able to construct and apply scientific groundwater models indipendently. They can work on different scenarios and can compare or assess different solutions for existing problems by application of selected software products. The students are able to use different software solutions (e.g. EPANET, EPA-SWMM).
Personal Competence	
Social Competence	Wird nicht vermittelt.
Autonomy	Wird nicht vermittelt.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	20 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0543: Groundwater Modeling using Modflow

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical backround of the modell, students do work with the model PMWIN for practical case studies.
Literature	MODFLOW-Handbuch Chiang, Wen Hsien: PMWIN

Course L0544: Groundwater Modeling using Modflow	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0875: Modeling of Water Supply and Sewer Network	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen, Weitere Mitarbeiter
Language	DE
Cycle	SoSe
Content	
Literature	Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014.

Module M1717: Advanced Vadose Zone Hydrology

Courses

Title	Typ	Hrs/wk	CP
Modeling Processes in Vadose Zone (L2734)	Lecture	1	1
Modeling Processes in Vadose Zone (L2735)	Recitation Section (small)	1	1
Vadose Zone Hydrology (L2732)	Lecture	2	2
Vadose Zone Hydrology (L2733)	Recitation Section (large)	2	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2734: Modeling Processes in Vadose Zone

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann, Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2735: Modeling Processes in Vadose Zone

Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L2732: Vadose Zone Hydrology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2733: Vadose Zone Hydrology	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1718: Multiphase Flow in Porous Media

Courses

Title	Typ	Hrs/wk	CP
Advanced Modeling Techniques for Multiphase Flow in Porous Media (L2738)	Recitation Section (small)	2	2
Fundamentals of Multiphase Flow in Porous Media (L2736)	Lecture	2	2
Fundamentals of Multiphase Flow in Porous Media (L2737)	Recitation Section (large)	2	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2738: Advanced Modeling Techniques for Multiphase Flow in Porous Media

Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2736: Fundamentals of Multiphase Flow in Porous Media

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2737: Fundamentals of Multiphase Flow in Porous Media	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Hannes Nevermann
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1721: Water and Environment: Theory and Application

Courses

Title	Typ	Hrs/wk	CP
Water and Environment: Application and Field Work (L2754)	Project-/problem-based Learning	3	4
Water and Environment: Theory (L2753)	Lecture	1	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Report (about 5-10 pages) and Presentation (about 15 min)
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2754: Water and Environment: Application and Field Work

Typ	Project-/problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Anna Luisa Hemshorn de Sánchez, Dr. Salome Shokri-Kuehni
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2753: Water and Environment: Theory

Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Module M0749: Waste Treatment and Solid Matter Process Technology

Courses

Title	Typ	Hrs/wk	CP
Solid Matter Process Technology for Biomass (L0052)	Lecture	2	2
Thermal Waste Treatment (L0320)	Lecture	2	2
Thermal Waste Treatment (L1177)	Recitation Section (large)	1	2

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	Basics of • thermo dynamics • fluid dynamics • chemistry
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can name, describe current issue and problems in the field of thermal waste treatment and particle process engineering and contemplate them in the context of their field. The industrial application of unit operations as part of process engineering is explained by actual examples of waste incineration technologies and solid biomass processes. Compostion, particle sizes, transportation and dosing, drying and agglomeration of renewable resources and wastes are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, electricity , heat and mineral recyclables.
Skills	The students are able to select suitable processes for the treatment of wastes or raw material with respect to their characteristics and the process aims. They can evaluate the efforts and costs for processes and select economically feasible treatment concepts.
Personal Competence	
Social Competence	Students can • respectfully work together as a team and discuss technical tasks • participate in subject-specific and interdisciplinary discussions, • develop cooperated solutions • promote the scientific development and accept professional constructive criticism.
Autonomy	Students can independently tap knowledge of the subject area and transform it to new questions. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0052: Solid Matter Process Technology for Biomass	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Werner Sitzmann
Language	DE
Cycle	SoSe
Content	The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture.
Literature	Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4 Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe, Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175

Course L0320: Thermal Waste Treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	SoSe
Content	• Introduction, actual state-of-the-art of waste incineration, aims. legal background, reaction principals • basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition • Incineration techniques: grate firing, ash transfer, boiler • Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination • Ash treatment: Mass, quality, treatment concepts, recycling, disposal
Literature	Thomé-Kozmiensky, K. J. (Hrsg.): Thermische Abfallbehandlung Bande 1-7. EF-Verlag für Energie- und Umwelttechnik, Berlin, 196 - 2013.

Course L1177: Thermal Waste Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0828: Urban Environmental Management

Courses

Title	Typ	Hrs/wk	CP
Noise Protection (L1109)	Lecture	2	2
Urban Infrastructures (L0874)	Project-/problem-based Learning	2	4

Module Responsible	Dr. Dorothea Rechtenbach
Admission Requirements	None
Recommended Previous Knowledge	• Knowledge on Urban planning • Knowledge on measures for climate protection • General knowledge of scientific writing/working
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe urban development corridors as well as current and future urban environmental problems. They are able to explain the causes of environmental problems (like noise). Students can specify applications for various technical innovations and explain why these contribute to the improvement of urban life. They can, for example, derive and discuss measures for effective noise abatement.
Skills	Students are able to develop specific solutions for correcting existing or future environment-related problems of urban development. They can define a range of conceptual and technical solutions for environmental problems for different development paths. To solve specific urban environmental problems they can select technical innovations and integrate them into the urban context.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare themselves for presentations and contributions to the discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Written Report plus oral Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1109: Noise Protection

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Jäschke
Language	EN
Cycle	SoSe
Content	
Literature	1) Müller & Möser (2013): Handbook of Engineering Acoustics (also available in German) 2) WHO (1999): Guidelines for Community Noise 3) Environmental Noise Directive 2002/49/EG 4) ISO 9613-2 (1996): Acoustics, Attenuation of sound during propagation outdoors, Part 2: General method of calculation

Course L0874: Urban Infrastructures	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Dorothea Rechtenbach
Language	EN
Cycle	SoSe
Content	Problem Based Learning Main topics are: • Central vs. Decentral Wastewater Treatment. • Compaction of Cities. • Car Free Cities. • Multifunctional Places in Cities. • The Sustainability of Freight Transport in Cities.
Literature	Depends on chosen topic.

Module M0857: Geochemical Engineering

Courses

Title	Typ	Hrs/wk	CP
Contaminated Sites and Landfilling (L0906)	Lecture	2	2
Contaminated Sites and Landfilling (L0907)	Recitation Section (large)	1	2
Geochemical Engineering (L0904)	Lecture	2	2

Module Responsible	Dr. Marco Ritzkowski
Admission Requirements	None
Recommended Previous Knowledge	Module: General and Inorganic Chemistry, Module:Organic Chemistry, Biology (Basic Knowledge)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	With the completion of this module students acquire profound knowledge of biogeochemical processes, the fate of pollutants in soil and groundwater, and techniques to deposit contaminated waste material. They are able to describe in principle the behaviour of chemicals in the environment. Students can explain and report the approach to remediate contaminated sites.
Skills	With the completion of this module students can apply the acquired theoretical knowledge to model cases of site pollution and critically assess the situation technically and conceptually. They are able to draw comparisons on different remediation strategies and techniques. Model projects can be devised and treated.
Personal Competence	
Social Competence	Students can discuss technical and scientific tasks within a seminar subject specific and interdisciplinary .
Autonomy	Students can independently exploit sources , acquire the particular knowledge of the subject and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2 hours
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0906: Contaminated Sites and Landfilling

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Marco Ritzkowski, Dr. Joachim Gerth
Language	EN
Cycle	SoSe
Content	The part Contaminated Sites gives an introduction into different scales of pollution and identifies key pollutants. Geochemical attenuation mechanisms and the role of organisms are highlighted affecting the fate of pollutants in leachate and groundwater. Techniques for site characterization and remediation are discussed including economical aspects. The part Landfilling is introduced by discussing fundamental aspects and the worldwide situation of waste management. The lecture highlights transformation processes in landfill bodies, emissions of gases and leachate, and the long-term behaviour of landfill sites with measures of aftercare.
Literature	1) **Waste Management**. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305 2) **Solid Waste Technology and Management.** Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332 3) **Natural attenuation of fuels and chlorinated solvents in the subsurface.** Todd H. Wiedemeier(Ed.), ISBN: 0471197491 Lesesaal 2: US - Umweltschutz, Signatur USH-844

Course L0907: Contaminated Sites and Landfilling	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Marco Ritzkowski, Dr. Joachim Gerth
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0904: Geochemical Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Gerth
Language	EN
Cycle	SoSe
Content	As an introduction cases are presented in which geochemical engineering was used to solve environmental problems. Environmentally important minerals are discussed and methods for their detection. It is demonstrated how solution equilibria can be modified to eliminate elevated concentrations of unwanted species in solution and how carbon dioxide concentration affects pH and the dissolution of carbonate minerals. Modifications of redox conditions, pH, and electrolyte concentration are shown to be effective tools for controlling the mobility and fate of hazardous species in the environment.
Literature	**Geochemistry, groundwater and pollution.** C. A. J. Appelo; D. Postma Leiden [u.a.] Balkema 2005 Lehrbuchsammlung der TUB, Signatur GWC-515

Module M0870: Management of Surface Water

Courses

Title	Typ	Hrs/wk	CP
Modelling of Flow in Rivers and Estuaries (L0810)	Lecture	3	4
Nature-Oriented Hydraulic Engineering / Integrated Flood Protection (L0961)	Project-/problem-based Learning	2	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Hydromechanics, Hydraulics, Hydrology and Hydraulic Engineering; Hydraulic Engineering I and Hydraulic Engineering II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to define in detail the basic processes that are related to the modelling of flows in hydraulic engineering. Besides, they can describe the basic aspects of numerical modelling and actual numerical models for the simulation of flows and waves. They can also depict the concepts of nature oriented hydraulic engineering.
Skills	Students are able to apply hydrodynamic-numerical models to practical hydraulic engineering tasks. Furthermore, the students are able to set up flood-risk management concepts and are able to apply basic concepts of renaturation to practical problems.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems of the practical nature-based hydraulic engineering. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 150 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0810: Modelling of Flow in Rivers and Estuaries	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Dr. Edgar Nehlsen, Prof. Peter Fröhle
Language	EN
Cycle	SoSe
Content	Introduction to numerical flow modelling • Processes affecting tht flow • Examples and applications of numerical models • Procedure of numerical modelling • Model concept Basic equations of hydrodynamics • Saint-Venant equations • Euler Equations • Navier-Stokes equations • Reynolds-averaged Navier-Stokes equations • Shallow water equations Solving schemes • Numerical discretization • Solution algorithms • Convergence
Literature	Vorlesungsskript Literaturempfehlungen Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt). Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019a): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 1: Geodaten in der Fließgewässermodellierung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-1). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019b): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 2: Bedarfsgerechte Datenerfassung und -aufbereitung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-2). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019c): Merkblatt DWA-M 543-3 Geodaten in der Fließgewässermodellierung - Teil 3: Aspekte der Strömungsmodellierung und Fallbeispiele. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-3). Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html. IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92. Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology. Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83). van Waveren, Harold (1999-): Good modelling practice handbook. [Utrecht], Lelystad, Den Haag: STOWA; Rijkswaterstaat-RIZA; SDU, afd. SEO/RIZA [etc. distr.] (Nota, nr. 99.036). Zielke, Werner (Hg.) (1999): Numerische Modelle von Flüssen, Seen und Küstengewässern. Deutscher Verband für Wasserwirtschaft und Kulturbau. Bonn: Wirtschafts- und Verl.-Ges. Gas und Wasser (Schriftenreihe des Deutschen Verbandes für Wasserwirtschaft und Kulturbau, 127).

Course L0961: Nature-Oriented Hydraulic Engineering / Integrated Flood Protection	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Natasa Manojlovic, Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Regime-Theory and application for the development of environmental guiding priciples of rivers • Engineering - biological measures for the stabilization of rivers • Risk management in flood protection • Design techniques in technical flood protection • Methods for the assessment of flood caused damages
Literature	Vorlesungsumdruck

Module M0871: Hydrological Systems

Courses

Title	Typ	Hrs/wk	CP
Applied Surface Hydrology (L0289)	Lecture	2	2
Applied Surface Hydrology (L1412)	Project-/problem-based Learning	1	2
Interaction Water - Environment in Fluvial Areas (L0295)	Project-/problem-based Learning	1	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Hydromechanics and Hydraulic Engineering: Hydraulic Engineering I and Hydraulic Engineering II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define the basic concepts of hydrology and water management. They are able to describe and quantify the relevant processes of the hydrological water cycle. Besides, the students know the main aspects of rainfall-run-off-models and are able to theoretically derive established reservoir / storage models and a unit-hydrograph.
Skills	The students are able to use the basic hydrological concepts and approaches and are able to theoretically derive established reservoir / storage models or a unit-hydrograph as the basis for rainfall-run-off-models. The student are able to explain the basic concepts of measurements of hydrological and hydrodynamic values in nature and are able to perform, analyze and statistically assess these measurements. Furthermore, they are able to apply a hydrological model to basic hydrological problems.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems of the hydrology and water management. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 90 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0289: Applied Surface Hydrology

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	Basics of hydrology: • Hydrological cycle • Data acquisition • Data analyses and statistical assessment • Statistics of extremes • Regionalization methods for hydrological values • Rainfall-run-off modelling on the basis of a unit hydrograph conceps • Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool.
Literature	http://de.wikipedia.org/wiki/Kalypso_(Software) http://kalypso.bjoernsen.de/ http://sourceforge.net/projects/kalypso/

Course L1412: Applied Surface Hydrology	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0295: Interaction Water - Environment in Fluvial Areas	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	A problem based learning course. The problem will be solved by the students more or less self-contained. The topics will be introduced and elaborated over the semester.
Literature	-

Module M0874: Wastewater Systems

Courses

Title	Typ	Hrs/wk	CP
Wastewater Systems - Collection, Treatment and Reuse (L0934)	Lecture	2	2
Wastewater Systems - Collection, Treatment and Reuse (L0943)	Recitation Section (large)	1	1
Advanced Wastewater Treatment (L0357)	Lecture	2	2
Advanced Wastewater Treatment (L0358)	Recitation Section (large)	1	1

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of wastewater management and the key processes involved in wastewater treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to outline key areas of the full range of treatment systems in waste water management, as well as their mutual dependence for sustainable water protection. They can describe relevant economic, environmental and social factors.
Skills	Students are able to pre-design and explain the available wastewater treatment processes and the scope of their application in municipal and for some industrial treatment plants.
Personal Competence	
Social Competence	Social skills are not targeted in this module.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0934: Wastewater Systems - Collection, Treatment and Reuse

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	•Understanding the global situation with water and wastewater •Regional planning and decentralised systems •Overview on innovative approaches •In depth knowledge on advanced wastewater treatment options for different situations, for end-of-pipe and reuse •Mathematical Modelling of Nitrogen Removal •Exercises with calculations and design
Literature	Henze, Mogens: Wastewater Treatment: Biological and Chemical Processes, Springer 2002, 430 pages George Tchobanoglous, Franklin L. Burton, H. David Stensel: Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy McGraw-Hill, 2004 - 1819 pages

Course L0943: Wastewater Systems - Collection, Treatment and Reuse	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0357: Advanced Wastewater Treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Survey on advanced wastewater treatment reuse of reclaimed municipal wastewater Precipitation Flocculation Depth filtration Membrane Processes Activated carbon adsorption Ozonation "Advanced Oxidation Processes" Disinfection
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Course L0358: Advanced Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Aggregate organic compounds (sum parameters) Industrial wastewater Processes for industrial wastewater treatment Precipitation Flocculation Activated carbon adsorption Recalcitrant organic compounds
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Module M0875: Nexus Engineering - Water, Soil, Food and Energy

Courses

Title	Typ	Hrs/wk	CP
Ecological Town Design - Water, Energy, Soil and Food Nexus (L1229)	Seminar	2	2
Water & Wastewater Systems in a Global Context (L0939)	Lecture	2	4

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of the global situation with rising poverty, soil degradation, migration to cities, lack of water resources and sanitation
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe the facets of the global water situation. Students can judge the enormous potential of the implementation of synergistic systems in Water, Soil, Food and Energy supply.
Skills	Students are able to design ecological settlements for different geographic and socio-economic conditions for the main climates around the world.
Personal Competence	
Social Competence	The students are able to develop a specific topic in a team and to work out milestones according to a given plan.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information can be found at the beginning of the smester in the StudIP course module handbook.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L1229: Ecological Town Design - Water, Energy, Soil and Food Nexus	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	• Participants Workshop: Design of the most attractive productive Town • Keynote lecture and video • The limits of Urbanization / Green Cities • The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities • Global Ecovillage Network: Upsides and Downsides around the World • Visit of an Ecovillage • Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competion • TUHH Rural Development Toolbox • Integrated New Town Development • Participants workshop: Design of New Towns: Northern, Arid and Tropical cases • Outreach: Participants campaign • City with the Rural: Resilience, quality of live and productive biodiversity
Literature	• Ralf Otterpohl 2013: Gründer-Gruppen als Lebensentwurf: "Synergistische Wertschöpfung in erweiterten Kleinstadt- und Dorfstrukturen", in „Regionales Zukunftsmanagement Band 7: Existenzgründung unter regionalökonomischer Perspektive, Pabst Publisher, Lengerich • http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation) • TEDx New Town Ralf Otterpohl: http://youtu.be/_M0J2u9BrbU

Course L0939: Water & Wastewater Systems in a Global Context	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	• Keynote lecture and video • Water & Soil: Water availability as a consequence of healthy soils • Water and it’s utilization, Integrated Urban Water Management • Water & Energy, lecture and panel discussion pro and con for a specific big dam project • Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation • Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches • Why are there excreta in water? Public Health, Awareness Campaigns • Rehearsal session, Q&A
Literature	• Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press • Liu, John D.: http://eempc.org/hope-in-a-changing_climate/ (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda) • http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)

Module M0922: City Planning

Courses

Title	Typ	Hrs/wk	CP
City Planning (L1066)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	for "Principles of Urban Planning": none for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • use technical terms of urban planning. • describe the main determinants of urban development. • explain and compare different possibilities of how urban development can be influenced. • discuss requirements for public streetscapes. • explain the importance of street design.
Skills	Students are able to: • read and analyze urban development concepts and designs for streetscapes • appraise such concepts in the context of competing requirements. • design, justify and reflect their own solutions for concrete examples.
Personal Competence	
Social Competence	Students are able to: • discuss intermediate results with each other. • constructively accept feedback on their own work. • provide constructive feedback to others.
Autonomy	Students are able to: • independently complete a written report including drawings following a broadly pre-defined process. • assess the consequences of their proposed solutions. • independently acquire knowledge and apply this to new issues or problem areas.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment, designwork during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1066: City Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz
Language	DE
Cycle	SoSe
Content	„Principles of Urban Planning“ deals with the determinants of urban development and their interactions. Topics include: • legal framework, • instruments and methods of planning, • functional requirements, • stakeholders and actors • basic design requirements • different planning levels and • historical contexts. The objective of the course is for students to acquire a basic understanding of urban development problems and approaches for solving them. They will also be able to comprehend the process of urban planning. The course also covers the various functional and aesthetic requirements for designing streetscape as the most important elements of public space. The project work deals with a real life scenario and includes drawing up a development plan, an urban design concept, a building masterplan and a street redesign.
Literature	Albers, Gerd; Wekel, Julian (2009) Stadtplanung: Eine illustrierte Einführung. Primus Verlag. Darmstadt. Frick, Dieter (2008) Theorie des Städtebaus: Zur baulich-räumlichen Organisation von Stadt. Wasmuth-Verlag. Tübingen Jonas, Carsten (2009) Die Stadt und ihr Grundriss. Wasmuth-Verlag. Tübingen Kostof, Spiro; Castillo, Greg (1998) Die Anatomie der Stadt. Geschichte städtischer Strukturen. Campus-Verlag. Frankfurt/New York.

Module M0982: Transportation Modelling

Courses

Title	Typ	Hrs/wk	CP
Transportation Modelling (L1180)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to understand the operation and potential applications of transport models.
Skills	Students are able to: • use travel demand modelling software packages for solving practical problems. • design a database structure for travel demand models. • assess modelling results. • appraise potential applications and limitations of such models.
Personal Competence	
Social Competence	Students are able to independently develop and document solutions.
Autonomy	Students are able to: • independently organise, manage and solve set tasks. • independently prepare written reports.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment with presentation during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L1180: Transportation Modelling

Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz
Language	DE
Cycle	SoSe
Content	• Principles of transport modelling • Role of transport modelling in the planning process • Fundamentals of mobility behaviour • Design and evaluation of transport/mobility surveys • mode of operation and data requirements for different stages of modelling • Forecasting and scenarios in the transport planning • The range of model applications (from transport infrastructure planning over simulation of traffic flows to integrated land-use and transport models as well as the use of models for evaluating locations) • Practice-oriented project for assessing consequences of infrastructure projects and changes in land-use
Literature	Lohse, Dieter und Schnabel, Werner (2011): Grundlagen der Straßenverkehrstechnik und der Verkehrsplanung – Band 2. 3. Auflage. Beuth. Ortúzar, Juan de Dios und Willumsen, Luis G. (2011): Modelling Transport. 4. Auflage. John Wiley & Sons.

Module M0663: Marine Geotechnics

Courses

Title	Typ	Hrs/wk	CP
Marine Geotechnics (L0548)	Lecture	1	2
Marine Geotechnics (L0549)	Recitation Section (large)	2	2
Steel Structures in Foundation and Hydraulic Engineering (L1146)	Lecture	2	2

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	complete modules: Geotechnics I-III, Mathematics I-III courses: Soil laboratory course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0548: Marine Geotechnics

Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	• Geotechnical investigation an description of the seabed • Foundations of Offshore-Constructions • cCliff erosion • Sea dikes • Port structures • Flood protection structures
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London • Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst & Sohn, Berlin

Course L0549: Marine Geotechnics

Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1146: Steel Structures in Foundation and Hydraulic Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Frank Feindt
Language	DE
Cycle	SoSe
Content	Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue
Literature	EAU 2012, EA-Pfähle, EAB

Module M1724: Smart Monitoring

Courses

Title	Typ	Hrs/wk	CP
Smart Monitoring (L2762)	Integrated Lecture	2	2
Smart Monitoring (L2763)	Recitation Section (small)	2	4

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpful. Interest in modern research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deepen skills of scientific working, are required. Basic knowledge in scientific writing and good English skills.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	The students will become familiar with the principles and practices of smart monitoring. The students will be able to design decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built and in the natural environment. In addition, the students will learn to design and to implement intelligent sensor systems using state-of-the-art data analysis techniques, modern software design concepts, and embedded computing methodologies. Besides lectures, project work is also part of this module. In small groups, the students will design smart monitoring systems that integrate a number of “intelligent” sensors to be implemented by the students. Specific focus will be put on the application of machine learning techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as bridges or slopes, or on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper. All students of this module will “automatically” participate with their smart monitoring system in the annual "Smart Monitoring" competition. The written papers and oral examinations form the final grades. The module will be taught in English. Limited enrollment.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Environmental Engineering: Specialisation Biotechnology: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Environmental Engineering: Specialisation Biotechnology: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2762: Smart Monitoring	
Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	WiSe/SoSe
Content	In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment.
Literature	

Course L2763: Smart Monitoring	
Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	WiSe/SoSe
Content	The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the “Smart Monitoring” competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature.
Literature	

Module M1123: Selected Topics in Environmental Engineering

Courses

Title	Typ	Hrs/wk	CP
Environmental Aquatic Chemistry (L1444)	Lecture	2	3
Excellence in International Project Delivery (L2387)	Integrated Lecture	2	2
Sludge Treatment (L0520)	Lecture	2	3
Thermal Biomass Utilization (L1767)	Lecture	2	2
Thermal Biomass Utilization (L2386)	Practical Course	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L1444: Environmental Aquatic Chemistry

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Klaus Johannsen
Language	EN
Cycle	SoSe
Content	• Concentration and activity • Gas-water partitioning • Acid/base equilibria • Alkalinity and acidity • Precipitation/dissolution equilibria • Redox equilibria • Complex formation • Sorption
Literature	Worch, E.: Hydrochemistry. Basic Concepts and Exercises. De Gruyter, Berlin, 2015

Course L2387: Excellence in International Project Delivery

Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	2 h
Lecturer	Dr. Jens Huckfeldt
Language	EN
Cycle	SoSe
Content	**Simply and easy to avoid mistake in project delivery can deliver projects within budget and as per schedule.You have to attend if you see yourself in project execution and potentially even abroad.**
Literature	

Course L0520: Sludge Treatment	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Sedimentation characteristic and thickening, Centrifugation, Flotation, Filtration, Aerobic sludge stabilisation, Sludge Digestion, Sludge Disintegration, Sludge Dewatering, Natural Processes for Sludge Treatment, Nutrient Recovery from Sludge, Thermal Processes and Incineration.
Literature	**Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes** Sludge Treatment and Disposal ISBN 9781843391661 IWA Publishing, 2007

Course L1767: Thermal Biomass Utilization	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	WiSe

Content	Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmental basics of all options to provide energy from biomass from a German and international point of view. Additionally different system approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and economic development potentials, and the current and expected future use within the energy system are presented.
	
	The course is structured as follows:
	
	• Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course
	• Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste
	• Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying
	• Thermo-chemical conversion of solid biofuels
	  ◦ Basics of thermo-chemical conversion
	  ◦ Direct thermo-chemical conversion through combustion: combustion technologies for small and large scale units, electricity generation technologies, flue gas treatment technologies, ashes and their use
	  ◦ Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels
	  ◦ Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for the provision of charcoal, oil cleaning technologies, options to use the pyrolysis oil and charcoal as an energy carrier as well as a raw material
	• Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil seeds and oil fruits, vegetable oil production, production of a biofuel with standardized characteristics (trans-esterification, hydrogenation, co-processing in existing refineries), options to use this fuel, options to use the residues (i.e. meal, glycerine)
	• Bio-chemical conversion of biomass
	  ◦ Basics of bio-chemical conversion
	  ◦ Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic waste fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry
	  ◦ Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage

Literature	**Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage**

Course L2386: Thermal Biomass Utilization	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	Protokolle
Lecturer	Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger
Language	DE
Cycle	WiSe
Content	The experiments of the practical lab course illustrate the different aspects of heat generation from biogenic solid fuels. First, different biomasses (e.g. wood, straw or agricultural residues) will be investigated; the focus will be on the calorific value of the biomass. Furthermore, the used biomass will be pelletized, the pellet properties analysed and a combustion test carried out on a pellet combustion system. The gaseous and solid pollutant emissions, especially the particulate matter emissions, are measured and the composition of the particulate matter is investigated in a further experiment. Another focus of the practical course is the consideration of options for the reduction of particulate matter emissions from biomass combustion. In the practical course, a method for particulate matter reduction will be developed and tested. All experiments will be evaluated and the results presented. Within the practical lab course the students discuss different technical-scientific tasks, both subject-specifically and interdisciplinary. They discuss various approaches to solving the problem and advise on the theoretical or practical implementation.
Literature	- Kaltschmitt, Martin; Hartmann, Hans; Hofbauer, Hermann: Energie aus Biomasse: Grundlagen, Techniken und Verfahren. 3. Auflage. Berlin Heidelberg: Springer Science & Business Media, 2016. -ISBN 978-3-662-47437-2 - Versuchsskript

Module M0581: Water Protection

Courses

Title	Typ	Hrs/wk	CP
Water Protection and Wastewater Management (L0226)	Lecture	3	3
Water Protection and Wastewater Management (L2008)	Project Seminar	3	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	• Basic knowledge in water management; • Good knowledge in urban drainage; • Good knowledge of wastewater treatment techniques; • Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties;
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe the basic principles of the regulatory framework related to the international and European water sector. They can explain limnological processes, substance cycles and water morphology in detail. They are able to assess complex problems related to water protection, such as ecosystem service and wastewater treatment with a special focus on innovative solutions, remediation measures as well as conceptual approaches.
Skills	Students can accurately assess current problems and situations in a country-specific or local context. They can suggest concrete actions to contribute to the planning of tomorrow's urban water cycle. Furthermore, they can suggest appropriate technical, administrative and legislative solutions to solve these problems.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	Term paper plus presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory

Course L0226: Water Protection and Wastewater Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	The lecture focusses on: • Regulatory Framework (e.g. WFD) • Main instruments for the water management and protection • In depth knowledge of relevant measures of water pollution control • Urban drainage, treatment options in different regions on the world • Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration • Case Studies and Field Trips
Literature	The literature listed below is available in the library of the TUHH. • Water and wastewater technology Hammer, M. J. 1., & . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International. • Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill. • Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ.

Course L2008: Water Protection and Wastewater Management	
Typ	Project Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	
Literature	

Module M0620: Special Aspects of Waste Resource Management

Courses

Title	Typ	Hrs/wk	CP
Advanced Topics in Waste Resource Management (L1055)	Project-/problem-based Learning	3	3
International Waste Management (L0317)	Project-/problem-based Learning	2	3

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	basics in waste treatment technologies
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe waste as a resource as well as advanced technologies for recycling and recovery of resources from waste in detail. This covers collection, transport, treatment and disposal in national and international contexts.
Skills	Students are able to select suitable processes for the treatment with respect to the national or cultural and developmental context. They can evaluate the ecological impact and the technical effort of different technologies and management systems.
Personal Competence	
Social Competence	Students can work together as a team of 2-5 persons, participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development of colleagues. Furthermore, they can give and accept professional constructive criticisms.
Autonomy	Students can independently gain additional knowledge of the subject area and apply it in solving the given course tasks and projects.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	Compulsory: Yes; Bonus: 20 %; Form: Written elaboration; Description:
Examination	Presentation
Examination duration and scale	PowerPoint presentation (10-15 minutes)
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L1055: Advanced Topics in Waste Resource Management

Typ	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Rüdiger Siechau
Language	EN
Cycle	WiSe
Content	Focus of the course "Advanced topics of waste resource management" lies on the organisational structures in waste management - such as planning, financing and logistics. One excursion will be offered to take part in (incineration plant, vehicle fleet and waste collection systems). The course is split into two parts: 1. part: “Conventional” lecture (development of waste management, legislation, collection, transportation and organisation of waste management, costs, fees and revenues). 2. part: Project base learning: You will get a project to work out in groups of 4 to 6 students; all tools and data you need to work out the project were given before during the conventional lecture. Course documents are published in StudIP and communication during project work takes place via StudIP. The results of the project work are presented at the end of the semester. The final mark for the course consists of the grade for the presentation.
Literature	Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010 PowerPoint slides in Stud IP

Course L0317: International Waste Management	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	Waste avoidance and recycling are the focus of this lecture. Additionally, waste logistics (Collection, transport, export, fees and taxes) as well as international waste shipment solutions are presented. Other specific wastes, e.g. industrial waste, treatment concepts will be presented and developed by students themselves Waste composition and production on international level, wast eulogistic, collection and treatment in emerging and developing countries. Single national projects and studies will be prepared and presented by students
Literature	Basel convention

Module M0619: Waste Treatment Technologies

Courses

Title	Typ	Hrs/wk	CP
Waste and Environmental Chemistry (L0328)	Practical Course	2	2
Biological Waste Treatment (L0318)	Project-/problem-based Learning	3	4

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	chemical and biological basics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The module aims possess knowledge concerning the planning of biological waste treatment plants. Students are able to explain the design and layout of anaerobic and aerobic waste treatment plants in detail, describe different techniques for waste gas treatment plants for biological waste treatment plants and explain different methods for waste analytics.
Skills	The students are able to discuss the compilation of design and layout of plants. They can critically evaluate techniques and quality control measurements. The students can recherché and evaluate literature and date connected to the tasks given in der module and plan additional tests. They are capable of reflecting and evaluating findings in the group.
Personal Competence	
Social Competence	Students can participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development in front of colleagues. Furthermore, they can give and accept professional constructive criticism.
Autonomy	Students can independently tap knowledge from literature, business or test reports and transform it to the course projects. They are capable, in consultation with supervisors as well as in the interim presentation, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description**: Yes / None / Subject theoretical and practical work
Examination	Presentation
Examination duration and scale	Elaboration and Presentation (15-25 minutes in groups)
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L0328: Waste and Environmental Chemistry	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	DE/EN
Cycle	WiSe
Content	The participants are divided into groups. Each group prepares a transcript on the experiment performed, which is then used as basis for discussing the results and to evaluate the performance of the group and the individual student. In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation. Experiments ar e.g. Screening and particle size determination Fos/Tac AAS Chalorific value
Literature	Scripte

Course L0318: Biological Waste Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	1. Introduction 2. biological basics 3. determination process specific material characterization 4. aerobic degradation (Composting, stabilization) 5. anaerobic degradation (Biogas production, fermentation) 6. Technical layout and process design 7. Flue gas treatment 8. Plant design practical phase
Literature	

Module M0801: Water Resources and -Supply

Courses

Title	Typ	Hrs/wk	CP
Chemistry of Drinking Water Treatment (L0311)	Lecture	2	1
Chemistry of Drinking Water Treatment (L0312)	Recitation Section (large)	1	2
Water Resource Management (L0402)	Lecture	2	2
Water Resource Management (L0403)	Recitation Section (small)	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of water management and the key processes involved in water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.
Skills	Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.
Personal Competence	
Social Competence	Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.
Autonomy	Students will be in a position to work on a subject independently and present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (chemistry) + presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0311: Chemistry of Drinking Water Treatment	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	The topic of this course is water chemistry with respect to drinking water treatment and water distribution Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards). Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework. Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course " Water resources management" in the beginning of the semester.
Literature	**MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004. **Jensen, J. N.**: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003.

Course L0312: Chemistry of Drinking Water Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0402: Water Resource Management	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview: • Current situation of global water resources - User and Stakeholder conflicts - Wasserressourcenmanagement in urbane Gebieten - Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen. - Ökobilanzierung, Benchmarking in der Wasserversorgung
Literature	• Aktuelle UN World Water Development Reports • Branchenbild der deutschen Wasserwirtschaft, VKU (2011) • Aktuelle Artikel wissenschaftlicher Zeitschriften • Ppt der Vorlesung

Course L0403: Water Resource Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0802: Membrane Technology

Courses

Title	Typ	Hrs/wk	CP
Membrane Technology (L0399)	Lecture	2	3
Membrane Technology (L0400)	Recitation Section (small)	1	2
Membrane Technology (L0401)	Practical Course	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of water chemistry. Knowledge of the core processes involved in water, gas and steam treatment
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to rank the technical applications of industrially important membrane processes. They will be able to explain the different driving forces behind existing membrane separation processes. Students will be able to name materials used in membrane filtration and their advantages and disadvantages. Students will be able to explain the key differences in the use of membranes in water, other liquid media, gases and in liquid/gas mixtures.
Skills	Students will be able to prepare mathematical equations for material transport in porous and solution-diffusion membranes and calculate key parameters in the membrane separation process. They will be able to handle technical membrane processes using available boundary data and provide recommendations for the sequence of different treatment processes. Through their own experiments, students will be able to classify the separation efficiency, filtration characteristics and application of different membrane materials. Students will be able to characterise the formation of the fouling layer in different waters and apply technical measures to control this.
Personal Competence	
Social Competence	Students will be able to work in diverse teams on tasks in the field of membrane technology. They will be able to make decisions within their group on laboratory experiments to be undertaken jointly and present these to others.
Autonomy	Students will be in a position to solve homework on the topic of membrane technology independently. They will be capable of finding creative solutions to technical questions.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0399: Membrane Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	The lecture on membrane technology supply provides students with a broad understanding of existing membrane treatment processes, encompassing pressure driven membrane processes, membrane application in electrodialyis, pervaporation as well as membrane distillation. The lectures main focus is the industrial production of drinking water like particle separation or desalination; however gas separation processes as well as specific wastewater oriented applications such as membrane bioreactor systems will be discussed as well. Initially, basics in low pressure and high pressure membrane applications are presented (microfiltration, ultrafiltration, nanofiltration, reverse osmosis). Students learn about essential water quality parameter, transport equations and key parameter for pore membrane as well as solution diffusion membrane systems. The lecture sets a specific focus on fouling and scaling issues and provides knowledge on methods how to tackle with these phenomena in real water treatment application. A further part of the lecture deals with the character and manufacturing of different membrane materials and the characterization of membrane material by simple methods and advanced analysis. The functions, advantages and drawbacks of different membrane housings and modules are explained. Students learn how an industrial membrane application is designed in the succession of treatment steps like pre-treatment, water conditioning, membrane integration and post-treatment of water. Besides theory, the students will be provided with knowledge on membrane demo-site examples and insights in industrial practice.
Literature	• T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage), Springer-Verlag, Berlin 2004. • Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands • Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley & Sons, Ltd., 2004

Course L0400: Membrane Technology	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0401: Membrane Technology	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0822: Process Modeling in Water Technology

Courses

Title	Typ	Hrs/wk	CP
Process Modelling of Wastewater Treatment (L0522)	Project-/problem-based Learning	2	3
Process Modeling in Drinking Water Treatment (L0314)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of the most important processes in drinking water and waste water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to explain selected processes of drinking water and waste water treatment in detail. They are able to explain basics as well as possibilities and limitations of dynamic modeling.
Skills	Students are able to use the most important features Modelica offers. They are able to transpose selected processes in drinking water and waste water treatment into a mathematical model in Modelica with respect to equilibrium, kinetics and mass balances. They are able to set up and apply models and assess their possibilities and limitations.
Personal Competence	
Social Competence	Students are able to solve problems and document solutions in a group with members of different technical background. They are able to give appropriate feedback and can work constructively with feedback concerning their work.
Autonomy	Students are able to define a problem, gain the required knowledge and set up a model.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0522: Process Modelling of Wastewater Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	WiSe
Content	Mass and energy balances Tracer modelling Activated Sludge Model Wastewater Treatment Plant Modelling (continously and SBR) Sludge Treatment (ADM, aerobic autothermal) Biofilm Modelling
Literature	**Henze, Mogens** (Seminar on Activated Sludge Modelling, ; Kollekolle Seminar on Activated Sludge Modelling, ;) Activated sludge modelling : processes in theory and practice ; selected proceedings of the 5th Kollekolle Seminar on Activated Sludge Modelling, held in Kollekolle, Denmark, 10 - 12 September 2001 ISBN: 1843394146 [London] : IWA Publ., 2002 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 TUB_HH_Katalog

Course L0314: Process Modeling in Drinking Water Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE/EN
Cycle	WiSe
Content	In this course selected drinking water treatment processes (e.g. aeration or activated carbon adsorption) are modeled dynamically using the programming language Modelica, that is increasingly used in industry. In this course OpenModelica is used, an free access frontend of the programming language Modelica. In the beginning of the course the use of OpenModelica is explainded by means of simple examples. Together required elements and structure of the model are developed. The implementation in OpenModelica and the application of the model is done individually or in groups respectively. Students get feedback and can gain extra points for the exam.
Literature	**OpenModelica:** https://openmodelica.org/index.php/download/download-windows **OpenModelica - Modelica Tutorial:** https://openmodelica.org/index.php/useresresources/userdocumentation **OpenModelica - Users Guide:** https://openmodelica.org/index.php/useresresources/userdocumentation **Peter Fritzson:** Principles of Object-Oriented Modeling and Simulation with Modelica 2.1,Wiley-IEEE Press, ISBN 0-471-471631. **MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.

Module M0894: Study Work Cities

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	Dozenten des SD B
Admission Requirements	None
Recommended Previous Knowledge	• Basics of Urban Planning • Urban Infrastructures (Water, Energy, Heat) • Environmental Technologies (Solid Waste Disposal, Air Quality Control, Wastewater Treatement, etc.)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to demonstrate their detailed knowledge in the field of Water and Environmental Engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society. The students can develop solving strategies and approaches for fundamental and practical problems in the field of Water and Environmental Engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society. Scientific work techniques that are used can be described and critically reviewed.
Skills	The students are able to independently select methods or planning approaches for the project work and to justify their choice. They can explain how these methods or approaches relate to solutions in the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.
Personal Competence	
Social Competence	The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.
Workload in Hours	Independent Study Time 180, Study Time in Lecture 0
Credit points	6
Course achievement	None
Examination	Study work
Examination duration and scale	
Assignment for the Following Curricula	Water and Environmental Engineering: Specialisation Cities: Compulsory

Module M0949: Rural Development and Resources Oriented Sanitation for different Climate Zones

Courses

Title	Typ	Hrs/wk	CP
Rural Development and Resources Oriented Sanitation for different Climate Zones (L0942)	Seminar	2	3
Rural Development and Resources Oriented Sanitation for different Climate Zones (L0941)	Lecture	2	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of the global situation with rising poverty, soil degradation, lack of water resources and sanitation
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe resources oriented wastewater systems mainly based on source control in detail. They can comment on techniques designed for reuse of water, nutrients and soil conditioners. Students are able to discuss a wide range of proven approaches in Rural Development from and for many regions of the world.
Skills	Students are able to design low-tech/low-cost sanitation, rural water supply, rainwater harvesting systems, measures for the rehabilitation of top soil quality combined with food and water security. Students can consult on the basics of soil building through “Holisitc Planned Grazing” as developed by Allan Savory.
Personal Competence	
Social Competence	The students are able to develop a specific topic in a team and to work out milestones according to a given plan.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information will be provided at the beginning of the smester.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0942: Rural Development and Resources Oriented Sanitation for different Climate Zones

Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	• Central part of this module is a group work on a subtopic of the lectures. The focus of these projects will be based on an interview with a target audience, practitioners or scientists. • The group work is divided into several Milestones and Assignments. The outcome will be presented in a final presentation at the end of the semester.
Literature	• J. Lange, R. Otterpohl 2000: Abwasser - Handbuch zu einer zukunftsfähigen Abwasserwirtschaft. Mallbeton Verlag (TUHH Bibliothek) • Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download) • Schober, Sabine: WTO/TUHH Award winning Terra Preta Toilet Design: http://youtu.be/w_R09cYq6ys

Course L0941: Rural Development and Resources Oriented Sanitation for different Climate Zones	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	• Living Soil - THE key element of Rural Development • Participatory Approaches • Rainwater Harvesting • Ecological Sanitation Principles and practical examples • Permaculture Principles of Rural Development • Performance and Resilience of Organic Small Farms • Going Further: The TUHH Toolbox for Rural Development • EMAS Technologies, Low cost drinking water supply
Literature	• Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk • Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press

Module M1716: Subsurface Processes

Courses

Title	Typ	Hrs/wk	CP
Modeling of Subsurface Processes (L2730)	Lecture	2	2
Modeling of Subsurface Processes (L2731)	Recitation Section (small)	1	1
Modern Techniques for Subsurface Solute Transport (L2728)	Lecture	2	2
Modern Techniques for Subsurface Solute Transport (L2729)	Recitation Section (large)	1	1

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic Mathematics, Hydrology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Upon completion of this module, the students will understand the mechanisms controlling solute transport in soil and natural porous media and will be able to work with the equations that govern the fate and transport of solutes in porous media. Analytical, numerical and experimental tools and techniques will be used in this module.
Skills	In addition to the physical insights, the students will be exposed to analytical, experimental and numerical tools and techniques in this module. This provides them with an excellent opportunity to improve their skills on multiple fronts which will be useful in their future career.
Personal Competence	
Social Competence	Teamwork & problem solving
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Report and Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L2730: Modeling of Subsurface Processes

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Sonja Götz
Language	EN
Cycle	WiSe
Content	
Literature	

Course L2731: Modeling of Subsurface Processes

Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Sonja Götz
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L2728: Modern Techniques for Subsurface Solute Transport	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	
Literature	

Course L2729: Modern Techniques for Subsurface Solute Transport	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1720: Emerging Trends in Environmental Engineering

Courses

Title	Typ	Hrs/wk	CP
Environmental Research Trends (L2752)	Seminar	2	2
Microplastics in Environment (L2750)	Lecture	2	2
Scientific Communication and Methods (L2751)	Lecture	1	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge on water, soil and environmental research.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will be exposed to up-to-date research topics focused on soil, water and climate related challenges with a particular focus on the effects of microplastics in environment. Data analysis, data measurement, curation and presentation will be other skills that the students will develop in this module.
Skills	Students' research skills will be improved in this module. How to prepare and deliver an effective presentation, how to write an abstract, research paper and proposal will be discussed in this module. Moreover, through Research-Based Learning approaches, the students will be exposed to current research trends in environmental engineering.
Personal Competence	
Social Competence	Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Report and Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Environmental Engineering: Specialisation Biotechnology: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2752: Environmental Research Trends	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Salome Shokri-Kuehni
Language	EN
Cycle	WiSe
Content	Introduction - course objectives, expectations and format Analyzing the Audience, purpose and occasion Constructing and delivering effective technical presentations How to write an abstract How to write a scientific paper Developing competitive and persuasive research proposals Databases and resources available for water and environmental research Individual proposal on water and environmental research Individual project on water and environmental research Presentation on water and environmental research
Literature	• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9 • Supplemental materials and web links which will be available to registered students.

Course L2750: Microplastics in Environment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	- Introduction, objectives, expectations, format, importance - Sources of microplastics in environment - Microplastics sampling; Characterization of microplastics - Distribution of microplastics in terrestrial environments - Fate of microplastics in terrestrial environments - Project discussion - Effects of microplastics on terrestrial environments - Health risks of microplastics in environments - Project presentations by all students
Literature	- Microplastics in Terrestrial Environments (2021), Edited by Defu He and Yongming Luo - Particulate Plastics in Terrestrial and Aquatic Environments (2020), Edited by Nanthi S. Bolan et al. - Microplastic Pollutants (2017), by Christopher B. Crawford and Brian Quinn

Course L2751: Scientific Communication and Methods	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	Introduction - course objectives, expectations and format Analyzing the Audience, purpose and occasion Constructing and delivering effective technical presentations How to write an abstract How to create a scientific poster How to write a scientific paper Developing competitive and persuasive research proposals Individual project (report and presentation) related to soil, water and environmental research
Literature	• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9 • Supplemental materials and web links which will be available to registered students.

Module M0981: Operation of Public Transportation Systems

Courses

Title	Typ	Hrs/wk	CP
Operation of Public Transportation Systems (L1179)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe public transport (PT) systems in technical language. • outline the entire PT system including the interdependencies of the different elements. • explain the requirements for a PT system from different perspectives. • explain the role of PT in the transport system.
Skills	Students are able to: • systematically develop a public transport system when there are no clear cut correct or incorrect approaches. • cope with imprecise and incomplete data. • develop and appraise alternative solutions. • distinguish or develop appropriate methods of analysis and modes of presentation. • reflect and evaluate their own transport concept, considering competing requirements.
Personal Competence	
Social Competence	Students are able to: • carry out and complete a group project, inclusive of an appropriate allocation of tasks. • constructively provide and accept feedback. • present their own results to others.
Autonomy	• independently develop a bus PT concept within a given framework. • determine and justify the focus of their work. • organize and follow their work process regarding time and content. • independently author a written report. • assess the consequences of the solutions they develop.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment as groupwork with presentation during the semester
Assignment for the Following Curricula	Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L1179: Operation of Public Transportation Systems	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz
Language	DE
Cycle	WiSe
Content	The course primarily deals with the planning and operational challenges of public transport systems. A bus-system is the example for studying these problems in depth. The following topics and systemic elements are covered: • PT network planning • timetabling • operational concepts • requirements for vehicle technology and operation • infrastructural requirements • inter- and multimodal connections • financing and competition • organisational structures The topics are discussed with guests lecturers from the public transport sector and are considered in practice during an excursion.
Literature	Verband Deutscher Verkehrsunternehmen / VDV-Förderkreis (Hrsg.) (2010) Nachhaltiger Nahverkehr. Köln. (2 Bände) Wuppertal Institut (2009) Handbuch zur Planung flexibler Bedienungsformen im ÖPNV : ein Beitrag zur Sicherung der Daseinsvorsorge in nachfrageschwachen Räumen. Bundesministerium für Verkehr, Bau und Stadtentwicklung / Bundesinstitut für Bau-, Stadt- und Raumforschung. Bonn. Forschungsgesellschaft für Straßen- und Verkehrswesen (2009) HVÖ - Hinweise für den Entwurf von Verknüpfungsanlagen des öffentlichen Personennahverkehrs. FGSV Verlag. Köln. Kirchhoff, Peter (2002) Städtische Verkehrsplanung – Konzepte, Verfahren, Maßnahmen. Vieweg+Teubner Verlag. Wiesbaden. Kirchhoff, Peter & Tsakarestos, Antonius (2007) Planung des ÖPNV in ländlichen Räumen, Ziele – Entwurf- Realisierung. Vieweg+Teubner Verlag. Wiesbaden Forschungsgesellschaft für Straßen- und Verkehrswesen (2008) Richtlinien für integrierte Netzgestaltung: RIN. FGSV-Verlag. Köln.

Module M1779: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)

Courses

Title	Typ	Hrs/wk	CP
Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC) (L2926)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydraulic Engineering • Hydromechanics, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-based Solutions (NBS) for Coastal Protection
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working in international groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report on a complex task with a presentation and subsequent discussion. The work on the complex task happens in the course of the lecture.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2926: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe
Content	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-Based Solutions (NBS) for Coastal Protection
Literature	• Materials provided on eLearning Platform (HOOU Platform)

Module M1505: Adaptation to Climate Change in Hydraulic Engineering (AKWAS)

Courses

Title	Typ	Hrs/wk	CP
Adaptation to climate change in hydraulic engineering (L2291)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydrology, Hydraulic Engineering • Hydromechanic, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection • Hydrological Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate protection and climate adaptation • Insights into climate change and its regional characteristics - fundamentals, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle • Fundamentals of analysis of climate data • Consequences of the impact of the climate change • Measures for climate adaptation • Assessment, prioritization and communication of adaptation measures • Fundamentals of the analysis of hydrometeorological and hydrological data
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report and a presentation of a complex task.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2291: Adaptation to climate change in hydraulic engineering	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	WiSe
Content	• Climate protection and climate adaptation • Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle(climate science view) • Fundamentals of the analysis of climate data • Concequences of the impacts of climate change (ingenieering science view) • Measures for climate change adaptation • Assessment, prioritization and communication of measures • Fundamentals of analysis of hydrometeorological and hydrological data
Literature	• Bereitgestellte eLearning Plattform

Specialization Environment

Module M0830: Environmental Protection and Management

Courses

Title	Typ	Hrs/wk	CP
Integrated Pollution Control (L0502)	Lecture	2	2
Health, Safety and Environmental Management (L0387)	Lecture	2	3
Health, Safety and Environmental Management (L0388)	Recitation Section (small)	1	1

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	• Good knowledge in Technologies for Environmental Protection (end-of-pipe, integrated solutions) • Good knowledge of the relevant Environmental Legislation • Basic knowledge of instruments for Environmental Assessment
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the basics of regulations, economic instruments, voluntary initiatives, fundamentals of HSE legislation ISO 14001, EMAS and Responsible Care ISO 14001 requirements. They can analyse and discuss industrial processes, substance cycles and approaches from end-of-pipe technology to eco-efficiency and eco-effectiveness, showing their sound knowledge of complex industry related problems. They are able to judge environmental issues and to widely consider, apply or carry out innovative technical solutions, remediation measures and further interventions as well as conceptual problem solving approaches in the full range of problems in different industrial sectors.
Skills	Students are able to assess current problems and situations in the field of environmental protection. They can consider the best available techniques and to plan and suggest concrete actions in a company- or branch-specific context. By this means they can solve problems on a technical, administrative and legislative level.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare themselves for presentations and contributions to the discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Management and Controlling: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0502: Integrated Pollution Control	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	The lecture focusses on: • The Regulatory Framework • Pollution & Impacts, Characteristics of Pollutants • Approaches of Integrated Pollution Control • Sevilla Process, Best Available Technologies & BREF Documents • Case Studies: paper industry, cement industry, automotive industry • Field Trip
Literature	**Förstner**, Ulrich (1998): Integrated Pollution Control, Springer-Verlag Berlin Heidelberg, ISBN 978-3-642-80313-0 **Shen**, Thomas T. (1999): Industrial Pollution Prevention, Springer-Verlag Berlin Heidelberg, ISBN 978-3-540-65208-3

Course L0387: Health, Safety and Environmental Management	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Hans-Joachim Nau
Language	EN
Cycle	WiSe
Content	• Objectives of and benefit from HSE management • From dilution and end-of-pipe technology to eco-efficiency and eco-effectiveness Behaviour control: regulations, economic instruments and voluntary initiatives • Fundamentals of HSE legislation ISO 14001, EMAS and Responsible Care ISO 14001 requirements Environmental performance evaluation Risk management: hazard, risk and safety Health and safety at the workplace • Crisis management
Literature	C. Stephan: Industrial Health, Safety and Environmental Management, MV-Verlag, Münster, 2007/2012 (can be found in the library under GTG 315) Exercises can be downloaded from StudIP

Course L0388: Health, Safety and Environmental Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hans-Joachim Nau
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0902: Wastewater Treatment and Air Pollution Abatement

Courses

Title	Typ	Hrs/wk	CP
Biological Wastewater Treatment (L0517)	Lecture	2	3
Air Pollution Abatement (L0203)	Lecture	2	3

Module Responsible	Dr. Swantje Pietsch-Braune
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of biology and chemistry Basic knowledge of solids process engineering and separation technology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of the module students are able to • name and explain biological processes for waste water treatment, • characterize waste water and sewage sludge, • discuss legal regulations in the area of emissions and air quality • explain the effects of air pollutants on the environment, • name and explan off gas tretament processes and to define their area of application
Skills	Students are able to • choose and design processs steps for the biological waste water treatment • combine processes for cleaning of off-gases depending on the pollutants contained in the gases
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0517: Biological Wastewater Treatment

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	WiSe
Content	Charaterisation of Wastewater Metobolism of Microorganisms Kinetic of mirobiotic processes Calculation of bioreactor for wastewater treatment Concepts of Wastewater treatment Design of WWTP Excursion to a WWTP Biofilms Biofim Reactors Anaerobic Wastewater and sldge treatment resources oriented sanitation technology Future challenges of wastewater treatment

Literature	**Gujer, Willi** Siedlungswasserwirtschaft : mit 84 Tabellen ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?id=2842122&prov=M&dok_var=1&dok_ext=htm Berlin [u.a.] : Springer, 2007 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Imhoff, Karl** (Imhoff, Klaus R.;) Taschenbuch der Stadtentwässerung : mit 10 Tafeln ISBN: 3486263331 ((Gb.)) München [u.a.] : Oldenbourg, 1999 TUB_HH_Katalog **Lange, Jörg** (Otterpohl, Ralf; Steger-Hartmann, Thomas;) Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334 Donaueschingen-Pfohren : Mall-Beton-Verl., 2000 TUB_HH_Katalog **Mudrack, Klaus** (Kunst, Sabine;) Biologie der Abwasserreinigung : 18 Tabellen ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903 Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003 TUB_HH_Katalog **Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Kunz, Peter** Umwelt-Bioverfahrenstechnik Vieweg, 1992 **Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt** (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, ;) Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe aus der Abwasserbehandlung, Kleinkläranlagen ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL: http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf Weimar : Universitätsverl, 2006 TUB_HH_Katalog **Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall** DWA-Regelwerk Hennef : DWA, 2004 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 TUB_HH_Katalog

Course L0203: Air Pollution Abatement	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Swantje Pietsch-Braune, Christian Eichler
Language	EN
Cycle	WiSe
Content	In the lecture methods for the reduction of emissions from industrial plants are treated. At the beginning a short survey of the different forms of air pollutants is given. In the second part physical principals for the removal of particulate and gaseous pollutants form flue gases are treated. Industrial applications of these principles are demonstrated with examples showing the removal of specific compounds, e.g. sulfur or mercury from flue gases of incinerators.
Literature	Handbook of air pollution prevention and control, Nicholas P. Cheremisinoff. - Amsterdam [u.a.] : Butterworth-Heinemann, 2002 Atmospheric pollution : history, science, and regulation, Mark Zachary Jacobson. - Cambridge [u.a.] : Cambridge Univ. Press, 2002 Air pollution control technology handbook, Karl B. Schnelle. - Boca Raton [u.a.] : CRC Press, c 2002 Air pollution, Jeremy Colls. - 2. ed. - London [u.a.] : Spon, 2002

Module M1403: Construction and Simulation of Sewerage Systems

Courses

Title	Typ	Hrs/wk	CP
Construction and renovation of urban sewer systems (L1998)	Seminar	3	3
Simulation of sewerage systems (L2006)	Seminar	3	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	• Hydraulics in pipes and gravity-sewers • Mechanics • Soil mechanics and foundation engineering • Knowledge about urban sewerage systems and water management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe urban wastewater systems by means of software-based modeling. In case studies they can perform system and weak point analyzes. In addition, they can analyze the hydraulic effects quantitatively. Furthermore, they have the knowledge to comprehend flow events in gravity-sewers based on the St. Venant equations. Students have knowledge of static and structural requirements of the sewer system. Cases of damage are investigated and the knowledge regarding different renovation technologies for sewer systems is acquired.
Skills	The students can simulate different run-off events in sewer systems and are able to dimension the sewer systems accordingly. Moreover, they can determine suitable construction materials and static requirements for different cases of application.
Personal Competence	
Social Competence	Students are able to apply the acquired skills in a team and can impart this knowledge.
Autonomy	Students can solve problems in the field of wastewater systems independently, concerning in particular dimensioning and simulation of sewer systems. Furthermore, they are able to present and justify their solutions.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	Compulsory: No; Bonus: 20 %; Form: Presentation; Description:
Examination	Written elaboration
Examination duration and scale	nach Absprache
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L1998: Construction and renovation of urban sewer systems	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ingo Weidlich
Language	EN
Cycle	WiSe
Content	The lecture focusses on construction and renovation of urban sewer pipelines. Construction: • Pipe materials, types and joint technology • Open trenches • Trenchless technologies Pipe Statics: • Design of sewers according to ATV A 127 • Earth pressure on pipes, pipe deformation, cutting forces • Comparison with other international calculation approaches Renovation: • Failure case study • Overview on the different renovation technologies • Liner design according to DWA-A 143

Literature	Nr.	Titel
	1	ATV A 127, Abwassertechnische Vereinigung e.V., Arbeitsblatt A 127, Regelwerk Abwasser-Abfall, Vertrieb: GFA, DK 628.22 (083),A 127, 2000
	2	DIN EN 1610, Verlegung und Prüfung von Abwasserleitungen und -kanälen, Beuth Verlag, Berlin, 1997
	3	Arbeitsblatt DWA-A 143-1, Sanierung von Entwässerungssystemen außerhalb von Gebäuden, Teil 1: Planung und Überwachung von Sanierungsmaßnahmen Februar 2015
	4	Arbeitsblatt DWA-A 143-2, Sanierung von Entwässerungssystemen außerhalb von Gebäuden Teil 2: Statische Berechnung zur Sanierung von Abwasserleitungen und -kanälen mit Lining und Montageverfahren, Juli 2015
	5	DIN EN 752:2008, 2008: Entwässerungssysteme außerhalb von Gebäuden - Kanalmanagement.
	6	Zeitschrift 3R, Fachzeitschrift für sichere und effiziente Rohrleitungssysteme
	7	Handbuch für den Rohrleitungsbau Band 1 und 2, 4. Auflage, Günter Wossog, 2015
	8	Rohrleitungstechnik, Walter Wagner, Vogel Buchverlag, 2006
	9	Stein D., Stein R., „Instandhaltung von Kanalisationen“, 1008 S., ISBN 978-3-9810648-4-1 | Verlag Prof. Dr.-Ing. Stein & Partner GmbH, 2014
	10	Stein, D., „Grabenloser Leitungsbau“, 1. Auflage, Gebundene Ausgabe - 1166 Seiten, Ernst & Sohn Verlag, 2003, ISBN: 3433017786
	11	Willoughby D:A: „Horizontal Directional Drilling: Utility and Pipeline Applications” Digital Engineering Library @ McGraw-Hill - The McGraw-Hill Companies, Inc., 2005
	12	Weidlich I., „Erddruck auf Rohre“, 1. Auflage, ISBN 3-89999-027-7, 227 Seiten, 2012

Course L2006: Simulation of sewerage systems	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	Modeling of sewer systems: • Modeling approaches in wastewater management, especially approaches to integrated modeling • Planning processes, calculations and design approaches for elements of gravity-sewers • Model setup • St. Venant equation and simplifications of models (kinematic wave etc.) • Calculation & modeling of solids transport (advection, diffusion, dispersion and sales processes) • Examples for modeling with SWMM (EPA, USA)
Literature	

Module M0581: Water Protection

Courses

Title	Typ	Hrs/wk	CP
Water Protection and Wastewater Management (L0226)	Lecture	3	3
Water Protection and Wastewater Management (L2008)	Project Seminar	3	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	• Basic knowledge in water management; • Good knowledge in urban drainage; • Good knowledge of wastewater treatment techniques; • Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties;
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe the basic principles of the regulatory framework related to the international and European water sector. They can explain limnological processes, substance cycles and water morphology in detail. They are able to assess complex problems related to water protection, such as ecosystem service and wastewater treatment with a special focus on innovative solutions, remediation measures as well as conceptual approaches.
Skills	Students can accurately assess current problems and situations in a country-specific or local context. They can suggest concrete actions to contribute to the planning of tomorrow's urban water cycle. Furthermore, they can suggest appropriate technical, administrative and legislative solutions to solve these problems.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	Term paper plus presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory

Course L0226: Water Protection and Wastewater Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	The lecture focusses on: • Regulatory Framework (e.g. WFD) • Main instruments for the water management and protection • In depth knowledge of relevant measures of water pollution control • Urban drainage, treatment options in different regions on the world • Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration • Case Studies and Field Trips
Literature	The literature listed below is available in the library of the TUHH. • Water and wastewater technology Hammer, M. J. 1., & . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International. • Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill. • Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ.

Course L2008: Water Protection and Wastewater Management	
Typ	Project Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	
Literature	

Module M0511: Electrical Energy from Solar Radiation and Wind Power

Courses

Title	Typ	Hrs/wk	CP
Sustainability Management (L0007)	Lecture	2	1
Hydro Power Use (L0013)	Lecture	1	1
Wind Turbine Plants (L0011)	Lecture	2	3
Wind Energy Use - Focus Offshore (L0012)	Lecture	1	1

Module Responsible	Dr. Isabel Höfer
Admission Requirements	None
Recommended Previous Knowledge	Module: Technical Thermodynamics I, Module: Technical Thermodynamics II, Module: Fundamentals of Fluid Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe. Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice.
Skills	Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects.
Personal Competence	
Social Competence	Students can discuss scientific tasks subjet-specificly and multidisciplinary within a seminar.
Autonomy	Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2.5 hours written exam + written elaboration (incl. presentation) in sustainability management
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0007: Sustainability Management	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Anne Rödl
Language	DE
Cycle	SoSe
Content	The lecture "Sustainability Management" gives an insight into the different aspects and dimensions of sustainability. First, essential terms and definitions, significant developments of the last years, and legal framework conditions are explained. The various aspects of sustainability are then presented and discussed in detail. The lecture mainly focuses on concepts for the implementation of the topic sustainability in companies: • What is "sustainability"? • Why is this concept an important topic for companies? • What opportunities and business risks are addressed or are associated with it? • How can the often mentioned three pillars of sustainability - economy, ecology, and social- be meaningfully integrated into corporate management despite their sometimes contradictory tendencies, and how a corresponding compromise can be found? • What concepts or frameworks exist for the implementation of sustainability management in companies? • Which sustainability labels exist for products or companies? What do they have in common, and where do they differ? Furthermore, the lecture is intended to provide insights into the concrete implementation of sustainability aspects into business practice. External lecturers from companies will be invited to report on how sustainability is integrated into their daily processes. In the course of an independently carried out group work, the students will analyze and discuss the implementation of sustainability aspects based on short case studies. By studying and comparing best practice examples, the students will learn about corporate decisions' effects and implications. It should become clear which risks or opportunities are associated if sustainability aspects are taken into account in management decisions.
Literature	Die folgenden Bücher bieten einen Überblick: Engelfried, J. (2011) Nachhaltiges Umweltmanagement. München: Oldenbourg Verlag. 2. Auflage Corsten H., Roth S. (Hrsg.) (2011) Nachhaltigkeit - Unternehmerisches Handeln in globaler Verantwortung. Wiesbaden: Gabler Verlag.

Course L0013: Hydro Power Use	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Stefan Achleitner
Language	DE
Cycle	SoSe
Content	• Introduction, importance of water power in the national and global context • Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies • Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems • Construction of hydroelectric power plants: description of the individual components and their technical system interaction • Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc. • Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection • Hydropower and the Environment • Examples from practice
Literature	• Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage • Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage • Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage • von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage • Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006

Course L0011: Wind Turbine Plants	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rudolf Zellermann
Language	DE
Cycle	SoSe
Content	• Historical development • Wind: origins, geographic and temporal distribution, locations • Power coefficient, rotor thrust • Aerodynamics of the rotor • Operating performance • Power limitation, partial load, pitch and stall control • Plant selection, yield prediction, economy • Excursion
Literature	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005

Course L0012: Wind Energy Use - Focus Offshore	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Skiba
Language	DE
Cycle	SoSe
Content	• Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering • Physical fundamentals for utilization of wind energy • Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships • Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures • Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection • Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics • Development and planning of offshore wind farms • Operation and optimization of offshore wind farms • Day excursion
Literature	• Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage • Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidel-berg, 1997, 3. Auflage • Hau, E.: Windkraftanalagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage • Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage • Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage

Module M0827: Modeling in Water Management

Courses

Title	Typ	Hrs/wk	CP
Groundwater Modeling using Modflow (L0543)	Lecture	1	1
Groundwater Modeling using Modflow (L0544)	Recitation Section (small)	2	2
Modeling of Water Supply and Sewer Network (L0875)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Groundwater • groundwater hydraulics and transport of substances Pipe Systems • Knowledge on urban water infrastructures, in particular drinking water systemsand urban drainage systems including special structures • Hydraulics of drinking water supply systems and sewer systems • Basic knowledge on water management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.
Skills	The students are able to construct and apply scientific groundwater models indipendently. They can work on different scenarios and can compare or assess different solutions for existing problems by application of selected software products. The students are able to use different software solutions (e.g. EPANET, EPA-SWMM).
Personal Competence	
Social Competence	Wird nicht vermittelt.
Autonomy	Wird nicht vermittelt.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	20 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0543: Groundwater Modeling using Modflow

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical backround of the modell, students do work with the model PMWIN for practical case studies.
Literature	MODFLOW-Handbuch Chiang, Wen Hsien: PMWIN

Course L0544: Groundwater Modeling using Modflow	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0875: Modeling of Water Supply and Sewer Network	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen, Weitere Mitarbeiter
Language	DE
Cycle	SoSe
Content	
Literature	Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014.

Module M1717: Advanced Vadose Zone Hydrology

Courses

Title	Typ	Hrs/wk	CP
Modeling Processes in Vadose Zone (L2734)	Lecture	1	1
Modeling Processes in Vadose Zone (L2735)	Recitation Section (small)	1	1
Vadose Zone Hydrology (L2732)	Lecture	2	2
Vadose Zone Hydrology (L2733)	Recitation Section (large)	2	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2734: Modeling Processes in Vadose Zone

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann, Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2735: Modeling Processes in Vadose Zone

Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L2732: Vadose Zone Hydrology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2733: Vadose Zone Hydrology	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1718: Multiphase Flow in Porous Media

Courses

Title	Typ	Hrs/wk	CP
Advanced Modeling Techniques for Multiphase Flow in Porous Media (L2738)	Recitation Section (small)	2	2
Fundamentals of Multiphase Flow in Porous Media (L2736)	Lecture	2	2
Fundamentals of Multiphase Flow in Porous Media (L2737)	Recitation Section (large)	2	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2738: Advanced Modeling Techniques for Multiphase Flow in Porous Media

Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2736: Fundamentals of Multiphase Flow in Porous Media

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2737: Fundamentals of Multiphase Flow in Porous Media	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Hannes Nevermann
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1721: Water and Environment: Theory and Application

Courses

Title	Typ	Hrs/wk	CP
Water and Environment: Application and Field Work (L2754)	Project-/problem-based Learning	3	4
Water and Environment: Theory (L2753)	Lecture	1	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Report (about 5-10 pages) and Presentation (about 15 min)
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2754: Water and Environment: Application and Field Work

Typ	Project-/problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Anna Luisa Hemshorn de Sánchez, Dr. Salome Shokri-Kuehni
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2753: Water and Environment: Theory

Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Module M0513: System Aspects of Renewable Energies

Courses

Title	Typ	Hrs/wk	CP
Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021)	Lecture	2	2
Energy Trading (L0019)	Lecture	1	1
Energy Trading (L0020)	Recitation Section (small)	1	1
Deep Geothermal Energy (L0025)	Lecture	2	2

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	None
Recommended Previous Knowledge	Module: Technical Thermodynamics I Module: Technical Thermodynamics II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to describe the processes in energy trading and the design of energy markets and can critically evaluate them in relation to current subject specific problems. Furthermore, they are able to explain the basics of thermodynamics of electrochemical energy conversion in fuel cells and can establish and explain the relationship to different types of fuel cells and their respective structure. Students can compare this technology with other energy storage options. In addition, students can give an overview of the procedure and the energetic involvement of deep geothermal energy.
Skills	Students can apply the learned knowledge of storage systems for excessive energy to explain for various energy systems different approaches to ensure a secure energy supply. In particular, they can plan and calculate domestic, commercial and industrial heating equipment using energy storage systems in an energy-efficient way and can assess them in relation to complex power systems. In this context, students can assess the potential and limits of geothermal power plants and explain their operating mode. Furthermore, the students are able to explain the procedures and strategies for marketing of energy and apply it in the context of other modules on renewable energy projects. In this context they can unassistedly carry out analysis and evaluations of energie markets and energy trades.
Personal Competence	
Social Competence	Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module.
Autonomy	Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	3 hours written exam
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Fröba
Language	DE
Cycle	SoSe

Content	1. Introduction to electrochemical energy conversion
	2. Function and structure of electrolyte
	3. Low-temperature fuel cell
	  ◦ Types
	  ◦ Thermodynamics of the PEM fuel cell
	  ◦ Cooling and humidification strategy
	4. High-temperature fuel cell
	  ◦ The MCFC
	  ◦ The SOFC
	  ◦ Integration Strategies and partial reforming
	5. Fuels
	  ◦ Supply of fuel
	  ◦ Reforming of natural gas and biogas
	  ◦ Reforming of liquid hydrocarbons
	6. Energetic Integration and control of fuel cell systems

Literature	• Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003

Course L0019: Energy Trading	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Michael Sagorje, Dr. Sven Orlowski
Language	DE
Cycle	SoSe
Content	• Basic concepts and tradable products in energy markets • Primary energy markets • Electricity Markets • European Emissions Trading Scheme • Influence of renewable energy • Real options • Risk management Within the exercise the various tasks are actively discussed and applied to various cases of application.
Literature	

Course L0020: Energy Trading	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Michael Sagorje, Dr. Sven Orlowski
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0025: Deep Geothermal Energy	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Ben Norden
Language	DE
Cycle	SoSe
Content	1. Introduction to the deep geothermal use 2. Geological Basics I 3. Geological Basics II 4. Geology and thermal aspects 5. Rock Physical Aspects 6. Geochemical aspects 7. Exploration of deep geothermal reservoirs 8. Drilling technologies, piping and expansion 9. Borehole Geophysics 10. Underground system characterization and reservoir engineering 11. Microbiology and Upper-day system components 12. Adapted investment concepts, cost and environmental aspect
Literature	• Dipippo, R.: Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact. Butterworth Heinemann; 3rd revised edition. (29. Mai 2012) • www.geo-energy.org • Edenhofer et al. (eds): Renewable Energy Sources and Climate Change Mitigation; Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2012. • Kaltschmitt et al. (eds): Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer, 5. Aufl. 2013. • Kaltschmitt et al. (eds): Energie aus Erdwärme. Spektrum Akademischer Verlag; Auflage: 1999 (3. September 2001) • Huenges, E. (ed.): Geothermal Energy Systems: Exploration, Development, and Utilization. Wiley-VCH Verlag GmbH & Co. KGaA; Auflage: 1. Auflage (19. April 2010)

Module M0828: Urban Environmental Management

Courses

Title	Typ	Hrs/wk	CP
Noise Protection (L1109)	Lecture	2	2
Urban Infrastructures (L0874)	Project-/problem-based Learning	2	4

Module Responsible	Dr. Dorothea Rechtenbach
Admission Requirements	None
Recommended Previous Knowledge	• Knowledge on Urban planning • Knowledge on measures for climate protection • General knowledge of scientific writing/working
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe urban development corridors as well as current and future urban environmental problems. They are able to explain the causes of environmental problems (like noise). Students can specify applications for various technical innovations and explain why these contribute to the improvement of urban life. They can, for example, derive and discuss measures for effective noise abatement.
Skills	Students are able to develop specific solutions for correcting existing or future environment-related problems of urban development. They can define a range of conceptual and technical solutions for environmental problems for different development paths. To solve specific urban environmental problems they can select technical innovations and integrate them into the urban context.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare themselves for presentations and contributions to the discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Written Report plus oral Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1109: Noise Protection

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Jäschke
Language	EN
Cycle	SoSe
Content	
Literature	1) Müller & Möser (2013): Handbook of Engineering Acoustics (also available in German) 2) WHO (1999): Guidelines for Community Noise 3) Environmental Noise Directive 2002/49/EG 4) ISO 9613-2 (1996): Acoustics, Attenuation of sound during propagation outdoors, Part 2: General method of calculation

Course L0874: Urban Infrastructures	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Dorothea Rechtenbach
Language	EN
Cycle	SoSe
Content	Problem Based Learning Main topics are: • Central vs. Decentral Wastewater Treatment. • Compaction of Cities. • Car Free Cities. • Multifunctional Places in Cities. • The Sustainability of Freight Transport in Cities.
Literature	Depends on chosen topic.

Module M1702: Process Imaging

Courses

Title	Typ	Hrs/wk	CP
Process Imaging (L2723)	Lecture	2	3
Process Imaging (L2724)	Project-/problem-based Learning	2	3

Module Responsible	Prof. Alexander Penn
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Energy and Bioprocess Technology: Elective Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Energy and Bioprocess Technology: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2723: Process Imaging

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Penn
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2724: Process Imaging	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Penn, Dr. Stefan Benders
Language	EN
Cycle	SoSe
Content	
Literature	

Module M0749: Waste Treatment and Solid Matter Process Technology

Courses

Title	Typ	Hrs/wk	CP
Solid Matter Process Technology for Biomass (L0052)	Lecture	2	2
Thermal Waste Treatment (L0320)	Lecture	2	2
Thermal Waste Treatment (L1177)	Recitation Section (large)	1	2

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	Basics of • thermo dynamics • fluid dynamics • chemistry
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can name, describe current issue and problems in the field of thermal waste treatment and particle process engineering and contemplate them in the context of their field. The industrial application of unit operations as part of process engineering is explained by actual examples of waste incineration technologies and solid biomass processes. Compostion, particle sizes, transportation and dosing, drying and agglomeration of renewable resources and wastes are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, electricity , heat and mineral recyclables.
Skills	The students are able to select suitable processes for the treatment of wastes or raw material with respect to their characteristics and the process aims. They can evaluate the efforts and costs for processes and select economically feasible treatment concepts.
Personal Competence	
Social Competence	Students can • respectfully work together as a team and discuss technical tasks • participate in subject-specific and interdisciplinary discussions, • develop cooperated solutions • promote the scientific development and accept professional constructive criticism.
Autonomy	Students can independently tap knowledge of the subject area and transform it to new questions. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0052: Solid Matter Process Technology for Biomass	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Werner Sitzmann
Language	DE
Cycle	SoSe
Content	The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture.
Literature	Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4 Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe, Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175

Course L0320: Thermal Waste Treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	SoSe
Content	• Introduction, actual state-of-the-art of waste incineration, aims. legal background, reaction principals • basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition • Incineration techniques: grate firing, ash transfer, boiler • Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination • Ash treatment: Mass, quality, treatment concepts, recycling, disposal
Literature	Thomé-Kozmiensky, K. J. (Hrsg.): Thermische Abfallbehandlung Bande 1-7. EF-Verlag für Energie- und Umwelttechnik, Berlin, 196 - 2013.

Course L1177: Thermal Waste Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0857: Geochemical Engineering

Courses

Title	Typ	Hrs/wk	CP
Contaminated Sites and Landfilling (L0906)	Lecture	2	2
Contaminated Sites and Landfilling (L0907)	Recitation Section (large)	1	2
Geochemical Engineering (L0904)	Lecture	2	2

Module Responsible	Dr. Marco Ritzkowski
Admission Requirements	None
Recommended Previous Knowledge	Module: General and Inorganic Chemistry, Module:Organic Chemistry, Biology (Basic Knowledge)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	With the completion of this module students acquire profound knowledge of biogeochemical processes, the fate of pollutants in soil and groundwater, and techniques to deposit contaminated waste material. They are able to describe in principle the behaviour of chemicals in the environment. Students can explain and report the approach to remediate contaminated sites.
Skills	With the completion of this module students can apply the acquired theoretical knowledge to model cases of site pollution and critically assess the situation technically and conceptually. They are able to draw comparisons on different remediation strategies and techniques. Model projects can be devised and treated.
Personal Competence	
Social Competence	Students can discuss technical and scientific tasks within a seminar subject specific and interdisciplinary .
Autonomy	Students can independently exploit sources , acquire the particular knowledge of the subject and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2 hours
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0906: Contaminated Sites and Landfilling

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Marco Ritzkowski, Dr. Joachim Gerth
Language	EN
Cycle	SoSe
Content	The part Contaminated Sites gives an introduction into different scales of pollution and identifies key pollutants. Geochemical attenuation mechanisms and the role of organisms are highlighted affecting the fate of pollutants in leachate and groundwater. Techniques for site characterization and remediation are discussed including economical aspects. The part Landfilling is introduced by discussing fundamental aspects and the worldwide situation of waste management. The lecture highlights transformation processes in landfill bodies, emissions of gases and leachate, and the long-term behaviour of landfill sites with measures of aftercare.
Literature	1) **Waste Management**. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305 2) **Solid Waste Technology and Management.** Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332 3) **Natural attenuation of fuels and chlorinated solvents in the subsurface.** Todd H. Wiedemeier(Ed.), ISBN: 0471197491 Lesesaal 2: US - Umweltschutz, Signatur USH-844

Course L0907: Contaminated Sites and Landfilling	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Marco Ritzkowski, Dr. Joachim Gerth
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0904: Geochemical Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Gerth
Language	EN
Cycle	SoSe
Content	As an introduction cases are presented in which geochemical engineering was used to solve environmental problems. Environmentally important minerals are discussed and methods for their detection. It is demonstrated how solution equilibria can be modified to eliminate elevated concentrations of unwanted species in solution and how carbon dioxide concentration affects pH and the dissolution of carbonate minerals. Modifications of redox conditions, pH, and electrolyte concentration are shown to be effective tools for controlling the mobility and fate of hazardous species in the environment.
Literature	**Geochemistry, groundwater and pollution.** C. A. J. Appelo; D. Postma Leiden [u.a.] Balkema 2005 Lehrbuchsammlung der TUB, Signatur GWC-515

Module M0870: Management of Surface Water

Courses

Title	Typ	Hrs/wk	CP
Modelling of Flow in Rivers and Estuaries (L0810)	Lecture	3	4
Nature-Oriented Hydraulic Engineering / Integrated Flood Protection (L0961)	Project-/problem-based Learning	2	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Hydromechanics, Hydraulics, Hydrology and Hydraulic Engineering; Hydraulic Engineering I and Hydraulic Engineering II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to define in detail the basic processes that are related to the modelling of flows in hydraulic engineering. Besides, they can describe the basic aspects of numerical modelling and actual numerical models for the simulation of flows and waves. They can also depict the concepts of nature oriented hydraulic engineering.
Skills	Students are able to apply hydrodynamic-numerical models to practical hydraulic engineering tasks. Furthermore, the students are able to set up flood-risk management concepts and are able to apply basic concepts of renaturation to practical problems.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems of the practical nature-based hydraulic engineering. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 150 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0810: Modelling of Flow in Rivers and Estuaries	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Dr. Edgar Nehlsen, Prof. Peter Fröhle
Language	EN
Cycle	SoSe
Content	Introduction to numerical flow modelling • Processes affecting tht flow • Examples and applications of numerical models • Procedure of numerical modelling • Model concept Basic equations of hydrodynamics • Saint-Venant equations • Euler Equations • Navier-Stokes equations • Reynolds-averaged Navier-Stokes equations • Shallow water equations Solving schemes • Numerical discretization • Solution algorithms • Convergence
Literature	Vorlesungsskript Literaturempfehlungen Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt). Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019a): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 1: Geodaten in der Fließgewässermodellierung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-1). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019b): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 2: Bedarfsgerechte Datenerfassung und -aufbereitung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-2). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019c): Merkblatt DWA-M 543-3 Geodaten in der Fließgewässermodellierung - Teil 3: Aspekte der Strömungsmodellierung und Fallbeispiele. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-3). Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html. IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92. Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology. Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83). van Waveren, Harold (1999-): Good modelling practice handbook. [Utrecht], Lelystad, Den Haag: STOWA; Rijkswaterstaat-RIZA; SDU, afd. SEO/RIZA [etc. distr.] (Nota, nr. 99.036). Zielke, Werner (Hg.) (1999): Numerische Modelle von Flüssen, Seen und Küstengewässern. Deutscher Verband für Wasserwirtschaft und Kulturbau. Bonn: Wirtschafts- und Verl.-Ges. Gas und Wasser (Schriftenreihe des Deutschen Verbandes für Wasserwirtschaft und Kulturbau, 127).

Course L0961: Nature-Oriented Hydraulic Engineering / Integrated Flood Protection	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Natasa Manojlovic, Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Regime-Theory and application for the development of environmental guiding priciples of rivers • Engineering - biological measures for the stabilization of rivers • Risk management in flood protection • Design techniques in technical flood protection • Methods for the assessment of flood caused damages
Literature	Vorlesungsumdruck

Module M0871: Hydrological Systems

Courses

Title	Typ	Hrs/wk	CP
Applied Surface Hydrology (L0289)	Lecture	2	2
Applied Surface Hydrology (L1412)	Project-/problem-based Learning	1	2
Interaction Water - Environment in Fluvial Areas (L0295)	Project-/problem-based Learning	1	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Hydromechanics and Hydraulic Engineering: Hydraulic Engineering I and Hydraulic Engineering II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define the basic concepts of hydrology and water management. They are able to describe and quantify the relevant processes of the hydrological water cycle. Besides, the students know the main aspects of rainfall-run-off-models and are able to theoretically derive established reservoir / storage models and a unit-hydrograph.
Skills	The students are able to use the basic hydrological concepts and approaches and are able to theoretically derive established reservoir / storage models or a unit-hydrograph as the basis for rainfall-run-off-models. The student are able to explain the basic concepts of measurements of hydrological and hydrodynamic values in nature and are able to perform, analyze and statistically assess these measurements. Furthermore, they are able to apply a hydrological model to basic hydrological problems.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems of the hydrology and water management. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 90 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0289: Applied Surface Hydrology

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	Basics of hydrology: • Hydrological cycle • Data acquisition • Data analyses and statistical assessment • Statistics of extremes • Regionalization methods for hydrological values • Rainfall-run-off modelling on the basis of a unit hydrograph conceps • Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool.
Literature	http://de.wikipedia.org/wiki/Kalypso_(Software) http://kalypso.bjoernsen.de/ http://sourceforge.net/projects/kalypso/

Course L1412: Applied Surface Hydrology	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0295: Interaction Water - Environment in Fluvial Areas	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	A problem based learning course. The problem will be solved by the students more or less self-contained. The topics will be introduced and elaborated over the semester.
Literature	-

Module M0874: Wastewater Systems

Courses

Title	Typ	Hrs/wk	CP
Wastewater Systems - Collection, Treatment and Reuse (L0934)	Lecture	2	2
Wastewater Systems - Collection, Treatment and Reuse (L0943)	Recitation Section (large)	1	1
Advanced Wastewater Treatment (L0357)	Lecture	2	2
Advanced Wastewater Treatment (L0358)	Recitation Section (large)	1	1

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of wastewater management and the key processes involved in wastewater treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to outline key areas of the full range of treatment systems in waste water management, as well as their mutual dependence for sustainable water protection. They can describe relevant economic, environmental and social factors.
Skills	Students are able to pre-design and explain the available wastewater treatment processes and the scope of their application in municipal and for some industrial treatment plants.
Personal Competence	
Social Competence	Social skills are not targeted in this module.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0934: Wastewater Systems - Collection, Treatment and Reuse

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	•Understanding the global situation with water and wastewater •Regional planning and decentralised systems •Overview on innovative approaches •In depth knowledge on advanced wastewater treatment options for different situations, for end-of-pipe and reuse •Mathematical Modelling of Nitrogen Removal •Exercises with calculations and design
Literature	Henze, Mogens: Wastewater Treatment: Biological and Chemical Processes, Springer 2002, 430 pages George Tchobanoglous, Franklin L. Burton, H. David Stensel: Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy McGraw-Hill, 2004 - 1819 pages

Course L0943: Wastewater Systems - Collection, Treatment and Reuse	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0357: Advanced Wastewater Treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Survey on advanced wastewater treatment reuse of reclaimed municipal wastewater Precipitation Flocculation Depth filtration Membrane Processes Activated carbon adsorption Ozonation "Advanced Oxidation Processes" Disinfection
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Course L0358: Advanced Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Aggregate organic compounds (sum parameters) Industrial wastewater Processes for industrial wastewater treatment Precipitation Flocculation Activated carbon adsorption Recalcitrant organic compounds
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Module M0875: Nexus Engineering - Water, Soil, Food and Energy

Courses

Title	Typ	Hrs/wk	CP
Ecological Town Design - Water, Energy, Soil and Food Nexus (L1229)	Seminar	2	2
Water & Wastewater Systems in a Global Context (L0939)	Lecture	2	4

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of the global situation with rising poverty, soil degradation, migration to cities, lack of water resources and sanitation
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe the facets of the global water situation. Students can judge the enormous potential of the implementation of synergistic systems in Water, Soil, Food and Energy supply.
Skills	Students are able to design ecological settlements for different geographic and socio-economic conditions for the main climates around the world.
Personal Competence	
Social Competence	The students are able to develop a specific topic in a team and to work out milestones according to a given plan.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information can be found at the beginning of the smester in the StudIP course module handbook.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L1229: Ecological Town Design - Water, Energy, Soil and Food Nexus	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	• Participants Workshop: Design of the most attractive productive Town • Keynote lecture and video • The limits of Urbanization / Green Cities • The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities • Global Ecovillage Network: Upsides and Downsides around the World • Visit of an Ecovillage • Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competion • TUHH Rural Development Toolbox • Integrated New Town Development • Participants workshop: Design of New Towns: Northern, Arid and Tropical cases • Outreach: Participants campaign • City with the Rural: Resilience, quality of live and productive biodiversity
Literature	• Ralf Otterpohl 2013: Gründer-Gruppen als Lebensentwurf: "Synergistische Wertschöpfung in erweiterten Kleinstadt- und Dorfstrukturen", in „Regionales Zukunftsmanagement Band 7: Existenzgründung unter regionalökonomischer Perspektive, Pabst Publisher, Lengerich • http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation) • TEDx New Town Ralf Otterpohl: http://youtu.be/_M0J2u9BrbU

Course L0939: Water & Wastewater Systems in a Global Context	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	• Keynote lecture and video • Water & Soil: Water availability as a consequence of healthy soils • Water and it’s utilization, Integrated Urban Water Management • Water & Energy, lecture and panel discussion pro and con for a specific big dam project • Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation • Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches • Why are there excreta in water? Public Health, Awareness Campaigns • Rehearsal session, Q&A
Literature	• Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press • Liu, John D.: http://eempc.org/hope-in-a-changing_climate/ (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda) • http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)

Module M0922: City Planning

Courses

Title	Typ	Hrs/wk	CP
City Planning (L1066)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	for "Principles of Urban Planning": none for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • use technical terms of urban planning. • describe the main determinants of urban development. • explain and compare different possibilities of how urban development can be influenced. • discuss requirements for public streetscapes. • explain the importance of street design.
Skills	Students are able to: • read and analyze urban development concepts and designs for streetscapes • appraise such concepts in the context of competing requirements. • design, justify and reflect their own solutions for concrete examples.
Personal Competence	
Social Competence	Students are able to: • discuss intermediate results with each other. • constructively accept feedback on their own work. • provide constructive feedback to others.
Autonomy	Students are able to: • independently complete a written report including drawings following a broadly pre-defined process. • assess the consequences of their proposed solutions. • independently acquire knowledge and apply this to new issues or problem areas.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment, designwork during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1066: City Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz
Language	DE
Cycle	SoSe
Content	„Principles of Urban Planning“ deals with the determinants of urban development and their interactions. Topics include: • legal framework, • instruments and methods of planning, • functional requirements, • stakeholders and actors • basic design requirements • different planning levels and • historical contexts. The objective of the course is for students to acquire a basic understanding of urban development problems and approaches for solving them. They will also be able to comprehend the process of urban planning. The course also covers the various functional and aesthetic requirements for designing streetscape as the most important elements of public space. The project work deals with a real life scenario and includes drawing up a development plan, an urban design concept, a building masterplan and a street redesign.
Literature	Albers, Gerd; Wekel, Julian (2009) Stadtplanung: Eine illustrierte Einführung. Primus Verlag. Darmstadt. Frick, Dieter (2008) Theorie des Städtebaus: Zur baulich-räumlichen Organisation von Stadt. Wasmuth-Verlag. Tübingen Jonas, Carsten (2009) Die Stadt und ihr Grundriss. Wasmuth-Verlag. Tübingen Kostof, Spiro; Castillo, Greg (1998) Die Anatomie der Stadt. Geschichte städtischer Strukturen. Campus-Verlag. Frankfurt/New York.

Module M0663: Marine Geotechnics

Courses

Title	Typ	Hrs/wk	CP
Marine Geotechnics (L0548)	Lecture	1	2
Marine Geotechnics (L0549)	Recitation Section (large)	2	2
Steel Structures in Foundation and Hydraulic Engineering (L1146)	Lecture	2	2

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	complete modules: Geotechnics I-III, Mathematics I-III courses: Soil laboratory course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0548: Marine Geotechnics

Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	• Geotechnical investigation an description of the seabed • Foundations of Offshore-Constructions • cCliff erosion • Sea dikes • Port structures • Flood protection structures
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London • Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst & Sohn, Berlin

Course L0549: Marine Geotechnics

Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1146: Steel Structures in Foundation and Hydraulic Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Frank Feindt
Language	DE
Cycle	SoSe
Content	Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue
Literature	EAU 2012, EA-Pfähle, EAB

Module M1724: Smart Monitoring

Courses

Title	Typ	Hrs/wk	CP
Smart Monitoring (L2762)	Integrated Lecture	2	2
Smart Monitoring (L2763)	Recitation Section (small)	2	4

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpful. Interest in modern research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deepen skills of scientific working, are required. Basic knowledge in scientific writing and good English skills.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	The students will become familiar with the principles and practices of smart monitoring. The students will be able to design decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built and in the natural environment. In addition, the students will learn to design and to implement intelligent sensor systems using state-of-the-art data analysis techniques, modern software design concepts, and embedded computing methodologies. Besides lectures, project work is also part of this module. In small groups, the students will design smart monitoring systems that integrate a number of “intelligent” sensors to be implemented by the students. Specific focus will be put on the application of machine learning techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as bridges or slopes, or on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper. All students of this module will “automatically” participate with their smart monitoring system in the annual "Smart Monitoring" competition. The written papers and oral examinations form the final grades. The module will be taught in English. Limited enrollment.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Environmental Engineering: Specialisation Biotechnology: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Environmental Engineering: Specialisation Biotechnology: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2762: Smart Monitoring	
Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	WiSe/SoSe
Content	In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment.
Literature	

Course L2763: Smart Monitoring	
Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	WiSe/SoSe
Content	The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the “Smart Monitoring” competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature.
Literature	

Module M1123: Selected Topics in Environmental Engineering

Courses

Title	Typ	Hrs/wk	CP
Environmental Aquatic Chemistry (L1444)	Lecture	2	3
Excellence in International Project Delivery (L2387)	Integrated Lecture	2	2
Sludge Treatment (L0520)	Lecture	2	3
Thermal Biomass Utilization (L1767)	Lecture	2	2
Thermal Biomass Utilization (L2386)	Practical Course	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L1444: Environmental Aquatic Chemistry

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Klaus Johannsen
Language	EN
Cycle	SoSe
Content	• Concentration and activity • Gas-water partitioning • Acid/base equilibria • Alkalinity and acidity • Precipitation/dissolution equilibria • Redox equilibria • Complex formation • Sorption
Literature	Worch, E.: Hydrochemistry. Basic Concepts and Exercises. De Gruyter, Berlin, 2015

Course L2387: Excellence in International Project Delivery

Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	2 h
Lecturer	Dr. Jens Huckfeldt
Language	EN
Cycle	SoSe
Content	**Simply and easy to avoid mistake in project delivery can deliver projects within budget and as per schedule.You have to attend if you see yourself in project execution and potentially even abroad.**
Literature	

Course L0520: Sludge Treatment	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Sedimentation characteristic and thickening, Centrifugation, Flotation, Filtration, Aerobic sludge stabilisation, Sludge Digestion, Sludge Disintegration, Sludge Dewatering, Natural Processes for Sludge Treatment, Nutrient Recovery from Sludge, Thermal Processes and Incineration.
Literature	**Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes** Sludge Treatment and Disposal ISBN 9781843391661 IWA Publishing, 2007

Course L1767: Thermal Biomass Utilization	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	WiSe
Content	Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmental basics of all options to provide energy from biomass from a German and international point of view. Additionally different system approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and economic development potentials, and the current and expected future use within the energy system are presented. The course is structured as follows: • Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course • Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste • Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying • Thermo-chemical conversion of solid biofuels ◦ Basics of thermo-chemical conversion ◦ Direct thermo-chemical conversion through combustion: combustion technologies for small and large scale units, electricity generation technologies, flue gas treatment technologies, ashes and their use ◦ Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels ◦ Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for the provision of charcoal, oil cleaning technologies, options to use the pyrolysis oil and charcoal as an energy carrier as well as a raw material • Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil seeds and oil fruits, vegetable oil production, production of a biofuel with standardized characteristics (trans-esterification, hydrogenation, co-processing in existing refineries), options to use this fuel, options to use the residues (i.e. meal, glycerine) • Bio-chemical conversion of biomass ◦ Basics of bio-chemical conversion ◦ Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic waste fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry ◦ Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage
Literature	**Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage**

Course L2386: Thermal Biomass Utilization	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	Protokolle
Lecturer	Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger
Language	DE
Cycle	WiSe
Content	The experiments of the practical lab course illustrate the different aspects of heat generation from biogenic solid fuels. First, different biomasses (e.g. wood, straw or agricultural residues) will be investigated; the focus will be on the calorific value of the biomass. Furthermore, the used biomass will be pelletized, the pellet properties analysed and a combustion test carried out on a pellet combustion system. The gaseous and solid pollutant emissions, especially the particulate matter emissions, are measured and the composition of the particulate matter is investigated in a further experiment. Another focus of the practical course is the consideration of options for the reduction of particulate matter emissions from biomass combustion. In the practical course, a method for particulate matter reduction will be developed and tested. All experiments will be evaluated and the results presented. Within the practical lab course the students discuss different technical-scientific tasks, both subject-specifically and interdisciplinary. They discuss various approaches to solving the problem and advise on the theoretical or practical implementation.
Literature	- Kaltschmitt, Martin; Hartmann, Hans; Hofbauer, Hermann: Energie aus Biomasse: Grundlagen, Techniken und Verfahren. 3. Auflage. Berlin Heidelberg: Springer Science & Business Media, 2016. -ISBN 978-3-662-47437-2 - Versuchsskript

Module M0620: Special Aspects of Waste Resource Management

Courses

Title	Typ	Hrs/wk	CP
Advanced Topics in Waste Resource Management (L1055)	Project-/problem-based Learning	3	3
International Waste Management (L0317)	Project-/problem-based Learning	2	3

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	basics in waste treatment technologies
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe waste as a resource as well as advanced technologies for recycling and recovery of resources from waste in detail. This covers collection, transport, treatment and disposal in national and international contexts.
Skills	Students are able to select suitable processes for the treatment with respect to the national or cultural and developmental context. They can evaluate the ecological impact and the technical effort of different technologies and management systems.
Personal Competence	
Social Competence	Students can work together as a team of 2-5 persons, participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development of colleagues. Furthermore, they can give and accept professional constructive criticisms.
Autonomy	Students can independently gain additional knowledge of the subject area and apply it in solving the given course tasks and projects.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	Compulsory: Yes; Bonus: 20 %; Form: Written elaboration; Description:
Examination	Presentation
Examination duration and scale	PowerPoint presentation (10-15 minutes)
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L1055: Advanced Topics in Waste Resource Management

Typ	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Rüdiger Siechau
Language	EN
Cycle	WiSe
Content	Focus of the course "Advanced topics of waste resource management" lies on the organisational structures in waste management - such as planning, financing and logistics. One excursion will be offered to take part in (incineration plant, vehicle fleet and waste collection systems). The course is split into two parts: 1. part: “Conventional” lecture (development of waste management, legislation, collection, transportation and organisation of waste management, costs, fees and revenues). 2. part: Project base learning: You will get a project to work out in groups of 4 to 6 students; all tools and data you need to work out the project were given before during the conventional lecture. Course documents are published in StudIP and communication during project work takes place via StudIP. The results of the project work are presented at the end of the semester. The final mark for the course consists of the grade for the presentation.
Literature	Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010 PowerPoint slides in Stud IP

Course L0317: International Waste Management	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	Waste avoidance and recycling are the focus of this lecture. Additionally, waste logistics (Collection, transport, export, fees and taxes) as well as international waste shipment solutions are presented. Other specific wastes, e.g. industrial waste, treatment concepts will be presented and developed by students themselves Waste composition and production on international level, wast eulogistic, collection and treatment in emerging and developing countries. Single national projects and studies will be prepared and presented by students
Literature	Basel convention

Module M0801: Water Resources and -Supply

Courses

Title	Typ	Hrs/wk	CP
Chemistry of Drinking Water Treatment (L0311)	Lecture	2	1
Chemistry of Drinking Water Treatment (L0312)	Recitation Section (large)	1	2
Water Resource Management (L0402)	Lecture	2	2
Water Resource Management (L0403)	Recitation Section (small)	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of water management and the key processes involved in water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.
Skills	Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.
Personal Competence	
Social Competence	Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.
Autonomy	Students will be in a position to work on a subject independently and present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (chemistry) + presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0311: Chemistry of Drinking Water Treatment	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	The topic of this course is water chemistry with respect to drinking water treatment and water distribution Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards). Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework. Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course " Water resources management" in the beginning of the semester.
Literature	**MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004. **Jensen, J. N.**: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003.

Course L0312: Chemistry of Drinking Water Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0402: Water Resource Management	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview: • Current situation of global water resources - User and Stakeholder conflicts - Wasserressourcenmanagement in urbane Gebieten - Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen. - Ökobilanzierung, Benchmarking in der Wasserversorgung
Literature	• Aktuelle UN World Water Development Reports • Branchenbild der deutschen Wasserwirtschaft, VKU (2011) • Aktuelle Artikel wissenschaftlicher Zeitschriften • Ppt der Vorlesung

Course L0403: Water Resource Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0802: Membrane Technology

Courses

Title	Typ	Hrs/wk	CP
Membrane Technology (L0399)	Lecture	2	3
Membrane Technology (L0400)	Recitation Section (small)	1	2
Membrane Technology (L0401)	Practical Course	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of water chemistry. Knowledge of the core processes involved in water, gas and steam treatment
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to rank the technical applications of industrially important membrane processes. They will be able to explain the different driving forces behind existing membrane separation processes. Students will be able to name materials used in membrane filtration and their advantages and disadvantages. Students will be able to explain the key differences in the use of membranes in water, other liquid media, gases and in liquid/gas mixtures.
Skills	Students will be able to prepare mathematical equations for material transport in porous and solution-diffusion membranes and calculate key parameters in the membrane separation process. They will be able to handle technical membrane processes using available boundary data and provide recommendations for the sequence of different treatment processes. Through their own experiments, students will be able to classify the separation efficiency, filtration characteristics and application of different membrane materials. Students will be able to characterise the formation of the fouling layer in different waters and apply technical measures to control this.
Personal Competence	
Social Competence	Students will be able to work in diverse teams on tasks in the field of membrane technology. They will be able to make decisions within their group on laboratory experiments to be undertaken jointly and present these to others.
Autonomy	Students will be in a position to solve homework on the topic of membrane technology independently. They will be capable of finding creative solutions to technical questions.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0399: Membrane Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	The lecture on membrane technology supply provides students with a broad understanding of existing membrane treatment processes, encompassing pressure driven membrane processes, membrane application in electrodialyis, pervaporation as well as membrane distillation. The lectures main focus is the industrial production of drinking water like particle separation or desalination; however gas separation processes as well as specific wastewater oriented applications such as membrane bioreactor systems will be discussed as well. Initially, basics in low pressure and high pressure membrane applications are presented (microfiltration, ultrafiltration, nanofiltration, reverse osmosis). Students learn about essential water quality parameter, transport equations and key parameter for pore membrane as well as solution diffusion membrane systems. The lecture sets a specific focus on fouling and scaling issues and provides knowledge on methods how to tackle with these phenomena in real water treatment application. A further part of the lecture deals with the character and manufacturing of different membrane materials and the characterization of membrane material by simple methods and advanced analysis. The functions, advantages and drawbacks of different membrane housings and modules are explained. Students learn how an industrial membrane application is designed in the succession of treatment steps like pre-treatment, water conditioning, membrane integration and post-treatment of water. Besides theory, the students will be provided with knowledge on membrane demo-site examples and insights in industrial practice.
Literature	• T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage), Springer-Verlag, Berlin 2004. • Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands • Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley & Sons, Ltd., 2004

Course L0400: Membrane Technology	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0401: Membrane Technology	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0822: Process Modeling in Water Technology

Courses

Title	Typ	Hrs/wk	CP
Process Modelling of Wastewater Treatment (L0522)	Project-/problem-based Learning	2	3
Process Modeling in Drinking Water Treatment (L0314)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of the most important processes in drinking water and waste water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to explain selected processes of drinking water and waste water treatment in detail. They are able to explain basics as well as possibilities and limitations of dynamic modeling.
Skills	Students are able to use the most important features Modelica offers. They are able to transpose selected processes in drinking water and waste water treatment into a mathematical model in Modelica with respect to equilibrium, kinetics and mass balances. They are able to set up and apply models and assess their possibilities and limitations.
Personal Competence	
Social Competence	Students are able to solve problems and document solutions in a group with members of different technical background. They are able to give appropriate feedback and can work constructively with feedback concerning their work.
Autonomy	Students are able to define a problem, gain the required knowledge and set up a model.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0522: Process Modelling of Wastewater Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	WiSe
Content	Mass and energy balances Tracer modelling Activated Sludge Model Wastewater Treatment Plant Modelling (continously and SBR) Sludge Treatment (ADM, aerobic autothermal) Biofilm Modelling
Literature	**Henze, Mogens** (Seminar on Activated Sludge Modelling, ; Kollekolle Seminar on Activated Sludge Modelling, ;) Activated sludge modelling : processes in theory and practice ; selected proceedings of the 5th Kollekolle Seminar on Activated Sludge Modelling, held in Kollekolle, Denmark, 10 - 12 September 2001 ISBN: 1843394146 [London] : IWA Publ., 2002 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 TUB_HH_Katalog

Course L0314: Process Modeling in Drinking Water Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE/EN
Cycle	WiSe
Content	In this course selected drinking water treatment processes (e.g. aeration or activated carbon adsorption) are modeled dynamically using the programming language Modelica, that is increasingly used in industry. In this course OpenModelica is used, an free access frontend of the programming language Modelica. In the beginning of the course the use of OpenModelica is explainded by means of simple examples. Together required elements and structure of the model are developed. The implementation in OpenModelica and the application of the model is done individually or in groups respectively. Students get feedback and can gain extra points for the exam.
Literature	**OpenModelica:** https://openmodelica.org/index.php/download/download-windows **OpenModelica - Modelica Tutorial:** https://openmodelica.org/index.php/useresresources/userdocumentation **OpenModelica - Users Guide:** https://openmodelica.org/index.php/useresresources/userdocumentation **Peter Fritzson:** Principles of Object-Oriented Modeling and Simulation with Modelica 2.1,Wiley-IEEE Press, ISBN 0-471-471631. **MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.

Module M0923: Integrated Transportation Planning

Courses

Title	Typ	Hrs/wk	CP
Integrated Transportation Planning (L1068)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineerin
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe interdependencies between land-use/location choice and transportation/mobility behaviour • explain and evaluate the social, ecological and economic effects of transport and land-use policy measures. • relate current issues in the area of integrated transport planning and formulate an opinion on them.
Skills	Students are able to: • quantify important parameters, which influence travel demand or are influenced by it. • comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document the results in accordance with scientific conventions.
Personal Competence	
Social Competence	Students are able to: • provide feedback on topical contents and their teaching. • constructively handle feedback on their own work. • produce results in group work and document these.
Autonomy	Students are able to: • assess potential consequences of their future professional activities • independently plan working on a pre-defined project topic, acquire the necessary knowledge and use appropriate means for its execution.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment with presentation during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1068: Integrated Transportation Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz, Dr. Philine Gaffron, Jacqueline Bianca Maaß
Language	DE
Cycle	WiSe
Content	The course will provide students with an understanding of interdependencies between land-use and transportation. Specific topics include a.o.: • interactions between transport and the environment and consequent limitations • characteristics of integrated planning • complex planning processes • interdependencies of location choice and mobility behaviour • transport and land-use policies • project on current issues in transportation studies
Literature	Kutter, Eckhard (2005) Entwicklung innovativer Verkehrsstrategien für die mobile Gesellschaft. Erich Schmidt Verlag. Berlin. Bracher, Tilman u. a. (Hrsg.) (68. Ergänzung 2013) Handbuch der kommunalen Verkehrsplanung. Herbert Wichmann Verlag. Berlin, Offenbach. (Loseblattsammlung mit kontinuierlichen Ergänzungen)

Module M0949: Rural Development and Resources Oriented Sanitation for different Climate Zones

Courses

Title	Typ	Hrs/wk	CP
Rural Development and Resources Oriented Sanitation for different Climate Zones (L0942)	Seminar	2	3
Rural Development and Resources Oriented Sanitation for different Climate Zones (L0941)	Lecture	2	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of the global situation with rising poverty, soil degradation, lack of water resources and sanitation
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe resources oriented wastewater systems mainly based on source control in detail. They can comment on techniques designed for reuse of water, nutrients and soil conditioners. Students are able to discuss a wide range of proven approaches in Rural Development from and for many regions of the world.
Skills	Students are able to design low-tech/low-cost sanitation, rural water supply, rainwater harvesting systems, measures for the rehabilitation of top soil quality combined with food and water security. Students can consult on the basics of soil building through “Holisitc Planned Grazing” as developed by Allan Savory.
Personal Competence	
Social Competence	The students are able to develop a specific topic in a team and to work out milestones according to a given plan.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information will be provided at the beginning of the smester.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0942: Rural Development and Resources Oriented Sanitation for different Climate Zones

Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	• Central part of this module is a group work on a subtopic of the lectures. The focus of these projects will be based on an interview with a target audience, practitioners or scientists. • The group work is divided into several Milestones and Assignments. The outcome will be presented in a final presentation at the end of the semester.
Literature	• J. Lange, R. Otterpohl 2000: Abwasser - Handbuch zu einer zukunftsfähigen Abwasserwirtschaft. Mallbeton Verlag (TUHH Bibliothek) • Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download) • Schober, Sabine: WTO/TUHH Award winning Terra Preta Toilet Design: http://youtu.be/w_R09cYq6ys

Course L0941: Rural Development and Resources Oriented Sanitation for different Climate Zones	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	• Living Soil - THE key element of Rural Development • Participatory Approaches • Rainwater Harvesting • Ecological Sanitation Principles and practical examples • Permaculture Principles of Rural Development • Performance and Resilience of Organic Small Farms • Going Further: The TUHH Toolbox for Rural Development • EMAS Technologies, Low cost drinking water supply
Literature	• Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk • Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press

Module M0950: Study Work Environment

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	Dozenten des SD B
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to demonstrate their detailed knowledge in the field of Water and Environmental Engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society. The students can develop solving strategies and approaches for fundamental and practical problems in the field of Water and Environmental Engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society. Scientific work techniques that are used can be described and critically reviewed.
Skills	The students are able to independently select methods or planning approaches for the project work and to justify their choice. They can explain how these methods or approaches relate to solutions in the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.
Personal Competence	
Social Competence	The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.
Workload in Hours	Independent Study Time 180, Study Time in Lecture 0
Credit points	6
Course achievement	None
Examination	Study work
Examination duration and scale	
Assignment for the Following Curricula	Water and Environmental Engineering: Specialisation Environment: Compulsory

Module M1716: Subsurface Processes

Courses

Title	Typ	Hrs/wk	CP
Modeling of Subsurface Processes (L2730)	Lecture	2	2
Modeling of Subsurface Processes (L2731)	Recitation Section (small)	1	1
Modern Techniques for Subsurface Solute Transport (L2728)	Lecture	2	2
Modern Techniques for Subsurface Solute Transport (L2729)	Recitation Section (large)	1	1

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic Mathematics, Hydrology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Upon completion of this module, the students will understand the mechanisms controlling solute transport in soil and natural porous media and will be able to work with the equations that govern the fate and transport of solutes in porous media. Analytical, numerical and experimental tools and techniques will be used in this module.
Skills	In addition to the physical insights, the students will be exposed to analytical, experimental and numerical tools and techniques in this module. This provides them with an excellent opportunity to improve their skills on multiple fronts which will be useful in their future career.
Personal Competence	
Social Competence	Teamwork & problem solving
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Report and Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L2730: Modeling of Subsurface Processes

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Sonja Götz
Language	EN
Cycle	WiSe
Content	
Literature	

Course L2731: Modeling of Subsurface Processes

Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Sonja Götz
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L2728: Modern Techniques for Subsurface Solute Transport	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	
Literature	

Course L2729: Modern Techniques for Subsurface Solute Transport	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0619: Waste Treatment Technologies

Courses

Title	Typ	Hrs/wk	CP
Waste and Environmental Chemistry (L0328)	Practical Course	2	2
Biological Waste Treatment (L0318)	Project-/problem-based Learning	3	4

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	chemical and biological basics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The module aims possess knowledge concerning the planning of biological waste treatment plants. Students are able to explain the design and layout of anaerobic and aerobic waste treatment plants in detail, describe different techniques for waste gas treatment plants for biological waste treatment plants and explain different methods for waste analytics.
Skills	The students are able to discuss the compilation of design and layout of plants. They can critically evaluate techniques and quality control measurements. The students can recherché and evaluate literature and date connected to the tasks given in der module and plan additional tests. They are capable of reflecting and evaluating findings in the group.
Personal Competence	
Social Competence	Students can participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development in front of colleagues. Furthermore, they can give and accept professional constructive criticism.
Autonomy	Students can independently tap knowledge from literature, business or test reports and transform it to the course projects. They are capable, in consultation with supervisors as well as in the interim presentation, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description**: Yes / None / Subject theoretical and practical work
Examination	Presentation
Examination duration and scale	Elaboration and Presentation (15-25 minutes in groups)
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L0328: Waste and Environmental Chemistry	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	DE/EN
Cycle	WiSe
Content	The participants are divided into groups. Each group prepares a transcript on the experiment performed, which is then used as basis for discussing the results and to evaluate the performance of the group and the individual student. In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation. Experiments ar e.g. Screening and particle size determination Fos/Tac AAS Chalorific value
Literature	Scripte

Course L0318: Biological Waste Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	1. Introduction 2. biological basics 3. determination process specific material characterization 4. aerobic degradation (Composting, stabilization) 5. anaerobic degradation (Biogas production, fermentation) 6. Technical layout and process design 7. Flue gas treatment 8. Plant design practical phase
Literature	

Module M1720: Emerging Trends in Environmental Engineering

Courses

Title	Typ	Hrs/wk	CP
Environmental Research Trends (L2752)	Seminar	2	2
Microplastics in Environment (L2750)	Lecture	2	2
Scientific Communication and Methods (L2751)	Lecture	1	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge on water, soil and environmental research.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will be exposed to up-to-date research topics focused on soil, water and climate related challenges with a particular focus on the effects of microplastics in environment. Data analysis, data measurement, curation and presentation will be other skills that the students will develop in this module.
Skills	Students' research skills will be improved in this module. How to prepare and deliver an effective presentation, how to write an abstract, research paper and proposal will be discussed in this module. Moreover, through Research-Based Learning approaches, the students will be exposed to current research trends in environmental engineering.
Personal Competence	
Social Competence	Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Report and Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Environmental Engineering: Specialisation Biotechnology: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2752: Environmental Research Trends	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Salome Shokri-Kuehni
Language	EN
Cycle	WiSe
Content	Introduction - course objectives, expectations and format Analyzing the Audience, purpose and occasion Constructing and delivering effective technical presentations How to write an abstract How to write a scientific paper Developing competitive and persuasive research proposals Databases and resources available for water and environmental research Individual proposal on water and environmental research Individual project on water and environmental research Presentation on water and environmental research
Literature	• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9 • Supplemental materials and web links which will be available to registered students.

Course L2750: Microplastics in Environment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	- Introduction, objectives, expectations, format, importance - Sources of microplastics in environment - Microplastics sampling; Characterization of microplastics - Distribution of microplastics in terrestrial environments - Fate of microplastics in terrestrial environments - Project discussion - Effects of microplastics on terrestrial environments - Health risks of microplastics in environments - Project presentations by all students
Literature	- Microplastics in Terrestrial Environments (2021), Edited by Defu He and Yongming Luo - Particulate Plastics in Terrestrial and Aquatic Environments (2020), Edited by Nanthi S. Bolan et al. - Microplastic Pollutants (2017), by Christopher B. Crawford and Brian Quinn

Course L2751: Scientific Communication and Methods	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	Introduction - course objectives, expectations and format Analyzing the Audience, purpose and occasion Constructing and delivering effective technical presentations How to write an abstract How to create a scientific poster How to write a scientific paper Developing competitive and persuasive research proposals Individual project (report and presentation) related to soil, water and environmental research
Literature	• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9 • Supplemental materials and web links which will be available to registered students.

Module M1505: Adaptation to Climate Change in Hydraulic Engineering (AKWAS)

Courses

Title	Typ	Hrs/wk	CP
Adaptation to climate change in hydraulic engineering (L2291)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydrology, Hydraulic Engineering • Hydromechanic, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection • Hydrological Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate protection and climate adaptation • Insights into climate change and its regional characteristics - fundamentals, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle • Fundamentals of analysis of climate data • Consequences of the impact of the climate change • Measures for climate adaptation • Assessment, prioritization and communication of adaptation measures • Fundamentals of the analysis of hydrometeorological and hydrological data
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report and a presentation of a complex task.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2291: Adaptation to climate change in hydraulic engineering	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	WiSe
Content	• Climate protection and climate adaptation • Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle(climate science view) • Fundamentals of the analysis of climate data • Concequences of the impacts of climate change (ingenieering science view) • Measures for climate change adaptation • Assessment, prioritization and communication of measures • Fundamentals of analysis of hydrometeorological and hydrological data
Literature	• Bereitgestellte eLearning Plattform

Module M1779: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)

Courses

Title	Typ	Hrs/wk	CP
Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC) (L2926)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydraulic Engineering • Hydromechanics, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-based Solutions (NBS) for Coastal Protection
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working in international groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report on a complex task with a presentation and subsequent discussion. The work on the complex task happens in the course of the lecture.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2926: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe
Content	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-Based Solutions (NBS) for Coastal Protection
Literature	• Materials provided on eLearning Platform (HOOU Platform)

Specialization Water

Module M0801: Water Resources and -Supply

Courses

Title	Typ	Hrs/wk	CP
Chemistry of Drinking Water Treatment (L0311)	Lecture	2	1
Chemistry of Drinking Water Treatment (L0312)	Recitation Section (large)	1	2
Water Resource Management (L0402)	Lecture	2	2
Water Resource Management (L0403)	Recitation Section (small)	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of water management and the key processes involved in water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.
Skills	Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.
Personal Competence	
Social Competence	Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.
Autonomy	Students will be in a position to work on a subject independently and present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (chemistry) + presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0311: Chemistry of Drinking Water Treatment	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	The topic of this course is water chemistry with respect to drinking water treatment and water distribution Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards). Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework. Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course " Water resources management" in the beginning of the semester.
Literature	**MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004. **Jensen, J. N.**: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003.

Course L0312: Chemistry of Drinking Water Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0402: Water Resource Management	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview: • Current situation of global water resources - User and Stakeholder conflicts - Wasserressourcenmanagement in urbane Gebieten - Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen. - Ökobilanzierung, Benchmarking in der Wasserversorgung
Literature	• Aktuelle UN World Water Development Reports • Branchenbild der deutschen Wasserwirtschaft, VKU (2011) • Aktuelle Artikel wissenschaftlicher Zeitschriften • Ppt der Vorlesung

Course L0403: Water Resource Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1716: Subsurface Processes

Courses

Title	Typ	Hrs/wk	CP
Modeling of Subsurface Processes (L2730)	Lecture	2	2
Modeling of Subsurface Processes (L2731)	Recitation Section (small)	1	1
Modern Techniques for Subsurface Solute Transport (L2728)	Lecture	2	2
Modern Techniques for Subsurface Solute Transport (L2729)	Recitation Section (large)	1	1

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L2730: Modeling of Subsurface Processes

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Sonja Götz
Language	EN
Cycle	WiSe
Content	
Literature	

Course L2731: Modeling of Subsurface Processes

Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Sonja Götz
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L2728: Modern Techniques for Subsurface Solute Transport	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	
Literature	

Course L2729: Modern Techniques for Subsurface Solute Transport	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1403: Construction and Simulation of Sewerage Systems

Courses

Title	Typ	Hrs/wk	CP
Construction and renovation of urban sewer systems (L1998)	Seminar	3	3
Simulation of sewerage systems (L2006)	Seminar	3	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	• Hydraulics in pipes and gravity-sewers • Mechanics • Soil mechanics and foundation engineering • Knowledge about urban sewerage systems and water management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe urban wastewater systems by means of software-based modeling. In case studies they can perform system and weak point analyzes. In addition, they can analyze the hydraulic effects quantitatively. Furthermore, they have the knowledge to comprehend flow events in gravity-sewers based on the St. Venant equations. Students have knowledge of static and structural requirements of the sewer system. Cases of damage are investigated and the knowledge regarding different renovation technologies for sewer systems is acquired.
Skills	The students can simulate different run-off events in sewer systems and are able to dimension the sewer systems accordingly. Moreover, they can determine suitable construction materials and static requirements for different cases of application.
Personal Competence	
Social Competence	Students are able to apply the acquired skills in a team and can impart this knowledge.
Autonomy	Students can solve problems in the field of wastewater systems independently, concerning in particular dimensioning and simulation of sewer systems. Furthermore, they are able to present and justify their solutions.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	Compulsory: No; Bonus: 20 %; Form: Presentation; Description:
Examination	Written elaboration
Examination duration and scale	nach Absprache
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L1998: Construction and renovation of urban sewer systems	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ingo Weidlich
Language	EN
Cycle	WiSe
Content	The lecture focusses on construction and renovation of urban sewer pipelines. Construction: • Pipe materials, types and joint technology • Open trenches • Trenchless technologies Pipe Statics: • Design of sewers according to ATV A 127 • Earth pressure on pipes, pipe deformation, cutting forces • Comparison with other international calculation approaches Renovation: • Failure case study • Overview on the different renovation technologies • Liner design according to DWA-A 143

Literature	Nr.	Titel
	1	ATV A 127, Abwassertechnische Vereinigung e.V., Arbeitsblatt A 127, Regelwerk Abwasser-Abfall, Vertrieb: GFA, DK 628.22 (083),A 127, 2000
	2	DIN EN 1610, Verlegung und Prüfung von Abwasserleitungen und -kanälen, Beuth Verlag, Berlin, 1997
	3	Arbeitsblatt DWA-A 143-1, Sanierung von Entwässerungssystemen außerhalb von Gebäuden, Teil 1: Planung und Überwachung von Sanierungsmaßnahmen Februar 2015
	4	Arbeitsblatt DWA-A 143-2, Sanierung von Entwässerungssystemen außerhalb von Gebäuden Teil 2: Statische Berechnung zur Sanierung von Abwasserleitungen und -kanälen mit Lining und Montageverfahren, Juli 2015
	5	DIN EN 752:2008, 2008: Entwässerungssysteme außerhalb von Gebäuden - Kanalmanagement.
	6	Zeitschrift 3R, Fachzeitschrift für sichere und effiziente Rohrleitungssysteme
	7	Handbuch für den Rohrleitungsbau Band 1 und 2, 4. Auflage, Günter Wossog, 2015
	8	Rohrleitungstechnik, Walter Wagner, Vogel Buchverlag, 2006
	9	Stein D., Stein R., „Instandhaltung von Kanalisationen“, 1008 S., ISBN 978-3-9810648-4-1 | Verlag Prof. Dr.-Ing. Stein & Partner GmbH, 2014
	10	Stein, D., „Grabenloser Leitungsbau“, 1. Auflage, Gebundene Ausgabe - 1166 Seiten, Ernst & Sohn Verlag, 2003, ISBN: 3433017786
	11	Willoughby D:A: „Horizontal Directional Drilling: Utility and Pipeline Applications” Digital Engineering Library @ McGraw-Hill - The McGraw-Hill Companies, Inc., 2005
	12	Weidlich I., „Erddruck auf Rohre“, 1. Auflage, ISBN 3-89999-027-7, 227 Seiten, 2012

Course L2006: Simulation of sewerage systems	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	Modeling of sewer systems: • Modeling approaches in wastewater management, especially approaches to integrated modeling • Planning processes, calculations and design approaches for elements of gravity-sewers • Model setup • St. Venant equation and simplifications of models (kinematic wave etc.) • Calculation & modeling of solids transport (advection, diffusion, dispersion and sales processes) • Examples for modeling with SWMM (EPA, USA)
Literature	

Module M0513: System Aspects of Renewable Energies

Courses

Title	Typ	Hrs/wk	CP
Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021)	Lecture	2	2
Energy Trading (L0019)	Lecture	1	1
Energy Trading (L0020)	Recitation Section (small)	1	1
Deep Geothermal Energy (L0025)	Lecture	2	2

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	None
Recommended Previous Knowledge	Module: Technical Thermodynamics I Module: Technical Thermodynamics II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to describe the processes in energy trading and the design of energy markets and can critically evaluate them in relation to current subject specific problems. Furthermore, they are able to explain the basics of thermodynamics of electrochemical energy conversion in fuel cells and can establish and explain the relationship to different types of fuel cells and their respective structure. Students can compare this technology with other energy storage options. In addition, students can give an overview of the procedure and the energetic involvement of deep geothermal energy.
Skills	Students can apply the learned knowledge of storage systems for excessive energy to explain for various energy systems different approaches to ensure a secure energy supply. In particular, they can plan and calculate domestic, commercial and industrial heating equipment using energy storage systems in an energy-efficient way and can assess them in relation to complex power systems. In this context, students can assess the potential and limits of geothermal power plants and explain their operating mode. Furthermore, the students are able to explain the procedures and strategies for marketing of energy and apply it in the context of other modules on renewable energy projects. In this context they can unassistedly carry out analysis and evaluations of energie markets and energy trades.
Personal Competence	
Social Competence	Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module.
Autonomy	Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	3 hours written exam
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Fröba
Language	DE
Cycle	SoSe

Content	1. Introduction to electrochemical energy conversion
	2. Function and structure of electrolyte
	3. Low-temperature fuel cell
	  ◦ Types
	  ◦ Thermodynamics of the PEM fuel cell
	  ◦ Cooling and humidification strategy
	4. High-temperature fuel cell
	  ◦ The MCFC
	  ◦ The SOFC
	  ◦ Integration Strategies and partial reforming
	5. Fuels
	  ◦ Supply of fuel
	  ◦ Reforming of natural gas and biogas
	  ◦ Reforming of liquid hydrocarbons
	6. Energetic Integration and control of fuel cell systems

Literature	• Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003

Course L0019: Energy Trading	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Michael Sagorje, Dr. Sven Orlowski
Language	DE
Cycle	SoSe
Content	• Basic concepts and tradable products in energy markets • Primary energy markets • Electricity Markets • European Emissions Trading Scheme • Influence of renewable energy • Real options • Risk management Within the exercise the various tasks are actively discussed and applied to various cases of application.
Literature	

Course L0020: Energy Trading	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Michael Sagorje, Dr. Sven Orlowski
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0025: Deep Geothermal Energy	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Ben Norden
Language	DE
Cycle	SoSe
Content	1. Introduction to the deep geothermal use 2. Geological Basics I 3. Geological Basics II 4. Geology and thermal aspects 5. Rock Physical Aspects 6. Geochemical aspects 7. Exploration of deep geothermal reservoirs 8. Drilling technologies, piping and expansion 9. Borehole Geophysics 10. Underground system characterization and reservoir engineering 11. Microbiology and Upper-day system components 12. Adapted investment concepts, cost and environmental aspect
Literature	• Dipippo, R.: Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact. Butterworth Heinemann; 3rd revised edition. (29. Mai 2012) • www.geo-energy.org • Edenhofer et al. (eds): Renewable Energy Sources and Climate Change Mitigation; Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2012. • Kaltschmitt et al. (eds): Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer, 5. Aufl. 2013. • Kaltschmitt et al. (eds): Energie aus Erdwärme. Spektrum Akademischer Verlag; Auflage: 1999 (3. September 2001) • Huenges, E. (ed.): Geothermal Energy Systems: Exploration, Development, and Utilization. Wiley-VCH Verlag GmbH & Co. KGaA; Auflage: 1. Auflage (19. April 2010)

Module M0827: Modeling in Water Management

Courses

Title	Typ	Hrs/wk	CP
Groundwater Modeling using Modflow (L0543)	Lecture	1	1
Groundwater Modeling using Modflow (L0544)	Recitation Section (small)	2	2
Modeling of Water Supply and Sewer Network (L0875)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Groundwater • groundwater hydraulics and transport of substances Pipe Systems • Knowledge on urban water infrastructures, in particular drinking water systemsand urban drainage systems including special structures • Hydraulics of drinking water supply systems and sewer systems • Basic knowledge on water management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.
Skills	The students are able to construct and apply scientific groundwater models indipendently. They can work on different scenarios and can compare or assess different solutions for existing problems by application of selected software products. The students are able to use different software solutions (e.g. EPANET, EPA-SWMM).
Personal Competence	
Social Competence	Wird nicht vermittelt.
Autonomy	Wird nicht vermittelt.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	20 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0543: Groundwater Modeling using Modflow

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical backround of the modell, students do work with the model PMWIN for practical case studies.
Literature	MODFLOW-Handbuch Chiang, Wen Hsien: PMWIN

Course L0544: Groundwater Modeling using Modflow	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Sonja Götz
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0875: Modeling of Water Supply and Sewer Network	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen, Weitere Mitarbeiter
Language	DE
Cycle	SoSe
Content	
Literature	Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014.

Module M0857: Geochemical Engineering

Courses

Title	Typ	Hrs/wk	CP
Contaminated Sites and Landfilling (L0906)	Lecture	2	2
Contaminated Sites and Landfilling (L0907)	Recitation Section (large)	1	2
Geochemical Engineering (L0904)	Lecture	2	2

Module Responsible	Dr. Marco Ritzkowski
Admission Requirements	None
Recommended Previous Knowledge	Module: General and Inorganic Chemistry, Module:Organic Chemistry, Biology (Basic Knowledge)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	With the completion of this module students acquire profound knowledge of biogeochemical processes, the fate of pollutants in soil and groundwater, and techniques to deposit contaminated waste material. They are able to describe in principle the behaviour of chemicals in the environment. Students can explain and report the approach to remediate contaminated sites.
Skills	With the completion of this module students can apply the acquired theoretical knowledge to model cases of site pollution and critically assess the situation technically and conceptually. They are able to draw comparisons on different remediation strategies and techniques. Model projects can be devised and treated.
Personal Competence	
Social Competence	Students can discuss technical and scientific tasks within a seminar subject specific and interdisciplinary .
Autonomy	Students can independently exploit sources , acquire the particular knowledge of the subject and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2 hours
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0906: Contaminated Sites and Landfilling

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Marco Ritzkowski, Dr. Joachim Gerth
Language	EN
Cycle	SoSe
Content	The part Contaminated Sites gives an introduction into different scales of pollution and identifies key pollutants. Geochemical attenuation mechanisms and the role of organisms are highlighted affecting the fate of pollutants in leachate and groundwater. Techniques for site characterization and remediation are discussed including economical aspects. The part Landfilling is introduced by discussing fundamental aspects and the worldwide situation of waste management. The lecture highlights transformation processes in landfill bodies, emissions of gases and leachate, and the long-term behaviour of landfill sites with measures of aftercare.
Literature	1) **Waste Management**. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305 2) **Solid Waste Technology and Management.** Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332 3) **Natural attenuation of fuels and chlorinated solvents in the subsurface.** Todd H. Wiedemeier(Ed.), ISBN: 0471197491 Lesesaal 2: US - Umweltschutz, Signatur USH-844

Course L0907: Contaminated Sites and Landfilling	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Marco Ritzkowski, Dr. Joachim Gerth
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0904: Geochemical Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Gerth
Language	EN
Cycle	SoSe
Content	As an introduction cases are presented in which geochemical engineering was used to solve environmental problems. Environmentally important minerals are discussed and methods for their detection. It is demonstrated how solution equilibria can be modified to eliminate elevated concentrations of unwanted species in solution and how carbon dioxide concentration affects pH and the dissolution of carbonate minerals. Modifications of redox conditions, pH, and electrolyte concentration are shown to be effective tools for controlling the mobility and fate of hazardous species in the environment.
Literature	**Geochemistry, groundwater and pollution.** C. A. J. Appelo; D. Postma Leiden [u.a.] Balkema 2005 Lehrbuchsammlung der TUB, Signatur GWC-515

Module M1717: Advanced Vadose Zone Hydrology

Courses

Title	Typ	Hrs/wk	CP
Modeling Processes in Vadose Zone (L2734)	Lecture	1	1
Modeling Processes in Vadose Zone (L2735)	Recitation Section (small)	1	1
Vadose Zone Hydrology (L2732)	Lecture	2	2
Vadose Zone Hydrology (L2733)	Recitation Section (large)	2	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2734: Modeling Processes in Vadose Zone

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann, Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2735: Modeling Processes in Vadose Zone

Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hannes Nevermann
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L2732: Vadose Zone Hydrology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2733: Vadose Zone Hydrology	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1718: Multiphase Flow in Porous Media

Courses

Title	Typ	Hrs/wk	CP
Advanced Modeling Techniques for Multiphase Flow in Porous Media (L2738)	Recitation Section (small)	2	2
Fundamentals of Multiphase Flow in Porous Media (L2736)	Lecture	2	2
Fundamentals of Multiphase Flow in Porous Media (L2737)	Recitation Section (large)	2	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2738: Advanced Modeling Techniques for Multiphase Flow in Porous Media

Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2736: Fundamentals of Multiphase Flow in Porous Media

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2737: Fundamentals of Multiphase Flow in Porous Media	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Hannes Nevermann
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1721: Water and Environment: Theory and Application

Courses

Title	Typ	Hrs/wk	CP
Water and Environment: Application and Field Work (L2754)	Project-/problem-based Learning	3	4
Water and Environment: Theory (L2753)	Lecture	1	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Report (about 5-10 pages) and Presentation (about 15 min)
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2754: Water and Environment: Application and Field Work

Typ	Project-/problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Anna Luisa Hemshorn de Sánchez, Dr. Salome Shokri-Kuehni
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2753: Water and Environment: Theory

Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	
Literature	

Module M1702: Process Imaging

Courses

Title	Typ	Hrs/wk	CP
Process Imaging (L2723)	Lecture	2	3
Process Imaging (L2724)	Project-/problem-based Learning	2	3

Module Responsible	Prof. Alexander Penn
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Energy and Bioprocess Technology: Elective Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Energy and Bioprocess Technology: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2723: Process Imaging

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Penn
Language	EN
Cycle	SoSe
Content	
Literature	

Course L2724: Process Imaging	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Penn, Dr. Stefan Benders
Language	EN
Cycle	SoSe
Content	
Literature	

Module M0870: Management of Surface Water

Courses

Title	Typ	Hrs/wk	CP
Modelling of Flow in Rivers and Estuaries (L0810)	Lecture	3	4
Nature-Oriented Hydraulic Engineering / Integrated Flood Protection (L0961)	Project-/problem-based Learning	2	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Hydromechanics, Hydraulics, Hydrology and Hydraulic Engineering; Hydraulic Engineering I and Hydraulic Engineering II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to define in detail the basic processes that are related to the modelling of flows in hydraulic engineering. Besides, they can describe the basic aspects of numerical modelling and actual numerical models for the simulation of flows and waves. They can also depict the concepts of nature oriented hydraulic engineering.
Skills	Students are able to apply hydrodynamic-numerical models to practical hydraulic engineering tasks. Furthermore, the students are able to set up flood-risk management concepts and are able to apply basic concepts of renaturation to practical problems.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems of the practical nature-based hydraulic engineering. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 150 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0810: Modelling of Flow in Rivers and Estuaries	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Dr. Edgar Nehlsen, Prof. Peter Fröhle
Language	EN
Cycle	SoSe
Content	Introduction to numerical flow modelling • Processes affecting tht flow • Examples and applications of numerical models • Procedure of numerical modelling • Model concept Basic equations of hydrodynamics • Saint-Venant equations • Euler Equations • Navier-Stokes equations • Reynolds-averaged Navier-Stokes equations • Shallow water equations Solving schemes • Numerical discretization • Solution algorithms • Convergence
Literature	Vorlesungsskript Literaturempfehlungen Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt). Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019a): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 1: Geodaten in der Fließgewässermodellierung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-1). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019b): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 2: Bedarfsgerechte Datenerfassung und -aufbereitung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-2). Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019c): Merkblatt DWA-M 543-3 Geodaten in der Fließgewässermodellierung - Teil 3: Aspekte der Strömungsmodellierung und Fallbeispiele. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-3). Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html. IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92. Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology. Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83). van Waveren, Harold (1999-): Good modelling practice handbook. [Utrecht], Lelystad, Den Haag: STOWA; Rijkswaterstaat-RIZA; SDU, afd. SEO/RIZA [etc. distr.] (Nota, nr. 99.036). Zielke, Werner (Hg.) (1999): Numerische Modelle von Flüssen, Seen und Küstengewässern. Deutscher Verband für Wasserwirtschaft und Kulturbau. Bonn: Wirtschafts- und Verl.-Ges. Gas und Wasser (Schriftenreihe des Deutschen Verbandes für Wasserwirtschaft und Kulturbau, 127).

Course L0961: Nature-Oriented Hydraulic Engineering / Integrated Flood Protection	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Natasa Manojlovic, Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	• Regime-Theory and application for the development of environmental guiding priciples of rivers • Engineering - biological measures for the stabilization of rivers • Risk management in flood protection • Design techniques in technical flood protection • Methods for the assessment of flood caused damages
Literature	Vorlesungsumdruck

Module M0871: Hydrological Systems

Courses

Title	Typ	Hrs/wk	CP
Applied Surface Hydrology (L0289)	Lecture	2	2
Applied Surface Hydrology (L1412)	Project-/problem-based Learning	1	2
Interaction Water - Environment in Fluvial Areas (L0295)	Project-/problem-based Learning	1	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Hydromechanics and Hydraulic Engineering: Hydraulic Engineering I and Hydraulic Engineering II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to define the basic concepts of hydrology and water management. They are able to describe and quantify the relevant processes of the hydrological water cycle. Besides, the students know the main aspects of rainfall-run-off-models and are able to theoretically derive established reservoir / storage models and a unit-hydrograph.
Skills	The students are able to use the basic hydrological concepts and approaches and are able to theoretically derive established reservoir / storage models or a unit-hydrograph as the basis for rainfall-run-off-models. The student are able to explain the basic concepts of measurements of hydrological and hydrodynamic values in nature and are able to perform, analyze and statistically assess these measurements. Furthermore, they are able to apply a hydrological model to basic hydrological problems.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems of the hydrology and water management. Additionaly, they will be able to work in team with engineers of other disciplines.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	The duration of the examination is 90 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0289: Applied Surface Hydrology

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	Basics of hydrology: • Hydrological cycle • Data acquisition • Data analyses and statistical assessment • Statistics of extremes • Regionalization methods for hydrological values • Rainfall-run-off modelling on the basis of a unit hydrograph conceps • Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool.
Literature	http://de.wikipedia.org/wiki/Kalypso_(Software) http://kalypso.bjoernsen.de/ http://sourceforge.net/projects/kalypso/

Course L1412: Applied Surface Hydrology	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0295: Interaction Water - Environment in Fluvial Areas	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE/EN
Cycle	SoSe
Content	A problem based learning course. The problem will be solved by the students more or less self-contained. The topics will be introduced and elaborated over the semester.
Literature	-

Module M0874: Wastewater Systems

Courses

Title	Typ	Hrs/wk	CP
Wastewater Systems - Collection, Treatment and Reuse (L0934)	Lecture	2	2
Wastewater Systems - Collection, Treatment and Reuse (L0943)	Recitation Section (large)	1	1
Advanced Wastewater Treatment (L0357)	Lecture	2	2
Advanced Wastewater Treatment (L0358)	Recitation Section (large)	1	1

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of wastewater management and the key processes involved in wastewater treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to outline key areas of the full range of treatment systems in waste water management, as well as their mutual dependence for sustainable water protection. They can describe relevant economic, environmental and social factors.
Skills	Students are able to pre-design and explain the available wastewater treatment processes and the scope of their application in municipal and for some industrial treatment plants.
Personal Competence	
Social Competence	Social skills are not targeted in this module.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0934: Wastewater Systems - Collection, Treatment and Reuse

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	•Understanding the global situation with water and wastewater •Regional planning and decentralised systems •Overview on innovative approaches •In depth knowledge on advanced wastewater treatment options for different situations, for end-of-pipe and reuse •Mathematical Modelling of Nitrogen Removal •Exercises with calculations and design
Literature	Henze, Mogens: Wastewater Treatment: Biological and Chemical Processes, Springer 2002, 430 pages George Tchobanoglous, Franklin L. Burton, H. David Stensel: Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy McGraw-Hill, 2004 - 1819 pages

Course L0943: Wastewater Systems - Collection, Treatment and Reuse	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0357: Advanced Wastewater Treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Survey on advanced wastewater treatment reuse of reclaimed municipal wastewater Precipitation Flocculation Depth filtration Membrane Processes Activated carbon adsorption Ozonation "Advanced Oxidation Processes" Disinfection
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Course L0358: Advanced Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Aggregate organic compounds (sum parameters) Industrial wastewater Processes for industrial wastewater treatment Precipitation Flocculation Activated carbon adsorption Recalcitrant organic compounds
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Module M0875: Nexus Engineering - Water, Soil, Food and Energy

Courses

Title	Typ	Hrs/wk	CP
Ecological Town Design - Water, Energy, Soil and Food Nexus (L1229)	Seminar	2	2
Water & Wastewater Systems in a Global Context (L0939)	Lecture	2	4

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of the global situation with rising poverty, soil degradation, migration to cities, lack of water resources and sanitation
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe the facets of the global water situation. Students can judge the enormous potential of the implementation of synergistic systems in Water, Soil, Food and Energy supply.
Skills	Students are able to design ecological settlements for different geographic and socio-economic conditions for the main climates around the world.
Personal Competence	
Social Competence	The students are able to develop a specific topic in a team and to work out milestones according to a given plan.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information can be found at the beginning of the smester in the StudIP course module handbook.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L1229: Ecological Town Design - Water, Energy, Soil and Food Nexus	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	• Participants Workshop: Design of the most attractive productive Town • Keynote lecture and video • The limits of Urbanization / Green Cities • The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities • Global Ecovillage Network: Upsides and Downsides around the World • Visit of an Ecovillage • Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competion • TUHH Rural Development Toolbox • Integrated New Town Development • Participants workshop: Design of New Towns: Northern, Arid and Tropical cases • Outreach: Participants campaign • City with the Rural: Resilience, quality of live and productive biodiversity
Literature	• Ralf Otterpohl 2013: Gründer-Gruppen als Lebensentwurf: "Synergistische Wertschöpfung in erweiterten Kleinstadt- und Dorfstrukturen", in „Regionales Zukunftsmanagement Band 7: Existenzgründung unter regionalökonomischer Perspektive, Pabst Publisher, Lengerich • http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation) • TEDx New Town Ralf Otterpohl: http://youtu.be/_M0J2u9BrbU

Course L0939: Water & Wastewater Systems in a Global Context	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	• Keynote lecture and video • Water & Soil: Water availability as a consequence of healthy soils • Water and it’s utilization, Integrated Urban Water Management • Water & Energy, lecture and panel discussion pro and con for a specific big dam project • Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation • Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches • Why are there excreta in water? Public Health, Awareness Campaigns • Rehearsal session, Q&A
Literature	• Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press • Liu, John D.: http://eempc.org/hope-in-a-changing_climate/ (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda) • http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)

Module M0922: City Planning

Courses

Title	Typ	Hrs/wk	CP
City Planning (L1066)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	for "Principles of Urban Planning": none for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • use technical terms of urban planning. • describe the main determinants of urban development. • explain and compare different possibilities of how urban development can be influenced. • discuss requirements for public streetscapes. • explain the importance of street design.
Skills	Students are able to: • read and analyze urban development concepts and designs for streetscapes • appraise such concepts in the context of competing requirements. • design, justify and reflect their own solutions for concrete examples.
Personal Competence	
Social Competence	Students are able to: • discuss intermediate results with each other. • constructively accept feedback on their own work. • provide constructive feedback to others.
Autonomy	Students are able to: • independently complete a written report including drawings following a broadly pre-defined process. • assess the consequences of their proposed solutions. • independently acquire knowledge and apply this to new issues or problem areas.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment, designwork during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1066: City Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz
Language	DE
Cycle	SoSe
Content	„Principles of Urban Planning“ deals with the determinants of urban development and their interactions. Topics include: • legal framework, • instruments and methods of planning, • functional requirements, • stakeholders and actors • basic design requirements • different planning levels and • historical contexts. The objective of the course is for students to acquire a basic understanding of urban development problems and approaches for solving them. They will also be able to comprehend the process of urban planning. The course also covers the various functional and aesthetic requirements for designing streetscape as the most important elements of public space. The project work deals with a real life scenario and includes drawing up a development plan, an urban design concept, a building masterplan and a street redesign.
Literature	Albers, Gerd; Wekel, Julian (2009) Stadtplanung: Eine illustrierte Einführung. Primus Verlag. Darmstadt. Frick, Dieter (2008) Theorie des Städtebaus: Zur baulich-räumlichen Organisation von Stadt. Wasmuth-Verlag. Tübingen Jonas, Carsten (2009) Die Stadt und ihr Grundriss. Wasmuth-Verlag. Tübingen Kostof, Spiro; Castillo, Greg (1998) Die Anatomie der Stadt. Geschichte städtischer Strukturen. Campus-Verlag. Frankfurt/New York.

Module M0663: Marine Geotechnics

Courses

Title	Typ	Hrs/wk	CP
Marine Geotechnics (L0548)	Lecture	1	2
Marine Geotechnics (L0549)	Recitation Section (large)	2	2
Steel Structures in Foundation and Hydraulic Engineering (L1146)	Lecture	2	2

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	complete modules: Geotechnics I-III, Mathematics I-III courses: Soil laboratory course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0548: Marine Geotechnics

Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	• Geotechnical investigation an description of the seabed • Foundations of Offshore-Constructions • cCliff erosion • Sea dikes • Port structures • Flood protection structures
Literature	• EAK (2002): Empfehlungen für Küstenschutzbauwerke • EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke • Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London • Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst & Sohn, Berlin

Course L0549: Marine Geotechnics

Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1146: Steel Structures in Foundation and Hydraulic Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Frank Feindt
Language	DE
Cycle	SoSe
Content	Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue
Literature	EAU 2012, EA-Pfähle, EAB

Module M1724: Smart Monitoring

Courses

Title	Typ	Hrs/wk	CP
Smart Monitoring (L2762)	Integrated Lecture	2	2
Smart Monitoring (L2763)	Recitation Section (small)	2	4

Module Responsible	Prof. Kay Smarsly
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpful. Interest in modern research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deepen skills of scientific working, are required. Basic knowledge in scientific writing and good English skills.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	The students will become familiar with the principles and practices of smart monitoring. The students will be able to design decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built and in the natural environment. In addition, the students will learn to design and to implement intelligent sensor systems using state-of-the-art data analysis techniques, modern software design concepts, and embedded computing methodologies. Besides lectures, project work is also part of this module. In small groups, the students will design smart monitoring systems that integrate a number of “intelligent” sensors to be implemented by the students. Specific focus will be put on the application of machine learning techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as bridges or slopes, or on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper. All students of this module will “automatically” participate with their smart monitoring system in the annual "Smart Monitoring" competition. The written papers and oral examinations form the final grades. The module will be taught in English. Limited enrollment.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	10 pages of work with 15-minute oral presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Environmental Engineering: Specialisation Biotechnology: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Environmental Engineering: Specialisation Biotechnology: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2762: Smart Monitoring	
Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	WiSe/SoSe
Content	In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment.
Literature	

Course L2763: Smart Monitoring	
Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Kay Smarsly
Language	EN
Cycle	WiSe/SoSe
Content	The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the “Smart Monitoring” competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature.
Literature	

Module M1123: Selected Topics in Environmental Engineering

Courses

Title	Typ	Hrs/wk	CP
Environmental Aquatic Chemistry (L1444)	Lecture	2	3
Excellence in International Project Delivery (L2387)	Integrated Lecture	2	2
Sludge Treatment (L0520)	Lecture	2	3
Thermal Biomass Utilization (L1767)	Lecture	2	2
Thermal Biomass Utilization (L2386)	Practical Course	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L1444: Environmental Aquatic Chemistry

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Klaus Johannsen
Language	EN
Cycle	SoSe
Content	• Concentration and activity • Gas-water partitioning • Acid/base equilibria • Alkalinity and acidity • Precipitation/dissolution equilibria • Redox equilibria • Complex formation • Sorption
Literature	Worch, E.: Hydrochemistry. Basic Concepts and Exercises. De Gruyter, Berlin, 2015

Course L2387: Excellence in International Project Delivery

Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	2 h
Lecturer	Dr. Jens Huckfeldt
Language	EN
Cycle	SoSe
Content	**Simply and easy to avoid mistake in project delivery can deliver projects within budget and as per schedule.You have to attend if you see yourself in project execution and potentially even abroad.**
Literature	

Course L0520: Sludge Treatment	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Joachim Behrendt
Language	EN
Cycle	SoSe
Content	Sedimentation characteristic and thickening, Centrifugation, Flotation, Filtration, Aerobic sludge stabilisation, Sludge Digestion, Sludge Disintegration, Sludge Dewatering, Natural Processes for Sludge Treatment, Nutrient Recovery from Sludge, Thermal Processes and Incineration.
Literature	**Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes** Sludge Treatment and Disposal ISBN 9781843391661 IWA Publishing, 2007

Course L1767: Thermal Biomass Utilization	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	WiSe

Content	Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmental basics of all options to provide energy from biomass from a German and international point of view. Additionally different system approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and economic development potentials, and the current and expected future use within the energy system are presented.
	
	The course is structured as follows:
	
	• Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course
	• Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste
	• Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying
	• Thermo-chemical conversion of solid biofuels
	  ◦ Basics of thermo-chemical conversion
	  ◦ Direct thermo-chemical conversion through combustion: combustion technologies for small and large scale units, electricity generation technologies, flue gas treatment technologies, ashes and their use
	  ◦ Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels
	  ◦ Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for the provision of charcoal, oil cleaning technologies, options to use the pyrolysis oil and charcoal as an energy carrier as well as a raw material
	• Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil seeds and oil fruits, vegetable oil production, production of a biofuel with standardized characteristics (trans-esterification, hydrogenation, co-processing in existing refineries), options to use this fuel, options to use the residues (i.e. meal, glycerine)
	• Bio-chemical conversion of biomass
	  ◦ Basics of bio-chemical conversion
	  ◦ Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic waste fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry
	  ◦ Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage

Literature	**Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage**

Course L2386: Thermal Biomass Utilization	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	Protokolle
Lecturer	Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger
Language	DE
Cycle	WiSe
Content	The experiments of the practical lab course illustrate the different aspects of heat generation from biogenic solid fuels. First, different biomasses (e.g. wood, straw or agricultural residues) will be investigated; the focus will be on the calorific value of the biomass. Furthermore, the used biomass will be pelletized, the pellet properties analysed and a combustion test carried out on a pellet combustion system. The gaseous and solid pollutant emissions, especially the particulate matter emissions, are measured and the composition of the particulate matter is investigated in a further experiment. Another focus of the practical course is the consideration of options for the reduction of particulate matter emissions from biomass combustion. In the practical course, a method for particulate matter reduction will be developed and tested. All experiments will be evaluated and the results presented. Within the practical lab course the students discuss different technical-scientific tasks, both subject-specifically and interdisciplinary. They discuss various approaches to solving the problem and advise on the theoretical or practical implementation.
Literature	- Kaltschmitt, Martin; Hartmann, Hans; Hofbauer, Hermann: Energie aus Biomasse: Grundlagen, Techniken und Verfahren. 3. Auflage. Berlin Heidelberg: Springer Science & Business Media, 2016. -ISBN 978-3-662-47437-2 - Versuchsskript

Module M0620: Special Aspects of Waste Resource Management

Courses

Title	Typ	Hrs/wk	CP
Advanced Topics in Waste Resource Management (L1055)	Project-/problem-based Learning	3	3
International Waste Management (L0317)	Project-/problem-based Learning	2	3

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	basics in waste treatment technologies
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe waste as a resource as well as advanced technologies for recycling and recovery of resources from waste in detail. This covers collection, transport, treatment and disposal in national and international contexts.
Skills	Students are able to select suitable processes for the treatment with respect to the national or cultural and developmental context. They can evaluate the ecological impact and the technical effort of different technologies and management systems.
Personal Competence	
Social Competence	Students can work together as a team of 2-5 persons, participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development of colleagues. Furthermore, they can give and accept professional constructive criticisms.
Autonomy	Students can independently gain additional knowledge of the subject area and apply it in solving the given course tasks and projects.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	Compulsory: Yes; Bonus: 20 %; Form: Written elaboration; Description:
Examination	Presentation
Examination duration and scale	PowerPoint presentation (10-15 minutes)
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L1055: Advanced Topics in Waste Resource Management

Typ	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Rüdiger Siechau
Language	EN
Cycle	WiSe
Content	Focus of the course "Advanced topics of waste resource management" lies on the organisational structures in waste management - such as planning, financing and logistics. One excursion will be offered to take part in (incineration plant, vehicle fleet and waste collection systems). The course is split into two parts: 1. part: “Conventional” lecture (development of waste management, legislation, collection, transportation and organisation of waste management, costs, fees and revenues). 2. part: Project base learning: You will get a project to work out in groups of 4 to 6 students; all tools and data you need to work out the project were given before during the conventional lecture. Course documents are published in StudIP and communication during project work takes place via StudIP. The results of the project work are presented at the end of the semester. The final mark for the course consists of the grade for the presentation.
Literature	Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010 PowerPoint slides in Stud IP

Course L0317: International Waste Management	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	Waste avoidance and recycling are the focus of this lecture. Additionally, waste logistics (Collection, transport, export, fees and taxes) as well as international waste shipment solutions are presented. Other specific wastes, e.g. industrial waste, treatment concepts will be presented and developed by students themselves Waste composition and production on international level, wast eulogistic, collection and treatment in emerging and developing countries. Single national projects and studies will be prepared and presented by students
Literature	Basel convention

Module M0802: Membrane Technology

Courses

Title	Typ	Hrs/wk	CP
Membrane Technology (L0399)	Lecture	2	3
Membrane Technology (L0400)	Recitation Section (small)	1	2
Membrane Technology (L0401)	Practical Course	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of water chemistry. Knowledge of the core processes involved in water, gas and steam treatment
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to rank the technical applications of industrially important membrane processes. They will be able to explain the different driving forces behind existing membrane separation processes. Students will be able to name materials used in membrane filtration and their advantages and disadvantages. Students will be able to explain the key differences in the use of membranes in water, other liquid media, gases and in liquid/gas mixtures.
Skills	Students will be able to prepare mathematical equations for material transport in porous and solution-diffusion membranes and calculate key parameters in the membrane separation process. They will be able to handle technical membrane processes using available boundary data and provide recommendations for the sequence of different treatment processes. Through their own experiments, students will be able to classify the separation efficiency, filtration characteristics and application of different membrane materials. Students will be able to characterise the formation of the fouling layer in different waters and apply technical measures to control this.
Personal Competence	
Social Competence	Students will be able to work in diverse teams on tasks in the field of membrane technology. They will be able to make decisions within their group on laboratory experiments to be undertaken jointly and present these to others.
Autonomy	Students will be in a position to solve homework on the topic of membrane technology independently. They will be capable of finding creative solutions to technical questions.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0399: Membrane Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	The lecture on membrane technology supply provides students with a broad understanding of existing membrane treatment processes, encompassing pressure driven membrane processes, membrane application in electrodialyis, pervaporation as well as membrane distillation. The lectures main focus is the industrial production of drinking water like particle separation or desalination; however gas separation processes as well as specific wastewater oriented applications such as membrane bioreactor systems will be discussed as well. Initially, basics in low pressure and high pressure membrane applications are presented (microfiltration, ultrafiltration, nanofiltration, reverse osmosis). Students learn about essential water quality parameter, transport equations and key parameter for pore membrane as well as solution diffusion membrane systems. The lecture sets a specific focus on fouling and scaling issues and provides knowledge on methods how to tackle with these phenomena in real water treatment application. A further part of the lecture deals with the character and manufacturing of different membrane materials and the characterization of membrane material by simple methods and advanced analysis. The functions, advantages and drawbacks of different membrane housings and modules are explained. Students learn how an industrial membrane application is designed in the succession of treatment steps like pre-treatment, water conditioning, membrane integration and post-treatment of water. Besides theory, the students will be provided with knowledge on membrane demo-site examples and insights in industrial practice.
Literature	• T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage), Springer-Verlag, Berlin 2004. • Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands • Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley & Sons, Ltd., 2004

Course L0400: Membrane Technology	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0401: Membrane Technology	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0822: Process Modeling in Water Technology

Courses

Title	Typ	Hrs/wk	CP
Process Modelling of Wastewater Treatment (L0522)	Project-/problem-based Learning	2	3
Process Modeling in Drinking Water Treatment (L0314)	Project-/problem-based Learning	2	3

Module Responsible	Dr. Klaus Johannsen
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of the most important processes in drinking water and waste water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to explain selected processes of drinking water and waste water treatment in detail. They are able to explain basics as well as possibilities and limitations of dynamic modeling.
Skills	Students are able to use the most important features Modelica offers. They are able to transpose selected processes in drinking water and waste water treatment into a mathematical model in Modelica with respect to equilibrium, kinetics and mass balances. They are able to set up and apply models and assess their possibilities and limitations.
Personal Competence	
Social Competence	Students are able to solve problems and document solutions in a group with members of different technical background. They are able to give appropriate feedback and can work constructively with feedback concerning their work.
Autonomy	Students are able to define a problem, gain the required knowledge and set up a model.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0522: Process Modelling of Wastewater Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	WiSe
Content	Mass and energy balances Tracer modelling Activated Sludge Model Wastewater Treatment Plant Modelling (continously and SBR) Sludge Treatment (ADM, aerobic autothermal) Biofilm Modelling
Literature	**Henze, Mogens** (Seminar on Activated Sludge Modelling, ; Kollekolle Seminar on Activated Sludge Modelling, ;) Activated sludge modelling : processes in theory and practice ; selected proceedings of the 5th Kollekolle Seminar on Activated Sludge Modelling, held in Kollekolle, Denmark, 10 - 12 September 2001 ISBN: 1843394146 [London] : IWA Publ., 2002 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 TUB_HH_Katalog

Course L0314: Process Modeling in Drinking Water Treatment	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE/EN
Cycle	WiSe
Content	In this course selected drinking water treatment processes (e.g. aeration or activated carbon adsorption) are modeled dynamically using the programming language Modelica, that is increasingly used in industry. In this course OpenModelica is used, an free access frontend of the programming language Modelica. In the beginning of the course the use of OpenModelica is explainded by means of simple examples. Together required elements and structure of the model are developed. The implementation in OpenModelica and the application of the model is done individually or in groups respectively. Students get feedback and can gain extra points for the exam.
Literature	**OpenModelica:** https://openmodelica.org/index.php/download/download-windows **OpenModelica - Modelica Tutorial:** https://openmodelica.org/index.php/useresresources/userdocumentation **OpenModelica - Users Guide:** https://openmodelica.org/index.php/useresresources/userdocumentation **Peter Fritzson:** Principles of Object-Oriented Modeling and Simulation with Modelica 2.1,Wiley-IEEE Press, ISBN 0-471-471631. **MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.

Module M0902: Wastewater Treatment and Air Pollution Abatement

Courses

Title	Typ	Hrs/wk	CP
Biological Wastewater Treatment (L0517)	Lecture	2	3
Air Pollution Abatement (L0203)	Lecture	2	3

Module Responsible	Dr. Swantje Pietsch-Braune
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of biology and chemistry Basic knowledge of solids process engineering and separation technology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of the module students are able to • name and explain biological processes for waste water treatment, • characterize waste water and sewage sludge, • discuss legal regulations in the area of emissions and air quality • explain the effects of air pollutants on the environment, • name and explan off gas tretament processes and to define their area of application
Skills	Students are able to • choose and design processs steps for the biological waste water treatment • combine processes for cleaning of off-gases depending on the pollutants contained in the gases
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0517: Biological Wastewater Treatment

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	WiSe
Content	Charaterisation of Wastewater Metobolism of Microorganisms Kinetic of mirobiotic processes Calculation of bioreactor for wastewater treatment Concepts of Wastewater treatment Design of WWTP Excursion to a WWTP Biofilms Biofim Reactors Anaerobic Wastewater and sldge treatment resources oriented sanitation technology Future challenges of wastewater treatment

Literature	**Gujer, Willi** Siedlungswasserwirtschaft : mit 84 Tabellen ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?id=2842122&prov=M&dok_var=1&dok_ext=htm Berlin [u.a.] : Springer, 2007 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Imhoff, Karl** (Imhoff, Klaus R.;) Taschenbuch der Stadtentwässerung : mit 10 Tafeln ISBN: 3486263331 ((Gb.)) München [u.a.] : Oldenbourg, 1999 TUB_HH_Katalog **Lange, Jörg** (Otterpohl, Ralf; Steger-Hartmann, Thomas;) Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334 Donaueschingen-Pfohren : Mall-Beton-Verl., 2000 TUB_HH_Katalog **Mudrack, Klaus** (Kunst, Sabine;) Biologie der Abwasserreinigung : 18 Tabellen ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903 Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003 TUB_HH_Katalog **Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Kunz, Peter** Umwelt-Bioverfahrenstechnik Vieweg, 1992 **Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt** (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, ;) Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe aus der Abwasserbehandlung, Kleinkläranlagen ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL: http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf Weimar : Universitätsverl, 2006 TUB_HH_Katalog **Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall** DWA-Regelwerk Hennef : DWA, 2004 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 TUB_HH_Katalog

Course L0203: Air Pollution Abatement	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Swantje Pietsch-Braune, Christian Eichler
Language	EN
Cycle	WiSe
Content	In the lecture methods for the reduction of emissions from industrial plants are treated. At the beginning a short survey of the different forms of air pollutants is given. In the second part physical principals for the removal of particulate and gaseous pollutants form flue gases are treated. Industrial applications of these principles are demonstrated with examples showing the removal of specific compounds, e.g. sulfur or mercury from flue gases of incinerators.
Literature	Handbook of air pollution prevention and control, Nicholas P. Cheremisinoff. - Amsterdam [u.a.] : Butterworth-Heinemann, 2002 Atmospheric pollution : history, science, and regulation, Mark Zachary Jacobson. - Cambridge [u.a.] : Cambridge Univ. Press, 2002 Air pollution control technology handbook, Karl B. Schnelle. - Boca Raton [u.a.] : CRC Press, c 2002 Air pollution, Jeremy Colls. - 2. ed. - London [u.a.] : Spon, 2002

Module M0923: Integrated Transportation Planning

Courses

Title	Typ	Hrs/wk	CP
Integrated Transportation Planning (L1068)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Carsten Gertz
Admission Requirements	None
Recommended Previous Knowledge	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineerin
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe interdependencies between land-use/location choice and transportation/mobility behaviour • explain and evaluate the social, ecological and economic effects of transport and land-use policy measures. • relate current issues in the area of integrated transport planning and formulate an opinion on them.
Skills	Students are able to: • quantify important parameters, which influence travel demand or are influenced by it. • comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document the results in accordance with scientific conventions.
Personal Competence	
Social Competence	Students are able to: • provide feedback on topical contents and their teaching. • constructively handle feedback on their own work. • produce results in group work and document these.
Autonomy	Students are able to: • assess potential consequences of their future professional activities • independently plan working on a pre-defined project topic, acquire the necessary knowledge and use appropriate means for its execution.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	written assignment with presentation during the semester
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L1068: Integrated Transportation Planning	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Carsten Gertz, Dr. Philine Gaffron, Jacqueline Bianca Maaß
Language	DE
Cycle	WiSe
Content	The course will provide students with an understanding of interdependencies between land-use and transportation. Specific topics include a.o.: • interactions between transport and the environment and consequent limitations • characteristics of integrated planning • complex planning processes • interdependencies of location choice and mobility behaviour • transport and land-use policies • project on current issues in transportation studies
Literature	Kutter, Eckhard (2005) Entwicklung innovativer Verkehrsstrategien für die mobile Gesellschaft. Erich Schmidt Verlag. Berlin. Bracher, Tilman u. a. (Hrsg.) (68. Ergänzung 2013) Handbuch der kommunalen Verkehrsplanung. Herbert Wichmann Verlag. Berlin, Offenbach. (Loseblattsammlung mit kontinuierlichen Ergänzungen)

Module M0948: Study Work Water/ Waste Water

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	Dozenten des SD B
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to demonstrate their detailed knowledge in the field of Water and Environmental Engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society. The students can develop solving strategies and approaches for fundamental and practical problems in the field of Water and Environmental Engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society. Scientific work techniques that are used can be described and critically reviewed.
Skills	The students are able to independently select methods or planning approaches for the project work and to justify their choice. They can explain how these methods or approaches relate to solutions in the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.
Personal Competence	
Social Competence	The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.
Workload in Hours	Independent Study Time 180, Study Time in Lecture 0
Credit points	6
Course achievement	None
Examination	Study work
Examination duration and scale	
Assignment for the Following Curricula	Water and Environmental Engineering: Specialisation Water: Compulsory

Module M0949: Rural Development and Resources Oriented Sanitation for different Climate Zones

Courses

Title	Typ	Hrs/wk	CP
Rural Development and Resources Oriented Sanitation for different Climate Zones (L0942)	Seminar	2	3
Rural Development and Resources Oriented Sanitation for different Climate Zones (L0941)	Lecture	2	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of the global situation with rising poverty, soil degradation, lack of water resources and sanitation
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe resources oriented wastewater systems mainly based on source control in detail. They can comment on techniques designed for reuse of water, nutrients and soil conditioners. Students are able to discuss a wide range of proven approaches in Rural Development from and for many regions of the world.
Skills	Students are able to design low-tech/low-cost sanitation, rural water supply, rainwater harvesting systems, measures for the rehabilitation of top soil quality combined with food and water security. Students can consult on the basics of soil building through “Holisitc Planned Grazing” as developed by Allan Savory.
Personal Competence	
Social Competence	The students are able to develop a specific topic in a team and to work out milestones according to a given plan.
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information will be provided at the beginning of the smester.
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0942: Rural Development and Resources Oriented Sanitation for different Climate Zones

Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	• Central part of this module is a group work on a subtopic of the lectures. The focus of these projects will be based on an interview with a target audience, practitioners or scientists. • The group work is divided into several Milestones and Assignments. The outcome will be presented in a final presentation at the end of the semester.
Literature	• J. Lange, R. Otterpohl 2000: Abwasser - Handbuch zu einer zukunftsfähigen Abwasserwirtschaft. Mallbeton Verlag (TUHH Bibliothek) • Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download) • Schober, Sabine: WTO/TUHH Award winning Terra Preta Toilet Design: http://youtu.be/w_R09cYq6ys

Course L0941: Rural Development and Resources Oriented Sanitation for different Climate Zones	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	• Living Soil - THE key element of Rural Development • Participatory Approaches • Rainwater Harvesting • Ecological Sanitation Principles and practical examples • Permaculture Principles of Rural Development • Performance and Resilience of Organic Small Farms • Going Further: The TUHH Toolbox for Rural Development • EMAS Technologies, Low cost drinking water supply
Literature	• Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk • Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press

Module M0581: Water Protection

Courses

Title	Typ	Hrs/wk	CP
Water Protection and Wastewater Management (L0226)	Lecture	3	3
Water Protection and Wastewater Management (L2008)	Project Seminar	3	3

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	• Basic knowledge in water management; • Good knowledge in urban drainage; • Good knowledge of wastewater treatment techniques; • Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties;
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe the basic principles of the regulatory framework related to the international and European water sector. They can explain limnological processes, substance cycles and water morphology in detail. They are able to assess complex problems related to water protection, such as ecosystem service and wastewater treatment with a special focus on innovative solutions, remediation measures as well as conceptual approaches.
Skills	Students can accurately assess current problems and situations in a country-specific or local context. They can suggest concrete actions to contribute to the planning of tomorrow's urban water cycle. Furthermore, they can suggest appropriate technical, administrative and legislative solutions to solve these problems.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	Term paper plus presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory

Course L0226: Water Protection and Wastewater Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	The lecture focusses on: • Regulatory Framework (e.g. WFD) • Main instruments for the water management and protection • In depth knowledge of relevant measures of water pollution control • Urban drainage, treatment options in different regions on the world • Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration • Case Studies and Field Trips
Literature	The literature listed below is available in the library of the TUHH. • Water and wastewater technology Hammer, M. J. 1., & . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International. • Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill. • Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ.

Course L2008: Water Protection and Wastewater Management	
Typ	Project Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	
Literature	

Module M1720: Emerging Trends in Environmental Engineering

Courses

Title	Typ	Hrs/wk	CP
Environmental Research Trends (L2752)	Seminar	2	2
Microplastics in Environment (L2750)	Lecture	2	2
Scientific Communication and Methods (L2751)	Lecture	1	2

Module Responsible	Prof. Nima Shokri
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge on water, soil and environmental research.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will be exposed to up-to-date research topics focused on soil, water and climate related challenges with a particular focus on the effects of microplastics in environment. Data analysis, data measurement, curation and presentation will be other skills that the students will develop in this module.
Skills	Students' research skills will be improved in this module. How to prepare and deliver an effective presentation, how to write an abstract, research paper and proposal will be discussed in this module. Moreover, through Research-Based Learning approaches, the students will be exposed to current research trends in environmental engineering.
Personal Competence	
Social Competence	Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.
Autonomy	The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Report and Presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Environmental Engineering: Specialisation Biotechnology: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2752: Environmental Research Trends	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Salome Shokri-Kuehni
Language	EN
Cycle	WiSe
Content	Introduction - course objectives, expectations and format Analyzing the Audience, purpose and occasion Constructing and delivering effective technical presentations How to write an abstract How to write a scientific paper Developing competitive and persuasive research proposals Databases and resources available for water and environmental research Individual proposal on water and environmental research Individual project on water and environmental research Presentation on water and environmental research
Literature	• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9 • Supplemental materials and web links which will be available to registered students.

Course L2750: Microplastics in Environment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	- Introduction, objectives, expectations, format, importance - Sources of microplastics in environment - Microplastics sampling; Characterization of microplastics - Distribution of microplastics in terrestrial environments - Fate of microplastics in terrestrial environments - Project discussion - Effects of microplastics on terrestrial environments - Health risks of microplastics in environments - Project presentations by all students
Literature	- Microplastics in Terrestrial Environments (2021), Edited by Defu He and Yongming Luo - Particulate Plastics in Terrestrial and Aquatic Environments (2020), Edited by Nanthi S. Bolan et al. - Microplastic Pollutants (2017), by Christopher B. Crawford and Brian Quinn

Course L2751: Scientific Communication and Methods	
Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	Introduction - course objectives, expectations and format Analyzing the Audience, purpose and occasion Constructing and delivering effective technical presentations How to write an abstract How to create a scientific poster How to write a scientific paper Developing competitive and persuasive research proposals Individual project (report and presentation) related to soil, water and environmental research
Literature	• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9 • Supplemental materials and web links which will be available to registered students.

Module M1779: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)

Courses

Title	Typ	Hrs/wk	CP
Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC) (L2926)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydraulic Engineering • Hydromechanics, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-based Solutions (NBS) for Coastal Protection
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working in international groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report on a complex task with a presentation and subsequent discussion. The work on the complex task happens in the course of the lecture.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2926: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	EN
Cycle	WiSe
Content	• Climate and Climate Change • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-Based Solutions (NBS) for Coastal Protection
Literature	• Materials provided on eLearning Platform (HOOU Platform)

Module M1505: Adaptation to Climate Change in Hydraulic Engineering (AKWAS)

Courses

Title	Typ	Hrs/wk	CP
Adaptation to climate change in hydraulic engineering (L2291)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	• Hydrology, Hydraulic Engineering • Hydromechanic, Hydraulics • Fundamentals of Coastal Engineering, Coastal- and Flood Protection • Hydrological Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Climate protection and climate adaptation • Insights into climate change and its regional characteristics - fundamentals, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle • Fundamentals of analysis of climate data • Consequences of the impact of the climate change • Measures for climate adaptation • Assessment, prioritization and communication of adaptation measures • Fundamentals of the analysis of hydrometeorological and hydrological data
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • Autonomous work on complex tasks
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Preparation of a written report and a presentation of a complex task.
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L2291: Adaptation to climate change in hydraulic engineering	
Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	WiSe
Content	• Climate protection and climate adaptation • Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models • Impacts of climate change on the components of the regional hydrological cycle(climate science view) • Fundamentals of the analysis of climate data • Concequences of the impacts of climate change (ingenieering science view) • Measures for climate change adaptation • Assessment, prioritization and communication of measures • Fundamentals of analysis of hydrometeorological and hydrological data
Literature	• Bereitgestellte eLearning Plattform

Thesis

Module M-002: Master Thesis

Courses			
Title	**Typ**	**Hrs/wk**	**CP**

Module Responsible	Professoren der TUHH
Admission Requirements	• According to General Regulations §21 (1): At least 60 credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues. • The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject, describing current developments and taking up a critical position on them. • The students can place a research task in their subject area in its context and describe and critically assess the state of research.
Skills	The students are able: • To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question. • To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/or incompletely defined problems in a solution-oriented way. • To develop new scientific findings in their subject area and subject them to a critical assessment.
Personal Competence	
Social Competence	Students can • Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way. • Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressees while upholding their own assessments and viewpoints convincingly.
Autonomy	Students are able: • To structure a project of their own in work packages and to work them off accordingly. • To work their way in depth into a largely unknown subject and to access the information required for them to do so. • To apply the techniques of scientific work comprehensively in research of their own.
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0
Credit points	30
Course achievement	None
Examination	Thesis
Examination duration and scale	According to General Regulations
Assignment for the Following Curricula	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory Logistics, Infrastructure and Mobility: Thesis: Compulsory Materials Science: Thesis: Compulsory Mechanical Engineering and Management: Thesis: Compulsory

	Mechatronics: Thesis: Compulsory Biomedical Engineering: Thesis: Compulsory Microelectronics and Microsystems: Thesis: Compulsory Product Development, Materials and Production: Thesis: Compulsory Renewable Energies: Thesis: Compulsory Naval Architecture and Ocean Engineering: Thesis: Compulsory Ship and Offshore Technology: Thesis: Compulsory Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory Theoretical Mechanical Engineering: Thesis: Compulsory Process Engineering: Thesis: Compulsory Water and Environmental Engineering: Thesis: Compulsory Certification in Engineering & Advisory in Aviation: Thesis: Compulsory