TUHH
Hamburg
University of
Technology

Module Manual

Master of Science (M.Sc.)

Environmental Engineering

Cohort: Winter Term 2019

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Program description

Content

Environmental engineering has never been more relevant than it is today. In the past 20 years, the field has moved from purely focusing on the technical and logistical side of waste disposal to encompass material recovery and circular economy. Innovative materials, integrated material and process flow analysis, as well as the involvement of energy sector issues, have brought environmental technology - once a niche sector perceived to be partly driven by ideology - into mainstream areas of the international economy. Germany is a global market leader in many areas of environmental engineering expertise. This status requires ongoing success at different levels: innovative and integrated technology, favourable legal and economic standards and, not least, high-quality German university education in environmental sciences.

With this in mind, the International Master Program in Environmental Engineering at the Hamburg University of Technology (TUHH) focuses on current developments in environmental technology, while also providing a solid grounding in the subject’s scientific and economic foundations. Students can specialise in one of three areas: (i) Water, (ii) Waste & Energy or (iii) Biotechnology. Interdisciplinary considerations are essential to all subject areas. How can environmental pollution be reduced and valuable resources recovered at the same time? How does one measure the sustainability of a product or service? Which innovative technologies assure minimum energy use in production processes? Which environmental law constraints favour sustainable development? All these questions are relevant in the Environmental Engineering program.

Graduates of the Environmental Engineering program have a detailed understanding of key areas of environmental sciences. At the start of the Master’s program, all students take compulsory courses in environmental management, waste and wastewater treatment, fluid dynamics and hydrology, and environmental analytics. In the second semester, students can choose from a number of potential core areas. These include courses in geochemical engineering, technical microbiology and water and wastewater technology. From the third semester, students develop a specialisation in one of the areas mentioned above (Water, Waste and Energy, or Biotechnology). In addition to course-specific modules, students also take non-technical classes in subjects such as business economics or foreign languages.

Career prospects

Graduates of the International Master Program in Environmental Engineering are sought after in a broad range of different fields and have excellent prospects in terms of career development. Graduates may work, for example, for environmental authorities, water and wastewater companies, energy and waste management companies, engineering firms or in the biotechnology industry. Owing to the breadth and diversity of the course, Environmental Engineering graduates are able to quickly familiarise themselves with new information, which is highly beneficial when working in interdisciplinary teams, as will often be the case. Worldwide, the environmental technology sector is growing strongly. Inadequate environmental management can have a significantly negative impact on the economic development of a region or country. In light of the above, Environmental Engineering graduates are international in their outlook and employed around the world. In addition to preparing students for demanding careers in industry, the Master’s in Environmental Engineering also equips students with the necessary academic skills for pursuing their possible further specialisation at PhD level.

Learning target

Environmental Engineering graduates should have certain core skills and knowledge. These are listed below in the following categories: knowledge, skills, social skills and independence.

Knowledge:

1. Graduates are able to describe the fundamentals of environmental management and outline environmental standards, environmental economic instruments, the content of ISO 14001 and environmental performance evaluation.
2. They are able to explain the procedural fundamentals of important water and wastewater treatment techniques, biotechnological processes, biological waste treatment (aerobic and anaerobic) and relevant environmental chemicals and their analytical determination, particularly in water and wastewater analysis.
3. They can discuss hydrological and fluid mechanical models and the technical boundary conditions for sustainable water protection.
4. They are able to define the key principles of circular economy (water/waste) and outline the fundamentals of business economics.
5. Depending on the specialisation they choose, graduates can demonstrate their broader understanding in the areas of water, waste and energy or biotechnology.

Skills:

1. Graduates are able to complete practical laboratory work in the area of municipal water engineering taking into consideration the procedure selection for water and wastewater treatment processes.
2. They are able to conduct specialist scientific research and geographical data processing and apply hydrological models.
3. They are able to argue and write scientifically.
4. Graduates are able to produce incisive individual presentations and coordinated team presentations, as practised in classes involving problem-based learning (PBL).
5. They are able to apply fundamental business economics methods.
6. Depending on their chosen specialisation, they have further skills in the areas of water, energy and waste, or biotechnology. For example, they are able to design membrane separation processes, conduct modelling in water technology, select technical and regional planning solutions for tasks in a biorefinery or analyse and evaluate integrated waste management solutions.

Social skills:

1. The degree program Environmental Engineering attracts students from all over the world. From the beginning of the course, students work in diverse teams, in which they are able to use their different skill sets and values productively when working on technical problems.
2. On completion of their studies, students are able to develop technical proposals, comprehensively review results and, where relevant, confirm them through peer discussion.
3. They can present technical solutions as a team.
4. They can also give constructive feedback to fellow students and integrate feedback on their own performance appropriately into their own work.

Autonomy:

1. Graduates of the Environmental Engineering program are able to conduct independent research using scientific literature; read test reports; gain knowledge from these reports and transfer it to the project at hand.
2. In consultation with teaching staff, they are able to evaluate their own learning in concrete terms and define subsequent steps for ongoing progress.
3. They can independently define research and development tasks for theoretical and experimental investigation of environmental issues and plan and carry out projects in this regard.

Program structure

The Master’s program in Environmental Engineering is composed primarily of modules with six credit points (CPs). One CP equates to a student workload of 30 hours (classroom contact hours and study undertaken at home, including examination preparation). Master’s students must complete 120 CPs in four semesters over a two-year period.

The modules are divided into: (i) **core qualification,** (ii) **specialisation** and (iii) **thesis**. For the **core qualification**, all students initially attend compulsory courses amounting to 42 CPs. These are primarily completed in the first and second semesters. Based on their individual interests, students take a further 18 CPs from a possible 30 CPs of elective courses. These modules are primarily completed in the second and third semesters. It is obligatory for students to take one business economics module and a module with non-technical courses (foreign language, art or cultural courses). **Specialisation** encompasses 12 CPs of obligatory courses (project work) and 18 CPs elective courses, to be selected from the study options in the specialisations Water, Waste and Energy, or Biotechnology. These modules are primarily completed in the third semester. In the fourth semester, students complete their **thesis** (30 CPs). This is preferably completed in the student’s specialisation, though this is not obligatory. The third or fourth semester is most suited to students wishing to spend time abroad or on an industry placement as project and thesis work can be completed independent of lecture periods and in direct agreement with the supervising Professor.

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 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**: Yes; **Bonus**: None; **Form**: Subject theoretical and practical work; **Description**:
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 Energy and Environmental Engineering: Specialisation Environmental Engineering: 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 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 Energy and Environmental Engineering: Specialisation Environmental Engineering: 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 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 M1311: Sustainable Water Management and Microbiology of Water Supply

Courses

Title	Typ	Hrs/wk	CP
Microbiology of water supply (L1782)	Lecture	2	3
Sustainable Water Management (L0406)	Project-/problem-based Learning	2	3

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in water chemistry, Knowledge of main water treatment processes
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to explain the relevance of local and national water cycles on basis of water recycling targets. They will be able to separate into conventional and advanced treatment processes for both, drinking and wastewater treatment. Students are capable to name basic differences between water chemical parameters in drinking and wastewater analysis and define their significance for a sustainable water management. Students will be able to differentiate between natural and hygienically relevant bacteria in drinking water and will know modern microbiological methods for routine and scientific analyses of drinking water. They are familiar with the diverse microbiological processes in drinking water treatment and supply. The students know the legal regulations of the microbiological drinking water quality.
Skills	On basis of water use targets students will be able to prepare combinations of naturally based as well as technical water treatment processes. They will be able to calculate key parameters of treatment pathways for a water recycling study. Students will be able to deputise their conceptual design study by argumentation. Students will be capable to assess risks for the hygienic state of drinking water. Based on knowledge of methods they are able to evaluate results of routine analyses and research. Based on knowledge of processes, students will be able to suggest solutions to problems in drinking water supply.
Personal Competence	
Social Competence	Students will be able to work in diverse teams on problems in the field of sustainable water management. They will be able to coordinate complex tasks within their group and hand out duties accordingly.
Autonomy	Students will be in a position to work out presentations in the field of sustainable water management. They will be capable of finding creative solutions for water recycling concepts. Students will know how to use their technical knowledge for solving problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** Yes, **Bonus** 20 %, **Form** Presentation, **Description**
Examination	Written exam
Examination duration and scale	90 min exam
Assignment for the Following Curricula	Environmental Engineering: Core Qualification: Compulsory

Course L1782: Microbiology of water supply	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Anna Krüger
Language	EN
Cycle	WiSe
Content	• Natural and hygienically relevant microorganisms in drinking water • Quantification of bacteria in drinking water • Identification of bacteria • Bacterial population analyses • Growth of bacteria and VBNC-state • Activity of bacteria in the environment • Biofilms in drinking water systems • Disinfection of drinking water and drinking water systems • Microbiological processes in drinking water treatment • Technical realization for optimized use of microbiological processes for drinking water production • Impact factors on microbiological drinking water quality during distribution and compliance with legal requirements on hygiene at the consumer’s tap
Literature	• Allgemeine Mikrobiologie. 2007. Fuchs, G. (Hrsg.), 8. Aufl., Thieme Verlag, Stuttgart. • Brock Biology of Microorganisms. 2015. Madigan, M. T., Martinko, J. M., Bender, K. S., Buckley, D. H., and Stahl, D. A. (eds.), 14. edition, Pearson Education Ltd, Harlow, UK. • Microbial growth in drinking- water supplies: Problems, causes control and research needs. 2014. Van der Kooij, D. and Van der Wielen, P. W. J. J. (eds.) IWA Publishing, London.

Course L0406: Sustainable Water 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. Mathias Ernst
Language	EN
Cycle	WiSe
Content	The course provides knowledge on the sustainable treatment and management of the resource water. Used water is an alternative resource and can be recycled in any field of the urban water cycle after adequate treatment. The resulting water quality is the decisive issue. In the course the central quality parameters of drinking- as well as wastewater assessment will be presented and discussed. Moreover the legal frame for water reuse in the EU and examples from all over the world will be communicated. The students receive the task to develop a conceptual design study of an indirect potable reuse facility in given boundary conditions. To fulfill this task, the students will work in small groups representing a consulting firm. Later in the course the firms will present their concepts. In preparation to the team presentation further knowledge on alternative water resources and sustainable management will be provided. International case studies will be presented and discussed. Next to the communication of technical details, planning tools for the implementation of alternative water management will be given also Option for an effective public perception program of later water users.
Literature	• Milestones in Water Reuse, V. Lazarova, T. Asano, A. Bahri, J. Anderson, IWA Publishing 2013 • Current UN World Water Development Reports • Water Security for Better Lives, OECD Studie 2013 • PPT’s provided during the course

Module M1313: Fluid Mechanics, Hydraulics and Geo-information-systems in Water Management

Courses

Title	Typ	Hrs/wk	CP
Geo-Information-Systems in Water Management and Hydraulic Engineering (L0963)	Project-/problem-based Learning	2	2
Fluid Mechanics and Hydraulics (L1246)	Lecture	2	2
Fluid Mechanics and Hydraulics (L1656)	Recitation Section (small)	1	2

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Mathematics (calculus) and physics; Knowledge of statics and thermodynmaik would be beneficial.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After finishing the module the students will lern the properties of fluid, hydrostatics, Fluid kinematics, conservation equations (mass, energy and momentum), flow in pipes, boundary layer theory , viscous flow (skin friction and drag forces), flow in pipes, hydraulics of open channel, flow in compound and natural channels, energy head losses.
Skills	The students will be capable to calculate and analyse the forces in the fluids as well as flow in pipes and channels.
Personal Competence	
Social Competence	The students learn to deploy their knowledge in applied problems such as calculation of water level and the rate of water rise in flood events. Furthermore, they will be able to work in team with engineers of other disciplines, for instance by designing of gates.
Autonomy	The students will be able to independently extend their knowledge and applyit 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	90 minutes including definition and descriptions as well as calculations
Assignment for the Following Curricula	Environmental Engineering: Core Qualification: Compulsory

Course L0963: Geo-Information-Systems in Water Management and Hydraulic Engineering

Typ	Project-/problem-based Learning
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	WiSe
Content	Theoretical basics of Geo-Information-Systems • Data models, geographical coordinates, geo-referencing, map-views • Data mining and – analyses of geo-data • Analysis techniques
Literature	None

Course L1246: Fluid Mechanics and Hydraulics

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Mohammad Hassan Nasermoaddeli
Language	EN
Cycle	WiSe
Content	Properties of fluid, hydrostatics, Fluid kinematics, conservation equations (mass, energy and momentum), flow in pipes, boundary layer theory of laminar and turbulent flow, viscous flow (skin friction and drag forces), open channel hydraulics, flow in compound and natural channels, local energy head losses
Literature	R.L. Street, G.Z. Watters, J.K. Vennard: Elementary Fluid Mechanics, 7th edition, 1996 Chow, V.T., Open Channel hydraulics, Ven Te Chow, 1988

Course L1656: Fluid Mechanics and Hydraulics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Mohammad Hassan Nasermoaddeli
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1312: Environmental Analysis and water technology practice

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Practical Course in Water and Wastewater Technology I (L0503)	Practical Course	2	3
Environmental Analysis (L0354)	Lecture	2	3

Module Responsible	Dr. Dorothea Rechtenbach
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in chemistry and physics (knowledge required at school)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know basic analytical procedures for evaluating the quality of different environmental compartments.
Skills	The students are able to understand and to practically apply methodologies for environmental analysis as well as descriptions of experiments and experimental setups in wasterwater analysis.
Personal Competence	
Social Competence	The students are able to organize working processes within a team in a targeted way and based on the divison of labour.
Autonomy	The students are able to independently exploit sources and conduct experiments following written procedures without external assistance.
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	45 minutes written exam plus written report fpr the practical
Assignment for the Following Curricula	Environmental Engineering: Core Qualification: Compulsory

Course L0503: Practical Course in Water and Wastewater Technology I

Typ	Practical Course
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Dorothea Rechtenbach
Language	EN
Cycle	WiSe
Content	- Impact of pretreatment of wastewater samples on analytical results - Analysis of nutrients in wastewater samples (different methods for nitrate analysis) - Alkalinity - TOC, COD - microscopic analysis of microorganisms relevant in wastewater treatment
Literature	Skript auf StudIP

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 M1123: Selected Topics in Environmental Engineering

Courses

Title	Typ	Hrs/wk	CP
Environmental Aquatic Chemistry (L1444)	Lecture	2	3
Hydrobiology (L0416)	Lecture	2	3
Sludge Treatment (L0520)	Lecture	2	3
Thermal Utilization of Biomass (L1767)	Lecture	2	2
Thermal Utilization of Biomass (L1768)	Recitation Section (small)	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 L0416: Hydrobiology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	bis zu 8 DIN-A4-Seiten
Lecturer	Dr. Ludwig Tent
Language	EN
Cycle	SoSe
Content	• Running and stagnant waters with their surroundings as living sphere for plants, animals and man. Natural situation and nowadays reality • Goals for future developments • Demands of nature to engineering projects like city planning, constructions like e.g. brigdes, advanced waste water treatment and river maintenance • Practical exercise to get to know characteristic organisms of running waters • Sediments: origin, characterisation, how to get rid of problems in an environ-mentally acceptable way • Restructuring of aquatic habitats, river restoration, rehabilitation of stagnant waters • Diffuse immissions, erosion, soil conservation = improvement of the health of waters • Social implications
Literature	Script / original presentations for private use only Tent, L. (1998): Reconstruction versus ecological maintenance - improving lowland rivers in Hamburg and Lower Saxony. - in: HANSEN, H.O. and B.L. MADSEN (eds.): River Restoration ´96; Tent, L. (2001): Trout 2010 - Restructuring Urban Brooks with engaged Citizens. - in: Nijland, H. and M.J.R. Cals (eds.): River Restoration in Europe; Practical Approaches Internet, e.g. River Restoration like 2011 - http://web.natur.cuni.cz/hydroeco2011/index.php?id=33h , session H and more https://www.tub.tuhh.de/en/study/course-reserve-collections/?semapp=sem+tent&semappname=Tent

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 Utilization of Biomass	
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 L1768: Thermal Utilization of Biomass	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	WiSe
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	DE/EN
Cycle	SoSe
Content	Basics of numerial models / application of models • classification of models • model concept • modelling 1D Working Equation Mathematical description of physical processes • Equation of motions • ◦ conservation of mass ◦ conservation of momentum • Initial conditions and boundary conditions Numerical Methods • Time step procedure • Finite differences • Finite volumes
Literature	Vorlesungsskript

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 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 M0914: Technical Microbiology

Courses

Title	Typ	Hrs/wk	CP
Applied Molecular Biology (L0877)	Lecture	2	3
Technical Microbiology (L0999)	Lecture	2	2
Technical Microbiology (L1000)	Recitation Section (large)	1	1

Module Responsible	Dr. Anna Krüger
Admission Requirements	None
Recommended Previous Knowledge	Bachelor with basic knowledge in microbiology and genetics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successfully finishing this module, students are able • to give an overview of genetic processes in the cell • to explain the application of industrial relevant biocatalysts • to explain and prove genetic differences between pro- and eukaryotes
Skills	After successfully finishing this module, students are able • to explain and use advanced molecularbiological methods • to recognize problems in interdisciplinary fields
Personal Competence	
Social Competence	Students are able to • write protocols and PBL-summaries in teams • to lead and advise members within a PBL-unit in a group • develop and distribute work assignments for given problems
Autonomy	Students are able to • search information for a given problem by themselves • prepare summaries of their search results for the team • make themselves familiar with new topics
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** No / 10 % / Excercises / Multiple Choice Aufgaben No / 10 % / Group discussion / PBL Diskussionen
Examination	Written exam
Examination duration and scale	60 min exam
Assignment for the Following Curricula	Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0877: Applied Molecular Biology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Garabed Antranikian
Language	EN
Cycle	SoSe
Content	Lecture and PBL - Methods in genetics / molecular cloning - Industrial relevance of microbes and their biocatalysts - Biotransformation at extreme conditions - Genomics - Protein engineering techniques - Synthetic biology
Literature	Relevante Literatur wird im Kurs zur Verfügung gestellt. Grundwissen in Molekularbiologie, Genetik, Mikrobiologie und Biotechnologie erforderlich. Lehrbuch: Brock - Mikrobiologie / Microbiology (Madigan et al.)

Course L0999: Technical Microbiology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Anna Krüger
Language	EN
Cycle	SoSe
Content	• History of microbiology and biotechnology • Enzymes • Molecular biology • Fermentation • Downstream Processing • Industrial microbiological processes • Technical enzyme application • Biological Waste Water treatment
Literature	**Microbiology**, 2013, Madigan, M., Martinko, J. M., Stahl, D. A., Clark, D. P. (eds.), formerly „Brock“, Pearson **Industrielle Mikrobiologie**, 2012, Sahm, H., Antranikian, G., Stahmann, K.-P., Takors, R. (eds.) Springer Berlin, Heidelberg, New York, Tokyo. **Angewandte Mikrobiologie**, 2005, Antranikian, G. (ed.), Springer, Berlin, Heidelberg, New York, Tokyo.

Course L1000: Technical Microbiology	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Christin Burkhardt
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.

Specialization Waste and Energy

Graduates of the Waste & Energy specialization learn to use their knowledge in management for the planning of waste disposal processes and projects. Furthermore they have extended knowledge in special topics, such as bio-treatment of waste, energy conversion and international waste management. Graduates are able to evaluate the necessary technological key figures and to make decisions based on these. They are able to put their theoretical knowledge into practice and to analyze complex questions in waste management and technology. They learn diverse methods and techniques of waste and energy process technology and are able to use them successful for different tasks.

Module M0518: Waste and Energy

Courses

Title	Typ	Hrs/wk	CP
Waste Recycling Technologies (L0047)	Lecture	2	2
Waste Recycling Technologies (L0048)	Recitation Section (small)	1	2
Waste to Energy (L0049)	Project-/problem-based Learning	2	2

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	None
Recommended Previous Knowledge	Basics of process engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to describe and explain in detail techniques, processes and concepts for treatment and energy recovery from wastes.
Skills	The students are able to select suitable processes for the treatment and energy recovery of wastes. They can evaluate the efforts and costs for processes and select economically feasible treatment Concepts. Students are able to evaluate alternatives even with incomplete information. Students are able to prepare systematic documentation of work results in form of reports, presentations and are able to defend their findings in a 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 of collegues. Furthermore, they can give 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	**Compulsory** Yes; **Bonus** 20 %; **Form** Written elaboration; **Description**
Examination	Presentation
Examination duration and scale	PowerPoint presentation (10-15 minutes)
Assignment for the Following Curricula	Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory

Course L0047: Waste Recycling Technologies	
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	• Fundamentals on primary and secondary production of raw materials (steel, aluminum, phosphorous, copper, precious metals, rare metals) • Use and demand of metals and minerals in industry and society • collection systems and concepts • quota and efficiency • Advanced sorting technologies • mechanical pretreatment • advanced treatment • Chemical analysis of Critical Materials in post-consumer products • Analytical tools in Resource Management (Material Flow Analysis, Recycling Performance Indicators, Criticality Assessment, statistical analysis of uncertainties)
Literature	

Course L0048: Waste Recycling Technologies	
Typ	Recitation Section (small)
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	• Fundamentals on primary and secondary production of raw materials (steel, aluminum, phosphorous, copper, precious metals, rare metals) • Use and demand of metals and minerals in industry and society • collection systems and concepts • quota and efficiency • Advanced sorting technologies • mechanical pretreatment • advanced treatment • Chemical analysis of Critical Materials in post-consumer products • Analytical tools in Resource Management (Material Flow Analysis, Recycling Performance Indicators, Criticality Assessment, statistical analysis of uncertainties)
Literature	

Course L0049: Waste to Energy	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Rüdiger Siechau
Language	EN
Cycle	SoSe
Content	• Project-based lecture • Introduction into the " Waste to Energy " consisting of: ◦ Thermal Process (incinerator , RDF combustion) ◦ Biological processes (Wet-/Dryfermentation) ◦ technology , energy , emissions, approval , etc. • Group work ◦ design of systems/plants for energy recovery from waste ◦ The following points are to be processed : ▪ Input: waste (fraction collection and transportation, current quantity , material flows , possible amount of development) ▪ Plant (design, process diagram , technology, energy production) ▪ Output (energy quantity / type , by-products) ▪ Costs and revenues ▪ Climate and resource protection (CO2 balance , substitution of primary raw materials / fossil fuels) ▪ Location and approval (infrastructure , expiration authorization procedure) ▪ Focus at the whole concept (advantages, disadvantages , risks and opportunities , discussion) • Grading: No Exam , but presentation of the results of the working group
Literature	**Literatur:** Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010 Powerpoint-Folien in Stud IP **Literature:** Introduction to Waste Management; Kranert Martin , Klaus Cord - Landwehr (Ed.), Vieweg + Teubner Verlag , 2010 PowerPoint slides in Stud IP

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 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 • classify 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 Energy and Environmental Engineering: Specialisation Environmental 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
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 M1125: Bioresources and Biorefineries

Courses

Title	Typ	Hrs/wk	CP
Biorefinery Technology (L0895)	Lecture	2	2
Biorefinery Technologie (L0974)	Recitation Section (small)	1	1
Bioresource Management (L0892)	Lecture	2	2
Bioresource Management (L0893)	Recitation Section (small)	1	1

Module Responsible	Dr. Ina Körner
Admission Requirements	None
Recommended Previous Knowledge	Basics on engineering; Basics of waste and energy management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can give on overview on principles and theories in the field’s bioresource management and biorefinery technology and can explain specialized terms and technologies.
Skills	Students are capable of applying knowledge and know-how in the field’s bioresource management and biorefinery technology in order to perform technical and regional-planning tasks. They are also able to discuss the links to waste management, energy management and biotechnology.
Personal Competence	
Social Competence	Students can work goal-oriented with others and communicate and document their interests and knowledge in acceptable way.
Autonomy	Students are able to solve independently, with the aid of pointers, practice-related tasks bearing in mind possible societal consequences.
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	Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Environmental Engineering: Specialisation Biotechnology: Elective 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

Course L0895: Biorefinery Technology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Ina Körner
Language	EN
Cycle	WiSe
Content	The Europe 2020 strategy calls for bioeconomy as the key for smart and green growth of today. Biorefineries are the fundamental part on the way to convert the use of fossil-based society to bio-based society. For this reason, agriculture and forestry sectors are increasingly deliver bioresources. It is not only for their traditional applications in the food and feed sectors such as pulp or paper and construction material productions, but also to produce bioenergy and bio-based products such as bio-plastics. However although bioresources are renewable, they are considered as limited resources as well. The bioeconomy's limitation factor is the availability land on our world. In the context of the development of the bioeconomy, the sustainable and reliable supply of noon-food biomass feedstock is a critical success factor for the long-term perspective of bioenergy and other bio-based products production. Biorefineries are complex of technologies and process cascades using the available primary, secondary and tertiary bioresources to produce a multitude of products - a product mix from material and energy products. The lecture gives an overview on biorefinery technology and shall contribute to promotion of international biorefinery developments. Lectures: • What is a biorefinery: Overview on basic organic substrates and processes which lead to material and energy products • The way from a fossil based to a biobased economy in the 21st century • The worlds most advanced biorefinery • Presentation of various biorefinery systems and their products (e.g. lignocellulose biorefinery, green biorefinery, whole plant biorefinery, civilization biorefinery) • Example projects (e.g. combination of anaerobic digestion and composting in practice; demonstration project in Hamburgs city quarter Jenfelder Au) The lectures will be accompanied by technical tours. Optional it is also possible to visit more biorefinery lectures in the University of Hamburg (lectures in German only). In the exercise students have the possibility to work in groups on a biorefinery project or to work on a student-specific task.
Literature	Biorefineries - Industrial Process and Products - Status Qua and Future directions by Kamm, Gruber and Kamm (2010); Wiley VCH, available on-line in TUHH-library Powerpoint-Präsentations / selected Publications / further recommendations depending on the actual developments Industrial Biorefineries and White Biorefinery, by Pandey, Höfer, Larroche, Taherzadeh, Nampoothiri (Eds.); (2014 book development in progress)

Course L0974: Biorefinery Technologie	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Ina Körner
Language	EN
Cycle	WiSe
Content	1.) Selection of a topic within the thematic area "Biorefinery Technologie" from a given list or self-selected. 2.) Self-dependent recherches to the topic. 3.) Preparation of a written elaboration. 4.) Presentation of the results in the group.
Literature	Vom Thema abhängig. Eigene Recherchen nötig. Depending on the topic. Own recheches necassary.

Course L0892: Bioresource Management	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Ina Körner
Language	EN
Cycle	WiSe
Content	In the context of limited fossil resources, climate change mitigation and increasing population growth, Bioresources has a special role. They have to feed the population and in the same time they are important for material production such as pulp and paper or construction materials. Moreover they become more and more important in chemical industry and in energy provision as fossil substitution. Although Bioresources are renewable, they are also considered as limited resources. The availability of land on our planet is the main limitation factor. The sustainable and reliable supply of non-food biomass feedstock is a critical for successful and long term perspective on production of bioenergy and other bio-based products. As the consequence, the increasing competition and shortages continue to happen at the traditional sectors. On the other side, huge unused but potentials residue on waste and wastewater sector exist. Nowadays, a lot of activities to develop better processes, to create new bio-based products in order to become more efficient, the inclusion of secondary and tertiary bio-resources in the valorisation chain are going on. The lecture deals with the current state-of-the-art of bioresource management. It shows deficits and potentials for improvement especially in the sector of utilization of organic residues for material and energy generation: *Lectures on:* • Bioresource generation and utilization including lost potentials today • Basic biological, mechanical, physico-chemical and logistical processes • The conflict of material vs. energy generation from wood / waste wood • The basics of pulp & paper production including waste paper recycling • The Pros and Cons from biogas and compost production *Special lectures by invited guests from research and practice:* • Pathways of waste organics on the example of Hamburg`s City Cleaning Company • Utilization options of landscaping materials on the example of grass • Increase of process efficiency of anaerobic digestions • Decision support tools on the example of an municipality in Indonesia *Optional: Technical visits*
Literature	Power-Point presentations in STUD-IP

Course L0893: Bioresource Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Ina Körner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1127: Study Work Waste and Energy

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	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0
Credit points	12
Course achievement	None
Examination	Study work
Examination duration and scale	depending on task
Assignment for the Following Curricula	Environmental Engineering: Specialisation Waste and Energy: Compulsory

Specialization Biotechnology

Graduates of the Biotechnology specialization learn to use their knowledge in management for the planning of biotechnological processes and projects. Furthermore they have extended knowledge in special topics, such as bio resources, bio catalysis and bio-system-technology. Graduates are able to evaluate the necessary technological key figures and to make decisions based on these. They are able to put their theoretical knowledge into practice and to analyze complex questions in biotechnological management. They learn diverse methods and techniques of bio-process technology and are able to use them successful for different tasks.

Module M0896: Bioprocess and Biosystems Engineering

Courses

Title	Typ	Hrs/wk	CP
Bioreactor Design and Operation (L1034)	Lecture	2	2
Bioreactors and Biosystems Engineering (L1037)	Project-/problem-based Learning	1	2
Biosystems Engineering (L1036)	Lecture	2	2

Module Responsible	Prof. An-Ping Zeng
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of bioprocess engineering and process engineering at bachelor level
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After completion of this module, participants will be able to: • differentiate between different kinds of bioreactors and describe their key features • identify and characterize the peripheral and control systems of bioreactors • depict integrated biosystems (bioprocesses including up- and downstream processing) • name different sterilization methods and evaluate those in terms of different applications • recall and define the advanced methods of modern systems-biological approaches • connect the multiple "omics"-methods and evaluate their application for biological questions • recall the fundamentals of modeling and simulation of biological networks and biotechnological processes and to discuss their methods • assess and apply methods and theories of genomics, transcriptomics, proteomics and metabolomics in order to quantify and optimize biological processes at molecular and process levels.
Skills	After completion of this module, participants will be able to: • describe different process control strategies for bioreactors and chose them after analysis of characteristics of a given bioprocess • plan and construct a bioreactor system including peripherals from lab to pilot plant scale • adapt a present bioreactor system to a new process and optimize it • develop concepts for integration of bioreactors into bioproduction processes • combine the different modeling methods into an overall modeling approach, to apply these methods to specific problems and to evaluate the achieved results critically • connect all process components of biotechnological processes for a holistic system view.
Personal Competence	
Social Competence	After completion of this module, participants will be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork. The students can reflect their specific knowledge orally and discuss it with other students and teachers.
Autonomy	After completion of this module, participants will be able to solve a technical problem in teams of approx. 8-12 persons independently including a presentation of the results. •
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** Yes · **Bonus** 20 % · **Form** Presentation · **Description**
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Environmental Engineering: Specialisation Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory

	Process Engineering: Core Qualification: Compulsory

Course L1034: Bioreactor Design and Operation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. An-Ping Zeng
Language	EN
Cycle	SoSe
Content	**Design of bioreactors and peripheries:** • reactor types and geometry • materials and surface treatment • agitation system design • insertion of stirrer • sealings • fittings and valves • peripherals • materials • standardization • demonstration in laboratory and pilot plant **Sterile operation:** • theory of sterilisation processes • different sterilisation methods • sterilisation of reactor and probes • industrial sterile test, automated sterilisation • introduction of biological material • autoclaves • continuous sterilisation of fluids • deep bed filters, tangential flow filters • demonstration and practice in pilot plant **Instrumentation and control:** • temperature control and heat exchange • dissolved oxygen control and mass transfer • aeration and mixing • used gassing units and gassing strategies • control of agitation and power input • pH and reactor volume, foaming, membrane gassing **Bioreactor selection and scale-up:** • selection criteria • scale-up and scale-down • reactors for mammalian cell culture **Integrated biosystem:** • interactions and integration of microorganisms, bioreactor and downstream processing • Miniplant technologies **Team work with presentation:** • Operation mode of selected bioprocesses (e.g. fundamentals of batch, fed-batch and continuous cultivation)
Literature	• Storhas, Winfried, Bioreaktoren und periphere Einrichtungen, Braunschweig: Vieweg, 1994 • Chmiel, Horst, Bioprozeßtechnik; Springer 2011 • Krahe, Martin, Biochemical Engineering, Ullmann's Encyclopedia of Industrial Chemistry • Pauline M. Doran, Bioprocess Engineering Principles, Second Edition, Academic Press, 2013 • Other lecture materials to be distributed

Course L1037: Bioreactors and Biosystems Engineering	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. An-Ping Zeng
Language	EN
Cycle	SoSe
Content	**Introduction to Biosystems Engineering (Exercise)** **Experimental basis and methods for biosystems analysis** • Introduction to genomics, transcriptomics and proteomics • More detailed treatment of metabolomics • Determination of in-vivo kinetics • Techniques for rapid sampling • Quenching and extraction • Analytical methods for determination of metabolite concentrations **Analysis, modelling and simulation of biological networks** • Metabolic flux analysis • Introduction • Isotope labelling • Elementary flux modes • Mechanistic and structural network models • Regulatory networks • Systems analysis • Structural network analysis • Linear and non-linear dynamic systems • Sensitivity analysis (metabolic control analysis) **Modelling and simulation for bioprocess engineering** • Modelling of bioreactors • Dynamic behaviour of bioprocesses **Selected projects for biosystems engineering** • Miniaturisation of bioreaction systems • Miniplant technology for the integration of biosynthesis and downstream processin • Technical and economic overall assessment of bioproduction processes
Literature	E. Klipp et al. Systems Biology in Practice, Wiley-VCH, 2006 R. Dohrn: Miniplant-Technik, Wiley-VCH, 2006 G.N. Stephanopoulos et. al.: Metabolic Engineering, Academic Press, 1998 I.J. Dunn et. al.: Biological Reaction Engineering, Wiley-VCH, 2003 Lecture materials to be distributed

Course L1036: Biosystems Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. An-Ping Zeng
Language	EN
Cycle	SoSe
Content	**Introduction to Biosystems Engineering** **Experimental basis and methods for biosystems analysis** • Introduction to genomics, transcriptomics and proteomics • More detailed treatment of metabolomics • Determination of in-vivo kinetics • Techniques for rapid sampling • Quenching and extraction • Analytical methods for determination of metabolite concentrations **Analysis, modelling and simulation of biological networks** • Metabolic flux analysis • Introduction • Isotope labelling • Elementary flux modes • Mechanistic and structural network models • Regulatory networks • Systems analysis • Structural network analysis • Linear and non-linear dynamic systems • Sensitivity analysis (metabolic control analysis) **Modelling and simulation for bioprocess engineering** • Modelling of bioreactors • Dynamic behaviour of bioprocesses **Selected projects for biosystems engineering** • Miniaturisation of bioreaction systems • Miniplant technology for the integration of biosynthesis and downstream processin • Technical and economic overall assessment of bioproduction processes
Literature	E. Klipp et al. Systems Biology in Practice, Wiley-VCH, 2006 R. Dohrn: Miniplant-Technik, Wiley-VCH, 2006 G.N. Stephanopoulos et. al.: Metabolic Engineering, Academic Press, 1998 I.J. Dunn et. al.: Biological Reaction Engineering, Wiley-VCH, 2003 Lecture materials to be distributed

Module M0973: Biocatalysis

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Biocatalysis and Enzyme Technology (L1158)	Lecture	2	3
Technical Biocatalysis (L1157)	Lecture	2	3

Module Responsible	Prof. Andreas Liese
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of bioprocess engineering and process engineering at bachelor level
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this course, students will be able to • reflect a broad knowledge about enzymes and their applications in academia and industry • have an overview of relevant biotransformations und name the general definitions
Skills	After successful completion of this course, students will be able to • understand the fundamentals of biocatalysis and enzyme processes and transfer this to new tasks • know the several enzyme reactors and the important parameters of enzyme processes • use their gained knowledge about the realisation of processes. Transfer this to new tasks • analyse and discuss special tasks of processes in plenum and give solutions • communicate and discuss in English
Personal Competence	
Social Competence	After completion of this module, participants will be able to debate technical and biocatalytical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork.
Autonomy	After completion of this module, participants will be able to solve a technical problem independently including a presentation of the results.
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	Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Environmental Engineering: Specialisation Biotechnology: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L1158: Biocatalysis and Enzyme Technology

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	EN
Cycle	WiSe
Content	1. Introduction: Impact and potential of enzyme-catalysed processes in biotechnology. 2. History of microbial and enzymatic biotransformations. 3. Chirality - definition & measurement 4. Basic biochemical reactions, structure and function of enzymes. 5. Biocatalytic retrosynthesis of asymmetric molecules 6. Enzyme kinetics: mechanisms, calculations, multisubstrate reactions. 7. Reactors for biotransformations.
Literature	• K. Faber: Biotransformations in Organic Chemistry, Springer, 5th Ed., 2004 • A. Liese, K. Seelbach, C. Wandrey: Industrial Biotransformations, Wiley-VCH, 2006 • R. B. Silverman: The Organic Chemistry of Enzyme-Catalysed Reactions, Academic Press, 2000 • K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology. VCH, 2005. • R. D. Schmidt: Pocket Guide to Biotechnology and Genetic Engineering, Woley-VCH, 2003

Course L1157: Technical Biocatalysis	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	EN
Cycle	WiSe
Content	1. Introduction 2. Production and Down Stream Processing of Biocatalysts 3. Analytics (offline/online) 4. Reaction Engineering & Process Control • Definitions • Reactors • Membrane Processes • Immobilization 5. Process Optimization • Simplex / DOE / GA 6. Examples of Industrial Processes • food / feed • fine chemicals 7. Non-Aqueous Solvents as Reaction Media • ionic liquids • scCO2 • solvent free
Literature	• A. Liese, K. Seelbach, C. Wandrey: Industrial Biotransformations, Wiley-VCH, 2006 • H. Chmiel: Bioprozeßtechnik, Elsevier, 2005 • K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, VCH, 2005 • R. D. Schmidt: Pocket Guide to Biotechnology and Genetic Engineering, Woley-VCH, 2003

Module M1125: Bioresources and Biorefineries

Courses

Title	Typ	Hrs/wk	CP
Biorefinery Technology (L0895)	Lecture	2	2
Biorefinery Technologie (L0974)	Recitation Section (small)	1	1
Bioresource Management (L0892)	Lecture	2	2
Bioresource Management (L0893)	Recitation Section (small)	1	1

Module Responsible	Dr. Ina Körner
Admission Requirements	None
Recommended Previous Knowledge	Basics on engineering; Basics of waste and energy management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can give on overview on principles and theories in the field’s bioresource management and biorefinery technology and can explain specialized terms and technologies.
Skills	Students are capable of applying knowledge and know-how in the field’s bioresource management and biorefinery technology in order to perform technical and regional-planning tasks. They are also able to discuss the links to waste management, energy management and biotechnology.
Personal Competence	
Social Competence	Students can work goal-oriented with others and communicate and document their interests and knowledge in acceptable way.
Autonomy	Students are able to solve independently, with the aid of pointers, practice-related tasks bearing in mind possible societal consequences.
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	Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory Environmental Engineering: Specialisation Biotechnology: Elective 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

Course L0895: Biorefinery Technology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Ina Körner
Language	EN
Cycle	WiSe
Content	The Europe 2020 strategy calls for bioeconomy as the key for smart and green growth of today. Biorefineries are the fundamental part on the way to convert the use of fossil-based society to bio-based society. For this reason, agriculture and forestry sectors are increasingly deliver bioresources. It is not only for their traditional applications in the food and feed sectors such as pulp or paper and construction material productions, but also to produce bioenergy and bio-based products such as bio-plastics. However although bioresources are renewable, they are considered as limited resources as well. The bioeconomy's limitation factor is the availability land on our world. In the context of the development of the bioeconomy, the sustainable and reliable supply of noon-food biomass feedstock is a critical success factor for the long-term perspective of bioenergy and other bio-based products production. Biorefineries are complex of technologies and process cascades using the available primary, secondary and tertiary bioresources to produce a multitude of products - a product mix from material and energy products. The lecture gives an overview on biorefinery technology and shall contribute to promotion of international biorefinery developments. Lectures: • What is a biorefinery: Overview on basic organic substrates and processes which lead to material and energy products • The way from a fossil based to a biobased economy in the 21st century • The worlds most advanced biorefinery • Presentation of various biorefinery systems and their products (e.g. lignocellulose biorefinery, green biorefinery, whole plant biorefinery, civilization biorefinery) • Example projects (e.g. combination of anaerobic digestion and composting in practice; demonstration project in Hamburgs city quarter Jenfelder Au) The lectures will be accompanied by technical tours. Optional it is also possible to visit more biorefinery lectures in the University of Hamburg (lectures in German only). In the exercise students have the possibility to work in groups on a biorefinery project or to work on a student-specific task.
Literature	Biorefineries - Industrial Process and Products - Status Qua and Future directions by Kamm, Gruber and Kamm (2010); Wiley VCH, available on-line in TUHH-library Powerpoint-Präsentations / selected Publications / further recommendations depending on the actual developments Industrial Biorefineries and White Biorefinery, by Pandey, Höfer, Larroche, Taherzadeh, Nampoothiri (Eds.); (2014 book development in progress)

Course L0974: Biorefinery Technologie	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Ina Körner
Language	EN
Cycle	WiSe
Content	1.) Selection of a topic within the thematic area "Biorefinery Technologie" from a given list or self-selected. 2.) Self-dependent recherches to the topic. 3.) Preparation of a written elaboration. 4.) Presentation of the results in the group.
Literature	Vom Thema abhängig. Eigene Recherchen nötig. Depending on the topic. Own recheches necassary.

Course L0892: Bioresource Management	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Ina Körner
Language	EN
Cycle	WiSe
Content	In the context of limited fossil resources, climate change mitigation and increasing population growth, Bioresources has a special role. They have to feed the population and in the same time they are important for material production such as pulp and paper or construction materials. Moreover they become more and more important in chemical industry and in energy provision as fossil substitution. Although Bioresources are renewable, they are also considered as limited resources. The availability of land on our planet is the main limitation factor. The sustainable and reliable supply of non-food biomass feedstock is a critical for successful and long term perspective on production of bioenergy and other bio-based products. As the consequence, the increasing competition and shortages continue to happen at the traditional sectors. On the other side, huge unused but potentials residue on waste and wastewater sector exist. Nowadays, a lot of activities to develop better processes, to create new bio-based products in order to become more efficient, the inclusion of secondary and tertiary bio-resources in the valorisation chain are going on. The lecture deals with the current state-of-the-art of bioresource management. It shows deficits and potentials for improvement especially in the sector of utilization of organic residues for material and energy generation: *Lectures on:* • Bioresource generation and utilization including lost potentials today • Basic biological, mechanical, physico-chemical and logistical processes • The conflict of material vs. energy generation from wood / waste wood • The basics of pulp & paper production including waste paper recycling • The Pros and Cons from biogas and compost production *Special lectures by invited guests from research and practice:* • Pathways of waste organics on the example of Hamburg`s City Cleaning Company • Utilization options of landscaping materials on the example of grass • Increase of process efficiency of anaerobic digestions • Decision support tools on the example of an municipality in Indonesia *Optional: Technical visits*
Literature	Power-Point presentations in STUD-IP

Course L0893: Bioresource Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Ina Körner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1128: Study Work Biotechnology

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	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0
Credit points	12
Course achievement	None
Examination	Study work
Examination duration and scale	depending on task
Assignment for the Following Curricula	Environmental Engineering: Specialisation Biotechnology: Compulsory

Specialization Water

Graduates of the Water specialization learn to use their knowledge in management for the planning of water technology processes and projects. Furthermore they have extended knowledge in special topics, such as aquatic chemistry, groundwater engineering, modelling or membrane technology. Graduates are able to evaluate the necessary technological key figures and to make decisions based on these. They are able to put their theoretical knowledge into practice and to analyze complex questions in water management. They learn diverse methods in techniques of water engineering and are able to use them successful for different tasks.

Module M1116: Groundwater Modeling

Courses

Title	Typ	Hrs/wk	CP
Applied Groundwater Modeling (IMPEE) (L1451)	Project-/problem-based Learning	2	3
Groundwater Engineering (L1449)	Lecture	1	1
Groundwater Engineering (L1450)	Recitation Section (small)	1	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	• Groundwater hydrology • Hydromechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to define typical aquifer types and the occuring flow and storage processes can be explained technically. They are able to derive the Darcy law and the mathematical description of flow processes as well as their solution. They are in a position to explain the physical background of well hydraulics. Fundamentals of solute transport can be reflected.They are able to use the flow and tranport model MODFLOW/MT3D
Skills	The students are able to build a concept model for ground water flow and to transfer this in a numerical flow model. They can use the model MODFLOW expertly and they are able to apply it for practicaL problems.
Personal Competence	
Social Competence	none
Autonomy	Are not imparted in this module.
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	60 min
Assignment for the Following Curricula	Environmental Engineering: Specialisation Water: Elective Compulsory

Course L1451: Applied Groundwater Modeling (IMPEE)

Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	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 L1449: Groundwater Engineering	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	NN
Language	EN
Cycle	SoSe
Content	Hydrologic water bilance, aquifertyps, groundwater velocities, Darcy law, groundwater contour lines, storage capacity, flow equation, pumping tests, method of Beyer, solute transport in groundwater
Literature	Todd; K. (2005): Groundwater Hydrology Fetter, C.W. (2001): Applied Hydrogeology Hölting & Coldewey (2005): Hydrogeologie Charbeneau, R.J. (2000): Groundwater Hydraulics and pollutant Transport

Course L1450: Groundwater Engineering	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	NN
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

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 Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: 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 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	DE
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	DE
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 M1126: Study Work 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	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0
Credit points	12
Course achievement	None
Examination	Study work
Examination duration and scale	see FSPO
Assignment for the Following Curricula	Environmental Engineering: Specialisation Water: Compulsory

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 Energy and Environmental Engineering: Specialisation Energy and Environmental 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	Written exam
Examination duration and scale	1,5 hours
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 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 Energy and Environmental Engineering: Specialisation Energy and Environmental 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	

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 and Environmental Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computational Science and Engineering: Thesis: Compulsory Information and Communication Systems: 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 Mathematical Modelling in Engineering: Theory, Numerics, Applications: 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