Handbook of Modules

International M.Sc.
Water Resources and
Environmental Management
(WATENV)

Legend:

HA	Term paper
LÜ	Laboratory exercise
K	Written examination without choice format
KA	Written examination with choice format
KO	Colloquium
MA	Master Thesis
MP	Oral examination
P	Project work
PF	Portfolio
PR	Presentation
SA	Seminar paper
SE	Seminar performance
V	Oral presentation
Ü	Practice
ZP/VbP	Combined assessment

Contents

The examination format for the Winter semester for the module can be found at the link below.

https://www.fbg.uni-hannover.de/fileadmin/fbg/Studium/Bauingenieurwesen/Prueferlisten/Prueferliste_WS_DE.xlsx

1st. Semester

Research Planning & Scientific Communication

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
VbP (SE 100%) / - **Course achievements:** - (-)	2S	E	3	WS	6011

Learning Objectives

The course introduces several basic aspects of performing research according to scientific standards. Furthermore, students will practise to write scientific texts and present scientific information. Students will conduct a literature review on a selected water resources or environmental management topic. In this course, students will learn to:

- Search for literature;
- Efficiently and critically read scientific literature;
- Present about a water resources or environmental problem;
- Write about a scientific topic in a clear and concise manner;
- Structure scientific documents (understand what goes where);
- Be able to create effective tables and figures;
- Learn basics about organizing research from student theses to poposal to lab to results presentation.

Contents

- Carry out scientific and project related literature search
- Learn to work with the search systems Scopus and Google Scholar
- Understand the goals and challenges of scientific writing
- Scientific standards including referencing and awareness of plagiarism
- Specifics of scientific writing: structure and red line of documents, style, figures, equations

Workload	90 h (30 h in-class teaching and 60 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	-
Literature	Alley, M. (1996). The Craft of Scientific Writing, 3rd Edition. New York, U.S.A., Springer. Booth, W.C., Colomb, G. G. & Williams, J. M. (2008). The Craft of Research, 3rd Edition. Chicago, U.S.A., University of Chicago Press. Booth, A., Sutton, A. & Papaioannou, D. (2016). Systematic approaches to a succesful literature review, 2nd edition. London, UK, SAGE Publications Hofmann, A. H. (2010). Scientific Writing and Communication. Oxford, U.K.: Oxford Press. Kumar, R. (2011). Research Methodology: A Step-by -step Guide for Beginners. London, U.K., SAGE Publications.
Media	Whiteboard, Powerpoint-Presentation, Videos, Stud-IP, Computer
Particularities	

Organizer	Dietrich, Jörg
Lecturer	Dietrich, Jörg; Paul, Maike
Supervisor	Dietrich, Jörg; Paul, Maike; Ghostabspour, Golbarg
Examiner	Dietrich, Jörg; Paul, Maike
Institute	Institute of Hydrology and Water Resources Management and Franzius-Institute for Hydraulic, Estuarine and Coastal Engineering http://www.iww.uni-hannover.de/ http://www.lufi.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	P	P

Hydrochemistry and –biology

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** - (-)	1V / 1Ü	E	3	WS	6021

Learning Objectives

The engineering students will gain competences about to describe and analyse basic chemical and biological
processes occurring in the natural and the engineered environment.

After successful completion of this module, students will be able to:

- identify acid-base, redox, and precipitation reactions,
- describe the kinetics of chemical reactions,
- describe microbial kinetics and stoichiometry,
- examine the processes of carbon and nutrients removal in wastewater treatment

Contents

- Stoichiometry of acid-base, redox, and precipitation reactions,
- Kinetics of chemical reactions; Basic aspects of the growth of microorganisms,
- Kinetic description of microbial growth; Basic energetics of microbial growth,
- Wastewater characterization; Biological aerobic/anaerobic processes in wastewater treatment

Workload	90 h (30 h in-class teaching and 60 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	-
Literature	Lester, J.N. & Birkett, J.W. (2002). Microbiology and chemistry for environmental scientists and engineers, 2nd Edition. E & FN Spon, London. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M. & Stahl, D.A. (2018). Brock Biology of Microorganisms, 15th Edition, Pearson Prentice Hall. Wallace, J. M. & Hobbs, P. V. (2006). Atmospheric science: an introductory survey, 2ndEdition. Elsevier, Amsterdam.
Media	Blackboard, PowerPoint
Particularities	none

Organizer	Nogueira, Regina
Lecturer	Nogueira, Regina
Supervisor	Shafi Zadeh, Shima; Thoms, Anna
Examiner	Nogueira, Regina
Institute	Institute of Sanitary Engineering and Waste Management,

	http://www.isah.uni-hannover.de/ Faculty of Civil Engineering and Geodesic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	P	P

Environmental Hydraulics

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** - (-)	2V / 2Ü	E	6	WS	6031

Learning Objectives

This module introduces the general principles needed to describe and model surface and subsurface flows. Elementary theories such as the conservation of mass, energy and flux as well as quantities to describe flow properties are described. The module also gives an insight into the concepts of physical and numerical modeling. Furthermore, knowledge about hydraulic structures and their main purposes are presented. Upon successful completion of this module the students are able

- to understand the physical processes and phenomena that are relevant for surface and subsurface flow;
- to remember the fundamental principles for modeling flow processes and implementing them for practical problems;
- to apply simple hydro-numerical solution schemes.

Contents

1. Groundwater Hydraulics:
- Continuum description of porous media
- Darcy's law
- Continuum equation for ground water
- Application for different types of aquifers
- Well hydraulics
- Regional ground water flow
- Numerical schemes for groundwater flow

2. River Hydraulics:
- Kinematics and kinetics of flow (balance equations)
- Laminar and turbulent flow
- Flow models, similarity theory, physical modeling
- Potential theory
- Stationary, steady state open channel flow
- Normal discharge, supercritical and subcritical flow
- St. Venant equations, iterative solutions for the water table
- Fundamentals of hydronumerical simulations (floods)

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	-
Literature	Baer, J., 1979: Hydraulics of Groundwater. McGraw-Hill, New York.

	Freeze, R.A. and Cherry, J.A., 1979: Groundwater. Prentice-Hall Inc. Englewood Cliffs. Kinzelbach, W. 1986: Groundwater Modeling, Elsevier. Lamb, H., 1993: Hydrodynamics. Cambridge Mathematical Library, Cambridge University Press. Chadwick, A., 2004: Hydraulics in Civil and Environmental Engineering. Taylor & Francis
Media	Blackboard, Beamer, StudIP
Particularities	none

Organizer	Graf, Thomas
Lecturer	Graf, Thomas; Welzel, Mario
Supervisor	Graf, Thomas
Examiner	Graf, Thomas
Institute	Institute of Fluid Mechanics and Environmental Physics in Civil Engineering and Franzius-Institute for Hydraulic, Estuarine and Coastal Engineering http://www.hydromech.uni-hannover.de/ http://www.lufi.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	P	P

Meteorology and Climatology

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** - (-)	2V	E	3	SS	?

Learning Objectives

The objective of this course is to impart fundamental knowledge about weather, climate and atmospheric phenomena. After successful completion of the module, students will have the ability to describe the atmosphere's composition and characteristics, to distinguish between different weather variabilities, and to solve problems regarding the atmospheric variables and processes, either analytically or with numerical methods. This also includes a brief review on instruments used in atmospheric sciences.

Contents

- Introduction to weather, climate and the atmosphere
- Basic physical laws of the atmosphere and basic quantities (temperature, pressure, wind, and humidity)
- Atmospheric processes and their interaction: e.g., radiation, thermodynamics including adiabatic processes, general circulation, formation of precipitation
- Instruments to measure meteorological quantities
- Climate and climate change

Workload	90 h (30 h in-class teaching and 60 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	-
Literature	Wallace, J. M. and Hobbs, P. V.: Atmospheric science: an introductory survey, 2nd Edition. Elsevier, Amsterdam, 2006 Kraus, H.: Die Atmosphäre der Erde, 3rd Edition, Springer, Berlin, 2004.
Media	Blackboard, PowerPoint
Particularities	none

Organizer	Maronga, Björn
Lecturer	Mount, Christopher
Supervisor	
Examiner	Mount, Christopher
Institute	Institute of Meteorology and Climatology, http://www.muk.uni-hannover.de/ Faculty of Mathematics and Physics

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	P	P

Hydrology and Water Resources Management

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** - (-)	2V / 2Ü	E	6	WS	6041

Learning Objectives

This modul introduces the basic understanding of hydrological processes, and the application for planning and designing human activities in the management of water resources. Upon completion of the module, students are able to:

- understand the water balance components precipitation, evapotranspiration and runoff;
- apply different concepts for the calculation of runoff from rainfall;
- apply hydrological methods in water resources and environmental planning;
- design reservoirs and other structures e.g. for irrigation;
- evaluate options for the spatial and temporal redistribution of water resources including the technical feasibility and economic consequences;
- analyse the risk of extreme events in hydrology and water resources management.

Contents

1. Hydrology I:
- Cycle of water, energy and matter, catchment
- Precipitation: genesis, measurement, calculation
- Evaporation: types, measurement, calculation
- Stage and discharge: measurement, analysis
- Floods and droughts
- Subsurface water: soil water, groundwater
- Rainfall runoff relationships: runoff generation, runoff transformation, flood routing

2. Water Resources Management I:
- Reservoir design, retention; Flood risk management
- Irrigation and drainage; Economic project assessment.

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	-
Literature	Dyck, S., Peschke, G., 1995: Grundlagen der Hydrologie. Verlag für Bauwesen, Berlin. Maniak, U., 2010: Hydrologie und Wasserwirtschaft: Eine Einführung für Ingenieure. 6. Aufl., Springer.
Media	Blackboard, PowerPoint-Presentation, Script
Particularities	none

Organizer	Haberlandt, Uwe
Lecturer	Dietrich, Jörg; Haberlandt, Uwe
Supervisor	Brandt, Adina; Bovermann, Zoe
Examiner	Haberlandt, Uwe
Institute	Institute of Hydrology and Water Resources Management, http://www.iww.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	P	P

Statistical Methods

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
VbP (P 25%) / K (75%) **Course achievements:** - (-)	2V / 2Ü	E	6	WS	6051

Learning Objectives

The module teaches basic concepts and methods of statistics concerning environmental data analysis including knowledge for management and analyses of empirical data within the free statistical software R. The overall focus is on environmental data, which are relevant to hydrology and water resources management.

Upon completion of the module, students are able to:

- select suitable methods for data analyses,
- apply basic statistical methods and interpret results correctly,
- apply the statistical software R for basic data analyses and graphical representation.

Contents

1. Statistics:
- plausibility, consistence and homogeneity of data
- descriptive statistics, probability, distribution functions
- extreme value analysis, risk assessment, floods
- tests, correlation, regression
- time series analysis and synthesis

2. Statistical Software R:
- General introduction to R
- Data management and statistical calculations with R
- Interpretation of the results

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	-
Literature	- Haan, C.T., 2002. Statistical Methods in Hydrology. Blackwell, Ames, Iowa, USA. - Jones, C., 1999. Geographical Information Systems and Computer Cartography Logman. - Adler, Joseph (2012): R in a nutshell, a desktop quick reference. 2nd ed., O'Reilly, Sebastopol, CA. - Fox, John: The R Commander: A Basic-Statistics Graphical User Interface to R. Journal of Statistical Software, Sept. 2005, Vol. 14, Iss. 9.
Media	PowerPoint, Whiteboard, Computer, Lecture-Notes
Particularities	none

Organizer	Haberlandt, Uwe
Lecturer	Haberlandt, Uwe
Supervisor	Goshtasbpour, Golbart; Thiele, Luisa
Examiner	Haberlandt, Uwe
Institute	Institute of Hydrology and Water Resources Management, http://www.iww.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	P	P

Coastal and Estuarine Management

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
VbP (PF 100%) / - **Course achievements:** - (-)	2V / 2Ü	E	6	WS	6401

Learning Objectives

Students aquire principles of near-shore coastal processes and anticipated changes in coastal zones due to multiple drivers and stressors. Students are competent in applying basic assessment approaches and design tools for coastal management purposes regarding the dynamic, continous and iterative processes designated to promote sustainable management of coastal zones. On basis of this knowledge, students are capable to address and solve problems regarding coastal hazards, risks, vulnerability assessments and are acquainted with the fundamentals of policies and administration processes.

Contents

- Drivers and stressors of near-shore processes and changes in coastal zones
- Basic assessment approaches and design tools for coastal management, economics and ecology of coastal zones
- Stakeholders, coastal environment and measures to protect/defend/sustain the coastlines
- General design and maintenance of infrastractures and "low-regret" measures

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Environmental Hydraulics
Literature	-
Media	PPT, Matlab-Exercises
Particularities	none

Organizer	Schlurmann, Torsten	
Lecturer	Paul, Maike; Schlurmann, Torsten; Bunzel, Dorothea; Burkhard, Kremena	
Supervisor	Scheiber, Leon	
Examiner	Paul, Maike	
Institute	Franzius-Institute for Hydraulic, Estuarine and Coastal Engineering, http://www.lufi.uni-hannover.de Faculty of Civil Engineering and Geodetic Science	
Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Hydropower Engineering

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K (50%) + K (50%) **Course achievements:** - (-)	2V / 2Ü	E	6	WS	6411

Learning Objectives

In this course the students acquire extended knowledge about weir and dam construction as well as subsoil sealing. The students achieve general competences in planning, designing and dimensioning of hydro dams and their foundations. Furthermore, they obtain basic knowledge about economical energy aspects, hydropower station components, - design and utilisation as well as usage of hydro power in coastal areas.

After the successful participation in this course the students are able to

- develop basic construction plans for the construction of water supply and power structures;
- carry out basic stability checks on the respective buildings;
- design the above mentioned buildings for stability against erosion and permeability by application of filter laws;
- basic knowledge of designing the respective structures for the purpose of energy generation.

Contents

- design guidelines, principles of construction and dimensioning concepts for barrages
- different construction types and operation modes of hydropower plants
- river power plants and storage power plants
- design of turbines
- hydraulic design of flood spillways
- dam structures, operation and verification of stability
- FE-analyses of dams
- construction of earth
- fill dams and subsoil sealing

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Soil Mechanics and Foundations, Earthwork and Foundation Engineering, Flow in Hydrosystems
Literature	Siddiqui, I. H. (2009): Dams and reservoirs: planning and engineering. Oxford Univ. Press. R. Fell (2005): Geotechnical engineering of dams. Balkema. Hammond, R. (1958): Water power engineering and some electrical problems. Grundbau Taschenbuch, Teile 1-3, Verlag Ernst und Sohn; Hydraulic Structures, P. Novak et al., 4th ed., Taylor & Francis; Wasserkraftanlagen, J. Giesecke & E. Mosonyi, Springer Verlag, Heidelberg; Deiche und Erddämme, R. Davidenkoff, Werner Verlag Düsseldorf; Anwendung von Filtern im Wasserbau, R. Davidenkoff, Ernst & Sohn Verlag Berlin.
Media	StudIP, Script, beamer, blackboard, etc

Particularities	none

Organizer	Abdel-Rahman, Khalid
Lecturer	Schendel, Alexander; Abdel-Rahman, Khalid
Supervisor	Scheiber, Leon
Examiner	Schendel, Alexander
Institute	Institute for Geotechnical Engineering and Franzius-Institute for Hydraulic, Estuarine and Coastal Engineering, http://www.igth.uni-hannover.de/ http://www.lufi.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Research Project

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / ST (80%) mit KO (20%) **Course achievements:** - (-)	-	E	6	WS/SS	?

Learning Objectives

Students know how to plan and conduct research activities. They perform scientific literature research and they practise the structuring and writing of scientific texts. They present their results within a group of peers and supervisors. Upon completion of the module, students are able to:

- read and discuss advanced scientific research papers;
- write large scientific student documents;
- present a topic within a given time frame.

Contents

- Structuring and managing research projects
- Practise of writing a scientific thesis, including the presentation of scientific results (experimental and theoretical work)
- Writing of a student thesis based on data or scientific papers (approx. 15 to 20 pages)
- Presentation and discussion of the findings

Workload	180 h (0 h in-class teaching and 180 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Research Planning and Scientific Communication, basic modules within the field of the topic of the research project
Literature	-
Media	Individual supervision, student work
Particularities	The research project thesis has to be submitted within six months after assignment. The full results of the work including a pdf file of the final thesis have to be submitted electronically. Two hardcopy versions of the work have to be submitted. The student has to present the final results within a colloquium. This contains a presentation of the research project results plus discussion.

Organizer	Dean of Studies
Lecturer	
Supervisor	
Examiner	Lecturers of respective institutes
Institute	Institutes of the Faculty of Civil Engineering and Geodetic Science, https://www.fbg.uni-hannover.de/fakultaet.html?&L=1 Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	P WA	P WA

Soil Mechanics for Hydraulic Structures

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / MP **Course achievements:** - (-)	1V / 1Ü	E	3	WS	6421

Learning Objectives

I. Hydraulic structures:

Students know fundamentals about the construction and design of dams and barrages and about the possibilities to gain waterpower.

II. Soil Mechanics:

Students know the fundamentals of soil types and soil behaviour and can apply them for the determination of settlements and bearing capacity of foundations

Contents

I. Hydraulic structures:

- Construction and design of dams and barrages
- Waterpower Engineering

I. Soil Mechanics:

- Soil types and soil features
- Methods of field and laboratory investigations
- Shear strength, compressibility and permeability of soils
- Design of foundations

Workload	90 h (30 h in-class teaching and 60 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	-
Literature	Novak, P., Moffat, A.I.B., Nalluri, C., Narayanan, R., 1992. Hydraulic Structures, Chap¬man & Hall, London. Kutzner, C., 1997. Earth and Rockfill Dams, Principles of Design and Construction, A. A. Balkema, Rotterdam. Das, B.M., 2008. Advanced Soil Mechanics. Taylor & Francis, London. Mitchell, J.K., Soga, K., 2005. Fundamentals of soil behavior. Wiley, Hoboken/NJ.
Media	PowerPoint, Overhead, Blackboard
Particularities	none

Organizer	Achmus, Martin
Lecturer	Achmus, Martin
Supervisor	Abdel-Rahman, Khalid

Examiner	Achmus, Martin
Institute	Institute for Geotechnical Engineering, http://www.igth.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

2nd. Semester

Hydrological Extremes

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
VbP (AA 25%) / K (75%) **Course achievements:** - (-)	2V / 2Ü	E	6	SS	6201

Learning Objectives

First, the students learn advanced methods about the estimation of water balance components, description of rain-fall-runoff processes and climate change analyses. Then, they get to know how to deal with the two hydrological extremes floods and droughts. Finally, techniqes for the application of hydrological models are introduced and the students apply a model for flood simulation themselves in computer lab work. Upon completion of the module, students are able to

- understand processes of rainfall runoff transformation;
- compute design values for floods and low flow;
- apply models for flood prediction.

Contents

1. Hydrological extremes: Water balance components; Rainfall-runoff transformation; Floods and droughts; Forecasting; Climate change
2. Hydrological modelling: theory of hydrological modelling; parameter estimation, calibration, validation; data preprocessing, flood simulation

Workload	180 h (40 h in-class teaching and 140 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Hydology and Water Resources Management I & Statistical Methods (for WATENV) Foundations of Hydrology and Water Management (D) & Environmental Data Analysis (for WUK & UIW(D)
Literature	Maidment, D.R. (Editor), 1992. Handbook of Hydrology. McGraw-Hill Inc.
Media	PowerPoint, Blackboard, Computer
Particularities	The module is offered in German in the winter semester and in English in the summer semester.

Organizer	Haberlandt, Uwe
Lecturer	
Supervisor	Thiele, Luisa
Examiner	Haberlandt, Uwe
Institute	Institute of Hydrology and Water Resources Management, http://www.iww.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	P (mandatory) / W (elective) and Special Skills Area depending on Major	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	P Major	W

Industrial Water Supply and Water Management

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** - (-)	2V / 2Ü	E	6	SS	6301

Learning Objectives

This course introduces the basic principles and concrete technological aspects of industrial water management. The main objective of this course is to give the students a deep insight into management and treatment of boiler- and cooling water, principles of watercycles in industry in the context of Production-Integrated Environmental Protection as well as the main technogies for industrial water- and wastewater treatment including physical, chemical and biological methods. The technologies and approaches presented are substantiated with calculation examples during the tutorials. Students acquire the skills to design and calculate the mentioned technological processes. In addition, they get a comprehensive overview about the production-integrated environmental protection measures in different industries.

After successful completion of this module, students are capable of:

- explaining the boiler and cooling water processes, water quality requirements of different industries and production,
- assessing the possibilities for implementation of process-integrated environmental protection measures,
- explaining relevant water treatment processes in detail and, furthermore, designing these processes and interpreting them in the context of the special circumstances in industrial production,
- developing application possibilities for end-of-pipe solution for industrial wastewater treatment including relevant special treatment approaches (e.g. UASB reactors),
- evaluating technological solutions across media, comparing alternatives and benchmarking between process-integrated and end-of-pipe solutions

Contents

1) Industrial water supply and treatment:

- Relevant Regulatory Framework – IED, Cross-Media and Best Available Techniques Approaches(BAT)
- Hot water supply for power generation plants and cooling-water cycles
- Treatment approaches for industrial fresh water (softening, desalination, deacidification)
- Introduction and design of concrete treatment technologies such as Gas Exchange, Ion-Exchange, Chemical Precipitation, Membran Filtration, AC-Adsorption and many more

2) Industrial wastewater treatment:

- Types and composition of industrial effluents
- Examples for process-intergrated environmental protection measures
- Approaches for the treatment of industrial process waters and wastewaters
- Concrete design of the individual wastewater treatment steps
- Concepts for holistic industrial water and energy management in specific industries

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Environmental Biology and Chemistry, Urban Water Management and Waste Technology
Literature	The lecturers make an up-to-date bibliography available on StudIP for each semester, selection of literature: Mutschmann, J. Stimmelmayr, F. (2002): Taschenbuch der Wasserversorgung. 13. Auflage, Friedr. Vieweg & Sohn Verlagsgesellschaft mbH Metcalf & Eddy, Inc. et al. (2002): Wastewater Engineering: Treatment and Reuse. 4. Auflage, McGraw-Hill Science/Engineering/Math, NJ. Rosenwinkel, K.-H. et al. (2015): Anaerobtechnik. 3. Auflage, Springer-Verlag. Barnes, D. et al. (1984): Survey in industrial wastewater treatment: Food and allied industries, Vol. 1, Pitman Advanced Publishing Program, Boston. Byers, W. et al. (2003): Industrial water management: A Systems Approach. Wiley, NJ. Lehr, J., Keeley, J. (2005): Water Encyclopedia: Domestic, municipal, and industrial water supply and waste disposal. Wiley, NJ. Rosenwinkel, K.-H. et al. (2008): Considering water quality for use in the food industry. ILSI Europe Report Series, Brussels. Rosenwinkel, K.-H. et al. (2005): Industrial wastewater sources and treatment strategies. Environmental Biotechnology: Concepts and Applications. Wiley, Weinheim The lecturers make an up-to-date bibliography available on StudIP for each semester.
Media	Whiteboard, PowerPoint-Presentation, StudIP, ILIAS
Particularities	The examination can be held in German or English

Organizer	Köster, Stephan
Lecturer	Köster, Stephan
Supervisor	Dörrié, Beatriz; Hadler, Greta
Examiner	Köster, Stephan
Institute	Institute of Sanitary Engineering and Waste Management, http://www.isah.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	P Major

Solid Waste Management

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** 1	2V / 2Ü	E	6	SS	6311

Learning Objectives

The course imparts advanced knowledge on how to manage and treat “waste” with regard to sustainability and circular economy. At the beginning, definition of waste, general conditions as well as specific waste amounts will be briefly introduced. Solid Waste Management (SWM) steps such as collection, transportation, sorting, treatment, recycling and disposal is the next focus of this course. Moreover, the concepts and techniques for mechanical and biological treatment (composting, digestion, stabilization), their combination (MBT, MBSt) and techniques for thermal treatment (wte, combustion, gasification, etc.) are presented.

The next main thema of this course is the concepts and techniques for avoiding, up- or re-cycling, re-use and disposal of the waste treatment output according to EU‘s waste hierarchy. Process descriptions, design data and conditions as well as output qualities are disccssed according to legal criteria for disposal, emission or environmental protection. Furthermore, principles and requirements of landfill construction, their control and emissions as well as the handling of abandoned polluted areas are briefly introduced. The lecture focuses on contemporary practical examples, and the theoritical knowledge will be consolidated in tutorials in form of calculation examples.

After successful completion of this module, students are capable of:

- elucidating SWM techniques and recycling processes,
- developing treatment concepts for different kinds of waste and recycling materials,
- estimating treatment options for polluted areas,
- designing an organic waste treatment plant (composting, anaerobic digestion),
- conceptualizing a landfill considering leachate and gas production,
- discussing SWM issues within the legal framework of climate change and environment protection.

Contents

- Definition of waste and Introduction of related legislations
- Collection, transportation and specific treatment of waste
- Biological, mechanical-biological and thermal waste treatment incl. emmission control
- Construction, handling and management of landfills and abandoned polluted areas incl. treatment of their emissions (leachate and landfill gas)
- Recycling of glass, paper, plastics, wood, metal and construction waste
- Evaluation of waste treatment and management concepts

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Urban Water Management and Waste Technology
Literature	The lecturers make an up-to-date bibliography available on StudIP for each semester, selection of literature:

	Lens, P. et al. (2004): Resource Recovery and Reuse in Organic Solid Waste Management. IWA Publication, London. Cheremisinoff, N.P. (2003): Handbook of solid waste management and waste minimization technologies. Butterworth Heinemann, Amsterdam. McDougall, F.R. et al. (2001): Integrated solid waste management: A life cycle inventory. Blackwell Science, Oxford. Bilitewski, B.; Härdtle, G. (2013): Abfallwirtschaft: Handbuch für Praxis und Lehre. Springer, Berlin. Kranert, M.; Cord-Landwehr, K. (2010): Einführung in die Abfallwirtschaft. Vieweg + Teubner, Wiesbaden
Media	Blackboard, PowerPoint-Presentation, StudIP, ILIAS
Particularities	1. The examination can be taken in English or German. 2. Excursion to a waste treatment plant or recycling facilities.

Organizer	Weichgrebe, Dirk
Lecturer	Weichgrebe, Dirk
Supervisor	Shafi Zadeh, Shima; Zahedi Nezhad, Sara
Examiner	Weichgrebe, Dirk
Institute	Institute of Sanitary Engineering and Waste Management, http://www.isah.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	P Major

Ecology and Water Quality Management

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
VbP (AA 40% + Ü 30% + KU 30%) / - **Course achievements:** 1	3,5V / 2,5Ü	E	9	SS	6431 + 6436

Learning Objectives

In this module, students acquire in-depth knowledge of water quality management problems in fresh waters including chemical, morphological and ecological aspects as required for river basin mangement under the European Water Framework Directive. A holistic view covers geohydrological sources, catchment water transfer and fresh water ecology. The focus is on agriculturally used river basins and the associated diffuse substance input into water bodies including groundwater. Special focus is given on interdisciplinary aspects of water management including hydrogeochemistry (as a geological discipline) and ecology (as a biological discipline). An integrated technical view is given in a hands-on exercise in water quality modelling.

In the practical part of the module, students learn how to determine important groups of organisms, how to assess the ecological quality of fresh water bodies and how to measure relevant chemical-physical water parameters and stream flow. After successful completion of the module, students will be able to

- Understand the principles of river basin magement;
- Apply river quality assessment methods and develop rehabilitation measures;
- Classify aquatic organisms according to international standards;
- Develop measures to improve the ecological continuity of rivers;
- Analyze fluxes of matter, in particular nutrients, within river basins;
- Understand subsurface fluxes of water and matter including hydrogeochemical reactions;
- Solve problems regarding groundwater abstraction and pollution;
- Simulate in-stream water quality.

Contents

1. River basin management
- Legal and institutional framework according to the EU Water Framework Directive
- Natural hydraulic engineering and ecological continuity of watercourses
- Cycles of matter and pollutants at catchment scale
- Erosion and sediments
- Sources, transport and reaction of nutrients
- Measures for reducing nutrient pollution
- Water quality modelling

2. Applied limnology
- River morphology (function, structure, maintenance)
- Mapping of morphological, chemical-physical and biological parameters
- Overall ecological assessment of fresh water bodies and measures in water protection
- Practical training in fresh water (river and lake) ecology

3. Geohydrology - Geohydraulics - Groundwater chemistry - Grundwater balance - Management of groundwater resources - Grundwater pollution and protection

Workload	270 h (90 h in-class teaching and 180 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Basic knowledge in hydrology and water resources management is strongly recommended (module hydrology and water resources management or Grundlagen der Hydrologie und Wasserwirtschaft in German)
Literature	Dietrich, J., Schumann, A. (eds., 2006): Werkzeuge für das integrierte Flussgebietsmanagement: Ergebnisse der Fallstudie Werra. Weißensee-Verlag, Berlin. Domenico, P., Schwartz, F. (1997): Physical and Chemical Hydrogeology. 2nd ed., Wiley, New York. Schwoerbel, J., Brendelberger. H. (2022): Einführung in die Limnologie. Stoffhaushalt - Lebensgemeinschaften – Technologie. 11. Aufl., Springer Spektrum. Wetzel, R.G. (2001): Limnology - Lake and River Ecosystems. 3rd ed., Academic Press Inc., London.
Media	PowerPoint presentations, instructional videos, blackboard, lecture notes (German versions can be provided for parts of the module), field training (presence and online)
Particularities	The practical training in fresh water ecology includes investigations on a small river, the Weser River and a lake. It is offered in the following two variants a) and b), depending on the availability of places for students and depending on the feasibility of an excursion, where both versions are treated as equivalent for the module achievements: a) Four days excursion (own contribution of 100 Euro), which usually takes place after the pentecost holidays (Pfingstwoche) near Uslar. The number of participants of the excursion is limited to 24 students from all study programs due to available transport capacity. During the first week of the module, a binding registration must be made at responsible examiner for the module. In case of over-subscription, the excursion places will be first given to students in mandatory modules, then to students in tracks recommending the module, and then the rest of places will be drawn by lot if required, all among the students being present. Students not showing up will be sorted to the virtual taining. b) Virtual training based on instructional videos. Before starting the practical training under a), evidence of an occupational health consultation on working in low vegetation must be provided. Please refer to the online offer of the university physicians (Betriebsarzt) and prove the consultation in time. The examination performance consists of three parts given during semester (VbP):

	- AA (report about practical training including choice questions, 40%) - Ü (modelling exercise, 30%) - KU (short exam about hydrogeochemistry, contains choice questions, 30%). Possible changes can be announced at start of classes.

Organizer	Dietrich, Jörg
Lecturer	Dietrich, Jörg; Bäthe, Jürgen; Houben, Georg
Supervisor	Iffland, Ronja; Fallah Mehdipour, Elahe
Examiner	Dietrich, Jörg
Institute	Institute for Hydrology and Water Management, http://www.iww.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Water Economics

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** - (-)	2V	E	5	SS	?

Learning Objectives

The course enables students to understand and discuss theoretical basics, practical problems and recent developments in water economics and policy

Contents

In detail, the course addresses water scarcity in the global food production and discusses water in environmental context. Students also learn about water valuation, including market (supply and demand), tariff structures, project assessment and payment for ecosystem services. Furthermore, water policy finds consideration, related to general governance (control and regulation systems; integrated water resource management), the Sustainable Development Goal 6 (clean water and sanitation), oceans, privatization and simulation models.

Finally, students focus on game theory and river-sharing and learn about water trends, the role of hydrogen and conflicts. Case study applications complement the course, for example from aquaculture. Participation in the related exercise on water economics is recommended.

Workload	150 h (60 h in-class teaching and 90 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Basic understanding of economics will be an advantage for participants.
Literature	Selected journal articles will be provided during the lecture.
Media	PowerPoint, Black-Board
Particularities	The course is in English. Exam students choose between English or German.

Organizer	Grote, Ulrike	
Lecturer	Ruesink, Brigitte; Müller, Tobias	
Supervisor	Grote, Ulrike	
Examiner	Grote, Ulrike	
Institute	Institute for Environmental Economics and World Trade, https://www.iuw.uni-hannover.de/ Faculty of Economics and Management	
Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Environmental Planning

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K (50%) + K (50%) **Course achievements:** - (-)	1V / 1Ü	E	3	WS	6511

Learning Objectives

Environmental planning:

- the methodology of analyzing an ecosystem for preserving biological diversity and ecosystem services
- the role of landscape planning and other instruments for nature conservation and sustainable development
- landscape aesthetics & integration of recreation and leisure activities,
- strategies for spatial planning and development and questions of implementation and participation
- consequences of global change for humanity, flora and fauna, and for ecological systems,
- planning at different levels and scales (local - global)

Learning outcomes:

Remembering (Knowledge) - Can you recall information?

- different instruments for sustainable development
- fundamentals about landscape ecology and methodologies in landscape planning and nature conservation
- landscapes in their complexity
- mastery of vocabulary from the subject matter

Understanding (Comprehension) - Can you explain ideas or concepts?

- the purposes of environmental and regional planning
- the contexts and approaches of planning practice
- the range of viewpoints about & perceptions of environmental planning by the different interest groups involved

Applying (Application) - Can you use the new knowledge in another familiar situation?

- pros and cons of different implementation strategies through case studies

Contents

Contents of the lecture series "Environmental Planning":

- Introduction – Introduction to environmental planning (Johannes Hermes, M.Sc.)
- Planning for renewable energies (Dr. Julia Thiele)
- Landscape planning and other instruments of nature conservation (Prof. Dr. Christina Von Haaren)
- Impact mitigation regulation (Prof. Dr. Christina Von Haaren)
- Aesthetic landscape quality assessment (Johannes Hermes, M.Sc.)
- Planning for biodiversity (Prof. Dr. Michael Reich)
- Ecological Networks (Prof. Dr. Michael Reich)
- Assessing impairments of water bodies (Apl. Prof. Dr. Michael Rode)
- Digital Environmental Planning (Prof. Dr. Jochen Hack)
- Spatial planning instruments (Dr. Lena Greinke)

- Tourism as a matter of planning in urban and rural contexts (Dr. Christoph Sommer & Dr. Nora Mehnen) - Instruments for spatial environmental assessment (Dr. Frank Scholles) - Environmental Impact Assessment and Natura 2000 Assessment for Projects (Dr. Frank Sholles)

Workload	90 h (30 h in-class teaching and 60 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Environmental Hydraulics, Hydrology and Water Resources Management
Literature	Selected publications will be provided at the beginning of the course.
Media	Blackboard, PowerPoint, StudIP, Overhead
Particularities	none

Organizer	Hermes, Johannes
Lecturer	Hermes, Johannes
Supervisor	
Examiner	Hermes, Johannes
Institute	Institute for Environmental Planning, http://www.umwelt.uni-hannover.de/ Faculty of Architeecture and Landscape Sciences

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Wetland Ecology and Management

Prüfungsleistungen:	Art/SWS	Sprache	LP	Semester	Prüfnr.
K/KA/MP/HA/PJ/VbP **Studienleistungen:** -	1V / 1Ü	E	3	SS	?

Ziel des Moduls

In this module, students acquire detailed knowledge about different wetlands types and the ecology of natural wetlands. Furthermore, the module introduces management issues, such as wetland restoration, treatment wetlands, and wetland protection.

After successfully completing this course, students will be able to

- identify and describe the ecological services provided by wetlands;
- design a plan for studying the hydrology of a wetland;
- understand how plants adapt to deal with different environmental conditions found in wetlands;
- differentiate between the six main wetland types;
- apply water and soil sampling methods in a wetland;
- discuss different environmental protection measures in a wetland;
- identify which treatment wetland is best used in which situation;
- create restoration plans for a degraded wetland.

Inhalt des Moduls

- introduction to wetlands: definition and importance
- wetland Environment: Hydrology, Biogeochemistry, Biological adaptations (plants and animals)
- wetland Ecosystems: Coastal wetlands, Freshwater marshes and swamps, Peatlands
- wetland management: Restoration, Types of treatment wetlands, Threats and degradation of wetlands

Workload	90 h (30 h Präsenz- und 60 h Eigenstudium einschl. Prüfungs-/Studienleistung)
Empf. Vorkenntnisse	Natural Sciences, Hydrology and Water Resources Management I
Literatur	Kadlec, R.H. & Wallace, S.D. 2009. Treatment Wetlands, 2nd Edition. CRC Press, Boca Raton, Florida, USA. Keddy, P.A. 2010. Wetland Ecology, 2nd Edition. Cambridge University Press, Cambridge, UK. Mitsch, W.J. and Gosselink, J.G. Wetlands, 4th Edition. Wiley & Sons.
Medien	PowerPoint, overhead, whiteboard, field training sampling equipment
Besonderheiten	none

Modulverantwortlich	Graf, Martha
Dozenten	Graf, Martha; Starke, Eva
Betreuer	
Verantwortl. Prüfer	Graf, Martha
Institut	Institut für Hydrologie und Wasserwirtschaft, http://www.iww.uni-hannover.de/ Fakultät für Bauingenieurwesen und Geodäsie

Wetland Ecology and Management with Excursion

Prüfungsleistungen:	Art/SWH	Language	CP	Semester	Exam. Number
K/KA/MP/HA/PJ/VbP **Studienleistung:1**	3V / 1Ü	E	6	SS	?

Learning Objectives

In this module, students acquire detailed knowledge about different wetlands types and the ecology of natural wetlands. Furthermore, the module introduces management issues, such as wetland restoration, treatment wetlands, and wetland protection.

After successfully completing this course, students will be able to

- identify and describe the ecological services provided by wetlands;
- design a plan for studying the hydrology of a wetland;
- understand how plants adapt to deal with different environmental conditions found in wetlands;
- differentiate between the six main wetland types;
- apply water and soil sampling methods in a wetland;
- discuss different environmental protection measures in a wetland;
- identify which treatment wetland is best used in which situation;
- create restoration plans for a degraded wetland.

Contents

- introduction to wetlands: definition and importance
- wetland Environment: Hydrology, Biogeochemistry, Biological adaptations (plants and animals)
- wetland Ecosystems: Coastal wetlands, Freshwater marshes and swamps, Peatlands
- wetland management: Restoration, Types of treatment wetlands, Threats and degradation of wetlands
- wadden Sea ecology and management incl. Field training

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Natural Sciences, Hydrology and Water Resources Management I
Literature	Kadlec, R.H. & Wallace, S.D. 2009. Treatment Wetlands, 2nd Edition. CRC Press, Boca Raton, Florida, USA. Keddy, P.A. 2010. Wetland Ecology, 2nd Edition. Cambridge University Press, Cambridge, UK. Mitsch, W.J. and Gosselink, J.G. Wetlands, 4th Edition. Wiley & Sons.
Media	PowerPoint, overhead, whiteboard, field training sampling equipment
Particularities	Field training incl. report – “Ausarbeitung” (course achievement “Studienleistung”) The number of participants is limited to 16 students. Preference will be given to WATENV students. Those who do not get a place can alternatively take the module "Wetland Ecology and Management" with 3 CP

Organizer	Graf, Martha
Lecturer	Graf, Martha; Starke, Eva
Supervisor	
Examiner	Graf, Martha
Institute	Institute of Hydrology and Water Resources Management, http://www.iww.uni-hannover.de/ Faculty of Civil Engineering andd Geodetic Science

Field Measuring Techniques in Coastal Engineering

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** 1	2V / 2Ü	E	6	SS	6441 + 6446

Learning Objectives

The module imparts knowledge about the basics, capabilities and the field of application of different measuring techniques used in coastal engineering. Modern techniques and devices are part of the module in order to capture, process and analyze hydro- and morphodynamic parameters.

After the successful participation in this course the students are able to:

- Apply statistics and signal processing to measured data
- Analyze sea-state data and assess characteristic parameters
- Understand the set-up and infrastructure of survey vessels
- Plan the use of unmanned aerial and underwater vehicles (ROVs, AUVs, UAVs)
- Apply different techniques for measuring currents
- Understand the basics of modern echo-sounders (multibeam echo-sounder, sub-bottom profiler)
- Assess the characteristics of coastal sediments
- Apply different techniques of sediment sampling
- Measure and analyse water quality parameters (CTD, pH, dissolved oxygen)
- Design stationary equipment carrier systems (poles, buoys, landers)
- Plan field surveys and assess involved risks
- Present relevant results / write scientific reports

Contents

- Lectures regarding above-mentioned topics accompanied by exercises
- Practical examples based on the scientific work of the Ludwig-Franzius-Institute and the Coastal Engineering Group, University of Queensland (UQ)
- Practical training in the field / in the laboratory
- Exchange and video tutorials with students of UQ

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Hydraulic and Coastal Engineering; Environmental Data Analysis
Literature	-
Media	PPT, Matlab-Exercises
Particularities	One-day excursions

Organizer	Welzel, Mario
Lecturer	Welzel, Mario

Supervisor	Scheiber, Leon
Examiner	Welzel, Mario
Institute	Ludwig Franzius Institute of Hydraulic, Estuarine and Coastal Engineering, http://www.lufi.uni-hannover.de Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Flow & Transport Processes

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** - (-)	2V / 2Ü	E	6	SS	?

Learning Objectives

In this module, the students learn about the physical processes and phenomena that are relevant for water flow, contaminant transport, and heat transfer. Equations that describe groundwater flow, contaminant transport and heat transfer will be developed. Numerical and analytical solutions of these equations are presented and discussed.

After successful participation of this module, the students can

- explain the physical processes describing groundwater flow, contaminant transport and heat transfer,
- derive equations governing groundwater flow, contaminant transport and heat transfer,
- quantify fluxes of groundwater mass, contaminant mass and heat,
- solve the governing differential equations both analytically and numerically,
- implement the most important physical processes in a numerical model,
- design and run a numerical (2D oder 3D) model describing transient groundwater flow, contaminant transport and heat transfer,
- visualize and analyze simulation results,
- apply the models to relevant problems in environmental engineering.

Contents

- Fully mixed systems
- Balance equations
- Derivation of the transient groundwater flow equation
- Scenarios of groundwater extraction by pumping
- Analytical and numerical solutions of the groundwater flow equation,
- Advection, dispersion, molecular diffusion, adsorption, radioactive decay
- Derivation of the complete contaminant transport equation
- Convection, heat dispersion, conduction
- Derivation of the complete heat transfer equation
- Initial and boundary conditions
- Flow and transport in fractured rock
- Coupling of flow and transport: variable-density flow

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Environmental Hydraulics
Literature	Domenico, P. and Schwartz, F., 1990. Physical and Chemical Hydrogeology; Wiley, New York.

	Rausch, R., Schäfer, W., Therrien, R. and Wagner, C., 2005. Solute transport modelling; Gebrüder Borntraeger, Berlin.
Media	PowerPoint-Presentation, Computer, Blackboard
Particularities	none

Organizer	Graf, Thomas
Lecturer	Graf, Thomas
Supervisor	Graf, Thomas
Examiner	Graf, Thomas
Institute	Institute of Fluid Mechanics and Environmental Physics in Civil Engineering, http://www.hydromech.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Maritime and Port Engineering

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** 1 (unbenoteter Vortrag)	2V / 2Ü	E	6	SS	6461 + 6466

Learning Objectives

The module imparts knowledge about the planning, managementand maintenance of ports and harbours. Furthermore, external speakers share their practical experiences in the field of Maritime and Port Engineering.

After the successful participation in this course the students are able to:

- Assess the role and development of maritime navigation and logistical concepts
- Plan and classify harbour structures
- Understand the management and maintenance of ports and port infrastructure
- Recognize/estimate hydraulic processes within ports and their interactions with vessels
- Estimate the importance of economical and ecological aspects for ports
- Classify different dredging technologies
- Understand, describe and assess relevant scientific literature

Contents

- Planning, layout and logistics of ports and harbours
- Economical aspects of Maritime and Port Engineering
- Infrastracture and management of ports and harbours
- Ecological aspects in regard of maintenance and operation
- Cross-shore and lateral sediment transport
- Design and maintenance of breakwaters and piers, seawalls and jetties
- Dredging technologies
- Small harbours and sport boat marinas
- Practical examples of Maritime and Port Engineering

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Hydraulic and Coastal Engineering
Literature	BRUUN, P., Port Engineering. Vol. 1 & 2, Gulf Publishing Company, Fourth Edition, 1990 TSINKER, G.P., Port Engineering – Planning, Construction, Maintenance and Security, John Wiley & Sons, 2004. CEM, 2002. Coastal Engineering Manual. United States Army Corps of Engineers (USACE), http://140.194.76.129/publications/eng-manuals/ EAK: Empfehlungen für die Ausführung von Küstenschutzbauwerken, Die Küste, 65, 2002

Media	PPT, Matlab-Exercises
Particularities	Big hydraulic engineering excursion (Pentecost week)

Organizer	Schlurmann, Torsten
Lecturer	Schlurmann, Torsten; Paul, Maike; Visscher, Jan
Supervisor	Scheiber, Leon
Examiner	Schlurmann, Torsten
Institute	Franzius-Institute for Hydraulic, Estuarine and Coastal Engineering, http://www.lufi.uni-hannover.de Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Urban Hydrology

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
VbP (AA 25%) / K (75%) **Course achievements:** - (-)	1V / 1Ü	E	3	SS	6481 + 6486

Learning Objectives

This module provides specific knowledge of the urban hydrological cycle and its characteristics. Emphasis is not only put on process understanding but also on urban storm water management including exercises and application of computer models. In this way, students will learn how urban areas alter the water balance including implications on the quantity and quality of water. Upon completion of the module, students are able to:

- Describe and analyse hydrological processes in urban areas including hydraulics.
- Design different measures in urban storm water management (e.g., retention, infiltration, drainage)
- Understand mechanisms of pluvial and fluvial floods in urban areas and measures to cope with flooding.
- Apply urban drainage models in order to study the impact of different measures (e.g. low impact development, retention etc.) on drainage in combined and separated collection systems.
- Identify challenges and opportunities of co-designing solutions that also acknowledge other targets (e.g., urban climate, climate change adaptation, waterway restoration) in the light of sustainability and liveable cities (Water sensitive design).

Contents

1. Hydrological processes in urban areas:
- Characteristics of the urban water balance and differences compared to natural environments
- Approaches to compute runoff generation, runoff concentration, and channel runoff in urban areas

2. Urban hydrometry (sensor networks)

3. Urban storm water management
- Flood protection and measures to restore the natural drainage capacity
- Combined sewer overflow (CSO) and its impact on receiving waters
- Real time control (RTC)

4. Exercises including rainwater infiltration and retention

5. Modelling, applications using computer models (including exercises)
- Rainfall-runoff modelling of urban hydrological systems (combined and separated collection systems)
- Model-based hydrological design and feasibility studies for different measures

6. Sustainability perspective: virtual water (blue & green water footprint), water sensitive cities / water smart cities

Workload	90 h (30 h in-class teaching and 60 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Basic knowledge in hydrology is recommended.
Literature	Price, R.K., Vojinović, Z. 2011. Urban Hydroinformatics. IWA Publishing, 520 pp.

	Pazwash, H. 2016. Urban Storm Water Management, 2nd Ed.,CRC Press, 684 pp. Technical bulletins of the German Association for Water, Wastewater and Waste (DWA) Recommended reading (scientific reports and articles provided in the lecture)
Media	PowerPoint, Black-Board, Computer
Particularities	As course achievement a numerical model application including a technical report has to be submitted (homework). A one day model teaching course will be given to introduce into the model. This course can be scheduled on a Saturday.

Organizer	Krämer, Stefan
Lecturer	Krämer, Stefan
Supervisor	Pesci, María Herminia
Examiner	Krämer, Stefan
Institute	Institute of Hydrology and Water Resources Management, http://www.iww.uni-hannover.de/ Faculty of Civil Engineering andd Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Modelling in Sanitary Engineering

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
VbP (P 100%) / - **Course achievements:** - (-)	2V / 2Ü	E	6	SS	6581

Learning Objectives

Simulation of processes has become a crucial tool for engineers for solving tasks such as design of plants, operation control, process optimization and for evaluation and development of systems (catchment area, circular economy,etc.).

This course aims to introduce the students into the modelling basics of wastewater treatment plants.

Within the scope of this course students will have to develop a strategy for a typical engineering task using the simulation software SIMBA classroom as a tool.

The requiered theoretical knowledge about commonly used activated sludge models (ASM), design of wastewater treatment plants, typical control strategies and about the simulation tool SIMBA classroom will be provided by the lectures and exercises.

After completing this course, students will have the competence to:

- assess the performance and identify the limitations of different models,
- create relevant computer-aided technical models for specific systems,
- understand biological processes and kinetic parameters of ASM 1-3 and ADM and apply them in the simulation software (SIMBA classroom),
- evaluate critically results of a simulation
- identify problems in the operation of a wastewater treatment plant and propose solutions.

Contents

- Biological processes in wastewater treatment (carbon, nitrogen and phosphorus removal)
- Mathematical basics of different activated sludge models
- Transport processes in different reactors (CSTR, PFR, Batch)
- Petersen matrix and its components
- Introduction to the basic steps of the Modelling, such as calibration, validation, sensitivity analysis, parameter identification and fitting, etc.
- Control stratgies for sewage treatment plants
- Application of simulation software SIMBA classroom (static and dynamic simulation)
- Simulation of different wastewater treatment plants and interpretation of the simulation results
- Experimental methods to determine parameters required for simulation

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	-
Literature	The lecturers makes an up-to-date bibliography available on StudIP for each semester.

	Selection of literature: Henze et al., Wastewater treatment, Biological and Chemical Processes, Springer-Verlag, 1995. Schütze, Modelling, Simulation and Control of Urban Wastewater Systems, Springer, 2002. Makinia, Mathematical Modelling and Computer Simulation of Activated Sludge Systems, IWA Publishing, 2010 Makinia,J.(2010): Mathematical Modelling and Computer Simulation of Activated Sludge Systems Olsson et al., Wastewater Treatment Systems , 2001
Media	Blackboard, PowerPoint-Presentations, StudIP, ILIAS, SIMBA-Classroom software
Particularities	Knowledge from previous courses in the field of Sanitary Engineerting is required for the development of the homework. Due to this it is recommended to do this course in the third or forth semester.

Organizer	Nogueira, Regina
Lecturer	
Supervisor	
Examiner	Nogueira, Regina
Institute	Institute of Sanitary Engineering and Waste Management, http://www.isah.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

3rd. Semester

GIS and Remote Sensing

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** 1	2V / 2Ü	E	6	WS	6221 + 6226

Learning Objectives

The modul introduces the underlying principles and methods about Geographical Information Systems (GIS) and Remote Sensing. The overall focus is on environmental data, which are relevant to hydrology and water resources management. In this module the students will obtain an overview over the most important basics and applications of remote sensing. In the end he/she will have understood the central methodologies and will be able to make use of the employed techniques. By independently preparing and then presenting the lab work he/she will further develop his/her learning strategies and presentation skills. Upon completion of the module, students are able to apply geographical information systems for analyses and manipulation of space related data from ground observation and remote sensing.

Contents

1. Geographical Information Systems

- data modelling: geometric, thematic, topologic
- data analysis and geoprocessing
- cartography: graphical variables, generalization, presentation
- data capture, topography: digital elevation models, data interpolation, geomorphology
- visualization, presentation and analysis: 2D, 3D, terrain

2. Remote Sensing

- basics: electromagnetic spectrum, interaction of electromagnetic waves and materials, limits of resolution, digital images
- sensors: multi-spectral satellite sensors, hyper-spectral sensors, airborne laser scanning, synthetic aperture radar
- processing: generation of thematic maps: classification of land cover using pattern recognition methods, determination of digital height models, in particular from laser scanner and radar data.

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	-
Literature	Jones, C., 1999. Geographical Information Systems and Computer Cartography Logman. T. Lillesand, R. Kiefer, Remote sensing and image interpretation.
Media	Beamer, blackboard, lecture-notes (StudIP), videos, computer
Particularities	In the GIS part, the students create a term paper that can be used to collect bonus points for the exam. Details will be explained in the lecture.

Organizer	Sester, Monika
Lecturer	Sester, Monika; Hasghshenas, Mahmud
Supervisor	N.N.
Examiner	Sester, Monika
Institute	Institute of Photogrammetry and Geoinformation and Institute of Cartography and Geoinformatics, https://www.ikg.uni-hannover.de/de/ https://www.ipi.uni-hannover.de/de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	P Major	W

Water Resources Systems Analysis

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
VbP (PR 60%) + VbP (LÜ 40%) / - **Course achievements:** 1	1V / 3Ü	E	6	WS	6211 + 6213 + 6216

Learning Objectives

This module provides in-depth and interdisciplinary extended knowledge of the conceptual and quantitative systems analytical treatment of water management issues. Ecological, climatic, socio-economic and environmental policy fundamentals are treated as external boundary conditions of integrated water resources management (IWRM). In a seminar on IWRM, in-depth study of a selected integrated or international water management issue takes place in the form of a role play and an individual term paper with multimedia presentation. Furthermore, the students learn the application of water management simulation as a system-analytical method of decision support. In the simulation exercises, students learn how to create models of water availability and water demand using the WEAP software in the context of IWRM.

After successful completion of the module, students will be able to

• analyze large water management projects, including those in developing countries, in an interdisciplinary manner;

• apply the water management simulation model WEAP.

Contents

1. External social and natural boundary conditions of integrated water resources management: participation, climate change, development cooperation.

2. International water management: transboundary problems, arid and semi-arid regions.

3. Seminar (role plays): selected water management problems from the topics of large dams and transboundary river basin management are discussed interactively by students in a game situation.

4. Seminar (presentations): examples of large water management projects in an international and integrated context plus water policy and ethics issues are presented by student posters with interactive discussion.

5. Water management simulation and decision support with WEAP

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Basic knowledge about water resources management is required (e.g., from module „Hydrology and Water Resources Management“ or „Grundlagen der Hydrologie und Wasserwirtschaft“). Knowledge about hydrological modelling is recommended (e.g., from module “Hydrological extremes”).
Literature	Loucks, D.P. and van Beek, E. (Editors), 2017. Water Resources Systems Planning and Management. Springer International Publishing (open access). Additional, subject specific literature will be announced in the course.
Media	Role play, poster, Powerpoint, instructional videos, specialized literature, computer exercises

Particularities	The participation in the seminar counts as a course credit (ungraded attendance exercise, Studienleistung). This includes active and constructive participation in a role play on a given IWRM problem and attendence of at least two seminar lessons of the poster presentations. The role play can be performed either in English or German language. The module includes two course-related and separately existing examinations (VbP): (a) Multimedia presentation on IWRM, in which a poster is individually prepared and presented as a term paper on a topic assigned from a list. The presentation is a short oral explanation of the poster of about 2 minutes plus discussion in the seminar (PR, 40 h, 60%). b) Laboratory exercise: a water management model is to be created and calibrated in the software WEAP within a given time frame according to the task. The examination takes place in a computer laboratory or with the own PC. A short summary and evaluation of the results as well as the model files have to be handed in or uploaded to Stud-IP. (LÜ, 5 h, 40%).

Organizer	Dietrich, Jörg
Lecturer	-
Supervisor	Fallah Mehdipour, Elahe; Bovermann, Zoe
Examiner	Dietrich, Jörg
Institute	Institute of Hydrology and Water Resources Management, http://www.iww.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	P Major	W

Infrastructures for Water Supply and Wastewater Disposal

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** - (-)	3V / 1Ü	E	6	WS	6321

Learning Objectives

The course seeks to impart the technological knowledge in layout, dimensioning and construction of buildings and equipment in sanitary engineering like water supply, sewage technology and waste management. Additionally, special topics and advanced technical themes regarding emerging pollutants, resource-efficiency and re-use of rainwater and wastewater are presented and discussed in the context of infrastructure development.

After successful completion of this module, students would have the knowledge to design water supply and wastewater disposal systems and to apply in-depth methods and dimensioning BAT approaches for all mentioned components and processes in the urban water cycle. Furthermore, the students acquire the competence to conceive and evaluate the operation of the water infrastructures and to implement adapted concepts for their maintenance.

Contents

- Identification and determination of relevant planning data, forecasts, uncertainties, risk and safety concepts
- Technical design of drinking water supply system (extraction, treatment, storage and distribution)
- Technical design of wastewater disposal systems (types of urban drainage systems, mechanical, biological and chemical treatment approaches on wwtps, dentrilised versus decentralised structures)
- General rules and strategies for operation of different water infrastructures
- Planning and implementation of innovative or even new urban water infrastructures (Green and Blue Cities)
- Identification of sustainable and maintenance strategies for long-term functionality of the infrastructures incl. concrete technical approaches for inspection, repair and replacement
- Approaches for modelling, also across infrastructures (e.g. how to link urban drainage systems with sewage treatment plants)

Workload	108 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	-
Literature	The lecturers make an up-to-date bibliography available on StudIP for each semester, selection of literature: Lens, P. et al. (2004): Resource Recovery and Reuse in Organic Solid Waste Management. IWA Publication, London. Cheremisinoff, N.P. (2003): Handbook of Solid Waste Management and Waste Minimization Technologies. Butterworth Heinemann, Amsterdam.

	McDougal, F.R. et all. (2001): Integrated Solid Waste Management: A Life Cyde Inventory. Blackwell Science, Oxford.
Media	Studip, Powerpoint, Blackboard, ILIAS
Particularities	Teaching materials for distance-learning course will be in German.

Organizer	Köster, Stephan
Lecturer	Köster, Stephan
Supervisor	Shafi Zadeh; Thoms, Anna
Examiner	Köster, Stephan
Institute	Institute of Sanitary Engineering and Waste Management, http://www.isah.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	P Major

Special Topics in Hydrology and Water Resources Management: Geostatistics

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
VbP (25%) / K/MP (75%) **Course achievements:** - (-)	1V / 1Ü	E	3	WS/SS	?

Learning Objectives

This module introduces advanced spatial statistical techniques and their application in hydrology and water resources management.

Upon completion of the module, students are able to:

- apply geostatistical interpolation methods for spatial and structural analyses of environmental data
- use spatial interpolation methods for regionalisation and gap filling
- use simulation techniques for model parameterisation and uncertainty analyses and
- apply the statistical software R for geostatistical analyses.

Contents

1. Statistical model
2. Variograms
3. Kriging I – stationary methods
4. Kriging II – non stationary methods
5. Indicator kriging
6. Simulation

Workload	90 h (20 h in-class teaching and 70 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Statistical Methods incl. statistical software R (B.Sc.), Hydrological Extremes (M.Sc.)
Literature	Goovaerts, P., 1997. Geostatistics for natural resources evaluation. Oxford University Press, New York, Oxford, 483 pp. Isaaks, E.H. and Strivastava, R.M.. An introduction to Applied Geostatistics. Oxford University Press, 1989. Deutsch, C.V. and Journel, A.G., 1992. GSLIB: Geostatistical software library and user's guide. Oxford University Press, New York, 340 pp.
Media	PowerPoint, Black-Board, Computer
Particularities	The lecture will be held exclusively in Englisch. Exam Format: ZP

Organizer	Haberlandt, Uwe
Lecturer	Haberlandt, Uwe
Supervisor	Iffland, Ronja
Examiner	Haberlandt, Uwe

Institute	Institute for Hydrology and Water Management, http://www.iww.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Special Topics in Sanitary Engineering

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / K **Course achievements:** - (-)	1V / 1Ü	E	3	WS	6571

Learning Objectives

The focus of this course is on practical aspects and approaches for designing water supply systems, wastewater and sludge treatment plants. Furthermore, economical efficiency calculation for planning and investment decisions in the urban water management is going to be discussed in detail.

After successful completion of this module, students are able to

- Make the necessary estimations for wastewater projects;
- Name diverse design parameters of wastewater treatment facilities;
- Design different components of wastewater treatment plants;
- Interpret the causes of operational problems at wastewater treatment plants;
- Differentiate cost types and perform a cost analysis;
- Execute mathematical processing of costs (cost-leveling);
- Compare project costs in different ways;
- Implement sensitivity analysis of critical values.

Contents

- Tutorials for the dimensioning of municipal waterworks
- Process engineering in wastewater treatment
- Design and dimensioning of wastewater treatment plants
- Investment and operating costs
- Ascertaining of costs
- Financial, mathematical processing of costs (levelised costs)
- Comparison of costs
- Sensitivity analyses and determination of critical value

Workload	90 h (30 h in-class teaching and 60 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Infrastructures for Water Supply and Wastewater Disposal; Natural Sciences
Literature	The lecturers make an up-to-date bibliography available on StudIP for each semester, selection of literature: IAWQ-NVA, Advanced wastewater treatment, International conference, 1996. Judd, Process science and engineering for water and wastewater treatment, IWA Publishing, 2002. Water Environment Federation, Financing and charges for wastewater systems, McGraw-Hill, 2005. Wilderer et al., Water in China. IWA Publishing, 2003.

	The lecturers make an up-to-date bibliography available on StudIP for each semester.
Media	Blackboard, PowerPoint-Presentations, StudIP, ILIAS
Particularities	The lecture is held by external lecturers.

Organizer	Köster, Stephan
Lecturer	Hartwig, Peter; Scheer, Holger
Supervisor	Shafi Zadeh, Shima; Thoms, Anna
Examiner	Köster, Stephan
Institute	Institute of Sanitary Engineering and Waste Management, http://www.isah.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Recycling and Circular Economy

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
VbP (P 40%) / K (60%) **Course achievements:** - (-)	2V / 2Ü	E	6	WS	6551

Learning Objectives

The trigger for global reflection on resource conservation and climate protection was certainly the "Limit to Growth" study presented by the Club of Rome in 1972, which predicted the global impact of industrialisation, population growth, malnutrition, the exploitation of raw material reserves and the destruction of habitats by computer simulation. The result was also that the current individual local action has all global effects, which, however, do not correspond to the time horizon and action space of the individual. In the meantime, these theoretical results have been more than confirmed and have been accelerated by globalization. Keywords such as climate change, energy turnaround and environmental migration are no longer just empty words but measurable global events.

The aim of the module is therefore to convey the global and local connections of resource use, material and energy cycle management and the associated influence on the environment and climate. The students will gain in-depth knowledge of how material cycles are closed, how by-products are recycled and how waste is avoided. Methods are presented (e.g. material flow analysis, life cycle assessment) which enable a holistic, life cycle-oriented assessment of material efficiency under different target parameters (ecological, economic, social) in the industrial value stream.

After successful completion of the module, the students will have the ability to

- recognize the sustainability challenges of the current generation and to create system-based approaches for the creation of a sustainable solution for society,
- use the methodology of material flow analysis for a targeted material or energy flow management (STAN2)
- apply the methodology of Life cycle assessment (LCA) (umberto nxt®)- for the assessment of process chains, products, services and energy systems,
- assess the ecological and economic relevance of the use of materials in technical products and services, and
- develop synergetic approaches of industrial as well as municipal (regional) supply and disposal systems.

Contents

- Impact of global resource use and industrialization (Sustainable Development Goals SDG)
- Recycling management concept and its application in the context of sustainability strategies for organisations, communities and consumers (regional material balance)
- Field of tension of durable products
- Consumer behaviour
- Conservation of resources
- cradle to cradle"
- a.o. approach in the building industry (Buildings as Material Banks)
- Applications according to the European Industrial Emissions Directive IED and Best Available Technologies
- Applications in accordance with the European packaging and recycling strategy

- Recycling of by-products as well as glass, metal, plastics, paper and organic residues
- Instruction and exercises with the LCA software umberto nxt® incl. the ecoinvent database
- Instruction and exercises with the software STAN2 for material and energy flow analysis

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Waste Technology / Solid Waste Management
Literature	The lecturers make an up-to-date bibliography available on StudIP for each semester.
Media	StudIP, ILIAS, whiteboard, PowerPoint-Presentation, software
Particularities	none

Organizer	Weichgrebe, Dirk
Lecturer	Weichgrebe, Dirk
Supervisor	Shafi Zadeh, Shima; Zahedi Nezhad, Sara; Thoms, Anna
Examiner	Weichgrebe, Dirk
Institute	Institute of Sanitary Engineering and Waste Management, http://www.isah.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

Innovative Bioprocesses for Wastewater/Waste Valorization

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
VbP (P 80% + KU 20%) **Course achievements:** - (-)	2V / 2S	E	6	WS	6531

Learning Objectives

Students will be able to:

• List the main organic and inorganic compounds in wastewater and waste streams

• Identify the compounds that can be recovered or transformed in products with an added-value

• Sketch a process diagram for the recovery of compounds/products by physicochemical or biological processes

• Calculate the mass flow of wastewater/waste stream recycled and the mass flow of compound/product recovered

• Propose a production process for the compound/product recovered

• Propose an analytical monitoring plan to ensure constant quality of the compound/product recovere

Contents

- Wastewater –based biorefinery (WWBR)
- Production of polymers via wastewater valorization
- Nitrogen removal and recovery
- Phosphorous removal and recovery
- Wastewater reuse
- Greywater and rainwater reuse

Workload	180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	Hydrochemistry and –biology or Natural Sciences
Literature	The lecturers make an up-to-date bibliography available on StudIP for each semester, selection of literature: Pepper, I. L., Gerba, C. P. and Gentry, T. J. 2015. Environmental Microbiology, 3rd ed. Amsterdam: Elsevier. Pott, R. et al. 2018. Wastewater Biorefineries: Integrating Water Treatment and Value Recovery. In W. L. Filho and D. Surroop (Eds.), The Nexus: Energy, Environment and Climate Change (pp. 289-304). Switzerland Springer International Publishing AG. Surendra K. C. et al. (2015). Anaerobic Digestion-Based Biorefinery for Bioenergy and Biobased Products. Industrial Biotechnology 11(2), 103-112. Verstraete, W., & Vlaeminck, S. E. (2011). Zero WasteWater: Short-cycling of wastewater resources for sustainable cities of the future. International Journal of Sustainable Development and World Ecology, 18(3), 253–264.

	The lecturers make an up-to-date bibliography available on StudIP for each semester.
Media	Blackboard, PowerPoint
Particularities	The module is structured in Lectures and a Seminar. In the seminar, the students will work in small teams. Each team will develop a project focused on the valorisation of a wastewater/waste stream. The project has 3 milestones: i) definition of the goal, ii) sketch of the process diagram and iii) estimation of productivity, operation costs and the market value of the product.

Organizer	Nogueira, Regina	
Lecturer	Nogueira, Regina	
Supervisor	Shafi Zadeh, Shima; Thoms, Anna	
Examiner	Nogueira, Regina	
Institute	Institute of Sanitary Engineering and Waste Management, http://www.isah.uni-hannover.de/ Faculty of Civil Engineering and Geodetic Science	
Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	W	W

4th. Semester

Master Thesis (24 CP)

Possible forms of Examination:	Art/SWH	Language	CP	Semester	Exam. Number
- / MA (80%) mit VbP (20%) **Course achievements:** - (-)	-	D und E	24	WS/SS	9999

Learning Objectives

In the module, techniques and skills of scientific working are expanded. After successful completion of the module, students may apply and further develop, within a specified period, scientific methods for the independent solution of a complex task from the field of water resources management, sanitary engineering, environmental and coastal engineering, or of related fields within the scope of the masters program.

Contents

The master thesis is a scientific paper based on knowledge and skills obtained during the studies and may include experimental investigations, simulations, or dimensioning tasks. The students have learned how to apply knowledge gained, to place it into a new context independently, and to use methods enabling them to work in a scientific manner. The results are documented in writing in the master thesis. The essential results are to be presented in a colloquium.

Workload	720 h (0 h in-class teaching and 720 h self-study incl. course achievements and examination performances)
Recommended Prior Knowledge	-
Literature	Theuerkauf, J.: Schreiben im Ingenieurstudium. Schöningh 2012. Franck, N.; Stary, J.: Die Technik wissenschaftlichen Arbeitens. UTB Stuttgart, aktuelle Auflage; Friedrich, Ch.: Schriftliche Arbeiten im technisch-naturwissenschaftlichen Studium. Mannheim, Dudenverlag, aktuelle Auflage.
Media	-
Particularities	The master's thesis has to be presented in a colloquium which is open to the faculty. The colloquium consists of a lecture on the topic of the master's thesis.

Organizer	Dean of Studies
Lecturer	
Supervisor	
Examiner	
Institute	Institutes of the Faculty of Civil Engineering and Geodetic Science and the Leibniz University Hannover, http://www.fbg.uni-hannover.de Faculty of Civil Engineering and Geodetic Science

Programme Specific Information	**P (mandatory) / W (elective) and Special Skills Area depending on Major**	
	Major A: Water Resources Management	**Major B: Sanitary Engineering**
	P WA	P WA