Appendix C

Handbook of Modules

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

Legend:

CO  Colloquium KO
CP  Complex Examination Performance
L   Lesson
LE  Laboratory Exercise
MT  Master Thesis
OE  Oral Examination
WT  Written Test
OP  Oral Presentation
P   Practice
SP  Seminar Performance
ST  Student Research Paper
TP  Term Paper
1\textsuperscript{st}. Semester
Coastal and Estuarine Management
Küsten- und Ästuaringenieurwesen

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**Learning Objectives**

Students acquire 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, continuous 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 infrastructures 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**

N.N.

**Supervisor**

N.N.

**Examiner**

N.N.

**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

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<td>Major A: Water Resources Management</td>
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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;
- remember the fundamental principles for modeling flow processes and implementing them for practical problems;
- 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 -

Chadwick, A., 2004: Hydraulics in Civil and Environmental Engineering. Taylor & Francis

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Learning Objectives
This module 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

Media
Blackboard, PowerPoint-Presentation, Script

Particularities
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<td><strong>Institute</strong></td>
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Hydro Power Engineering
Energiewasserbau

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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
Bodenmechanik und Gründungen (D), Erd- und Grundbau (D), Strömung in Hydrosystemen (D)

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Learning Objectives
I. Hydrobiology and Hydrochemistry
The engineering students will gain competences about to describe and analyse basic chemical and biological pro-cesses occurring in the natural and the engineered environment. Besides lectures, this module also includes experi-mental exercises in laboratory where the students will have the opportunity to generate and analyse experimental data related to selected chemical/biological process.
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
II. Meteorology and Climatology
The objective of this course is to impart fundamental knowledge about weather, climate and atmospheric pheno-mena. After successful completion of the module, students will have the ability to describe the atmosphere’s com-position 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
I. Hydrochemistry and Hydrobiology
- 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.
Experimental exercises in laboratory:
- Chemical characterization of wastewater composition,
- Determination of microbial metabolic activity,
- Microscopic assessment of complex microbial communities.
II. Meteorology and Climatology:
- Introduction to weather, climate and the atmopshere
- 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
- The climate of the past, climate variability and climate change
**Workload** | 180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)
---|---
**Recommended Prior Knowledge** | -
**Media** | Blackboard, PowerPoint
**Particularities** | none
**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) depending on Major
<p>| | Major A: Water Resources Management | Major B: Sanitary Engineering |
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**Learning Objectives**
At the end of this course, students will be able to research, write about, and present scientific information. Student teams of two will conduct a literature review on a water resources or environmental management project of their interest. Student teams will also give a poster presentation on the same topic. In this course, students will learn to:
- search for literature; efficiently and critically read scientific literature,
- identify and avoid common mistakes made by English as a second language (ESL) speakers,
- 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 how work well in a team,
- research and write about a waterresources or environmental problem, and
- present a poster on this topic.

**Contents**
- How to carry out a literature search
- Visit to the library to learn the search system of the Leibniz Universität
- Understand the goals of scientific writing
- Scientific Writing Parts 1-5: specific of scientific writing
- Students do a poster presentation on their topic

**Workload**
90 h (30 h in-class teaching and 60 h self-study incl. course achievements and examination performances)

**Recommended Prior Knowledge**
- 

**Literature**
Course textbook:

Other resources:
Water Resources and Environmental Management (M. Sc.)

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## Soil Mechanics for Hydraulic Structures  
**Bodenmechanik für den Wasserbau**

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### 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


### Media

PowerPoint, Overhead, Blackboard

### Particularities

- none

### Organizer

Achmus, Martin

### Lecturer

N.N.
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Learning Objectives
The modul 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
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2nd. Semester
Learning Objectives
In this module, students learn about ecological conditions and water quality management in catchments, including limnology (biology) and geohydrology, which are both strongly interlinked with hydrology and water resources. Focus in on agricultural catchments.
Upon completion of the module, students are able to
- analyse and simulate matter balances for catchments;
- apply river quality assessment methods and develop rehabilitation measures;
- collect aquatic organisms according to international standards of waterbody examination;
- solve problems regarding groundwater abstraction and pollution.

Contents
1. Water quality management
   - Erosion and sediments
   - Nutrients
2. Applied limnology with practical field training
   - aquatic ecosystems of stagnant and running waters: functions and physical characteristics, biocenosis
   - biogenic turnover, primary and secondary production, trophic and saprobic levels
   - field training of sampling methods (macrozoobenthos) and analysis
3. Geohydrology
   - aquifer types, geohydraulics
   - groundwater pollution, remediation and protection
4. Integrated simulation of catchments with SWAT+
   - Calibration of hydrological catchment models
   - Implementation of agricultural management (crop cultivation, irrigation)
   - evaluation of model results for catchment management

Workload
180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)

Recommended Prior Knowledge
- 

Literature
10. Aufl., Springer Spektrum.  
Loucks, D.P. and van Beek, E. (Editors), 2017. Water Resources Systems Planning and Management. Springer International Publishing (open access).

<table>
<thead>
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<th>The field training is scheduled for Thursday to Saturday within the &quot;Pfingsten&quot; week (3 days of excursion). Students will have to pay a contribution of 45 to 80 Euro depending on faculty support. A report about the exam is required (“Studienleistung”).</th>
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**Field Measuring Techniques in Coastal Engineering**

**Naturmessungen im Küsteningenieurwesen**

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**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**

Wasserbau und Küsteningenieurwesen (D); Umweldatenanalyse (D)

**Literature**

- 

**Media**

PPT, Matlab- Exercises

**Particularities**

One-day excursions
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<td>Franzius-Institute for Hydraulic, Estuarine and Coastal Engineering, <a href="http://www.lufi.uni-hannover.de">http://www.lufi.uni-hannover.de</a> Faculty of Civil Engineering and Geodetic Science</td>
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<th>Programme Specific Information</th>
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<td></td>
<td>Major A: Water Resources Management</td>
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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


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<thead>
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<tr>
<td>Examiner</td>
<td>N.N.</td>
</tr>
<tr>
<td>Institute</td>
<td>Institute of Fluid Mechanics and Environmental Physics in Civil Engineering, <a href="http://www.hydromech.uni-hannover.de/">http://www.hydromech.uni-hannover.de/</a> Faculty of Civil Engineering and Geodetic Science</td>
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Hydrological Extremes
Hydrologische Extreme

Mode of Examination
CP (WT 70% + TP 30%; 40h) / -

Art/SWH
2L / 2P

Language
D and E

CP
6

Semester
WS (D) / SS (E)

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, techniques 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
   - 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)
Grundlagen der Hydrologie und Wasserwirtschaft (D) & Umweltdatenanalyse (for WUK & UIW(D)

Literature

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
N.N.

Supervisor
N.N.
<table>
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<tr>
<th>Examiner</th>
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<tbody>
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<td>Institute</td>
<td>Institute of Hydrology and Water Resources Management, <a href="http://www.iww.uni-hannover.de/">http://www.iww.uni-hannover.de/</a> Faculty of Civil Engineering and Geodetic Science</td>
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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 wwtfps, decentralised 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 180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)

Recommended Prior Knowledge

Literature
Amsterdam.
The lecturers make an up-to-date bibliography available on StudIP for each semester.

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<td>Köster, Stephan</td>
</tr>
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<td>Institute</td>
<td>Institute of Sanitary Engineering and Waste Management, <a href="http://www.isah.uni-hannover.de/">http://www.isah.uni-hannover.de/</a> Faculty of Civil Engineering and Geodetic Science</td>
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Maritime and Port Coastal Engineering
See- und Hafenbau

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<th>CP</th>
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Learning Objectives
The module imparts knowledge about the planning, management and 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
• Infrastructure 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
Wasserbau und Küsteningenieurwesen (D)

Literature
Water Resources and Environmental Management (M. Sc.)

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<th>Media</th>
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<td>Big hydraulic engineering excursion (Pentecost week)</td>
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Learning Objectives
In the current working environment of (environmental) engineers, the increased use of simulation to support classical tasks such as plant design, operation control and last but not least, the evaluation and concept development of comprehensive systems (catchment area, circular economy, etc.) cannot be neglected. In accordance with the specific requirements of the fields mentioned above, various model systems and approaches have been developed in the environmental field, which could contribute to acceleration and simplification of the engineering tasks. This module includes a lecture block (2 SWH) as well as an exercise block (2 SWH), which is running parallel to the lecture. The students have to choose one of the three topic-specific small exercise groups based on their own interests. The main focus of the exercise block is to introduce topic-specific softwares and teach students how to use them on an advanced level.

Contents
Lecture Block:
- Description of the following systems: 1. wastewater treatment, 2. settlement area, 3. Water bodies
- Mathematical basics of different models
- Overview of various model families (dynamic process models, flow models, balance models, evaluation models...)
- Introduction to the basic steps of the Modeling, such as calibration, validation, sensitivity analysis, parameter identification and fitting, etc.
Exercise A „Wastewater treatment plant operation and design“:
- Design of biological wastewater treatment plants according to the rules of DWA-A131 Worksheet using static models
- Illustration of typical control concepts 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
- Measurement and control concepts.
Exercise B „Biological Processes of Wastewater Treatment“:
- Scientific basics and methodical procedures for the derivation of chemical-physical and biological parameters (analytics / calibration)
- Petersen matrix and its components
- Transport processes in different reactors (CSTR, PFR, Batch)
- Biological processes in wastewater treatment (carbon, nitrogen and phosphorus removal)
- Formulation of mathematical models for physical, chemical, and biological processes
- Processes in suspended and sessile biomass systems
- Biofilm processes
- Experimental methods

Exercise C „Circular Economy and Life Cycle Assessment (LCA)“:
- 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

Exercise D "Decision Support in Infrastructure Planning“:
- Input data generation for forecasting (prognosis) models, static process description, consideration of various decision criteria, dealing with forecast uncertainties. process module creation for implementation, interface definition.
- Applied software: simba # (static), cost models and simple static design models, Excel

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<tr>
<th>Workload</th>
<th>180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)</th>
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<tr>
<td>Recommended Prior Knowledge</td>
<td>Umweltbiologie und-chemie (D), Infrastructures for Water Supply and Wastewater Disposal, Abfallwirtschaft und Kreislauf (Depending on the chosen exercise) (D)</td>
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<td>Nogueira, Regina</td>
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<td>Nogueira, Regina, Weichgrebe Dirk; Beier, Maike</td>
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<td>Supervisor</td>
<td>Tajdini, Bahareh, Mondal, Moni Mohan; Kersten, Kim Laura; Manig, Nina</td>
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<tr>
<td>Institute</td>
<td>Institute of Sanitary Engineering and Waste Management, <a href="http://www.isah.uni-hannover.de/">http://www.isah.uni-hannover.de/</a> Faculty of Civil Engineering and Geodetic Science</td>
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**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

**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.
### Programme Specific Information

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# Solid Waste Management

**Abfallwirtschaft**

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## 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 theme 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 discussed 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 theoretical 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**

| Recommended Prior Knowledge | Siedlungswasserwirtschaft und Abfalltechnik (D) |

**Literature**

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The lecturers make an up-to-date bibliography available on StudIP for the current semester.

**Media**

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**Particularities**

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<td>2. Excursion to a waste treatment plant or recycling facilities.</td>
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**Institute**

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<td>Institut für Siedlungswasserwirtschaft und Abfalltechnik, <a href="http://www.isah.uni-hannover.de/">http://www.isah.uni-hannover.de/</a></td>
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<td>Fakultät für Bauingenieurwesen und Geodäsie</td>
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**Programme Specific Information**

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Urban Hydrology
Urbane Hydrologie

Mode of Examination
WT / ungraded Term Paper

Art/SWH
2L / 2P

Language
E

CP
6

Semester
SS

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).
• Implement simple rules for real time control (RTC) based on hydrometeorological forecasts and radar.
• 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.

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 impacts on receiving waters; Real time control (RTC)
4. Exercises including rainwater infiltration and retention, RTC based on rainfall forecasts and obs. system states
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
<table>
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<th>sensitive cities / water smart cities</th>
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<tr>
<td><strong>Workload</strong></td>
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<td><strong>Recommended Prior Knowledge</strong></td>
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Merk- und Abeitsblätter der DWA  
Empfohlene Literatur in der Vorlesung (ausgewählte wissenschaftliche Berichte und Artikel) |
| **Media** | PowerPoint, Tafel, Computer |
| **Particularities** | none |

| **Organizer** | Förster, Kristian |
| **Lecturer** | Förster, Kristian |
| **Supervisor** |  |
| **Examiner** | Förster, Kristian |
| **Institute** | Institute of Hydrology and Water Resources Management, http://www.iww.uni-hannover.de/  
Faculty of Civil Engineering and Geodetic Science |

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Water Economics
Wasser und Ökonomie

<table>
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<th>Semester</th>
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Learning Objectives
Students are able to describe the economics of water use and explain the importance of water resource management in environmental economics. In addition to assessing the applicability of different pricing mechanisms and (institutional) market structures for providing water, students are able to present methods for assessing water resources and apply them to specific case studies.

Contents
Furthermore, students can explain current water concepts (such as the water footprint) and methods of managing the resource water. It also discusses the privatization of water supply and the role of water related policies. The course will be complemented by case studies from developing countries.

Workload
180 h (60 h in-class teaching and 120 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
-

Organizer
Grote, Ulrike

Lecturer
Grote, Ulrike

Supervisor
Gronau, Steven

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) depending on Major

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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

Media
PowerPoint, overhead, whiteboard, field training sampling equipment
**Particularities**  
Field training incl. report - "Ausarbeitung" (course achievement "Studienleistung")

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<tr>
<th>Organizer</th>
<th>Graf, Martha</th>
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| Institute   | Institut für Hydrologie und Wasserwirtschaft,  
http://www.iww.uni-hannover.de/  
Fakultät für Bauingenieurwesen und Geodäsie |

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3rd. Semester
Environmental Planning
Umweltplanung

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**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 (Dr. Bartlett Warren-Kretzschmar)
- Landscape planning and other instruments of nature conservation and impact mitigation regulation (Prof. Dr. Christina Von Haaren)
- Assessing and evaluating landscape functions and ecosystem services (Junior-Prof. Dr. habil. Christian Albert)
- Scenario-based landscape planning (PD Dr. Sylvia Herrmann)
- Planning for renewable energies (Dr. Julia Wiehe)
- Planning for biodiversity (Prof. Dr. Reich)
- Ecological Networks(Prof. Dr. Reich)
- Assessing impairments of water bodies (Prof. Rode)
- Aesthetic landscape quality assessment (Johannes Hermes)
- Spatial planning instruments (Prof. Dr. Reiner Danielzyk)
- Instruments for spatial environmental assessment (Dr. Frank Scholles)
- Environmental Impact Assessment and Natura 2000 Assessment for Projects (Dr. Frank Scholles)

<table>
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<th>Workload</th>
<th>90 h (30 h in-class teaching and 60 h self-study incl. course achievements and examination performances)</th>
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<td>Major B: Sanitary Engineering</td>
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Geostatistics and Soft Computing

Learning Objectives
This module introduces advanced statistical and systems analytic techniques and their application in hydrology and water resources management. Upon completion of the module, students are able to:
- apply geostatistical methods for structural analyses, interpolation and spatial simulation of various geodata;
- apply methods of artificial intelligence (soft computing) as data based models and for optimization;
- understand fields of application and shortcomings of soft computing techniques.

Contents
1. Geostatistics:
   - Statistical model
   - Struktural analysis, Variographie
   - Kriging and Simulation
2. Soft Computing:
   - Fuzzy Logic
   - Evolutionary algorithms
   - Artificial neural networks

Workload
90 h (30 h in-class teaching and 60 h self-study incl. course achievements and examination performances)

Recommended Prior Knowledge
Grundlagen der Hydrologie & Wasserwirtschaft (D), Wasserressourcenbewirtschaftung (WuK & UIW) (D); Hydrology and Water Resources Management I, Water Resources Management, Statistical Methods (für WATENV)

Literature

Media
PowerPoint-Presentation, Blackboard, Computer

Particularities
none

Organizer
Haberlandt, Uwe

Lecturer
N.N.
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<td>Institute of Hydrology and Water Resources Management, <a href="http://www.iww.uni-hannover.de/">http://www.iww.uni-hannover.de/</a> Faculty of Civil Engineering and Geodetic Science</td>
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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

Workload 180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)

Recommended Prior Knowledge -

Literature
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.

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<td>Institute</td>
<td>Institute of Photogrammetry and Geoinformation and Institute of Cartography and Geoinformatics, <a href="http://www.ipi.uni-hannover.de">http://www.ipi.uni-hannover.de</a> und <a href="http://www.ikg.uni-hannover.de">http://www.ikg.uni-hannover.de</a></td>
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**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 technologies 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 & 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-integrated 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
Umweltbiologie und –chemie (D), Siedlungswasserwirtschaft und Abfalltechnik (D)

### Literature

The lecturers make an up-to-date bibliography available on StudIP for each semester.

### Media
- Blackboard
- PowerPoint-Presentation
- StudIP
- ILLIAS

### Particularities
The examination can be held in German or English

### Organizer
Köster, Stephan

### Lecturer
Köster, Stephan

### Supervisor
N.N.

### 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

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Innovative Bioprocesses for Wastewater/Waste Valorization
Innovative Bioprozesse zur Rückgewinnung von Ressourcen aus Abwasser/Abfall

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<td>2L / 2S</td>
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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 recovered

Contents
The module is structured in Lectures and a Seminar, the lectures are organized in 6 blocks:
Block 1 | Analytical tools: microbial Methods in biotechnology/environmental monitoring
1.1 Cultural and physiological methods
1.2 Molecular method
- Polymerase chain reaction
- Sequencing
- Fluorescence in situ hybridization
Block 2 | Toxicological tests to assess water and wastewater quality
2.1 Types of bioassays
2.2 Application of bioassays
Block 3 | Mathematical tools
3.1 Material flow analysis with SankeyMATIC
3.2 Material flow analysis with Humbero
Block 4 | Wastewater–based biorefinery (WWBR)
4.1 Introduction to the WWBR concept
4.2 Types of wastewater as feed for WWBR.
4.3 Potential products suitable for production from specific wastewaters
4.4 Microbially produced products using organic carbon-rich components
- Biopolymer production
- Biodiesel production
- Single cell protein production
4.5 Recovery of inorganic nutrients
4.6 Integrated wastewater treatment and product recovery
Block 5 | Anaerobic digestion-based biorefinery
5.1 Volatile fatty acids production from organic wastes
5.2 Bio hydrogen and methane
5.3 Microalgae biofuel industry
Block 6 | Microbial water quality aspects of recycled water
6.1 Recycled water reuse
6.2 Bacteria, viruses and protozoa
6.3 Toxicity testing
6.4 Quantitative microbial risk assessment

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. Each milestone is assessed in an oral presentation and discussion.

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Learning Objectives
In this module, students gain profound knowledge in the design of wastewater treatment plants according to the valid regulations of DWA Worksheets. Furthermore, the methodology of biological and technical modeling of wastewater treatment processes and their application in the field of urban water management is discussed in detail. One of the major goals of this module is to familiarize the students with various components of a P&ID map and as a result, teach them how to extract the simulation-relevant data from those maps. In addition, students have the opportunity to implement various control and operational strategies and select the one with the best performance based on the simulation results. The regulation and control of various components of a sewage treatment plant will be discussed in detail and students learn how to implement these strategies in a wastewater treatment plant with the help of a simulation software. Upon successful completion of this module, students would 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),
- critically question the results of simulation studies,
- identify problems in the operation of a wastewater treatment plant and propose solutions.

Contents
- Characterisation of municipal waste water
- Influent data evaluation according to recognized technical rules of DWA worksheets (eg DWA-A 198)
- Design of biological wastewater treatment plants according to recognized rules of DWA worksheets (eg DWA-A131) using static models; Illustration of typical control concepts for sewage treatment plants
- Mathematical procedures for the derivation of chemical-physical and biological parameters (analytics / calibration)
- Application of simulation software SIMBA classroom (during tutorials)
- Interpretation of the simulation results
- Measurement Systems and control concepts.

Workload 180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)

Recommended Prior Umweltbiologie und –chemie (held in german) or Natural Sciences, Infrastructures for Water Supply and Wastewater Disposal
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<tr>
<th>Knowledge</th>
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<tr>
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<tr>
<td>Henze et al., Wastewater treatment, Biological and Chemical Processes, Springer-Verlag, 1995.</td>
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<tr>
<td>Olsson et al., Wastewater Treatment Systems, 2001</td>
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<td>The lecturers make an up-to-date bibliography available on StudIP for each semester.</td>
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<td>2. It is mandatory for the students to submit the homeworks</td>
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<td>3. Limited number of participants</td>
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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

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<th>Workload</th>
<th>180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)</th>
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<td>Abfalltechnik / Solid Waste Management</td>
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</table>
## Learning Objectives
This module provides deep knowledge of the wastewater treatment and reuse concepts. The students learn to evaluate the quality of the wastewater and to determine the required treatment steps for a particular use such as irrigation, industrial processes, toilet flushing, groundwater recharge, etc. After successful completion of the module, students would have the competence to:
- define physical, chemical and microbiological water quality parameters,
- select suitable treatment methods for the reuse of wastewater,
- evaluate the suitability of treated water for each type reuse,
- Understand procedures for planning and managing water recovery projects,
- select suitable irrigation systems for the reuse of waste water,
- select adequate preventive measures for communicable and non-communicable diseases.

## Contents
- Sewage and rainwater reuse concepts and applications
- Determination of parameters for assessing the risk of getting infected by reusing wastewater in different sectors
- Treatment steps for specific wastewater reuse targets
- Risk-causing microbial pathogens; Quantitative microbial risk assessment (QMRA)
- Criteria for selecting the best treatment technique to minimize the risk of infection
- Methods for qualitative and quantitative analysis of microorganisms

## 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

## Literature

<table>
<thead>
<tr>
<th>Media</th>
<th>StudIP, Script, Beamer, Blackboard</th>
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<tbody>
<tr>
<td>Particularities</td>
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<tr>
<th>Organizer</th>
<th>Nogueira, Regina</th>
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<tbody>
<tr>
<td>Lecturer</td>
<td>Nogueira, Regina</td>
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<tr>
<td>Supervisor</td>
<td>Tajdini, Bahareh</td>
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<tr>
<td>Examiner</td>
<td>Nogueira, Regina</td>
</tr>
<tr>
<td>Institute</td>
<td>Institute of Sanitary Engineering and Waste Management, <a href="http://www.isah.uni-hannover.de/">http://www.isah.uni-hannover.de/</a> Faculty of Civil Engineering and Geodetic Science</td>
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<th>Programme Specific Information</th>
<th>P (mandatory) / W (elective) depending on Major</th>
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<tr>
<td>Major A: Water Resources Management</td>
<td>Major B: Sanitary Engineering</td>
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</table>
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.

Media
Blackboard, PowerPoint-Presentations, StudIP, ILIAS
### Particularities

The lecture is held by external lecturers.

<table>
<thead>
<tr>
<th>Organizer</th>
<th>Köster, Stephan</th>
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<tbody>
<tr>
<td>Lecturer</td>
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Water Resources Systems Analysis
Wasserwirtschaftliche Systemanalyse

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<td>D and E</td>
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Learning Objectives
The module deals with advanced aspects of water resources management. Ecological, climatological, socio-economic and policy aspects are regarded as environmental conditions for water resources management. A seminar is included, where students present and discuss their homework about integrated water resources management problems in developing countries. Furthermore, optimization is introduced as systems analytic technique.

Upon completion of the module, students are able to:
- understand the concept of integrative and sustainable approaches in water resources management;
- perform an interdisciplinary analysis of international projects, with special focus on developing countries;
- evaluate and optimize water resources problems with optimization techniques;
- compare alternative projects according to multi criteria and derive decision recommendations.

Contents
- IWRM definition and concepts
- Seminar: international projects and policies seen from an integrated perspective
- Linear and non-Linear Optimization, multi-criteria decision support
- External societal frame for WRM: capacity development, participation
- WRM problems of arid and semi-arid regions

Workload
180 h (60 h in-class teaching and 120 h self-study incl. course achievements and examination performances)

Recommended Prior Knowledge
„Grundlagen der Hydrologie und Wasserwirtschaft“ (D) "Hydrology and Water Resources Management I" (E)

Literature
Loucks, D.P. and van Beek, E. (Editors), 2017. Water Resources Systems Planning and Management. Springer International Publishing (open access).

Media
PowerPoint-Presentation, Blackboard, Computerexercise

Particularities
The student homework presentations will be organized as a seminar. Participation in the seminar is required (Studienleistung, one missing allowed without excuse).
<table>
<thead>
<tr>
<th>Organizer</th>
<th>Dietrich, Jörg</th>
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<tbody>
<tr>
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4th. Semester
Master Thesis (24 CP)
Masterarbeit (24 LP)

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<td>D and E</td>
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<td>WS/SS (P+F)</td>
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**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 master's 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**
Franck, N.; Stary, J.: Die Technik wissenschaftlichen Arbeitens. UTB Stuttgart, 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**
Study dean

**Lecturer**

**Supervisor**

**Examiner**

**Institute**
Institutes of the Faculty of Civil Engineering and Geodetic Science and the Leibniz University Hanover, 
http://www.fbg.uni-hannover.de