



Handbook of Modules

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



1st . Semester



Environmental data analysis

Mode of Examination K	Mandatory (P)/ Elective (WP) P	Art/SWH 2V / 2Ü	Language English	Credits 6	Sem. 1 (WS)
Level Master	Area of Competence Mandatory Basics		Organizer Haberlandt, Uwe		

Learning Objectives

The modul teaches basic concepts and methods of statistics concerning environmental data analysis. It introduces the underlying principles and methods about Geographical Information Systems (GIS). 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 geographics information systems for analyses and manipulation of space related data.

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. 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

Workload:	180 h (60 h Präsenz- u. 120 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	-
Literature:	Haan, C.T., 2002. Statistical Methods in Hydrology. Blackwell, Ames, Iowa, USA. Jones, C., 1999. Geographical Information Systems and Computer Cartography Logman.
Media:	blackboard, PowerPoint, lecture-notes
Particularities:	-



Institute:

Institute of Hydrology and Water Resources Management
Institute of Photogrammetry and Geoinformation
Institute of Cartography and Geoinformatics



Environmental Hydraulics

Mode of Examination K	Mandatory (P)/ Elective (WP) P	Art/SWH 2V / 2Ü	Language English	Credits 6	Sem. 1 (WS)
Level Master	Area of Competence Mandatory Basics		Organizer Neuweiler, Insa		

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 Präsenz- u. 120 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	-
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:	PowerPoint, overhead, blackboard
Particularities:	-
Institute:	Institute of Fluid Mechanics and Environmental Physics in Civil Engineering Franzius-Institute for Hydraulic, Waterways and Coastal Engineering



Hydrology and Water Resources Management I

Mode of Examination K	Mandatory (P)/ Elective (WP) P	Art/SWH 2V / 2U	Language English	Credits 6	Sem. 1 (WS)
Level Master	Area of Competence Mandatory Basics		Organizer Haberlandt, Uwe		

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, flood protection measures, irrigation structures and drainage systems;
- analyse the risk of extreme events in hydrology and water resources management including consideration of hazards, damage, and integrated risk.

Contents

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

Water Resources Management I:

- Reservoir design, retention
- Flood risk management and flood protection measures
- Irrigation and drainage
- Economic project assessment

Workload:	180 h (60 h Präsenz- u. 120 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	-
Literature:	Maidment, D.R. (Editor), 1992. Handbook of Hydrology. McGraw-Hill Inc. Loucks, D.P. and van Beek, E. (Editors), 2017. Water Resources Systems Planning and Management. Springer International



	Publishing (open access).
Media:	blackboard, PowerPoint
Particularities:	-

Institute:	Institute of Hydrology and Water Resources Management
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Natural Sciences

Mode of Examination K	Mandatory (P)/ Elective (WP) P	Art/SWH 2V / 2Ü	Language English	Credits 6	Sem. 1(W/S)
Level Master	Area of Competence Mandatory Basics			Organizer Nogueira, Regina	

Learning Objectives

1. Hydrobiology and Hydrochemistry

The engineering students will gain competences about to describe and analyse basic chemical and biological processes occurring in the natural and the engineered environment. Besides lectures, this module also includes experimental 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 und nutrients removal in wastewater treatment

2. Meteorology and Climatology

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

1. Hydrobiology and Hydrochemistry

- 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.

2. 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 lectures, exercises and excursion and 120 h self studies)
Prerequisites:	-
Literature:	Lester, J.N. & Birkett, J.W. (2002). Microbiology and chemistry for environmental scientists and engineers, 2 nd 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, 15 th Edition, Pearson Prentice Hall. Wallace, J. M. & Hobbs, P. V. (2006). Atmospheric science : an introductory survey, 2 nd Edition. Elsevier, Amsterdam
Media:	blackboard, PowerPoint
Particularities:	
Institute:	180 h (60 h lectures, exercises and excursion and 120 h self studies)



Remote Sensing

Mode of Examination K/MP+HA	Mandatory (P)/ Elective (WP) WP	Art/SWH 1V / 1Ü	Language English	Credits 3	Sem. 1 (WS)
Level Master	Area of Competence Elective Supplements		Organizer Heipke, Christian		

Learning Objectives

In this module the student 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.

Contents

- 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:	90 h (30 h Präsenz- u. 60 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	-
Literature:	T. Lillesand, R. Kiefer, Remote sensing and image interpretation
Media:	beamer, blackboard, lecture-notes (StudIP), videos, computer
Particularities:	-

Institute:	Institute of Photogrammetry and Geoinformation
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Research Planning and Scientific Communication

Mode of Examination HA/K/P	Mandatory (P)/ Elective (W) P	Art/SWH 3V	Language Englisch	Credits 3	Sem. 1 (WS)
Level Mastermodul	Area of Competence Soft Skills and Projects			Organizer Graf, Martha	

Learning Objectives

At the end of this course, students will be able to research, write about, and present scientific information. Student will review an article on a water resources or environmental management project of their interest. Students 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,
- understand what plagiarism is and how to avoid it,
- 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,
- research and write about a water resources or environmental problem, and
- present a poster on this topic.

Contents

- Search for scientific literature
- Visit to the library to learn the search engines of the Leibniz Universität
- Understand the goals of scientific writing
- Learn guidelines of scientific writing
- Students do a poster presentation on their topic

Workload:	90 h (30 h Präsenz- u. 60 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	-
Literature:	Course textbook: Hofmann, A. H. (2010). Scientific Writing and Communication. Oxford, U.K.: Oxford Press. Other resources: 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. Kumar, R. (2011). Research Methodology: A Step-by-step Guide for



	Beginners. London, U.K.: Sage Publications.
Media:	white board, PowerPoint presentations, computer
Particularities:	Grade is calculated from three assignments: written exam 30%, article summary 35%, poster presentation 35%
Institute:	Institute of Hydrology and Water Resources Management



Soil Mechanics for Hydraulic Structures

Mode of Examination K/MP	Mandatory (P)/ Elective (WP) WP	Art/SWH 1V / 1Ü	Language English	Credits 3	Sem. 1 (WS)
Level Master	Area of Competence Elective Supplements		Organizer Achmus, Martin		

Learning Objectives

The course conveys basic knowledge about soil mechanics and its application to the design of hydraulic structures like dams or barrages. Basic soil mechanical theories, the calculation of stresses and strains in soil and the calculation and evaluation of flow nets are dealt with. Also knowledge about erosion phenomena and the respective design methods is conveyed.

After successful completion the students are able

- to explain basic soil mechanical theories and parameters, to calculate stresses and strains in soils for basic cases and to carry out simple design proofs;
- to calculate and evaluate the effect of seepage forces on hydraulic structures and to make the design proofs regarding erosion phenomena.

Contents

- Soil types and soil features
- Field and laboratory investigations of soil parameters
- Shear strength, compressibility and permeability of soils
- Settlement calculations
- Design proofs for shallow footings
- Slope stability
- Flow nets and seepage forces
- Erosion phenomena
- Geotechnical design of hydraulic structures

Workload:	90 h (30 h Präsenz- u. 60 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	Basics in Mechanics
Literature:	Novak, P., Moffat, A.I.B., Nalluri, C., Narayanan, R., 1992: Hydraulic Structures, Chapman & Hall, London; Mitchell, J.K., Soga, K., 2005: Fundamentals of soil behavior. Wiley, Hoboken/NJ.
Media:	StudIP, script, beamer, blackboard
Particularities:	-

Institute:	Institute for Geotechnical Engineering, Foundation Engineering and Waterpower Engineering
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2nd. Semester



Ecology and Water Resources

Mode of Examination K/M+HV+SL	Mandatory (P)/ Elective (WP) P	Art/SWH 2V / 2U	Language English	Credits 6	Sem. 2 (SS)
Level Master	Area of Competence Major Water Resources Management		Organizer Dietrich, Jörg		

Learning Objectives

This module enables students to analyse water resources management problems from an integrated perspective, which includes societal and environmental conditions. Furthermore two specific fields from neighbouring sciences are introduced: limnology and geohydrology, which are both strongly interlinked with hydrology and water resources.

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;
- 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. Integrated water resources management (IWRM)

- external societal and environmental frame for IWRM: development, participation, climate change
- international and transboundary issues, arid and semi-arid regions
- seminar: international projects and policies seen from an integrated perspective

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

Workload:	180 h (30 h Presence, 30 h Excursion u. 120 h Self studies incl. Studien-/ Prüfungsleistung)
Prerequisites:	Natural Sciences, Hydrology and Water Resources Management I
Literature:	Rosegrant, M.W., X. Cai, S.A. Cline (2002): World Water and Food to 2025 - Dealing with Scarcity. Int. Food Policy Research Inst., Washington DC.



	Wetzel, R.G. (2001): Limnology - Lake and River Ecosystems. Academic Press Inc., London, http://www.iwrm-education.org . Domenico, P. and Schwartz, F. 1990. Physical and Chemical Hydrogeology; Wiley, New York.
Media:	blackboard, PowerPoint, fieldtraining
Particularities:	The student homework presentations will be organized as a seminar. The field training is scheduled for Thursday to Saturday within the "Pfingsten" week (3 days of excursion). Students will have to pay a contribution of 45 to 60 Euro depending on faculty support. The combined exam will be weighted by 40 % IWRM, 35 % ecology and 25 % geohydrology.
Institute:	Institute of Hydrology and Water Resources Management, EcoRing Consulting, Federal Institute of Geosciences and Natural Resources (BGR)



Flow and Transport Processes

Mode of Examination K	Mandatory (P)/ Elective (WP) WP	Art/SWH 2V /2Ü	Language English	Credits 6	Sem. 2 (SS)
Level Master	Area of Competence Elective Supplements			Organizer Graf, Thomas	

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 Präsenz- u. 120 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	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, computer, blackboard
Particularities:	Exam 100%
Institute:	Institute of Fluid Mechanics and Environmental Physics in Civil Engineering



Hydrology and Water Resources Management II

Mode of Examination K+SL	Mandatory (P)/ Elective (WP) P	Art/SWH 2V / 2Ü	Language English	Credits 6	Sem. 2 (SS)
Level Master	Area of Competence Major Water Resources Management		Organizer Haberlandt, Uwe		

Learning Objectives

This module introduces advanced methods about the estimation of water balance components as they can be applied in physical based modelling of rainfall-runoff processes. In addition students learn how to measure important hydrological variables in the field. Furthermore, the module deals with aspects of river basin management. Optimization is introduced as systems analytic technique.

Upon completion of the module, students are able to

- apply models for different phases of the rainfall-runoff process;
- compute design values for floods and low flow;
- handle hydrometric instruments under field conditions;
- analyse materials balances for catchments;
- develop structural measures for ecological continuity in cooperation with biologists;
- recognize WRM demands on catchment scale;
- evaluate and optimize water resources problems with optimization techniques;
- compare alternative projects according to multi criteria and derive decision recommendations.

Contents

Hydrology II

- Water balance components
- Rainfall-runoff modelling
- Floods and droughts
- Precipitation radar

Hydrometric Practical Training

- Measurement of discharge, soil moisture, infiltration, water quality parameters

Water Resources Management II

- River pollution from point and diffuse sources (erosion, sediments, nutrients)
- Ecological continuity of river systems
- 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: water harvesting, soil salinity

Workload:	180 h (60 h Präsenz- u. 120 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	Hydrology and Water Resources Management I



Literature:	Loucks, D.P. and van Beek, E. (Editors), 2017. Water Resources Systems Planning and Management. Springer International Publishing (open access). Maidment, D.R (Editor), 1992. Handbook of Hydrology. Mc Graw-Hill Inc.
Media:	blackboard, PowerPoint, computer
Particularities:	The hydrometric practical training requires the participation in field work and the evaluation of measurements (report).
Institute:	Institute of Hydrology and Water Resources Management



Research Project and Colloquium

Project Thesis

Mode of Examination ST+KO	Mandatory (P)/ Elective (WP) P	Art/SWH -	Language English	Credits 6	Sem. 2, 3 (SS/WS)
Level Mastermodul	Area of Competence Scientific Working		Organizer Steering Committee		

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 On-site and 180 h Private Studies, Including Course Achievement/ Examination Performance)
Prerequisites:	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. The module grade is weighted 80 % for the written thesis and 20 % for the colloquium.

Lecturer:	
Supervisor:	



Responsible Examiners:	Lecturers of respective institutes
Institute:	Institutes of the Faculty of Civil Engineering and Geodetic Science Faculty of Civil Engineering and Geodetic Science



Sanitary Engineering

Mode of Examination Written examination	Type of Module Mandatory	Art/SWH 4	Language English	Credits 6	Sem. 2 (SS)
Level Master	Area of Competence Major Sanitary Engineering		Organizer Köster, Stephan		

Learning Objectives

The course seeks to impart the technological knowledge in lay-out, dimensioning and construction of buildings and equipment in sanitary engineering like water supply, sewage technology and waste management. Additionally, special topics and advanced questions are discussed, i.e. regarding the resource-efficiency and re-use of water. After successful completion of this module, students are able to apply methods and dimensioning approaches of the whole water management in the field of sanitary engineering. Students are also able to illustrate the route of the water, the catchment the treatment and the collection and draining of wastewater in separated and combined systems.

Students will be able to design mechanical and biological wastewater and sludge treatment systems and find out save and economic technologies in municipal water management.

Contents

1. Water supply
 - Water supply
 - Methods of water treatment
 - Distribution, storage and conveyance of water
2. Sewage technology
 - Wastewater collection, sewage network, separate and combined systems
 - Rain water treatment and rating
3. Wastewater treatment
 - Wastewater consistence
 - Requirements on wastewater treatment
 - Methods of wastewater treatment and dimensioning approaches
 - Concepts for WWTPs and decentralised areas, sludge treatment

Workload:	90 h (30 h Präsenz- u. 60 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	-
Literature:	180 h (60 h lectures, exercises and excursion and 120h self studies)
Media:	-
Particularities:	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 al. (2001): Integrated Solid Waste Management: A Life Cycle Inventory. Blackwell Science, Oxford.
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Institute:	Institutes of the Faculty of Civil Engineering and Geodetic Science Faculty of Civil Engineering and Geodetic Science
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Soil, Water and Environment

Mode of Examination MP	Type of Module WP	Art/SWH 2V	Language English	Credits 3	Sem. 2(SS)
Level Master	Area of Competence Elective Supplements			Organizer Duijnisveld, Wilhelmus	

Learning Objectives

This module teaches fundamental knowledge about soil components, the geological and mineralogical basics of soils, processes of soil formation and the functions of soils. Based on this knowledge the fundamentals of measuring and modelling soil water dynamics in unsaturated soil will be taught. The students also learn how solutes in soils are transported, what processes are involved and how they can measure and model solute transport, especially leaching of nitrate from soils.

After successful completion of the module the students can:

- describe and interpret a soil profile, determine important soil properties;
- evaluate different functions of soils;
- measure and model soil water fluxes and capillary rise;
- determine the different components of the actual evapotranspiration;
- calculate longterm groundwater recharge;
- conduct solute leaching experiments to determine transport properties of soils;
- determine nitrate leaching from field soils;
- implement measures to reduce nitrate leaching from soils.

Contents

- inorganic and organic components of soils
- basic parameters of bulk soils
- soil formation factors and processes
- water retention and hydraulic conductivity of soils
- soil water dynamics: measurement, modelling
- processes of evapotranspiration and its calculation
- hydro-pedotransfer functions for predicting percolation rate
- solute transport through the unsaturated zone
- transport processes and parameters of solute transport
- leaching of nitrate and trace elements from soils into groundwater: causes and measures to minimize

Workload:	90 h (30 h Präsenz- u. 60 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	-
Literature:	Allen, R.G., L.S. Pereira, D. Raes & M. Smith (1998): Crop evapotranspiration (guidelines for computing crop water requirements). FAO Irrigation and Drainage Paper No. 56. 300 pp



	<p>Bridges, E.M. (1997): World Soils. 3. Edition. Cambridge University Press</p> <p>Bohne, K. (2005): An introduction into applied soil hydrology. Lecture notes in GeoEcology. Catena Verlag.</p> <p>Duijnsveld, W.H.M, J. Böttcher and co-workers (2014): Qualitative groundwater problems in the Fuhrberger Feld. Excursion guide to the field trip</p> <p>Duijnsveld, W.H.M., O. Strebel and J. Böttcher (1988): Are nitrate leaching from arable land and nitrate pollution of groundwater avoidable? Ecological Bulletins 39: 116-125, Copenhagen</p> <p>Kutilek, M. & D. Nielsen (1994): Soil hydrology: Textbook for students of soil science. Catena Verlag.</p>
Media:	PowerPoint, blackboard, computer, fieldtrip
Particularities:	A half-day field trip to the Fuhrberger Feld: "Water Quality and Water Quantity in the Fuhrberger Feld"
Institute:	Institute of Hydrology and Water Resources Management



Solid Waste Management

Mode of Examination Written examination	Type of Module Mandatory	Art/SWH 4	Language English	Credits 6	Sem. 2 (SS)
Level Master	Area of Competence Major Sanitary Engineering		Organizer Weichgrebe, Dirk		

Learning Objectives

The course imparts advanced aspects on how to manage and treat “waste” in the sense of sustainability and circular economy. At the beginning, waste and the responsibilities for waste will be defined and the general conditions as well as the specific waste amounts will be discussed. Then SWM techniques and processes like collection, transportation, sorting, treatment, recycling and disposal are shown. With regard to process engineering, 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.

With respect to EU’s waste hierarchy, concepts and techniques will be exposed in particular and related to each other for avoiding, up- or recycling, reuse and for the disposal of the waste treatment output. Process descriptions, design data and conditions as well as output qualities are debated according to legal criteria for disposal, emission or environment protection. Furthermore, principles and requirements of landfill’s construction, their control and emissions plus the handling of abandoned polluted areas are taught. Modern recycling techniques and requirements for glass, paper, plastics, wood, metal and construction waste are also part of this course as the evaluation (e.g. ecobalancing) and elaboration of administrative waste management concepts. The lecture focuses on contemporary practical examples and the knowledge will be consolidated in tutorials in form of calculation examples.

After successful completion of the module the students are able to

- identify crucial impacts on waste quality, waste collection measures and waste production
- elucidate SWM techniques and recycling processes,
- represent the legal criteria and requirements for SWM and disposal,
- develop treatment concepts for different kind of wastes and recycling materials,
- estimate treatment options for polluted areas,
- design a organic waste treatment plant (composting, anaerobic digestion)
- concept a landfill with respect to leachate and gas production
- discuss SWM issues within the legal framework of climate change and environment protection.

Contents

1. Introduction and definition of waste and related legislation
2. Description and composition of wastes, waste volume and waste products
3. Collection, transportation and specific treatment of waste
4. Biological, mechanical-biological and thermal waste treatment incl. Immission control
5. Construction, handling and management of landfills and abandoned polluted areas



incl. treatment of their emissions (leachate and landfill gas)
6. Recycling of glass, paper, plastics, wood, metal and construction waste
7. Evaluation of waste treatment and management concepts
8. Excursion to waste treatment or recycling facilities

Workload:	180 h (60 h lectures, exercises and excursion and 120h self studies)
Prerequisites:	-
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.
Media:	PowerPoint, blackboard
Particularities:	-

Institute:	Institute for Sanitary Engineering and Waste Management
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Urban Hydrology

Mode of Examination K + SL	Mandatory (P)/ Elective (W) WP	Art/SWS 2V / 2Ü	Language Englisch	Credits 6	Sem. 2 (SS)
Level Master	Area of Competence Elective Supplements			Organizer Förster, Kristian	

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 outflows (CSO) and their 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 sensitive cities / water smart cities



Workload:	180 h (60 h Präsenz- u. 120 h Eigenstudium einschl. Studien-/Prüfungsleistung)
Prerequisites:	Hydrology and Water Resources Management I & II
Literature:	Price, R.K., Vojinović, Z. 2011. Urban Hydroinformatics. IWA Publishing, 520 pp. Pazwash, H. 2016. Urban Storm Water Management, 2 nd 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).
Institute:	Institut für Hydrologie und Wasserwirtschaft, Fakultät für Bauingenieurwesen und Geodäsie



Water Vegetation

Mode of Examination K	Mandatory (P)/ Elective (WP) WP	Art/SWH 2V	Language English	Credits 3	Sem. 2 (SS)
Level Master	Area of Competence Elective Supplements			Organizer Pott, R.	

Learning Objectives

Soils and Environment:

Introduction to functions of soils, the geological and mineralogical basics of soils, soil components and factors and processes of soil formation. Students know the fundamentals of measuring and numerical modelling of soil water dynamics in the unsaturated zone and solute transport in soils and they have knowledge of the leaching of different solutes from soils into the groundwater.

Life in Water:

This course introduces students to the fundamentals of aquatic ecosystems with an emphasis on water vegetation. The goal of the course is to gain knowledge about the various parameters, both natural and anthropogenic, that affect vegetation in waters, with a special emphasis on how strongly these parameters are interconnected. Furthermore, the importance of intact aquatic ecosystems for economic prosperity and human health issues is presented.

Contents

- Overview of the basic characteristics and geological formation of rivers, lakes, springs, and brackish waters, with an emphasis on the associated vegetation types.
- Pollution and autopurification of aquatic ecosystems, with trophic level increases by nutrient pollution regarded in detail
- The indicator function of hydrophytes for the extent of water pollution as well as further important parameters like pH and oxygen levels
- Water chemistry and water physics and their impact on hydrophyte communities: The origin and cycles of the major elements and compounds in aquatic ecosystems, primary production, energy budget, and water movement
- Anthropogenic changes to aquatic ecosystems and the resulting severe effects on habitat quality, which partially led to renaturation efforts.

Workload:	90 h (30 h Präsenz- u. 60 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	-
Literature:	Bohne, K. (2005): An introduction into applied soil hydrology. Lecture notes in GeoEcology. Catena Verlag. Kutilek, M. & D. Nielsen (1994): Soil hydrology: Textbook for students of soil science. Catena Verlag. Pott, R. (1995): Die Pflanzengesellschaften Deutschlands, 2. Aufl., Verlag Eugen Ulmer, Stuttgart. Pott, R. (1996): Biotoptypen - Schützenswerte Lebensräume Deutschlands und angrenzender Regionen, Verlag Eugen Ulmer, Stuttgart Pott, R. & J. Hüppe (2007): Spezielle Geobotanik. Pflanze-Klima-Boden, Springer Verlag, Berlin, Heidelberg, New York. Pott, R. & D.



	Remy (2008): Gewässer des Binnenlandes, Verlag Eugen Ulmer, Stuttgart. Pott, R. (2014): Allgemeine Geobotanik, Biogeosysteme und Biodiversität, Springer Verlag, Berlin, Heidelberg, New York.
Media:	PowerPoint
Particularities:	none

Institute:	Institute of Geobotany Federal Institute of Geosciences and Natural Resources (BGR)
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Wetland Ecology and Management

Mode of Examination AA/PR/K	Mandatory (P)/ Elective (W) WP	Art/SWH 3V / 1Ü	Language Englisch	Credits 6	Sem. 2 (SS)
Level Master	Area of Competence Elective Supplements		Organizer Haberlandt, Uwe		

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, case studies from developing countries will be examined;
- Identify which treatment wetland is best used in which situation;

Contents

- Introduction to wetlands: definition and importance
- Wetland Environment: hydrology, biogeochemistry, biological adaptations of plants
- Wetland Ecosystems: coastal wetlands, freshwater marshes and swamps, peatlands
- Wetland management: restoration, types of treatment wetlands, threats and degradation of wetlands, case studies of wetlands restoration and conservation in developing countries
- Ramsar wetland/UNESCO World natural heritage site case study incl. field training

Workload:	180 h (60 h Präsenz- u. 120 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	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")



	Final grade is an averaged grade from oral presentation (20%) and written examination (80%)
Institute:	Institute of Hydrology and Water Resources Management and Institute of Environmental Planning Leibniz Universität Hannover



3rd. Semester



Environmental and Coastal Management

Mode of Examination K	Mandatory (P)/ Elective (WP) P	Art/SWH 2V / 2Ü	Language English	Credits 6	Sem. 3 (WS)
Level Master	Area of Competence Elective Supplements			Organizer Schlurmann, Torsten	

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)

Integrated Coastal Zone Management:

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 and vulnerability assessments and are acquainted with the fundamentals of policies and administration processes.

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, and perceptions of, environmental planning by the different interest groups involved with it

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 - What mean environmental planning (Dr. Scholles)
- Landscape planning and other instruments of nature conservation (Prof. Von Haaren)
- The visual landscape (Boll)
- Biodiversity: types, measurements, conservation, and effects on human wellbeing (Dr. Graf)
- ecological networks, Natura 2000 and climate change (Prof. Reich)
- Climate adaptation planning and multifunctionality (Dr. Rueter)
- Modeling with regard to participation (PD Dr. Herrmann)
- Introduction to renewable energy (Dr. Palmas)
- Planning for renewables from biomass (Prof. Rode)
- Landscape planning and Water Framework Directive (Galler)

- Spatial planning (Prof. Danielzyk)
- Strategic Environmental Assessment (Dr. Scholles)
- Environmental Impact Assessment (Dr. Scholles)
- Contents of the lecture series "Integrated Coastal Zone Management":
- 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 Präsenz- u. 120 h Eigenstudium einschl. Studien-/Prüfungsleistung)
Prerequisites:	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:	-

Institute:	Franzius-Institute for Hydraulic, Waterways and Coastal Engineering Institute of Environmental Planning
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Environmental Economics

Mode of Examination K/MP	Mandatory (P)/ Elective (WP) W	Art/SWH 2V / 2Ü	Language English	Credits 6	Sem. 3 (WS)
Level Master	Area of Competence Elective Supplements			Organizer Waibel, H.	

Learning Objectives

1. Students learn about the Planning and Evaluation of Development Projects. After completing the course, students know the principles of cost benefit analysis, and they will be able to apply concepts of investment analysis to project in the field of natural resources management and agriculture.

2. Students gain knowledge about Environmental Economics. Students learn about the problems, objectives and instruments related to the economics of pollution and the economics of natural resources. After completing the course, students are familiar with global environmental policies, and they have a solid knowledge about different methods and approaches for assessing environmental goods and services.

Contents

1. Planning and Evaluation of Development Projects

- Definition of project and project cycle
- Basics of welfare theory
- Principles of Cost Benefit Analysis
- Discounting and Compounding
- Investment Criteria
- Principles of valuation
- Financial and Economic Analysis

2.Environmental Economics

- Environmental externalities and polluter pays principle
- Basic concepts as solutions to environmental problems
- Economics of pollution
- Economics of natural resources
- Quantification of environmental goods and services
- Accounting and integrative methods
- Discussion of emission trading systems and climate change

Workload:	180 h (60 h Präsenz- u. 120 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	-
Literature:	1. Planning and Evaluation of Development Projects:



	<p>Gittinger, J. P. (1982). Economic Analysis of Agricultural Projects. Curry, S. and J. Weiss (1993): Project Analysis in Development Countries.</p> <p>2. Global Environmental Economics: Pearce, David and Kerry Turner (1990): Economics of Natural Resources and The Environment. Essex, England. Tietenberg, Tom and Lynne Lewis (2012): Environmental and Natural Resource Economics. Pearson International Edition, 9th Edition. Pearson, Charles S. (2000): Economics and the Global Environment. Cambridge University Press.</p>
Media:	blackboard, PowerPoint,
Particularities:	-
Institute:	Institute of Development and Agricultural Economics Institute of Environmental Economics and World Trade



Hydrological Modelling

Mode of Examination K+S	Mandatory (P)/ Elective (WP) P	Art/SWH 1V / 3U	Language English	Credits 6	Sem. 3 (WS)
Level Master	Area of Competence Major Water Resources Management		Organizer Haberlandt, Uwe		

Learning Objectives

This module provides special knowledge about the application of hydrological models and water resources management models. It deals with the design, functioning, calibration and validation of models for rainfall-runoff processes and for water resources management. Fields of application are flood forecasting, climate change impact analysis and water availability/demand scenarios.

Upon completion of the module, students are able to:

- select suitable models and conduct modelling studies,
- perform data pre- and postprocessing,
- apply hydrological and water resources models for different purposes,
- interpret and discuss the results of the models.

Contents

1. Hydrological modelling:

- theory of hydrological modelling
- parameter estimation, calibration, validation
- data preprocessing, flood simulation
- computer exercises

2. Modelling for water resources management

- theory of modelling in water resources management
- model based planning of water use
- computer exercises

3. Modelling project homework

Workload:	180 h (32 h Präsenz- u. 148 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	Hydrology and Water Resources Management I & II
Literature:	Beven, K., 2001. Rainfall-Runoff Modelling: The Primer. John Wiley & Sons, 360 pp.
Media:	PowerPoint, blackboard, computer
Particularities:	As course achievement a "Studienleistung" will be required based on a group homework without marking

Institute:	Institute of Hydrology and Water Resources Management
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Hydro Power Engineering

Mode of Examination K	Mandatory (P)/ Elective (WP) W	Art/SWH 2V / 2Ü	Language English	Credits 6	Sem. 3 (WS)
Level Master	Area of Competence Elective Supplements		Organizer Achmus, Martin		

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 Präsenz- u. 120 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	Environmental Hydraulics, Soil Mechanics for Hydraulic Structures
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:	-
Institute:	Ludwig-Franzius-Institute for Hydraulic, Estuarine and Coastal Engineering Institute for Geotechnical Engineering, Foundation Engineering and Waterpower Engineering



Industrial Water Supply and Water Management

Mode of Examination Written examination	Mandatory (P)/ Elective (WP) P	Art/SWH 4	Language English	Credits 6	Sem. 3 (WS)
Level Master	Area of Competence Major Sanitary Engineering			Organizer Köster, Stephan	

Learning Objectives

This course seeks to impart the basic principles and the technological aspects of industrial water management. The course includes management and treatment of boiler- and cooling water, the principles of watercycles in industry and the main treatment technologies in industrial water- and wastewater treatment including physical, chemical and biological methods. Students will learn the design, lay-out and calculation of the different processes including practical aspects. Additionally, students will get an overview of the aims of production-integrated environmental protection measures in different industries as the reuse of production-, washing- and rinsing water.

After successful completion of this module, students are able to

- Describe boiler and cooling water processes, water quality requirements of different industries and production-integrated environmental protection measures,
- Explain water treatment processes as well as calculating and interpreting them,
- Design and dimension industrial water and wastewater treatment facilities, especially treatment processes which are mainly used for industrial wastewater,
- Explain functional principles of the treatment processes and contrast their advantages and disadvantages.

Contents

Industrial water supply and treatment:

- Industrial water demand
- Cooling-Tower Systems and their characteristics
- Water quality requirements of different industries and for different purposes like cooling- and process water
- Production-integrated environmental protection measures
- Treatment processes like filtration (membrane), adsorption, ion-exchange, softening and desalination

Industrial wastewater treatment:

- Concentrations and loads of different industrial wastewaters
- Specific industrial wastewater treatment processes (chemical, physical, aerobic anaerobic processes)
- Design and dimension of industrial wastewater treatment plants
- Industrial water management in specific industries

Workload:	180 h (60 h lectures, exercises and excursion and 120 h self studies)
Prerequisites:	Natural Science, Sanitary Engineering
Literature:	Metcalf & Eddy, Inc. et al. (2002): Wastewater Engineering:



	Treatment and Reuse. 4. Auflage, McGraw-Hill Science/Engineering/Math, NJ. // 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 Encyclopaedia: 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.
Media:	PowerPoint, blackboard
Particularities:	-
Institute:	Institute for Sanitary Engineering and Water Management



Modelling in Sanitary Engineering

Mode of Examination Homework and written examination	Type of Module Elective	SWH 4	Language English	Credits 6	Sem. 3 (WS)
Level Master	Area of Competence Elective Supplements			Organizer Nogueira, Regina	

Learning Objectives

The goal of this course is to impart the dimensioning of biological wastewater treatment plants with acknowledged rules of technology, such as the DWA standard rules. Based on this the course will show the methods of biological and technical modelling of wastewater treatment processes and give an overview how those methods are used in sanitary engineering. By building up wastewater treatment plant models and simulation of different operation settings the students gain their first experience with the modelling software SIMBA classroom. The course is especially for those students, who would like to deepen their study in the field of modelling within e.g. their master thesis.

After successful completion of this module, students are able to

- determine the assessment basis for the conceptioning of wastewater treatment plants,
- dimension biological wastewater treatment plants,
- assess capacity and limitations of models,
- create computer-based, technical models for limited questions,
- understand the biological models ASM 1-3 and ADM, their processes and kinetic parameters as the basis of the simulation software SIMBA classroom,
- understand the main processes in sanitary engineering (sewer, wastewater treatment, sludge treatment) and transform them into a model with the simulation software SIMAB classroom, critically scrutinize results of simulations.

Contents

- wastewater characteristics, evaluation of the assessment basis with standard rules of technology
- process technology in biological wastewater treatment plants (phosphorus and nitrogen removal)
- dimensioning of biological wastewater treatment plants with standard rules of technology (e.g. DWA-A 131) and with the use of static models (e.g. B-Expert)
- basic concepts of modelling technique, model building and model types,
- representing the main processes of sanitary engineering (sewer, WWTP) by transferring into a model:
- mathematical formulation and understanding of models for physical, chemical and biological processes
- transformation of typical control concepts for treatment plants
- natural scientific basics and proceedings to discover physical-chemical and biological parameters
- application of simulation software SIMBA classroom:



- from model idea to dynamic simulation calculation based on example of wastewater treatment/ WWTP
- performance of example calculations and interpretation of simulation results, deepening understanding
- measurement, control and regulation concepts

Workload:	180 h (60 h lectures, exercises and excursion and 120 h self studies)
Prerequisites:	Natural Sciences, Sanitary Engineering
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 2010
Media:	PowerPoint, blackboard, modelling software SIMBA classroom
Particularities:	<ol style="list-style-type: none">1. Once per week 2 SWS lecture and 2 SWS as supported working in the CIP Pool.2. During the semester a homework is to be done (weighting 30 %)3. Additionally, a written exam is to be absolved (weighting 70 %)
Institute:	Institute for Sanitary Engineering and Waste Management



Special Topics in Hydrology and Water Resources Management

Mode of Examination MP	Mandatory (P)/ Elective (WP) WP	Art/SWH 1V / 1Ü	Language English	Credits 3	Sem. 3 (WS)
Level Master	Area of Competence Mandatory Basics		Organizer Haberlandt, Uwe		

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 Präsenz- u. 60 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	Hydrology and Water Resources Management I and II, Environmental Statistics
Literature:	Deutsch, C.V. and Journel, A.G., 1992. GSLIB: Geostatistical software library and user's guide. Oxford University Press, New York, 340 pp. Goovaerts, P., 1997. Geostatistics for natural resources evaluation. Oxford University Press, New York, Oxford, 483 pp. Araghinejad, S., 2014. Data-driven Modelling. Springer, 292 pp.
Media:	PowerPoint, blackboard, computer
Particularities:	-

Institute:	Institute of Hydrology and Water Resources Management
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Special Topics in Sanitary Engineering

Mode of Examination Written examination	Mandatory (P)/ Elective (WP) P	Art/SWH 2	Language English	Credits 3	Sem. 3 (WS)
Level Master	Area of Competence Major Water Resources Management		Organizer Köster, Stephan		

Learning Objectives

This course seeks to impart the basic and practical aspects and approaches for water supply plants and effluent disposal plants as well as for sludge treatment. Tutorials for dimensioning real and full-scale wastewater treatment plants engross the mind of theoretical knowledge. Some specific examples will cover the design and dimensioning of full scale plants.

Furthermore, economical efficiency calculation for planning and investment decisions in the urban water management will be educated.

After successful completion of this module, students are able to

- Resume 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 compile costs for calculations;
- 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
- Process engineering in sludge treatment
- Investment and operating costs
- Ascertaining of costs
- Financial, mathematical processing of costs (levelised costs)
- Comparison of costs
- Sensitivity analyses and determination of critical values

Workload:	90 h (30 h lectures and 60 h self studies)
Prerequisites:	Natural Science, Sanitary Engineering
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, Financial and Charges for



	Wastewater Systems, McGraw-Hill, 2005. Wilderer et al., Water in China. IWA Publishing, 2003.
Media:	PowerPoint, blackboard
Particularities:	1. The lecture is held by external lecturers. 2. The lecture is divided in several block seminars held on Friday afternoon during the semester.
Institute:	Institute for Sanitary Engineering and Waste Management



Statistics with R

Mode of Examination MP	Mandatory (P)/ Elective (WP) WP	Art/SWH 1V / 1Ü	Language English	Credits 3	Sem. 3 (WS)
Level Master	Area of Competence Elective Supplements		Organizer Haberlandt, Uwe		

Learning Objectives

This module provides knowledge for management and analyses of empirical data within the free statistical software R. Different statistical methods will be presented and the interpretation of the results will be discussed. Furthermore, the creation of graphs within R will be covered.

Upon completion of the module students

- are able to apply the statistical software R for basic data analyses and graphical representation;
- have better understanding of statistical analyses;
- can interpret results of statistical analyses objectively.

Contents

- General introduction to R
- Data management and statistical calculations with R
- Interpretation of the results

Workload:	90 h (30 h Präsenz- u. 60 h Eigenstudium einschl. Studien-/ Prüfungsleistung)
Prerequisites:	Environmental Data Analysis
Literature:	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, blackboard, computer
Particularities:	-

Institute:	Institute of Hydrology and Water Resources Management
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4th . Semester



Master's Thesis (30 CP)

Master's Thesis

Mode of Examination Master's Thesis + Colloquium (MA+KO)	Mandatory (P)/ Elective (WP) P	Kind/Semester Credit Hours -	Language English	Credits 30	Sem. 4
Examination No.	Level Master's Module	Area of Competence Scientific Working		Organizer Steering committee	

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's 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's thesis. The essential results are to be presented in a colloquium.

Workload:	900 h (0 h On-site and 900 h Private Studies, Including Course Achievement/ Examination Performance)
Prerequisites:	To be admitted to the master's thesis, at least 60 credit points must have been obtained in the master's examination.
Literature:	t.b.a.
Media:	n. s.
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. The examination performance will be assessed as follows: master's thesis 80 % and colloquium 20 %.

Lecturer:	-
Supervisor:	
Responsible Examiners:	Lecturers of respective institutes
Institute:	Institutes of the Faculty of Civil Engineering and Geodetic Science Faculty of Civil Engineering and Geodetic Science