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EU UNIVERSITIES' COURSES AND CONTENT

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Contents

List of abbreviations

AUTh	Aristotle University of Thessaloniki
BOKU	University of Natural Resources and Life Sciences, Vienna
CBHE	Capacity Building in Higher Education
EACEA	Education, Audiovisual and Culture Executive Agency
EHEA	European Higher Education Area
EQF	European Qualification Framework
HE	Higher Education
HEI	Higher Education Institution
NEO	National Erasmus Office
NMBU	Norwegian University of Life Sciences, Norway
PWMC VV	Public Water Management Company ''Vode Vojvodine''
SWARM	Strengthening of master curricula in water resources management for the Western Balkans HEIs and stakeholders
UACEG	University of Architecture, Civil Engineering and Geodesy, Bulgaria
UNI	University of Nis, Serbia
UL	University of Lisbon, Portugal
UoM	University of Montenegro
UNIRIFCE	University of Rijeka, Croatia
UNMO	Dzemal Bijedic University of Mostar
UNS	University of Novi Sad
UNSA	University of Sarajevo
UPKM	University of Pristina in Kosovska Mitrovica
TCASU	Technical College of Applied Sciences Urosevac with temporary seat in Leposavic
WB	Western Balkan
WRM	Water Resources Management

1. Introduction

This document is a part of activity WP2.2 Development of courses content and syllabi created under the project SWARM "Strengthening of master curricula in water resources management for the Western Balkans HEIs and stakeholders" (Project number 597888-EPP-1-2018-1-RS-EPPKA2-CBHE-JP).

It includes the courses of the EU Universities, participating in the project, which are relevant to the proposed courses of the WB Universities which have to be developed or upgraded in WP2 of this project.

2. Aristotle University of Thessaloniki (AUTh), Greece

2.1 Hydraulics

Course Content

A. Flow in pipes: General Equations. Hydraulic Head. Energy equation. Head losses. Friction losses. Moody diagram. Local Losses. Energy and piezometric line. Pipes in series and in parallel. Equivalent pipe. Pipes with a common junction. Water networks. Hydraulic computation of branched and looped networks. Pumps and pumping stations. Pump characteristics. Characteristic curves. Selection of pumps. Pumps in series and in parallel. Cavitation. Siphons.

B. Open channel flow: Flow characteristics. Uniform flow. Definitions and equations. Cross-sections of composite shape. Best hydraulic cross-section. Specific and total energy. Specific force. Critical depth. Calculation of critical depth. Control cross-sections. Flow over a step and through. Hydraulic jump and its features. Hydraulic jump on horizontal channel. Location of hydraulic jump. Gradually varied flow. General features. Profile classification. Flow calculations. Spillways.

C. Flow in alluvial channels: Sediment load, sediment erosion, deposition and transport in alluvial channels. Initiation of motion. Bed load, suspended load and total load. Mathematical and physical models.

2.2 Ground water flow

Course Content

Soil characteristics. Darcy law. Continuity equation. The mathematical model of groundwater flows. Types of boundaries and boundary conditions. Numerical solution of the mathematical model: Method of finite differences. Confined and free surface flows towards ditches and wells. Systems of wells. Method of images. Seepage force and the effect of piping. Anisotropic and inhomogeneous flow fields. Analogue and physical models.

The role of groundwater in water resources management. Aquifer classification. Hydraulic parameters, imhomogeneity and anisotropy. Mathematical simulation of groundwater flows. Analytical solutions for steady and non-steady flows in phreatic, confined and leaky aquifers. Well hydraulics. The method of images. Numerical simulation of groundwater flows. Pumping tests.

2.3 Hydrology

Course Content

Hydrologic cycle. Hydrologic balances. Measurements and analysis of rainfall and stream discharges. Estimation of hydrologic data for engineering works. Prevision of floods and droughts. Simulation of watersheds.

Collection and processing of hydrological data. Objectives of hydrologic analysis. Applications of statistical methods for hydrological assessments. Hydrologic balances. Analysis of rainfall. Infiltration. Estimation of evapotranspiration. Analysis of stream discharges. Rainfall-runoff relationship.

Simulation of watersheds. Flood runoff. Flood routing. Control of reservoir efficiency. Hydrologic drought. Hydrologic project elaboration with insufficient data. Measurements network design.

2.4 Water supply and sewerage

Course Content

Water supply systems: Historic review of wss. Public water demand. Drinking water quality and quantity measurements. Sources and pumping wells. Aquifer recharge. Storage reservoirs. Pumping stations and pressure pipes. Design of water supply networks. Water transfer mains and distribution networks. Branched and Looped networks. Selection of pipe diameter and material. Construction and fitting of pipes (depth, slopes).

Sewerage systems: Historic review of sewerage systems. Quantity and quality of waste water (residential, industrial, runoff). Design of separate and combined networks. Water inflows. Rainfall measurements. Estimation of runoff coefficients. Hydraulic calculations. Filling pipe limits and minimum diameter limits. Pipe material and construction. Installation instructions. Fitting of pipes (depth, slopes). Runoff manholes. Sewerage manholes. Rain water reservoirs and overflow constructions. Intersection, inflow and outflow works. Sewerage pumping.

2.5 Hydraulics of open channels and rivers

Course Content

Uniform flow. Composite roughness. Uniform flow in compound channels. Hydraulics of Bridges and Culverts. Gradually varied flow in streams and rivers. Computations. Sediment Discharge in natural streams. Bed Load. Suspended Load. Bridge scour River training works. The code HEC-RAS (River Analysis System). Applications.

2.6 Hydropower engineering

Course Content

Dam Hydraulics: Diversion works. Design Discharge. Types and selection of hydro-turbines. Spillways. Dissipation Basins and other methods. Safety and Sustainability of Dams. Examples from National and International Dams.

2.7 Water resources management

Course Content

Introduction to the design and system analysis of water resources. Greek national and international legislation concerning water resources management. Water resources management under climate change conditions. Principles of sustainable water policy: Integrated water resources management. Demand Management. Transboundary river basin management. Techniques for the solution of linear and non-linear mathematical programming problems. Techniques for system analysis – adaptation and simulation of complex linear and non-linear problems. Applications of mathematical programming in the solution of water resources management problems and operation of hydraulic works. Applications from all the fields of hydraulics, such as design of pipe networks, operation of

dams, development of groundwater aquifers and others. Uncertainty analysis, estimation of the probability of failure and the cost of uncertainty. Uncertainty management and introduction to decision support systems.

2.8 Water and waste water treatment

Course Content

WATER TREATMENT: Water, a natural resource. The hydrological cycle. Ground water, surface water, seawater. Water consumption. Pollution - contamination of water. Protection measures. Water quality characteristics: Physical, chemical, biological. Legislation: Potable water, irrigation water, bathing water. Water treatment processes. Primary and advanced treatment processes for ground and surface water. Flocculation and coagulation, sedimentation, filtration, adsorption, disinfection. Storage and distribution of water.

WASTEWATER TREATMENT: Municipal wastewater treatment. Compact systems. SBR systems. Natural systems. Reuse of treated wastewater and sludge. Biogas. Industrial wastewater treatment.

3. Norwegian University of Life Sciences, Norway

3.1 Treatment of Water and Sewage: Basic course

Course content

Status, challenges in water resources, aquatic chemistry, water supply and wastewater treatment in Norway and globally; laws, regulations, emission permits, control authorities; reactor hydraulics and process kinetics; water consumption and water quality and analysis parameters; Groundwater - water quality challenges; treatment processes and applications: aeration, oxidation, Fe/Mn- removal; Surface water - water quality challenges and treatment processes : membrane filtration , adsorption, ion exchange, coagulation, flocculation, sedimentation, flotation, filtration, ozone and biofiltration; Hygiene threats , methods of monitoring and control, barriers , corrosion and corrosion control;

Wastewater - composition and quantities, specific contaminants. Hydraulic dimensioning of facilities, Design of wastewater facilities; Challenges and opportunities with wastewater;

Mechanical treatment processes, chemical treatment processes: coagulants, flocculation, separation; biological treatment processes. Aerobic/anaerobic and activated sludge and biofilm processes, nitrogen removal and biological phosphorus removal; chemical and biological treatment: process selection and combinations; Pollution from industries - challenges and opportunities; Sludge Treatment - unit processes. Sludge Regulations; Visits to treatment facilities.

3.2 On-Site Wastewater Treatment - Planning, Design and Impact Assessment

Course content

Introduction to on-site systems for treatment of wastewater, source separated grey- and blackwater, stormwater in cities. Describing treatment processes and effects of discharges to water recipients. Health aspects in relation to treatment of wastewater, transport and inactivation of paracites, bacteria and viruses treatment filters, soil and groundwater. Source separating wastewater systems in combination with urban agricuture and park areas. Introduction to quantitative health risk assessment.

3.3 Introduction to Sustainable Water and Sanitation (NMBU)

Course content

The course utilizes problem-based learning and a selection of real life cases that give insight and overview over sustainable water and sanitation situations and possible solutions. Students will be introduced to cases, and confronted with the complexity of water and sanitary challenges. How should we approach and evaluate the situation? What physical, technical, economic and social factors are important for our choice of technology? Who are the stakeholders and how should they be involved? How do we secure a sustainable management of the situation? Students will work with specific aspects of case situations. The cases will introduce students to different technical solutions to address water and sanitation challenges in different locations world-wide. For each case, a series of questions will be asked, which will require students to seek out, evaluate and apply appropriate knowledge to the given situation and justify chosen solutions. The cases and support material are

available on Canvas and an internet database. Important issues are supported by lectures and each case is followed up by an in-class discussion.

3.4 Water Engineering

Course contents

This course introduces methods and technologies for water resources engineering, including hydraulic models for rivers and canals as well as drinking water, stormwater and sewer networks: Repetition of pressurized flow, hydraulic modeling of water distribution networks (EPANET), open channel flow, water surface profile computations including computer models (HEC-RAS), basic unsteady open-channel flow, hydraulic models for sewer networks (SWMM), flood discharge calculations and frequency analysis, urban hydrology including precipitation, interception, depression storage and infiltration, simple rainfall-runoff models, hydrologic routing and computation of detention storage, evaluation of erosion risk in rivers and channels, design of channels, culvert hydraulics including computer models (HY-8), weir hydraulics, street and highway drainage. The compulsory assignments will provide the students with a solid introduction to the above-mentioned computer models.

3.5 Water Supply, Sewerage and Drainage

Course content

Plans and design of systems for water supply, drainage and wastewater. Precipitation and surface water, urban hydrology and flood estimations. Transport network for water supply and waste water with their components, water demand, discharge of wastewater, ground water for water supply and well drilling. Renewal and rehabilitation of transport network and protection against pollution of water sources.

3.6 Water Resources Management and Treatment Technologies

Course content

Lectures on: Water resources management, Water treatment Wastewater treatment, Monitoring and control of water quality and treatment processes, Working with literature databases, Project report/scientific writing. Hands on practice: lab analysis and process simulation software Excursions: to water and wastewater treatment plants

3.7 Design of Decentralized and Small-Scale Water, Sanitary and Stormwater Systems

Course content

Decentralized water and sanitary systems are highly appropriate in rural areas. In urban areas, such systems are increasingly interesting especially in connection to "green and smart" cities. Urban sustainable development and climate change has resulted in more focus on storm water handling using "blue-green" structures. Blue-green structures can be very cost efficient and give added value to urban life. Design of blue-green structures is based on the same fundamental principles as for natural systems for wastewater treatment.

This course explores the possibilities of using small-scale decentralized solutions for poor, but also for rich countries in rural and urban settings. Through lectures and field exercises the students will be trained in design and implementation of rain-water harvesting systems (collection, treatment and storage), fog water harvesting, design and protection of shallow wells and boreholes, design of spring sources, sizing of reservoirs, membrane filtration units, and small gravity water supply systems for rural areas. Wastewater treatment has major focus on design of natural systems (soil infiltration, wetlands and ponds) as well as source separating solutions. An introduction will be given to storm-water handling in blue-green structures and to design of small diameter vacuum, pressure and gravity sewers.

Small diameter vacuum, pressure and gravity sewers open new possibility for cost-efficient sewer transport in rural and urban settings, when the natural conditions are challenging, and thus complement traditional gravity sewers.

3.8 Design of Decentralized and Water and Sanitary Systems - Natural and Recycling Systems - Stormwater Treatment

Course content

Decentralized Water and Sanitary Systems are highly appropriate in rural areas. In urban areas such systems are increasingly interesting especially in connection to "green city" development. Storm water handling through" blue-green" structures is designed based on similar principles as natural systems for wastewater treatment. This course builds on THT383 and expands on the different issues of THT383. In addition, aspects of nutrient recycling to agriculture are covered and design of blue-green urban stormwater systems is given more emphasis than in THT383. The course expands the understanding of natural and recycling systems for wastewater handling. The students will work in teams solving real cases. The cases will be presented in seminars and supplemented with lectures. The main focus will be on groundwater protection and supply, and on natural systems (soil infiltration, wetlands and ponds), source separating systems for wastewater treatment as well as blue-green stormwater treatment. The course views technology in a systems perspective where green "circular" economy becomes increasingly important.

3.9 Water Resources and Water Supply

Course contents:

Lectures on the following topics: Water as a resource, protection of water resources, the influence of various types of pollution on the quality of the drinking water and methods for treating drinking water. The classification of environmental quality in freshwater and chemical and biological quality requirements for water to be used with emphasis on drinking water regulations will also be covered. In addition, evaluation of different water supply sources will be considered. Regulation and mangements regarding water supplies/water management including the water directive. Group work: 3-4 students cooperate on a relevant topic that is presented in plenary for all the students taking the course. Excursion: 5-6 hour excursion.

4. University of Natural Resources and Life Sciences, Vienna, Austria

4.1 Hydrology and water management I

Course content

Basic concepts of statistical methods in hydrology (fitting of distributions to empirical data, statistics of extreme values, comparison of samples)

Simple deterministic hydrological models (Unit hydrograph, retention)

Water management (utility of flood protection measures, cost-benefit analysis)

4.2 Practical course in hydrology and water management II

Course content

Statistics of hydrological variables and conceptual description of hydrological processes. Essential methods of analysis of hydro-meteorological data series are demonstrated. Their characteristic parameters and their relevance for design purposes are explained. Extreme values (storm events, floods, droughts) are given special attention. Statistical relationships between various hydrological variables are described by multivariate statistical methods, considering temporal and spatial scales. In addition to statistical methods conceptual and deterministic hydrological models are discussed, with a focus on rainfall-runoff models, flood routing methods, snow melt modeling and river basin models. The development from simple input-output models to detailed 3-D methods that account for processes on the surface and in the unsaturated and saturated subsurface is illustrated with some typical models. The impact of climate and vegetation is discussed.

4.3 Hydraulic engineering and river basin management

Course contents:

Legal and administrative basics. River basin management. Historical development in hydraulic engineering. River engineering, - restoration. Integrated flood risk management. Weirs. Hydropower. Navigation. Hydraulic engineering at lakes. Hydraulic Modelling

4.4 Planning and design of hydraulic structures (river engineering & small hydro power)

Course content

A project in the following fields is finished up to the licensing level:

- flood protection

- bank and river bed stabilization

- river restoration

- hydro power.

Measures have to be integrated in the environment and the landscape based on the main goals of the water framework directive and the fauna-flora-habitat directive.

4.5 Hydromechanics

Course content

Considerations on the continuum concept of fluid flow and the fundamental laws of hydromechanics. Hydraulic modelling and dimensional analysis. Open channel flow, steady state: basics taught in Hydraulics are extended, e.g. by including the influence of vegetation in flood plains. Open channel flow, unsteady state: the de Saint Venant equations are discussed and numerical approaches ranging from simple modelling concepts to implementation in more sophisticated modelling schemes are presented. Special topics of hydraulic structures (e.g. retention basin). Treatment of transient pipe flow using water-hammer theory.

5. University of Rijeka, Faculty of Civil Engineering (UNIRIFCE), Croatia

5.1 Water supply and drinking water treatment

Course content

Introduction: significance of water and problems of water supply. Water sources in nature. Protection areas. Water quality indicators. Water consumers, quality and quantity requirements. Catchment structures. Water supply systems: function and design. Water reservoirs and tanks: function, volume calculation, design and construction. Pumping stations: function, power calculation and pump choice. Water supply pipes, fittings and valves. Pipelines: hydraulic calculations and construction. Hydro static pressure testing. Distribution network: allowed pressures, supply zones, dimensioning, construction. Connections to building plumbing. Plumbing in buildings as a final part of water supply systems. Water supply in states of emergency. Drinking water treatments. Disinfection. Desalinization.

5.2 Hydraulic structures

Course content

- Definitions, goals and tasks of hydrotechnics.
- Water resoursces management: water use, water conservation, flood control. Planning. Legislation.
- Basics of hydrology (hydrologic cycle, hydrometeorology, characteristics of catchment areas, hydrometrics).
- Basics of hydraulics (hydromechanics, pressure flow, open channel flow, flow over spillways and under gates, hydraulic jump, underground flow).
- Basics of water supply systems (types of water supply systems, categories of water use, water sources and water catchment, pumping stations, water treatment, water reservoirs and tanks, water supply nets).
- Basics of sewage systems (types of sewage systems, types of wastewaters, sewerage nets, structures, wastewater treatment, disposal of wastewater).

5.3 Engineering hydrology

Course content

Processes in atmosphere and hydrologic appearances. Precipitations: analysis of time-spatial distribution of precipitations, variations of short termed intensive precipitations during the time, modeling of intensive precipitations, storms for project making. Infiltration of water into the soli. Processes of interrelations between precipitations and runoffs: linear and non-linear modeling of discharge processes. Analyzes of hydrograms.

Regional hydrologic analyzes. Hydrologic prognoses. Multiple function of distribution. Stochasti processes and time series. Stochastic analysis of extreme appearances. Spectral analyzes. Markow's processes. Generation of synthetic time series. Autoregression models. ARMA and ARIMA models. Multiple regression models. Regionalisation of stochastic properties of water appearances in water catchments.

5.4 Hydraulic regulations and ameliorations

Course content

The purpose, problems and tasks of water flow regulations. Morphology of river bed. Suspended and drawed sediment; sediment's function. Longitudinal and transversal constructions; dams. Regulation constructions. Regulation of water regime; accumulations, retentions; outlet chanels. Flood protection; legislation; technique. Construction materials for regulations. Erosion processes; division and clasification of torrents. Basics of catchment regulation; technical and biological measures. Phases of torrents regulations and torrent's constructions.

Relations plant-soil-water. Drainage systems. Detailed drainage systems. Planning of detailed systems of underground drainage. Construction of drainage systems. Irrigation. Quality and the origine of water for irrigation. Calculation of water demands for irrigation. Elements of irrigation systems. Motive power for irrigation. Methods of irrigation. Planning and designing of irrigation systems.

5.5 Water resources management

Course content

- Basic concepts of water management: history, integral approach, sustainable development.
- Water resources. Catchment area as basic unit for water resources management.
- Natural water resources characteristics: surface waters and underground waters, sea, transitional waters.
- Water demands. Water resources and demands balance.
- Water resources use, conserving water resources and flood protection.
- Types and characteristics of water management structures. Reservoirs as the most complex multipurpose structures. Man influence in changing water regime.
- Water's role in socio-economic systems. Ecological components of hydrotehnical solutions.
- Water resources management: basics, goals and objectives, criteria and measures, methodology of generating alternative water management solutions and decision making.
- Use of simulation and optimization methods in decision making. Information support.
- Water resources management modelling.
- Legislative regulations. Water management plans.

5.6 Water power development

Course content

Water energy and power. Basic principles in water power development. Power and energy needs, water power role. Types of hydroelectric plants. Field research from the water power use view. Hydroenergetic calculations and analysis of water flows. Power and energy calculations with changing heads and flows. Economic characteristics of hydropower plants. Environmental impact. Low, middle and high head power plants. Structures by hydropower plants. Water turbines: basic characteristics and application area. Other equipment of hydropower plants: generators, transformations, electrical equipment. Management and maintenance of hydropower plants. Examples of existing hydropower plants. Small hydropower plants. Using tides and waves energy.

6. Instituto Superior Técnico/University of Lisbon (IST/UL), Portugal

6.1 Fluvial Hydraulics and Rehabilitation

Course content

1) Review of hydraulic concepts - Basics on open channel flows. - Dimensional analysis. 2) Mechanics of sediment transport - Soil erosion and sediment yield. Physical properties of sediments. Beginning of sediment motion. Design of non-erodible loose-boundary channels. Bed forms. Resistance to flow. Sediment transport rate. 3) Rehabilitation of rivers - Regime channels. Rehabilitation of low land rivers. 4) Local scour at river foundations; countermeasures against local scour.

6.2 Groundwater Modelling

Course content

1) Numerical solution of the differential equation of flow in porous media. Conceptual model. Finite difference method. Spatial and temporal discretization. Network design Explicit and implicit methods. Initial condition and type of boundary conditions. Calibration. Method of trial and error. Inverse Problem. Zoning method and coefficients of influence. Algorithms. Forecast and analysis of results. Praxis with the software ASMWIN. 2) Resolution of the equation of recession. Operating modes of karstic systems. Calculation of ground water availability. 3) Geostatitical analysis of hydrogeological variables: Variography and Kriging. 4) Water Balance: Global and local analysis. 5) Time series analysis using non-parametric statistical methods (Mann-Kendall). techniques. 6) Presentation of case studies: Aveiro, Castelo de Vide, Leirosa - Monte Real, Moura - Ficalho, Tagus basin, Querença - Silves.

6.3 Groundwater Pollution and Protection

Course content

1) Hydrochemical evolution according to the model of Chebotarev. Hydrochemical facies. Graphical representations of Stiff and Piper. Water-rock interaction. Hydrogeochemical reactions (PHREEQC software.); 2) Types and sources of pollution. Diffuse pollution by nitrates. The nitrogen cycle in the unsaturated zone. Nitrification and denitrification processes. Pollutant transport in the saturated zone of the aquifer. Advection, molecular diffusion and hydrodynamic dispersion. Laws governing their propagation. Concept of dispersity and its relation to heterogeneity. Adsorption and absorption. Linear isotherms, Langmuir and Freundlich. Retardation factor and decay.; 3) The phenomenon of saltwater intrusion in coastal aquifers and islands. Analysis of the movement of the interface freshwater - saltwater. Analytical solutions Ghyben-Herzberg, Glover and Fetter. 4) Vulnerability of aquifers and pollution risk. Methods for assessment of intrinsic and specific vulnerability; 5) Delineation of wellhead protection perimeters by the analytical techniques of Hoffman Lillich and Wyssling; 6) Quality of groundwater in Portugal.; 7) Introduction to numerical modelling of pollutant transport in porous media; 8) The model ASMWIN - design and architecture, initial and boundary conditions, resolution by the method of finite differences and Ramdom-Walk. Path lines and isochrones; 9) Modelling praxis; 10) Delimitation wellhead protection perimeters by numerical modelling.

6.4 Hydraulics I

Course content

1) Properties of fluid and flow. 2) Hydrostatic pressure distribution and hydrostatic force; on immerged and floating bodies and on plane and on curved surfaces. 3) Hydrokinematics. 4) Hydrodynamics - the integral equations based on control volumes. The Reynolds Transport Theorem (mass, momentum and energy, conservation principles) - the differential equations of continuity, Cauchy and Navier-Stokes. Ideal flows and Euler equations. Irrotational (potential). Bernoulli Theorem. Pumps and turbines. 5) Dimensional analysis and similitude. 6) Uniform flow - Fluid shear stress in a solid boundary. Laminar and turbulent flows. Laws for turbulent flows. 7) Hydrodynamic forces on immersed bodies. 8) Internal (pressure) flow - Friction and minor head losses. Pumps in series and in parallel. Hydraulic pressurized systems. 9) Unsteady pressurized flow – water hammer

6.5 Hydraulics II

Course content

1) Turbomachinery - introduction and classification. The centrifugal pump: elementary pump theory. Pump performance curves and similarity rules. Mixed- and axial-flow pumps: the specific speed. Matching pumps to systems characteristics. Net Positive Suction Head. Choice of pumps. Turbines: reaction turbines; idealized radial turbine theory; the specific speed; impulse turbines. 2) Open-channel flow - uniform flow: shear stress distribution; velocity profiles; resistance to flow; stage-discharge curves for mixed and compound channels. Bernoulli theorem and specific energy. Total momentum. Froude Number and flow control. Backwater curves with constant and space variable discharge. Steady rapidly varied flows (including the hydraulic jump). Unsteady open-channel flows. 3) Orifices and weirs - orifices. Weirs. Hydraulic measures. 4) Open-channel flow on mobile bed - beginning of motion and stable mobile bed channels. Bed-forms and flow resistance. Sediment transport: bed load; suspended load.

6.6 Hydraulics and Maritime Works

Course content

1) Introduction. The sea - its importance in a global and economic context. The continental shelf. 2) General concepts. Physical properties of the sea water. The Coriolis force and the geostrophic wind. Geostrophic balance and wind. Introductory concepts in the general circulation of the atmosphere. 3) Currents. Oceanic and coastal currents. Surface boundary layer flow and the Ekman spiral. Storm surges. 4) Surface waves. Linear theory: fundamentals and main results. Tsunamis. 5) Nearshore processes. Refraction. Diffraction. Reflection. Wave breaking. 6) Wind-generated waves. Generation. Statistical and spectral characterization. 7) Tides. Brief notions of the static theory. Dynamical aspects. Anphidromic system. 8) Design wave. 9) Coastal protection works: groins, seawalls, detached breakwaters, beach nourishment, rubble-mound breakwaters. 10) Port terminals: general cargo, container terminals, RO-RO, solid and bulk terminals. 11) design of : quay walls, slipways, ship lifts. 12) Introduction to dredging.

6.7 Hydraulic Structures and Hydro Systems

Course content

1) Fluvial hydraulic works for water storage and diversion: basic concepts and purposes. 2) Dams: main types, constraints and general layout. 3) Hydraulic design of the appurtenant structures of dams: spillways, bottom outlets and intakes. 4) River diversion during construction: hydraulic design and interaction with the definitive hydraulic works. 5) Hydromechanical equipment most frequently installed in the dams hydraulic works: general concepts and applicability. 6) Hydroelectric schemes: basic concepts, main components, turbine selection and operation criteria. 7) Hydraulic transient analysis in pressurized pipes: main principles and surge protection solutions.

6.8 Hydrogeology

Course content

1) Groundwater and the hydrological cycle. Aquifers, aquitards and aquicludes. Groundwater flow in porous, karstic and fractured aquifers, Darcy's Law. Hydraulic conductivity and permeability. Piezometry and Hubbert analysis; Equivalence of heterogeneity and anisotropy in multilayer aquifers. Definition of REV. Transmissivity and storage coefficient. Leakage. Fundamental groundwater equation in steady and transient regimes. 2) The groundwater flow equation in radial coordinates. Dupuit hypothesis. Pumping tests and interpretation. Analytical models (Thiem, Theis; DeGlee, Hantush). Boundary effects and image analysis method. Recharge evaluation method; Groundwater resources and aquifer over-exploitation. Introduction to groundwater mathematical modelling (software ASMWIN). 3) A brief introduction to groundwater quality. Hydrochemical fácies. Types of topic and diffuse pollution. Aquifer vulnerability. 4) Hydrogeological unities and aquifer systems of Portugal. Dominant lithological types, hydraulic mechanisms and average groundwater resources. Main hydrochemical characteristics and water quality for human supply and irrigation purposes.

6.9 Hydrology and water resources

Course content

1) Water storages and fluxes over the Globe, the continents, the Iberia, and the Portugal. 2) Hydrologic cycle. 3) Rainfall runoff processes. 4) Watershed and hydrologic processes analysis. 5) Hydrologic budget. 6) Spatial and temporal evaluation and characterization of the precipitation, evapotranspiration, infiltration, and streamflow. 7) Measurement of hydrological variables. 8) Statistical methods applied to hydrology. 9) Return period and risk. 10) Analysis and characterization of hydrologic droughts. 11) Intense rainfall. 12) Flood flow analysis. Flood hydrographs. Design discharges. 13) Water resources development. 14) Design of artificial reservoirs.

6.10 Integrated River Basin Management

Course content

1) Water and civilization. 2) Water governance and integrated water resources management. Main principles, concepts and purposes of water management 3) Water availability, use and other pressures. 4) Water resources and territory planning. European water legal framework. Water bodies

delimitation and status evaluation. Combined approach. River basin plans. Monitoring. Verification. Economical and financial aspects. Public participation. International shared waters. 5) Mathematical models to support water management. 6) Operating policies for water resource systems. Reliability, vulnerability and resilience indicators. 7) Integrated watershed management. Modelling interactions between water, soil and land use. Biogeochemical cycles in soil and water. 8) Optimization models: linear and dynamic programming. Case studies in water management. 9) Multi-criteria analysis. The concepts of dominance and trade-off. Negotiation processes in water management.

6.11 Sanitary Engineering

Course content

1) Scope and aim: fundamental concepts, urban water cycle. 2) Water supply systems: historical review and fundamental concepts; source development, water intakes and water supply mains; pumping systems; storage tanks; water distribution networks. Simplified water supply systems appropriate to developing countries. 3) Wastewater systems: historical review and fundamental concepts; source, flowrates and wastewater characteristics; planning and design of wastewater systems; appurtenances and special structures (inverted siphons, overflows and pumping facilities); stormwater drainage in urban areas. 4) Introduction to water quality. General concepts related to water and wastewater treatment. Simplified systems of sanitation (sewerage and treatment) appropriate to developing countries.

6.12 Urban Drainage and Pollution Control

Course content

1) Natural water characteristics. Water and Health. Concepts of water biology. Constituents in Natural Waters. Water uses. Methods of evaluating and monitoring water quality. Types and causes of water quality problems. 2) Components of stormwater and combined sewer systems. General Planning and design. Source control. Real time control. Flows and pollutant loads. 3) Criteria for surface flow in urban areas. 4) Retention basins in combined systems. Options. Technical aspects. Design methods. Characteristics and design of inverted syphons and overflows. Characteristics and design of pumping installations. 5) Oxygen balance in streams. Modelling notions. Regulation and standards in water quality control. EEC legal framework. Water cycle use. Causes and types of water pollution. Technologies for Water quality control in water bodies. Outlets and diffusers.

6.13 Water Resources Modelling and Planning

Course content

1) Analysis of hyetograms and hydrographs. 2) Effective rainfall and rainfall abstractions. 3) Direct runoff and base flow. 4) Runoff recession curves. 5) Unit hydrograph models. 6) Rainfall-runoff models. 7) Flood routing models. 8) Complex systems of interconnected watersheds. 9) HEC-HMS and HEC-RAS models. 10) Criteria for water resources planning. 11) Criteria for the economic analysis applied to water resources systems. 12) Planning, sustainability and uncertainty. 13) Reservoir design. 14) Flood plain management. 15) Flood forecasting and warning.

6.14 Water and Wastewater Treatment Plants

Course content

I OVERVIEW SOURCES AND WATER USES 1) Urban water cycle. 2) Water quality characteristics. 3) Water source selection for drinking water production. 4) Others water uses (agriculture and industry). II LEGAL AND INSTITUTIONAL ASPECTS IN WATER INDUSTRY IV UNIT PROCESSES 1) Chemical precipitation. 2) Chemical oxidation. 3) Coagulation. 4) Sedimentation and flotation. 5) Filtration. 6) Adsorption. 7) Desinfection. 8) Membranes. III BIOLOGICAL PROCESSES 1) Bacterial growth models and kinetics. 2) Aerobic suspended growth reactors. 3) Aerobic attached growth reactors. 4) Anaerobic reactors. IV DESIGN OF WATER AND WASTEWATER TREATMENT PLANTS 1) Design criteria. Plant capacity. Raw water quality. Water quality standards. Wastewater characterization. Final disposal. 2) Treatment process selection. 3) Process design criteria. 4) Hydraulic design. 5) Process instrumentation, automation and control. 6) Other areas: Electric systems. Structural and architectural design. V DESIGN AND CONSTRUCTION 1) Design and construction phases. Contracting approaches and types of bidding. Technical assistance.

7. University of Architecture, Civil Engineering and Geodesy, Bulgaria

7.1 Engineering Hydrology

Course content

Hydrology and Engineering Hydrology. Hydrologic cycle. Water resources and water balance of the World, Europe and Bulgaria. Rivers and watersheds - characteristics. Hydrographic characteristics. Longitudinal profile, cross section and river bed in plan in upper, middle and lower river course. Factors affecting the river runoff. Rainfalls. Intensive rainfalls. Air, soil and water temperature. Evapotranspiration. Atmospheric pressure. Vapour pressure deficit. Infiltration. Hydrometric station. Methods for runoff measurement. Rating curves. Statistical methods in hydrology. Return period and probability of occurrence. Distribution curves. Cumulative probability and Cumulative probability curves. Check of statistical hypotheses. Linear regression and multiple linear regression. Non-linear regression. River runoff – annual, monthly, distribution within the year. Rainfall-runoff relationship. Maximal runoff. Flood hydrograph. Volume and maximal discharge of the high waters. Minimal runoff. Stream load – regime, types of, devices for measurement. Topographic curves of a reservoir. Retention of a high waters by a reservoir.

7.2 Hydraulics

Course content

1) Hydrostatic pressure on flat, curves and cylindrical surfaces. Hydrostatic force in pipes. 2) Principles of buoyancy. Archimedes' law. Stability of immersed and floating bodies. 3) Bernoulli's equation for an entire steady/unsteady flow of a viscous fluid. Mechanical characteristics of the fluid flow. Laminar and turbulent flow. Reinolds number. 4) Flow regime and head losses. Hydraulic resistance and head losses. Basic equation of the uniform flow. Local (minor) head losses. 5) Steady flow in pressure pipelines (closed conduits). Basic relationships for a simple pipeline. Hydraulic calculation of simple systems. 6) Steady gradually varied open channel flow. Natural and artificial type of channels. Differential equation of a steady free surface flow. 7) Specific energy. Critical depth. Critical slope. Subcritical, critical and supercritical flows. 8) Uniform flow. Bed sustainability – permissible (nonerodable) velocities, sediment transport. Geometric and hydraulic parameters of the flow. Best hydraulic section. Basic problems. 9) Nonuniform steady flow in prismatic and nonprismatic channels. Types of nonuniform flows. Classification of surface profiles. 10) Discharge through small and large orifices. Discharge through nozzles. Discharge through control gates. Free and submerged underflow. 11) Weirs. Terminology. Classification. Sharp-crested (thin-plate) weirs (rectangular and "vee" weirs). Submerged weirs. Broad crested (free flow/submerged flow) weirs. Spillways. Gravity (Ogee) spillway. 12) Hydraulic jump. Thrust function. Equation for rectangular cross section. 13) Forms of conjugation of the surface profiles downstream of a dam. Energy dissipation. Stilling devices. 14) Groundwater flow. General considerations. Terminology. Darsy law. Dupuit formula. Uniform flow. 15) Well hydraulics. Unconfined steady flow (ordinary and recharging wells).

7.3 Water and Wastewater Treatment

Course content

Water treatment – Quality indicators of natural waters. Physical, chemical and bacteriological indicators. Drinking water quality requirements. Processes of coagulation and flocculation of water. Storage and preparation facilities for coagulants and flocculants, and lime. Mixers – types of, selection, sizing. Flocculation chambers. Water sedimentation. Sludge blanket clarification. Filtration. Rapid sand filters, slow sand filters and specific types of filters. Water disinfection by chlorine reagents, ozone and UV. Technological schemes for portable water treatment.

Wastewater treatment. Types of sewerage systems and their impact on wastewater treatment plants, Wastewater composition – physical characteristics, inorganic non-metallic, metallic and radioactive substances, biological characteristics and organic matter. Pollutant load at wastewater treatment plant input. Mechanical treatment. Primary treatment – primary clarifiers and alternatives. Basics of biological treatment – reactors with suspended and attached biomass. Biological removal of Nitrogen. Biological and chemical removal of Phosphorus. Secondary clarifiers. Membrane technologies and membrane bioreactors. Decontamination of wastewater. Odour control. Sludge types and methods for their treatment. Extensive methods for biological treatment. Wetlands, ponds. Wastewater treatment for individual and decentralized sewers.

7.4 Hydraulic Systems and Structures

Course content

Classification of hydraulic structures and systems. Basics of river morphology - water and stream load regimes, river bed erosion, non-scouring velocity, critical velocity, sediment transport capacity of flow, transverse circulation in curves; riverbed formation. Basics of river trainings – purpose, design discharges, cross section, layout plan, vertical disposition of river bed (longitudinal profile). Specifics of river trainings in rural and urban areas. Structures of river trainings – groins, falls, thresholds. Materials used for river trainings.

Dams and reservoirs– main elements and parameters. Topographic curves and specific storages of the reservoirs. Concrete dams – gravity, buttress and arch dams. Embankment dams – earth-fill, rock-fill and combined dams. Appurtenant structures – bottom outlets and spillways. Energy dissipators. Water intake structures of dams. Diversion dams (headworks) in rivers.

Hydropower systems. General information on national electric grid and sources of electric energy. Structure and elements of hydropower systems. Typology and classification. Types of Hydro electric power plants. Main and auxiliary equipment. Types of turbines. Performance curves and performance charts of turbines. Design parameters of hydro electric power plants and turbines. Selection of turbines. Delivery canals and regulating reservoirs. Penstock construction. Surge tanks. Other structures.

7.5 Irrigation and Drainage Systems and Structures

Course content

Necessity of irrigation and field drainage. Soil moisture and water contents of the soil. Soil water movement – infiltration (percolation) and filtration. Types of superfluous waters. Protection from external surface waters via levees and protection canals (cutslope ditches). Protection from external groundwaters. Surface field drainage for superfluous surface waters. Subsurface field drainage (tile drainage) for excess groundwaters – structure and elements of the drainage system. Main parameters of field drainage. Determination of distance between drains – Hooghoudt equation, Ernst equations. Drainage canals – collector drains and main drain. Typical structures of a drainage system.

Water balance equation of the soil and determination of its constituents. Irrigation dose and irrigation requirement. Water Duty. Structure and elements of an irrigation scheme. Typology and classification of irrigation schemes. Efficiencies. Performance indicators. Water distribution principles. Surface irrigation. Sprinkler irrigation. Drip irrigation. Conveyance and distribution network – types of irrigation canals. Structures of irrigation schemes. Pumping stations. Types of pumping stations. Main and auxiliary equipment. Types of pumps. Performance curves of pumps. Design parameters of pumping stations and pumps. Selection of pumps. Pipe sizing and head loss estimation. Operation of pumps in parallel and in series. Methods for regulation of pump discharge.

7.6 Water Supply Systems and Structures

Course content

Water supply systems and schemes- general information. Water requirements and water consumption. Water intake from surface water bodies. Water abstraction from groundwater bodies - tube and shaft wells, horizontal intake drains and galleries. Water intakes from springs. Protection of natural water sources from pollution and depletion. Water mains. Water supply networks –types, operating pressure requirements, network zoning. Pipe sizing and head loss estimation for branched and looped distribution networks. Pressure regulating structures – tanks, air vessels, water towers and columns. Network construction – types of pipes, fittings and valves. Shafts and manholes. Specifics of industrial water supply – schemes, requirements, recycling, cooling.

7.7 Sewerage Networks and Facilities

Course content

Wastewaters – basic characteristics. Sewerage systems – types of, general schemes and their elements. Design of sewerage networks – pipe materials and types, design flow rates. Assessment of sewerage network functionality frequency, duration, intensity and return period. Loss of rain water. Runoff coefficient. Modeling of rainfall-runoff relation -Linear hydrographs, Constant intensity and delayed runoff methods, Rational method. Physically based methods for hydrographs – Time-area method, conceptual methods, Unit hydrograph method. Reservoir method. Nash cascade of linear reservoirs. Types of flows in sewer pipes, hydraulic resistance and head losses. Saint-Venant equations and their approximations. Hydraulic sizing of pipes, minimal velocities. Manholes and drop shafts – types and design. Combined sewer overflows and dividing structures. Reservoirs. Inverted siphons. Construction and maintenance issues of sewer networks. Rehabilitation.

7.8 Water Resources Planning

Course content

Water resources, water sector and water use of Bulgaria. Runoff regulation. Types of runoff regulation. Parameters of water use. Runoff parameters. Water balance equation of a reservoir and ways for its solving. Optimization tasks in water resources planning. Possibilities for optimization of normative water consumption. Objective function, economic rationale and criteria. Water resources planning in case of an annual runoff regulation using the chronological balance method. Water resources planning in case of multi-annual runoff regulation using the chronological balance method. Water resources planning for more than one water user in case of multi-annual runoff regulation using the chronological balance method. Mathematical support of water resources planning studies. Probability theory and mathematical statistics - basic concepts and laws. Water resources planning in case of an annual runoff regulation using the statistical balance method. Water resources planning in case of multi-annual runoff regulation for the needs of a single user using the statistical balance method. Water resources planning in case of multi-annual runoff regulation for the needs of more than one user using the statistical balance method.

7.9 Coastal Engineering

Course content

Hydraulic processes in seashore. Terminology and definitions. Ocean wind generated waves – generation, development and attenuation. Probability characteristics of waves. Amplitude and energy spectra, including one-dimensional and directional spectra. Linear water wave theory. Wave classification in accordance with the relative water depth. Wave speed and pressure, trajectory of water particles according to Linear theory. Standing waves. Wave energy, energy flow and group velocity. Finite amplitude waves and long waves. Formation of deep-water waves and their transformation by shoaling, refraction and diffraction. Mechanics of waves and currents in the coastal zone: wave breaking, surf zone dynamics, cross and long-shore currents. Interaction of waves with vertical and horizontal cylindrical bodies. Interaction with vertical and inclined seawalls. Lithodynamic processes in the coastal zone - transverse and longitudinal displacement of marine deposits, methods for determining the transport of deposits.

7.10 Water Resources Management

Course content

Introduction. Water engineering infrastructure in Bulgaria – development and current status. Main definitions and tasks of water resources management. Water users and water consumption. Water budget. Institutional and legislative base of water resources management - Bulgarian Water Act, Water Framework Directive, Flood directive and other EU directives. Water operators and management and control institutions. General schemes for water use of river basins in Bulgaria. Water resources assessment. Water requirements and consumption. River basin management plans – aim, contents and development. Flood Risk Management Plans – aim, contents and development. Prognoses, tendencies and scenarios for development of water use under climate change. Sustainable

development of water resources. Environment impact assessment and ecological assessment. Public discussions for water resources development. Aarhus convention. Public access to information. Water use analyses – stages. Objective function and constraints. Optimization tasks. Linear programming. Dynamic programming. Data mining. Artificial neural networks, genetic algorithms and evolution programmes. Imitation approach – SYMIL model (programme).

7.11 Hydroinformatics

Course content

Hydroinformatics – historical development. Main definitions, tasks and available software. Data mining. Data – concept for an object and an attribute. sample, independent and dependent variable. Types of relations. Decision tree – elements, composition and algorithms for its creation. Artificial neural networks – model of an artificial neuron, main types of models, training methods. Genetic algorithms and evolution programmes. Numerical methods for solving of hydraulic tasks. Solving of non-linear equations. Methods of division by two. Newton-Raphson algorithm. Numerical integration of an ordinary differential equation. Euler-Cauchy method. Runge-Cutta method. Numerical integration of a partial differential equation. Characteristics method for solving of a system of partial differential equations. HEC-RAS – hydraulics basics, input of a geometrical information, boundary conditions, flow rate information, visualization of results. Geographical information systems (GIS). GIS components. Properties, categories and primitives of information. Topology. Graphic data. Plane modelling. databases. HEC-GeoRAS – basic concepts, input and processing of graphic and attributive data.

7.12 Water Distribution Modeling

Course content

Water distribution – essence and tasks. Basic approaches for water distribution – properties and applicability. Basic methodologies for water distribution – advantages and disadvantages. Main criteria for water distribution – applicability and effectiveness assessment. Main assessment parameters for water use. Strategies for withdrawal management of a reservoir.