COURSES DESCRIPTION

Winter Semester

1 FLUID MECHANICS OF HYDRAULIC STRUCTURES

Teacher: Angelidis P. Professor

This course will cover the following topics:

1. Hydrostatics - applications
2. Forces practiced on dams
3. Applications to forces exercised in dams
4. Cavitation Effect - Barbed Superflow Ventilators
5. Inflatable Dams
6. Bernoulli theorems - applications to flow problems
7. Bernoulli theorems - applications in non-permanent flow problems
8. Energy line, hydraulic gradient line, applications in water transport projects with closed conductors
9. Water turbines
10. Small hydroelectric projects
11. Dynamic and static stress from turbulent flow.
12. Turbulent flow, Reynolds equations
13. Turbulence models. Boundary layer

Once the course is completed, participant will be able to:

- To possess knowledge for the design and dimensioning of dams and inflatable dams
- To understand the dynamic and static stress from turbulent flow
- To apply the Bernoulli theorem for the design of various hydraulic works
- To analyze and calculate hydrostatic and other forces, exerted in various hydraulic works
- To combine and synthesize the knowledge he acquired, to deal with the phenomenon of cavitation in overflow and closed ducts
- Assess - in the context of the energy crisis - and plan small hydroelectric projects

Teaching Mode: 3 hours suggestion-exercises / week

2 ADVANCED ENGINEERING HYDROLOGY – FLOOD DEFENSE PROJECTS

Teachers:		
	Tsoukalas I.	Assis. Professor
	Maris F.	Professor
	Nikolopoulos D.	PhD in Civil Engineering
	Lalikidou S.	PhD Candidate

The course covers the following topics:

1. Rain-drainage models: model Lutz, model Soil Conservation Service
2. Rainfall and drainage models: black-box and physical models based on the unit hydrogram
3. Empirical and semi-empirical methods of calculating potential and actual vaporization as rain loss
4. Hydrological methods of flood passage through a reservoir
5. Hydrological methods for transiting flood through river section (Muskingum)
6. Flood prevention projects: flood prevention and traffic,
7. Flood protection projects in the mountainous part of a watercourse basin
8. Drought indicators
9. Frequency analysis of maximum or minimum values of rainfall heights and water supplies
10. Time series analysis
11. Numerical examples
12. HEC-HMS Hydrological Software
13. Subject (work at home) for the implementation of Sections 1, 3, 4 and 6

Upon completion of the course the student is able to:

- To possess the knowledge for the calculation of the water supply due to rainfall at the outlet of a catchment area.
- To possess the knowledge for the calculation of potential and actual vaporization as a category of rain losses.
- Apply his knowledge to the passage of a flood wave through a reservoir or through a section of a river.
- To combine his knowledge to design and dimensionalize flood containment and transit projects, as well as projects in the mountainous part of a watercourse basin.
- Assess whether there is extensive drought in a water catchment area.
- Evaluate the incidence of maximum or minimum values of rainfall heights and water supplies.
- To understand the extension of time in an artificial way of an existing time series of measured water supplies.
- Implement and understand HEC-HMS hydrological software.
- To combine his knowledge in order to be able to carry out hydrological studies in practice.

Teaching Mode: 3 hours suggestion-exercises / week

3 APPLICATIONS OF COASTAL ENGINEERING, COASTAL AND HARBOUR WORKS

Teachers:	Samaras A.	Assoc.Professor
	Rovithis E.	Asst. Professor

The course covers the following topics:

1. Specific issues of wind wave prediction/prediction and wave mechanics.
2. Specific issues of maritime traffic and level variations.
3. Specific issues of coastal stereotransfer and morphodynamic coastlines.
4. Specific issues relating to the planning of coastal and port projects I (advanced cargo calculation techniques, possible planning).
5. Specific issues relating to the planning of coastal and port projects II (technical and economic calculation of projects, vulnerability and reactance concepts).
6. Specific design issues for different types of ports I (commercial ports).
7. Specific design issues for different types of ports II (fishing ports).
8. Specific design issues for different types of ports III (comfort ports).
9. Coastal Zone Management and River Basin Systems - Coast (WACS).
10. Project design in the light of climate change (natural stress scenarios, technical-economic analysis, redesign and upgrading of projects).
11. Development of I-industrial studies (legislation, standards).
12. Preparation of Coastal Studies II (contents, Convoys PCE).
13. Personalized Work Semester: Presentation, Assignment, Elaboration with interactive teaching (solving queries and class corrections).

Once the course is completed, participants will be able to:

- Understand specific issues of wind wave forecasting/prediction, wave mechanics, marine traffic and level variations, coastal stereotransfer and coastal morphodynamics.
- They understand specific planning issues for coastal and port projects.
- They understand specific design issues for different types of ports.
- Understand coastal zone management practices and Basin-Coast Systems (WACS).
- They understand project design practices in the light of climate change.
- They understand the methodology of carrying out industrial studies (legislation, specifications, contents, UNHCR sessions).
- They combine and apply the knowledge they acquired for the design and study of port and coastal projects, examining them from a technical and economic point of view.

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Teaching Mode: 3 hours suggestion-exercises / week

4 WATER RESOURCES MANAGEMENT AND AQUATIC SYSTEMS RESTORATION

Teachers:	Akratos C.	Professor
	Kagalou I.	Professor
	Spiliotis M.	Associate Professor

The course covers the following topics:

1. Physical-chemical-biological processes in aquatic ecosystems
2. River basin management
3. Analysis of pressure in the catchment area/ uses and assessment
4. Indicators of the qualitative situation - Framework Directive 2000/60
5. Groundwater and the environment
6. Brackling of groundwater
7. Artificial groundwater enrichment
8. Water scarcity and water scarcity indicators, distinguishing between water scarcity and causes
9. Water demand.
10. Surface water potential of a water catchment area
11. Projects for the development of surface water resources
12. Comprehensive EDP with multiple criteria and choice of weights

Once the course is completed, participants will be able to:

- Knowledge of river basin management plans
- Understand water basin uses/pressures
- Apply quality assessment indicators
- Know technical and alternative rehabilitation methods
- Be aware of the principles of green infrastructure and nature-based solutions.
- Be aware of groundwater management issues
- Be familiar with techniques for treating groundwater brining
- Water scarcity and water scarcity indicators, distinguishing between water scarcity and causes
- Apply basic principles to the determination of water demand.
- Be able to estimate the surface water potential of a water catchment area and design a reservoir (from a hydrological point of view)
- Optimize the EDP
- Make complete EDP with multiple criteria and choice of weights, distance methods, entropy method and AHP for determining weights

Teaching Mode: 3 hours suggestion-exercises / week

5 NUMERICAL METHODS IN FLUID MECHANICS

Teachers: Makris Ch. Asst. Professor

This course will cover the following topics:

1. Finite Volumes I Method: Introduction and Spatial Differentiation (Computation Network Information and Variable Distribution),
2. Finite Volumes II method: Gauss theorem and calculation of flow quantities through the surfaces of computational cells.
3. Finite Volumes III method: Interpolation schemes, temporal differentiation and linear system solving.
4. OpenFOAM I Open Source Computational Engineering Software: General introduction to the structure, installation and basic use of the software.
5. OpenFOAM II Open Source Computational Fluid Engineering Software: Computational geometry design, creation and modification of computational networks.
6. OpenFOAM III Open Source Computational Fluid Engineering Software: Linear solvers, pressure-speed coupling, spatial and temporal discretization schemes.
7. OpenFOAM IV Open Source Computational Fluid Engineering Software: Simulations of permanent and non-permanent flows, introduction of initial and boundary conditions, running simulations with parallel processing.
8. OpenFOAM V Open Source Computational Fluid Engineering Software: Data processing during calculations, initialization and modification of resolution fields
9. OpenFOAM VI Open Source Computational Fluid Engineering Software: Data transformation, development of complex boundary and initial conditions,
10. OpenFOAM VII Open Source Computational Fluid Engineering Software: Qualitative and quantitative processing of resolution results.
11. Applications in the simulation of complex flows I: Turbulent flows and free surface flows.
12. Applications in the simulation of complex flows (I: Multiphase flows, particulate flows and diffusion flows).
13. Personalized Work Semester: Presentation, Assignment, Elaboration with interactive teaching (solving queries and class corrections).

After the section is completed, the participants are able to:

- They understand the basics of numerical analysis.
- They understand the basic equations of hydraulic and their methods of numerical solution.
- They understand the mathematical description and analysis of fluid mechanics problems.
- Analyze, understand and modify computational codes.
- Evaluate the correctness of numerical results and decide alternative strategies for resolution.
- They use programming tools for different applications (Civil Engineering problem solving, management, analysis and graphical data representation).

Teaching Mode: 3 Hours Suggestion-Workshop / Week

6 SPECIAL TOPICS IN RESEARCH AND MANAGEMENT OF GROUNDWATER AND GEOTHERMAL ENERGY

Teachers:	Pliakas F.-K.,	Emeritus Professor
	Siarkos I,	Asst. Professor
	Kazakis N.,	Asst. Professor

The course includes the following sections:

1. Elements of Hydrology, Groundwater Plumbing and Applied Hydrogeology
2. Marine penetration in coastal underground water bodies - 1 (hydraulic and hydrochemical elements, modern response trends and management parameters)
3. Marine penetration in coastal underground water systems - 2 (international and Greek experience) - Exercises
4. Management of groundwater enrichment - 1 (natural groundwater enrichment and climate change, methods, selection criteria, design and operation of artificial groundwater enrichment projects)
5. Management of groundwater enrichment - 2 (hydraulic, hydrogeological, technical and managerial elements of modern approaches, scientific activities)
6. Management of groundwater enrichment - 3 (surveys and applications in the international field and in Greece) - Exercises
7. Simulation of groundwater and computational codes - 1 (hydrogeological dummy, classification of simulation models of groundwater)
8. Simulation of groundwater and computational codes - 2 (computational codes, general principles of evaluation of simulation models of groundwater, cases of application in Greek space) - Exercises
9. Geothermal systems - Geothermal fields
10. Geothermal field survey methods
11. Geothermal Energy Applications: Direct Uses
12. Geothermal Energy Applications: Electricity Generation - Shallow Geothermal Energy
13. Problems: Environment - Economy - Management

After completing the course, the participants are able to:

· Identify hydraulic characteristics, elements and properties of groundwater bodies
· Combine, compose and adapt data, data and results of hydrological and hydraulic surveys and studies of groundwater
· Compare, assess the options for implementing actions and decide on the design and construction of technical projects, relating to the development and management of groundwater bodies, in particular: (i) the management of groundwater enrichment, (ii) the exploration and treatment of marine intrusion in coastal aquifers.
· To select and apply appropriate computational codes in the context of the simulation of groundwater.
· To analyze and evaluate data, data and research results related to the utilization of geothermal energy and to solve problems of use and exploitation of geothermal energy in relation to the various relevant energy needs and environment.

Teaching Mode: 3 hours suggestion-exercises / week

Spring Semester

7 SANITARY ENGINEERING AND SPECIAL TOPICS IN WASTEWATER TREATMENT

Teachers:	Akratos C.	Professor
	Kagalou I.	Professor
	Stavrakakis I.	PhD in Environmental Engineering

The course includes the following sections:

1. Concepts and Themes of Health Engineering (Contamination, Pathogenicity, Epidemiology Data, Waterborne Infections).
2. Waste water treatment methods.
3. Design/dimensioning conventional treatment plants with suspended biomass methods such as activated sludge, plants with attached biomass methods as well as natural wastewater treatment systems such as artificial wetlands and stabilization lakes.
4. Learning of waste water treatment plant design software Aqua Designer 8.1. and the budget calculation software of CAPDET processing units.
5. Modern trends in advanced wastewater and industrial wastewater treatment as well as sludge management.
6. Analytical biological adhesive and suspended growth processes for the removal of nutrient salts and micro-pollutants are presented, the modern trends in the treatment of liquid waste (MB R reactors, MBBR).
7. There are differences in methods of treatment of industrial and agro-industrial waste (anaerobic treatment, biological filters, membranes, natural treatment systems).
8. Modern methods for sludge treatment are presented (anaerobic digestion, energy utilization, nitrogen and phosphorus recovery from sludge).

After successful completion of the course the student is able to:

- Recognize the subject of Health Engineering.
- Apply mathematical water quality models.
- Analyze physico-chemical and biological/microbial indicator data.
- To combine and synthesize the acquired knowledge to protect aquatic systems and to respond to health crises
- To evaluate the health status of water bodies.
- To study, design, build, sewage treatment plants
- Know new techniques for urban and industrial waste water treatment

Teaching Mode: 3 hours suggestion-exercises / week

8 NUMERICAL MODELLING OF PROCESSES IN THE MARINE / COASTAL ENVIRONMENT AND IN WATERSHED-COAST SYSTEMS

Teachers:	Samaras A.	Assoc. Professor
	Makris Ch.	Asst. Professor

The course includes the following sections:

1. Process description equations in marine and coastal environment.
2. Numerical resolution methods and techniques.
3. Computational dummy structure.
4. Processing and analyzing field data and computational dummy input/output data.
5. Computational Dummy Applications I: Wind/Wave Circulation;
6. Computational dummy applications I: Ripple propagation
7. Computational dummy applications III: Estimating stereotransfer and morphodynamic changes.
8. IV Computational Dummy Applications: Project Interaction - Coastal Environment.
9. V modeling applications: Diffusion of oil pollution.
10. Holistic approach to simulation of Basin - Coast Systems (WACS) I: Methodology.
11. Holistic approach to simulation of Basin - Coast Systems (WACS) II: Tools.
12. Holistic approach to simulation of Basin - Coast Systems (WACS) III: Applications.
13. Personalized Work Semester: Presentation, Assignment, Elaboration with interactive teaching (solving queries and class corrections).

After completing the course, the participants are able to:

- They understand the process description equations in marine and coastal environments.
- They understand numerical resolution methods and techniques.
- They understand the structure of computational models.
- Understand the techniques of processing and analyzing field data and computational dummy input/output data.
- They understand the techniques of applying computer models.
- They understand the principles of a holistic approach to simulation of Basin-Coast Systems (WACS), with an emphasis on estuary systems and the coastal environment.
- They combine and apply the knowledge gained for the development and application of computational models to the above.

Teaching Mode: 3 Hours Suggestion-Workshop / Week

9 SEDIMENT TRANSPORT AND MOUNTAIN HYDRODISTRIBUTION WORKS

Teachers:	Chrysanthou V.,	Emeritus Professor
	Maris F.,	Professor
	Avgeris L.	PhD in Civil Engineering

The course covers the following topics:
1. Introduction. Physical properties of water
2. Flow characteristics
3. Fertile material properties. Sedimentation rate
4. Start moving fertile materials
5. Bed formations
6. Transportation of cargo bed. Transportation of cargo of suspended materials
7. Transport of total cargo
8. Localized erosion
9. Fertile transport models
10. Mountain hydronomy projects: Effect of fertile materials
11. Numerical examples
12. HEC-RAS Hydraulic Software
13. Topic (working at home) on the implementation of HEC-RAS

After successful completion of the course the student is able to:
- To apply basic knowledge of Hydraulics in the phenomenon of the transfer of fertile materials in watercourses and rivers.
- Evaluate grain curves.
- To possess the knowledge for the calculation of the sedimentation rate of suspended ferrals, critical flow rate and critical trolling voltage on the riverbed.
- To understand the effect of bed formations on the water flow and the transport of fertile materials on a river bed.
- To apply the appropriate equations for the calculation of load carrying bed and total load.
- Apply diffusion theory to the calculation of the transport of suspended ferments.
- Analyze the factors affecting local corrosion effect on bridge pedestals, downstream of barriers and open duct strictures, so as to be able to estimate the maximum depth of local corrosion.
- To apply the relationships between horizontal lengths, flow depths, ferryl densities and ferryl grains diameters to the physical models of the laboratory.
- To combine knowledge to design and dimensionalize a sedimentation tank.
- Evaluate the impact of fertile materials on mountain water projects.
- To implement the HEC-RAS hydraulic software with slide transfer.

Teaching Mode: 3 hours suggestion-exercises / week

10 HYBRID MODELS (STATISTICAL AND FUZZY) IN HYDRAULIC ENGINEERING

Teachers:	Spiliotis M.	Assoc. Professor
	Papadopoulos B.	Emeritus Professor
	Papadopoulos C.	PhD in Civil Engineering
	Bakas T.	PhD Candidate

The course covers the following topics:

1. Fuzzy logic and sets
2. A-sections
3. Compound incision and complement
4. Unclear numbers and extension of the rule
5. Comparison of fuzzy logic and statistics-fuzzy estimators
6. Max-min composition, vague logic
7. Intelligent systems with fuzzy logic
8. Fuzzy optimization
9. Fuzzy Multicriterion Analysis
10. Applications in Hydrology
11. Applications in the EDP
12. Applications in the EDP
13. Applications in the EDP

After successful completion of the course the student is able to:

- He distinguishes classical logic from fuzzy logic
- Elementary mathematical documentation of fuzzy logic
- To distinguish in which cases the ambiguous approach contributes to the problem and in which cases the classical approach or a hybrid approach is preferred
- Be able to apply intelligent systems to hydrology
- Be able to apply unclear systems to EDP decision-making

Teaching Mode: 3 Hours Suggestion-Workshop / Week

11 HYDROGEOINFORMATICS

Teachers:	Maris F.,	Professor
	Iliadis L.,	Professor
	Papaioannou C.,	Asst.Professor
	Papaleonidas A.,	E.D.I.P., PhD in Informatics

The course covers the following topics:

1. Introductory Concepts of Water Resource Management.
2. Water management software and systems.
3. Geospatial data for hydrology, spatial detail and map scale, coordinate reference systems (datum), data representation, metadata, digital terrain model.
4. Format hydrological data, check homogeneity, fill in, and extend data time series.
5. Surface formation, geospatial data production from point measurements, surface creation methods. Spatial variability.
6. Modeling of evaporation. Modeling of filtration. Hydraulic roughness and hydraulic drainage.
7. modeling hydrological processes.
8. Modeling of the unit hydrograph.
9. Development of reliable NON-linear estimation models of dependent hydrological variables
10. Development of N-dimensional non-linear ranking models (N dimensional classification) in water resource management using Computer Intelligence-Machine Learning
11. Artificial Neural Networks (NTN)
12. Support Vector Machines (MDY)
13. Fuzzy Logic (AL).

Software: Torrential-MIK, Esri ArcGis, Arc Hydro, Hec-Hms, Hec-Ras, Iric, Telemac, Erdas Imagine, Trimple eCognition, MATLAB 2016, WEKA (free open source), Neuralworks Professional II PLUS.

After successful completion of the course the participants are able to:

- Generate the primary input data of the models using Geographic Information Systems and remote sensing techniques.
- Model hydrological processes.
- To shape and solve water resource problems as optimization problems.
- Create and optimize water resource models that will act as decision support systems.
- Be able to develop non-linear models for estimating dependent hydrological variables.
- Assess the suitability for use of Computational Intelligence-Machine Learning techniques
- Propose and implement appropriate decision-making tools related to water problems.

Teaching Mode: 3 Hours Suggestion-Workshop / Week

12 WATER RESOURCES PROTECTION AND NATURAL DISASTER PREVENTION METHODS

Teachers:	Kazakis N.,	Asst. Professor
	Siarkos I.,	Asst. Professor
	Asteriou P.,	Asst. Professor

The course covers the following topics:

1. Water Resources: Pollution and protection, vulnerability and risk of groundwater systems to external pollution – Natural Hazards and Disasters: Key concepts and definitions, natural disaster management, system vulnerability to natural hazards and risk assessment.
2. Analysis of the concepts of vulnerability, risk, hazard, susceptibility, and exposure.
3. Methods for assessing vulnerability in granular/porous aquifers.
4. Methods for assessing vulnerability in fractured aquifers.
5. Methods for assessing vulnerability in karst aquifers.
6. Floods and the geophysical environment, methods of flood risk assessment.
7. Causes and impacts of floods – Projects, actions, and preventive and preparedness measures for addressing flood events.
8. Drought – Part 1: Basic concepts and definitions – Recent global events – Types, causes, characteristics, and impacts of drought.
9. Drought – Part 2: Quantification of drought – SPI Index – Use of software for SPI calculation.
10. Drought – Part 3: Drought risk assessment.
11. Geohazards – Part 1: Main types, causes, and impacts.
12. Geohazards – Part 2: Mitigation and protection measures.
13. Geohazards – Part 3: Hazard assessment methods.

At the end of the course the students will be able:

• To understand the concepts of groundwater vulnerability and risk, as well as the concept of hazard resulting from natural phenomena.
• To evaluate methods for the protection of water resources and prevention against natural disasters.
• To identify various types of aquifers and apply appropriate methods for assessing their vulnerability to external pollution.
• To analyze the causes of flood events, assess their impacts, and propose measures for reducing flood risk and mitigating their consequences.
• To recognize the main types of droughts, analyze the factors that cause them, examine the impacts of drought in various sectors, and utilize methods and tools to quantify drought.
• To comprehend the process and parameters required for assessing the risk associated with both floods and droughts.
• To identify major geological hazards and their dependence on water, understand their impacts, and be familiar with protection and mitigation measures.
• To evaluate methods for assessing geohazard risk.
• To develop and present a topic related to the protection of water resources and/or the prevention from natural disasters.

Teaching Mode: 3 Hours Suggestion-Workshop / Week

13 RENEWABLE ENERGY: EXPLOITATION OF HYDRODYNAMIC AND MARINE ENERGY

Teachers:	Chrysanthou V.,	Emeritus Professor
	Lalikidou S.,	PhD Candidate

The course covers the following topics:

1. Technical works for capturing, abducting and abducting water
2. Characteristics and types of reservoirs
3. Flood containment and water storage reservoirs design and dimensioning
4. Technical security projects - Dimensions of security launcher and floor evacuation
5. Topics (homework) on the design and dimensioning of reservoirs
6. Application of optimization methods to reservoir management
7. Regeneration tower: water level oscillation equations, hydraulic shock, unstable flow within closed conductors
8. Drop duct: pipe diameter selectors, static investigation of the duct supports
9. Spiral shell: specifying spiral shell rays
10. Hydroturbines: hydroturbine classes, action hydroturbine function, reaction hydroturbine function
11. Hydroturbine output conductor: output conductor configuration, cavitation
12. Marine wave motion, energy and power
13. Provisions for the generation of electricity through wave energy. Tidal wave power, tidal range power. Provisions for the generation of electricity through the tides. Numerical examples.

At the end of the course the student is competent:

- To possess knowledge for the design and dimensioning of flood containment and water storage reservoirs, as well as for the dimensioning of the safety drawer and the floor evacuator.
- Understand the parameters for the design and dimensioning of the regeneration tower and to study the propagation of the hydraulic shock.
- Apply the knowledge for the design, dimensioning and static investigation of the fall duct.
- Combine the knowledge for the design and dimensioning of the spiral shell.
- Evaluate knowledge on the selection of the type of water turbine.
- To evaluate the knowledge on the design and dimensioning of the outlet pipeline of the water turbine taking into account the phenomenon of cavitation.
- Possess theoretical knowledge of motion, energy and sea-wave power in order to understand how the relevant power generators operate.
- Possess theoretical knowledge of tidal current and tidal range power in order to understand how the relevant power generators are operated.

Teaching Mode: 3 hours suggestion-exercises / week

14 GEOSYNTHETICS IN HYDRAULIC AND ENVIRONMENTAL ENGINEERING

Teachers: Markou I., Professor

The course covers the following topics:

1. Introduction – Types and functions of geosynthetics
2. Properties of geosynthetics
3. Drainage applications
4. Filtration applications
5. Slope erosion control
6. Landfills – Part 1
7. Landfills – Part 2
8. Embankments
9. Dams
10. Ponds, reservoirs and canals
11. Specialized applications of geosynthetics – Part 1
12. Specialized applications of geosynthetics – Part 2
13. Examples of hydraulic and environmental projects

At the end of the course the student will be able to understand per type of hydraulic and environmental projects:

• the types of geosynthetics used (geotextiles, geogrids, geomembranes, geonets, geosynthetic clay liners, geocells, geocomposites, etc.)
• the objectives and functions that geosynthetics are required to perform (barrier, separation, filtration, drainage, erosion control, protection, reinforcement)
• the required properties of geosynthetic materials
• the design methodologies applied, and
• the construction methods followed.

Additionally, the student will be able to understand the economic and environmental benefits, as well as the sustainability of the solutions resulting from the use of geosynthetics in hydraulic and environmental engineering

Teaching Mode: 3 Hours Suggestion-Workshop / Week

15 POLLUTION AND PROTECTION OF GROUNDWATER RESOURCES

Teachers:	Siarkos I.,	Asst Professor
	Adamidis A.,	PhD in Civil Engineering

The course covers the following topics:

1. Groundwater and aquifer systems – The threat of groundwater pollution – Pollution sources and types of pollutants – The importance of protecting groundwater resources against pollution.
2. Groundwater quality characteristics – Physical, chemical, and biochemical properties – Physico-chemical processes and their impact on groundwater pollution.
3. Groundwater sampling methods and techniques – Chemical analysis of groundwater – Methods for processing, analyzing, presenting and interpreting the results of hydrochemical analyses.
4. Pollutant transport in groundwater – Mechanisms of pollutant transport (advection, hydrodynamic dispersion, adsorption, degradation, etc.) and their effects – The mathematical formulation of pollutant transport – Analytical and numerical solution methods.
5. Examples of analytical methods for solving pollutant transport problems.
6. Numerical models for simulating pollutant transport – 1 (Basic features, necessary data, and the process of formulating pollutant transport models).
7. Numerical models for simulating pollutant transport – 2 (Use of an interactive tool for simulating pollutant transport).
8. Numerical models for simulating pollutant transport – 3 (Demonstration of pollutant transport simulation software).
9. Groundwater pollution phenomena – 1 (Classification of pollution phenomena from various activities and their risk level – Specialized analysis of various types of pollution).
10. Groundwater pollution phenomena – 2 (The problem of groundwater nitrate contamination: Theoretical approach).
11. Groundwater pollution phenomena – 3 (The problem of groundwater nitrate contamination: Numerical simulation).
12. Protection of groundwater against pollution – Aquifer vulnerability – Protection of abstraction wells (Wellhead Protection Zones, WPZs) – Control and mitigation of pollution sources.
13. Pollution containment and groundwater aquifer restoration – Pump-and-treat systems – Modern remediation methods and alternative techniques.

At the end of the course, the students will be able:

- To identify and categorize the various types of pollutants in groundwater, and assess the level of pollution using appropriate monitoring parameters.
- To understand the necessary procedures for conducting water sampling and hydrochemical analyses, as well as process, present and interpret the results of the analyses.
- To understand the mechanisms that govern the transport of pollutants in groundwater, as well as the significance and role of physico-chemical parameters and processes.
- To apply analytical solutions to solve mass transport problems.
- To use numerical models and specialized software packages to simulate pollutant transport in groundwater.
- To study and analyze pollution phenomena of anthropogenic origin, which are characteristic of groundwater systems.
- To understand the problem of groundwater nitrate contamination and apply theoretical and practical knowledge to study and confront it.
- To design and develop scenarios to mitigate the qualitative degradation of groundwater and propose protection measures against various forms of pollution.
- To implement methods and techniques for the remediation of aquifers, tailored to different categories of pollutants and aquifer systems.

Teaching Mode: 3 hours suggestion-exercises / week

16 MASTER’S THESIS

Teachers:

The Master’s Thesis may be theoretical, applied, or experimental and must contain identifiable elements of originality and a contribution to scientific knowledge. The text must meet the standards and structure of a scientific paper; specifically, it must include a description of the thesis topic, a presentation of the findings and results, the methodology, assumptions, bibliography, and any other necessary supporting or explanatory material (required figures, charts, photographs, images, etc.).

Upon completion of the Master’s Thesis, participants should be able to:

- Demonstrate in-depth knowledge of the subject matter addressed in their thesis.
- Possess a holistic understanding of the subjects covered in the Master's Programme (MSc).
- Search for and evaluate international literature.
- Analyze data.
- Design hydraulic works using environmental protection as a key design parameter.