Aquifer-Dependant Natural Systems (250MAG007)

General Information

School	ETSECCPB
Departments	Departament d'Enginyeria Civil i Ambiental (DECA)
Credits	5.0 ECTS
Programs	MÀSTER UNIVERSITARI EN ENGINYERIA DE L'AIGUA (pla 2025)
Course	2025/26

Main teaching language at each group

- Group 10Q2 Spanish (Q2)

Faculty

Responsible Faculty: Guillem Solé Marí
Faculty: Audrey Hucks Sawyer, Guillem Solé Marí

Objectives of Education

Understand the physical, chemical, and biological processes associated with the interaction between aquifers and other natural systems.

Gain in-depth knowledge of the hydrological functioning of the unsaturated zone, the hyporheic zone, and coastal systems, and how they interact with the aquifer.

Develop skills to model and assess the behaviour of these systems under natural and human-impacted conditions.

Be able to interpret problems and use data for diagnosis and decision-making.

Total hours of student work

		Hours	Percentage
Supervised Learning	Large group	45.0 h	100.00 %
	Medium group	0.0 h	0.00 %
	Laboratory classes	0.0 h	0.00 %
	Guided Activities	0.0 h	0.00 %
Self Study		80.0 h	

Contents

Introduction

Introduction to natural systems dependent on aquifers. Hydroecological importance and ecosystem services. Relationship between surface and groundwater hydrology. Concepts of saturated zone, unsaturated zone, and hydraulic connection. Introduction to water balance and the spatial and temporal scale of processes.

Unsaturated flow and multiphase flow

Movement of water and gas in the unsaturated zone. Richards equation and boundary conditions. Retention curves and conductivity curves. Hysteresis and soil heterogeneity. Multiphase flow at the pore scale. Applications in contamination and recharge processes.

Recharge and unsaturated zone

Types of recharge: diffuse, focused, and event-based. Recharge estimation: empirical methods, balances, and modelling. Interaction between recharge and land use. Role of vegetation and evapotranspiration. Temporal analysis: seasonality and long-term trends.

Rivers, springs and wetlands

Groundwater–surface water exchange. Hyporheic zone and vertical flow. Springs as discharge points. Aquifer-fed wetlands. Influence of alluvium and river regime. Temporal variability of flow and hydraulic connection.

Variable density flow

Movement of water with different density due to salinity or temperature. Variable-density flow equations. Convection and instability in saturated media. Applications in coastal systems and saline contamination areas. Specific numerical modelling.

Submarine groundwater discharge and saltwater intrusion

Submarine groundwater discharge (SGD). Controlling factors: geology, gradient, and density. Seawater intrusion: salinity balance and intrusion front. Ghyben-Herzberg equation. Impacts of coastal groundwater extraction. Management and monitoring strategies.

Modeling

Conceptual and numerical modelling of natural systems. Flow and transport simulation tools (MODFLOW, SEAWAT, HYDRUS). Spatial and temporal scales. Validation with field data. Impact assessment and management scenarios. Model limitations and uncertainty.

Teaching Methodology

There are 3 hours per week of face-to-face classes in the classroom. In these classes, concepts and content are explained, with examples and problem solving.

Three modelling sessions will take place in the computer lab, unless all students prefer to use their laptops in the classroom.

The main and supplementary support materials will be provided through the ATENEA virtual campus.

Grading Rules

(*) The evaluation calendar and grading rules will be approved before the start of the course.

Four practical assignments are proposed to be completed at home during the course, and an exam is held at the end of the semester.

The final grade is calculated as
FG = 0.6 * EG + 0.4 * PG,
where EG is the exam grade and PG is the average grade of the practical assignments.

Bibliography

Basic

- Freeze, R. Allan; Cherry, John A. Groundwater. Englewood Cliffs (N.J.): Prentice-Hall, cop. 1979. ISBN 9780133653120.

- Bear, Jacob. Dynamics of fluids in porous media. New York: Dover, 1972. ISBN 0486656756.
- Jury, William A; Horton, Robert. Soil physics. 6th ed. Hoboken, NJ: John Wiley & Sons, cop. 2004. ISBN 9780471059650.
- Bear, Jacob; Cheng, Alexander H.D. Modeling groundwater flow and contaminant transport. Dordrecht, [etc.]: Springer, cop. 2010. ISBN 9781402066818.
- Sophocleous, M.. "Interactions between groundwater and surface water: the state of the science". Hydrogeology Journal [en línia]. vol. 10, p. 52–67 (2002) [Consulta: 25/06/2025]. Disponible a: https://link-springer-com.recursos.biblioteca.upc.edu/article/10.1007/s10040-001-0170-8.