Course guide
250MEA003 - 250MEA003 - Modeling of Biogeochemical Processes

Last modified: 13/06/2024

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.

Degree: MASTER'S DEGREE IN ENVIRONMENTAL ENGINEERING (Syllabus 2024). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: IGNACIO CASANOVA HORMAECHEA

Others: IGNACIO CASANOVA HORMAECHEA

TEACHING METHODOLOGY

The course consists of 2.5 hours per week of classroom activity (large size group) and 1.3 hours weekly with half the students (medium size group).

The 2.5 hours in the large size groups are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.

The 1.3 hours in the medium size groups is devoted to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives.

Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of learning and assessment activities conducted and literature.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

LEARNING OBJECTIVES OF THE SUBJECT

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STUDY LOAD

Type	Hours	Percentage
Hours large group	25,5	20.38
Hours small group	9,8	7.83
Self study	80,0	63.95
Hours medium group	9,8	7.83

Total learning time: 125.1 h

CONTENTS

Aqueous systems

Description:
Solutions, suspensions and colloidal systems. Speciation. Solubility. Eh-pH diagrams.
Product of activity, strength and ionic potential. Adsorption isotherms. Piper and stiff diagrams.
Problems of aqueous systems

Specific objectives:
Identify the components of natural waters and their physico-chemical characteristics. Work quantitatively with equilibrium diagrams.
Know the parameters that describe the composition and geochemical behavior of natural waters. Get acquainted with different types of graphic representation.

Full-or-part-time: 13h 40m
Theory classes: 3h
Practical classes: 2h 40m
Laboratory classes: 1h
Self study : 7h

Carbonate geochemistry the carbon cycle

Description:
The inorganic carbon in the atmosphere and hydrosphere. Atmospheric CO2 carbonate species and the pH of rainwater. Alkalinity. Solubility. The effect of partial pressure of CO2 on the stability of carbonates.
Oxidation states of carbon. Global fluxes and reservoirs. Fixation of carbon into the crust. The oceanic reservoir. Carbon fixation in the oceans. The atmospheric reservoir. Carbon capture and storage.
Exercises

Specific objectives:
Identify the main reservoirs of carbon on Earth and speciation based on environmental conditions
Understand the main characteristics of the biogeochemical cycle of carbon

Full-or-part-time: 13h 40m
Theory classes: 3h
Practical classes: 2h 40m
Laboratory classes: 1h
Self study : 7h

Other biogeochemical cycles

Description:
Oxidation, nitrogen species. The nitrogen cycle processes. Global flows and reservoirs. Anthropogenic disturbance and environmental impacts. Cycles of phosphorus in soils. The global cycle. Phosphorus and eutrophication. Sulfur: oxidation states, species. The global cycle. The cycle marine. Soil and biota. Atmosphere. Flows in inland waters
Applied exercises

Specific objectives:
Characteristics of the biogeochemical cycles of these elements and their links with other cycles

Full-or-part-time: 9h 51m
Theory classes: 2h
Practical classes: 2h 40m
Laboratory classes: 1h
Self study : 4h 11m

Chemical weathering and soils

Description:
Mineral stability. Secondary minerals. Mechanisms and reaction products.
Factors that control the mineralogy of a soil. Mineral stability diagrams
Applied Problems

Specific objectives:
Application of the principles of thermodynamics and kinetics to the description of mineral alteration processes
Know how to plan the reactions of mineral weathering according to the environmental physico-chemical conditions, and represent them quantitatively.

Full-or-part-time: 13h 40m
Theory classes: 3h
Practical classes: 2h 40m
Laboratory classes: 1h
Self study : 7h

Stable isotope geochemistry and environmental applications

Description:
Atomic masses. Delta notation. Isotopic fractionation.
Applications in climate analysis. Hydrological cycle tracers.
Paleoenvironmental analysis. Carbon isotopes in hydrology and chemical weathering. Sulfur isotope fractionation with microbial mediation.
Problems of stable isotope geochemistry

Specific objectives:
Identify the main stable isotopes in nature and how the study of their distribution and fractionation is used in the modeling of environmental geochemical processes.
Apply the concepts of isotopic fractionation to the study of water-soil-atmosphere interactions and understand the implications for the analysis of climate, meteorological evolution and the hydrological cycle
Use the isotopes of carbon and sulfur for the modeling of environmental processes of inorganic and microbiological origin

Full-or-part-time: 14h 40m
Theory classes: 4h
Practical classes: 2h 40m
Laboratory classes: 1h
Self study : 7h

Radioactive isotope geochemistry

Description:
Mechanisms and products of disintegration. Average life, rates and decay constants. Radioactive tracers of environmental systems
Cosmogenic radionuclides and dating of surface processes. Sediment and mineral dating methods.
Problems of Geochemistry of radioactive isotopes

Specific objectives:
Achieve knowledge bases on isotopy of radioactive elements and know how to identify their applications in environmental geochemistry studies
Have a reference on the main principles and methods of dating geological and anthropogenic materials.

Full-or-part-time: 17h 03m
Theory classes: 5h
Practical classes: 2h 40m
Laboratory classes: 1h
Self study : 8h 23m

Case Study

Description:
Magnitude of the problem. Mineralogy of the mouth of the deposits. The oxidation and the generation of sulfide oxidation products. Bacteria and sulfide oxidation. Mechanisms of neutralization of acids. Acid drainage and mining waste. Prediction methods. Bioaccumulation and toxicity of the oxidation products. Approaches to the prevention and remedying
Source and composition of leachate. Diffusion of contaminants in groundwater. Biogeochemistry of landfill leachate plumes. Redox environments. Microbial activity and redox processes. Processes that control the fate of landfill leachate compounds. Dissolved organic matter, inorganic macro-components and heavy metals. Xenobiotic organic compounds. Environmental restoration. Future challenges and research issues
Nature and environmental dangers of radioactive contamination. Field studies of the behavior of radionuclides. Applications: geochemical risk assessment models
Geomaterials and human health. Routes of exposure, absorption, biodistribution, metabolism, and detoxification. Geochemistry biodurable medical materials: asbestos, erionite, other fibrous materials, crystalline silica. Medical Geochemistry of materials readily soluble, bioaccessible components, and / or bioreactive

Specific objectives:
Analysis and prevention of geochemical environmental effects of mining operations (mainly metal ores as sulfides)
Establishment of criteria for the assessment and prevention of environmental risks in groundwater caused by leachate from landfill facilities
Establishment of criteria for the assessment and prevention of environmental risks of storage facilities for nuclear waste
Concentration, transport and distribution of geomaterials harmful to human health

Full-or-part-time: 38h 32m
Laboratory classes: 16h 40m
Self study : 21h 52m

GRADING SYSTEM

Problems (assignments by topics): 30%
Written test nº1: 30%
Case study: 30%
Class participation and proactivity: 10%

EXAMINATION RULES.

Failure to perform a laboratory or continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

BIBLIOGRAPHY

Basic:
- Ryan, P. Environmental and low temperature geochemistry. 2nd ed. Hoboken, NJ: Wiley-Blackwell, 2020. ISBN 9781119568582.
- Anderson, G.M. Thermodynamics of natural systems: theory and applications in geochemistry and environmental science. 3rd ed. Cambridge: Cambridge University Press, 2017. ISBN 9781107175211.
- Brantley, S.L.; Kubicki, J.D.; White, A.F. (eds.). Kinetics of water-rock interaction. New York: Springer, 2008. ISBN 9780387735627.
- Lollar, B.S. (ed.). Environmental geochemistry. Amsterdam: Elsevier, 2005. ISBN 9780080446431.
- Misra, K.C. Introduction to geochemistry: principles and applications. Chichester, West Sussex ; Hoboken, NJ: Wiley-Blackwell, 2012. ISBN 9781405121422.

Complementary:
- Fegley, B. Practical chemical thermodynamics for geoscientists. Waltham: Academic Press, 2013. ISBN 9780122511004.
- Fleet M.E. (ed.). Environmental geochemistry: a short course sponsored by the Mineralogical Association of Canada. London: Mineralogical Association of Canada, 1984.
- Blowes, D.W.; Jambor, J.L. (eds.). The environmental geochemistry of sulfide mine-wastes. Vancouver: Mineralogical Association of Canada, 1994.
- Sahai, N.; Schoonen, M.A.A. (eds.). "Medical mineralogy and geochemistry". Reviews in mineralogy and geochemistry. 2006, Vol. 64.
- Valsaraj, K.T. Elements of environmental engineering: thermodynamics and kinetics. 3rd ed. Boca Raton, FL: CRC Press, 2009. ISBN 9781420078190.
- Zhu, C.; Anderson, G. Environmental applications of geochemical modeling. Cambridge: Cambridge University, 2002. ISBN 0521005779.