COURSE SYLLABUS

Environmental Geochemistry

2627-2-F7402Q010

Aims

The environmental geochemistry course offers to the students a wide view about the study of the Geochemistry applied to environmental themes. At the end of the course the students will be able will be able to deal with complex themes related to the environment. Students will be able to apply their knowledge, understanding, and problem solving abilities in the multidisciplinary contexts related to Environmental Geochemistry. The acquired scientific methodologies and knowledge will be essential to plan and solve the problems related to Environmental Geochemistry.

Knowledge and Understanding
The student will complete and strengthen the preparation and comprehension skills acquired through the Bachelor's course in Geochemistry. They will gain in-depth knowledge of geochemical processes applied to the environment, enabling them to understand and interpret complex processes such as radioactive waste storage, surface and groundwater pollution, and waste management resulting from extraction activities. These skills are acquired through attendance at lectures, laboratory activities, and/or classroom exercises. The level of learning is assessed by means of an individual practical test to be taken during the course and an oral examination after the end of the course. The final grade will be based on the evaluation of the practical test, accounting for 50%, and the oral examination, accounting for 50%.

Ability to Apply Knowledge and Understanding

Thanks to the knowledge acquired, the student will be able to:

- Analyze in detail the geochemical processes related to the environment;
- Independently carry out study and research activities in the field of environmental geochemistry;
- Use their theoretical knowledge to identify critical situations and propose possible solutions;
- Independently solve geochemical-environmental problems essential for assessing environmental hazards and risks.

Autonomy of Judgment

The student will develop the ability to characterize and evaluate the reliability of collected information, the level of uncertainty in data and measurements, and the complexity of available models for problem-solving. This capacity will allow the student to independently assess problems and formulate solutions even based on limited or incomplete information. Additionally, the student will learn to evaluate the consequences of their choices and proposed solutions on the environmental context. All these skills are developed through the study and discussion of real cases in class.

Communication Skills
The student will acquire the ability to communicate their evaluations and proposed solutions concisely and effectively, both to a specialized audience (e.g., conferences, colleagues) and to a non-specialist audience (clients, the general public). This latter aspect is crucial for risk management topics, as technical assessments must be clearly conveyed to policymakers who interact with the population. Communication skills are developed through classroom discussions of studied issues.

Learning Ability
The student will develop the ability to autonomously learn new concepts and theories, mainly by consulting literature in English. The various topics of the course will be covered through articles published in specialized journals, laboratory work, and/or practical exercises. The level of learning achieved will be assessed on the basis of the practical test, accounting for 50%, and the oral examination, accounting for 50%.

Contents

The Environmental Geochemistry course is specifically concerned with the interconnession between the geochemical processes and the environment. The themes of the course cover: mobility of the elements (dispersibility and bioavailability); evaluation and monitoring of heavy metal pollution; water quality (natural waters and water for drinking, agricultural and industrial use); pollutant agents in water, air and soil; wastes (mine wastes, radioactive wastes, urban wastes); interactions between geochemistry and human health.

Detailed program

1. Arsenic: chemistry and mineralogy of arsenic; arsenic in groundwaters in Southern Asia; Arsenic in soils, mine tailings, and former industrial sites; arsenic in drinking water and its impact on human health.

2. Atmospheric particles: solid particulate matter in the atmosphere; atmospheric brown clouds - from local air pollution to climate change; airborne particles in the urban environment; atmospheric and environmental impact of volcanic particulates; airbornr mineral dust; interactions between mineral dust, climate, and ocean ecosystems.

3. Deep mined geological disposal of radiocative waste: geological disposal of nuclear waste; geological disposal of radioactive waste in clay; crystalline rock as a repository for Swedish spent nuclear fuel; the Russian strategy of using crystalline rock as a repository for nuclear waste; salt as a host rock for the geological repository for nuclear waste; geological disposal of nuclear waste in tuff: Yucca Mountain (USA); selecting a site for a radioactive waste repository: a historical analysis.

4. Deep-ocean mineral deposits: metal resources and windows into Earth's processes; metal extraction from deep-ocean mineral deposits; mining deep-ocean mineral deposits: what are the ecological risks?; deep-sea mining: international regulatory challenges and responses.

5. Global water sustainability: water and sanitation in developing countries; hydrogeochemical processes;

groundwater: a resource in decline; water management in production of shale gas; conservation, efficiency, and reuse.

6. Kaolin: kaolin-group minerals as environmental recorders; interactions in the environments, kaolins and health.

7. Medical mineralogy and geochemistry: toxic potential of mineral dusts.

8. Metal stable isotopes: mercury cycling in ecosystems; isotope fractionation by plants; environmental applications.

9. Mine wastes: geochemistry and mineralogy of solid mine waste, essential knowledge for predicting environmental impact; waste streams of oil sands: characteristics and remediation, mine waters; mine wastes and human health; recycling, reuse and rehabilitation of mine wastes.

10. Phosphates and sustainability: phosphate mineral reactivity and global sustainability; the phosphorus cycle; phosphate minerals and environmenatl pollution; phosphorus removal and recovery from municipal wastewaters; phosphates and nuclear waste storage.

11. Social and economic impact of geochemistry: the impact of geochemistry; applied geochemistry in mineral exploration and mining; environmental mineralogy: new challenges, new materials; geochemically based solutions for urban society: London, a case study; stable isotopes from adulterated foods to crime scenes; mestal stable isotopes in the human body.

12. Sustainable soils remedation: the need for sustainable soil remediation;mineral-based amendments for remediation; nanoparticles for remediation: solving big problems with little particles.

13. The nuclear fuel cycle - environmental aspects: the role of mineralogy and geochemistry; uranium mill tailings: geochemistry, mineralogy, and environmental impact; spent nuclear fuel; uranium mineralogy and neptunium mobility; nuclear waste glasses - how durable?; ceramic waste forms for actinides.

14. Toxic metals: the role of surfaces; Earth's nano-compartment for toxic metals; metal retention and transport on colloidal particles in the environment; shining light on metals in the environment; synchrotron X-ray investigations of minerals-microbre-metal interactions; trace metal retention on biogenic manganese oxide nanoparticles.

15. Urban geochemistry: why urban geochemistry?; legacy problems in urban geochemistry; impact of urban development on physical and chemical hydrogeology; urban geochemistry and human health; greenhouse gas emissions at the urban scale; environmental and medical geochemistry in urban disaster response and preparedness.

Prerequisites

Good knowledge of chemistry and geochemistry.

Teaching form

The total 76 hours of the course (8 CFU), to be carried out in person, are divided into 28 hours of lectures (4 CFU) and 48 hours of practical exercises and/or laboratory work (4 CFU). Attendance at practical exercises and laboratory sessions is mandatory for at least 75% of the scheduled hours.

Textbook and teaching resource

powerpoint presentations provided by the professor

Semester

first semester

Assessment method

Assessment is carried out through a practical test to be taken during the course and an oral examination after the end of the course, consisting of an interview on the topics covered during the course. The oral examination will consist of a minimum of three questions; students who attend at least 90% of the classes will have the opportunity to choose three topics on which to develop the oral examination. Evaluation will take into account the level of knowledge and depth of understanding of the various topics, the ability to make connections between subjects, clarity of expression, as well as the use of appropriate technical and scientific language. The final grade will be based on the evaluation of the practical test, accounting for 50%, and the oral examination, accounting for 50%.

Office hours

by appointment via email: alessandro.fabbrizio@unimib.it

Sustainable Development Goals