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|---|---|---|
| **Form:<br>Course Syllabus** | **Form Number** | EXC-01-02-02A |
| | **Issue Number and Date** | 2/3/24/2022/2963<br>05/12/2022 |
| | **Number and Date of Revision or Modification** | 2023/10/15 |
| | **Deans Council Approval Decision Number** | 265/2024/24/3/2 |
| | **The Date of the Deans Council Approval Decision** | 2024/1/23 |
| | **Number of Pages** | 08 |

| | | |
|---|---|---|
| **1.** | **Course Title** | **Hydrogeochemistry** |
| **2.** | **Course Number** | 0305961 |
| **3.** | **Credit Hours (Theory, Practical)** | 3, theory |
| | **Contact Hours (Theory, Practical)** | 3, theory |
| **4.** | **Prerequisites/ Corequisites** | - |
| **5.** | **Program Title** | Ph.D in Geology |
| **6.** | **Program Code** | - |
| **7.** | **School/ Center** | School of Science |
| **8.** | **Department** | Geology |
| **9.** | **Course Level** | Ph D program |
| **10.** | **Year of Study and Semester (s)** | First or second year |
| **11.** | **Program Degree** | Ph.D. Program |
| **12.** | **Other Department(s) Involved in Teaching the Course** | None |
| **13.** | **Learning Language** | English |
| **14.** | **Learning Types** | ☒Face to face learning ☐Blended ☐Fully online |
| **15.** | **Online Platforms(s)** | ☒Moodle ☐Microsoft Teams |
| **16** | **Issuing Date** | 01-10-2024 |
| **17.** | **Revision Date** | |

**18. Course Coordinator:**

Name: Mustafa Al Kuisi  Office number: Geo307  Contact hours:

Phone number:0796906169  Email: mkuisi@ju.edu.jo

**19. Other Instructors:**

Name:  Office number:
Phone number:  Email:
Contact hours:

**20. Course Description:**

This course provides an in-depth understanding of the chemical processes that govern the composition of natural waters and groundwater systems. It covers the fundamentals of thermodynamics, kinetics, chemical equilibrium, and their applications in hydrogeology, focusing on the interactions between water, minerals, and organic compounds. The course also explores the role of stable isotopes, the fate of contaminants, and the geochemical cycling of elements in the hydrosphere.

**21. Program Intended Learning Outcomes:**

(SO1) Students will be able to design and execute original research, employing advanced methodologies to generate new knowledge in their specialized area of geology

(SO2) Students will display the potential to seriously evaluate complex geological problems, the usage of analytical and problem-fixing capabilities to develop modern answers and interpretations of their studies.

(SO3) Students will benefit know-how in using cutting-edge gear, techniques, and technology applicable to their geological research, applying these abilities to research and cope with complicated geological phenomena.

(SO4) Students will effectively communicate their studies findings via academic guides, presentations, and conferences, making significant contributions to the scientific network and attractive technical and non-technical audiences.

(SO5) Students will showcase a sturdy dedication to ethical studies practices and apprehend the broader societal and environmental effects of their work, promoting sustainability and integrity within the subject.

(SO6) Students will demonstrate a determination to persistent mastering, actively enticing with rising studies, and professional improvement possibilities to maintain and amplify their know-how throughout their careers.

| **PILO's** | *National Qualifications Framework Descriptors* | | |
|---|---|---|---|
| | **Knowledge (A)** | **Skills (B)** | **Competency (C)** |
| 1 | ☐ | ☒ | ☐ |
| 2 | ☐ | ☒ | ☐ |
| 3 | ☐ | ☒ | ☐ |
| 4 | ☐ | ☒ | ☐ |
| 5 | ☐ | ☐ | ☒ |
| 6 | ☐ | ☐ | ☒ |

* Choose only one descriptor for each learning outcome of the program, whether knowledge, skill, or competency.

**22. Course Intended Learning Outcomes:** (Upon completion of the course, the student will be able to achieve the following intended learning outcomes)

**A- Aim of the course:**

To provide advanced knowledge and applied skills in the geochemical processes that control groundwater systems, including contaminant transport and environmental interactions.

**B- Student Learning Outcomes:**

**Academic Knowledge & Understanding:**

1. Demonstrate advanced understanding of thermodynamic and kinetic principles, and their role in governing chemical reactions, equilibria, and mineral-water-organic interactions in natural and groundwater systems using theoretical models and case studies.
2. Critically evaluate geochemical element cycling and its environmental implications, with an emphasis on sustainable management of water resources and ecosystem health.

**Practical Skills:**

3. Apply stable isotope techniques and geochemical modeling tools to investigate hydrogeochemical processes and trace the transport and transformation of natural and anthropogenic contaminants in the hydrosphere.
4. Analyze the biogeochemical behavior of pollutants, including redox-sensitive elements and organic compounds, to assess water quality evolution and contamination pathways in various groundwater environments.
5. Design and execute independent hydrogeochemical research by integrating field investigations, laboratory analyses, and software-based modeling to solve complex environmental and geological problems.

**Practical Skills: Students will be able to:**

| Course ILOs # | The learning levels to be achieved | | | | | |
|---|---|---|---|---|---|---|
| | **Remember** | **Understand** | **Apply** | **Analyse** | **Evaluate** | **Create** |
| 1. | ☐ | ☒ | ☒ | ☒ | ☐ | ☐ |
| 2. | ☐ | ☐ | ☒ | ☒ | ☒ | ☐ |
| 3. | ☐ | ☐ | ☒ | ☒ | ☐ | ☐ |
| 4. | ☐ | ☒ | ☐ | ☒ | ☒ | ☐ |
| 5. | ☐ | ☐ | ☐ | ☒ | ☒ | ☐ |

**23. The matrix linking the intended learning outcomes of the course -CLO's with the intended learning outcomes of the program -PILOs:**

| PILO's * / CLO's | 1 | 2 | 3 | 4 | 5 | 6 | Descriptors** | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | A | B | C |
| 1 | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ | ☐ | ☒ | ☐ |
| 2 | ☐ | ☒ | ☐ | ☒ | ☐ | ☐ | ☐ | ☒ | ☐ |
| 3 | ☐ | ☒ | ☒ | ☐ | ☐ | ☒ | ☐ | ☒ | ☐ |
| 4 | ☐ | ☐ | ☐ | ☒ | ☐ | ☐ | ☐ | ☒ | ☐ |
| 5 | ☐ | ☐ | ☐ | ☐ | ☒ | ☐ | ☐ | ☐ | ☒ |

*Linking each course learning outcome (CLO) to only one program outcome (PLO) as specified in the course matrix.

**Descriptors are determined according to the program learning outcome (PLO) that was chosen and according to what was specified in the program learning outcomes matrix in clause (21).

## 24. Topic Outline and Schedule:

| Week | Lecture | Topic | CLO/s Linked to the Topic | Learning Types (Face to Face/ Blended/ Fully Online) | Platform Used | Synchronous / Asynchronous Lecturing | Evaluation Methods | Learning Resources |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | **Introduction to Hydrogeochemistry**<br>Overview of hydrogeochemistry and its relevance in water resource management.<br>Key concepts: water-rock interaction, geochemical cycles, and groundwater chemistry | 1, 5 | Face to Face | MS | S | | Eby (2010) |
| 2 | 2 | **Equilibrium Thermodynamics and Kinetics**<br>Principles of chemical equilibrium in natural waters.<br>Thermodynamic stability and solubility of minerals.<br>Reaction kinetics and its role in geochemical processes.<br>Applications in groundwater chemistry and mineral dissolution/precipitation | 1, 2 | Face to Face | MS | S | | Eby (2010) |
| 3 | 3 | **Acid-Base Reactions and the Carbonate System**<br>Understanding pH, alkalinity, and buffering capacity in natural waters.<br>The carbonate system: CO2 solubility, carbonate equilibria, and precipitation/dissolution.<br>Influence of acid-base reactions on water chemistry and aquatic environments. | 1, 2 | Face to Face | MS | S | | Eby (2010) |
| 4 | 4 | **Redox Reactions and Processes**<br>Redox fundamentals: oxidation and reduction reactions in aqueous systems.<br>Redox potential (Eh), oxygen levels, and their significance in groundwater.<br>Key redox-sensitive elements: Fe, Mn, S, and N.<br>Applications in groundwater contamination and water treatment | 1, 2, 5 | Face to Face | MS | S | | Eby (2010) |
| 5 | 5 | **Clay Minerals and Cation Exchange, Adsorption**<br>Introduction to clay minerals and their role in hydrogeochemistry. Cation exchange processes: mechanisms and implications for water chemistry.<br>Adsorption of metals and ions on mineral surfaces.<br>Impact on contaminant mobility and nutrient cycling. | 2, 5 | Face to Face | MS | S | | Eby (2010) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 6 | 6 | **Organic Compounds in Natural Waters**<br>Overview of natural organic matter (NOM) and dissolved organic carbon (DOC).<br>Behavior and transformation of organic compounds in water. Organic pollutants and their interaction with geochemical processes.<br>Analytical techniques for detecting and quantifying organic compounds. | 2, 4 | Face to Face | MS | S | | Eby (2010) |
| 7 | 7 | **Heavy Metals and Metalloids**<br>Geochemistry of heavy metals (e.g., Pb, Hg, Cd) and metalloids (e.g., As).<br>Sources of metal contamination in groundwater.<br>**Transport, fate, and bioavailability of metals.**<br>**Remediation strategies and environmental impact.** | | Face to Face | MS | S | | Eby (2010) |
| | | | | | MS | S | | Eby (2010) |
| 8 | 8 | Midterm Exam | | | | | | |
| 9 | 9 | **Chemical Changes in Groundwater Flow Systems**<br>Hydrochemical facies and the evolution of groundwater chemistry. Role of residence time, water-rock interaction, and flow paths.<br>Mixing of different water types and its chemical implications.<br>Practical examples of changes in groundwater chemistry over time. | 2, 5 | Face to Face | MS | S | | Eby (2010) |
| 10 | 10 | **Hydrogeochemistry of Contaminants**<br>Hydrogeochemical behavior of contaminants in groundwater systems.<br>Mechanisms of transport, degradation, and attenuation of contaminants.<br>Case studies: nitrate contamination, heavy metal pollution, and organic pollutants.<br>Remediation techniques and groundwater protection strategies | 3, 4, 5 | Face to Face | MS | S | | Eby (2010) |
| 11 | 11 | **Introduction to Ecohydrology**<br>Interactions between water cycles and ecosystems.<br>The role of vegetation, wetlands, and aquatic systems in water regulation.<br>Ecohydrological principles for sustainable water management. Water flow and nutrient cycling in ecosystems.<br>The influence of hydrological processes on biodiversity and ecosystem health.<br>Case studies: Ecohydrological approaches in river basin management and wetland restoration | 5 | Face to Face | MS | S | | Eby (2010) |
| 12 | 12 | **Application of Phytotechnology in Integrated Watershed Management**<br>Phytotechnology and its relevance in watershed management.<br>Vegetation's role in controlling runoff, erosion, and sedimentation. Water quality improvement through natural filtration systems.<br>Green infrastructure: Riparian buffers, constructed wetlands, and vegetated swales.<br>Integration of phytotechnology into watershed restoration projects. Case studies: Using plant-based systems for storm water management and habitat restoration | 5 | Face to Face | MS | S | | Eby (2010) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 13 | 13 | **Phytoremediation and Bioremediation Technology**<br>Phytoremediation: Using plants to remove, stabilize, or degrade contaminants.<br>Bioremediation: Microbial and plant-based techniques for pollution control.<br>Mechanisms of pollutant uptake, degradation, and detoxification. Applications in contaminated soil and groundwater treatment.<br>Types of phytoremediation: Phytoextraction, rhizofiltration, phytostabilization.<br>Practical examples of phytoremediation projects and their effectiveness.<br>Case studies: Successful bioremediation of organic and heavy metal pollutants | 4, 5 | Face to Face | MS | S | | Eby (2010) |
| 14<br>15 | 14<br>15 | **Software Skills Application of Software in Hydrogeochemistry**<br>Introducing specialized software tools used in hydrogeochemical modeling, data analysis, and interpretation to solve complex water chemistry problems. | 2, 3, 4 | Face to Face | MS | S | | |

## 25. Evaluation Methods:

Opportunities to demonstrate achievement of the ILOs are provided through the following assessment methods and requirements:

| Evaluation Activity | *Mark wt. | CILO's | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** |
| First Exam | 30 | ☒ | ☒ | | ☒ | ☒ | |
| Second Exam –If any | | | | | | | |
| Final Exam | 40 | | | ☒ | ☒ | ☒ | ☒ |
| **Class work | | | | | | | |
| Projects/reports | | | | | | | |
| Research working papers | 10 | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ |
| Field visits | | | | | | | |
| Practical Exam | | | | | | | |
| Performance Completion file | | | | | | | |
| Presentation/exhibition | 20 | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ |
| Any other approved works | | | | | | | |
| Total 100% | 100 | | | | | | |

* According to the instructions for granting a Bachelor's degree.

**According to the principles of organizing semester work, tests, examinations, and grades for the bachelor's degree.

## Mid-term exam specifications table*

| No. of questions/ cognitive level | | | | | | No. of questions per CLO | Total exam mark | Total no. of questions | CILO/ Weight | CILO no. |
|---|---|---|---|---|---|---|---|---|---|---|
| Create **%10** | Evaluate **%10** | analyse **%10** | Apply %20 | Understand **%20** | Remember %30 | | | | | |
| 1 | 1 | 1 | 4 | 2 | 1 | 10 | 100 | 100 | 10% | 1 |
| | | | | | | | | | | 2 |
| | | | | | | | | | | 3 |
| | | | | | | | | | | 4 |
| | | | | | | | | | | 5 |

## Final exam specifications table

| No. of questions/ cognitive level | | | | | | No. of questions per CLO | Total exam mark | Total no. of questions | CILO Weight | CILO no. |
|---|---|---|---|---|---|---|---|---|---|---|
| Create **%10** | Evaluate **%10** | analyse **%10** | Apply %20 | Understand **%20** | Remember %30 | | | | | |
| | | | | | | | | | | 1 |
| | | | | | | | | | | 2 |
| | | | | | | | | | | 3 |
| | | | | | | | | | | 4 |
| | | | | | | | | | | 5 |

## 26. Course Requirements:

students should have a computer, internet connection, account on a specific software/platform…(elearning) Software:

- PHREEQC: A tool for geochemical modeling of aqueous solutions, minerals, gases, and surface reactions. Focus on thermodynamic calculations, reaction-path modeling, and speciation analysis.
- AquaChem: Software for graphical analysis and reporting of water quality data. Learn to generate plots like Piper diagrams, Stiff diagrams, and Durov plots.
- Geochemist's Workbench (GWB): For advanced geochemical and reactive transport modeling. Explore its applications in predicting the fate of contaminants, simulating geochemical reactions, and integrating groundwater flow with chemistry.
- GIS Applications: Integration of Geographic Information Systems (GIS) with hydrogeochemical data to visualize spatial distribution of water quality and contamination.
- Case studies: Application of these tools in hydrogeological investigations, environmental assessments, and remediation projects.

## 27. Course Policies:

A. Attendance policies: Students should attend at least 80% of the total number of lectures.
B. Absences from exams and submitting assignments on time: Students who miss an exam must submit and acceptable excuse and then a makeup exam will be appointed.
C. Health and safety procedures: Students should follow the university regulations.
D. Honesty policy regarding cheating, plagiarism, misbehavior: According to university regulations.
E. Grading policy:
   1. Mid exam 30%
   2. Homework/Seminar/Quiz 30%
   3. Final exam: 40%.

The current university's letter grade scale is adopted.

F. Available university services that support achievement in the course: Central library, personal computer labs at different locations in the university, e-learning site, faculty member's website, etc.

## 28. References:

A- Required book(s), assigned reading and audio-visuals:

1. Nelson Eby (2010) Environmental Geochemistry
2. Drever, J. I. (1997). The Geochemistry of Natural Waters: Surface and Groundwater Environments.
3. Appelo, C. A. J., & Postma, D. (2005). Geochemistry, Groundwater and Pollution.
4. Langmuir, D. (1997). Aqueous Environmental Geochemistry.

B- Recommended books, materials, and media:

5. Kendall, C., & McDonnell, J. J. (Eds.). (1998). *Isotope tracers in catchment hydrology*. Elsevier.
6. Faure, G., & Mensing, T. M. (2005). *Isotopes: Principles and applications* (3rd ed.). Wiley.
7. Hoefs, J. (2018). *Stable isotope geochemistry* (8th ed.). Springer.

## 29. Additional information:

Development of ILOs is promoted through the following teaching and learning methods:

- Motivate the creative thinking through lectures, practical classes and discussion.
- Students are expected to use the material presented on e-learning system and to read the relevant sections of prescribed and recommended textbooks as well as references provided by lecturers.
- Perform practical exercises using remote sensing software for different geological and environmental applications.

| Name | Signature | Date |
|---|---|---|
| Name of the Instructor or the Course Coordinator: Prof. Dr. Mustafa Al Kuisi | [signature] | 20/01/2025 |
| Name of the Head of Department Dr Bety Saqarat | [signature] | 20/01/2025 |
| Name of the Head of Graduate Studies/ School of Science Prof. Kamal Swaidan | [signature] | 23/1/2025 |
| Name of the Dean or the Director Prof. Mahmoud I. Jaghoub | [signature] | 27/1/2025 |