**NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE**

Department of Analytical and Bioinorganic Chemistry And Water Quality

**APPROVED**

by the Dean of the Faculty of Plant Protection, Biotechnology and Ecology

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# CURRICULUM OF ACADEMIC DISCIPLINE

CHEMISTRY WITH THE FOUNDATIONS OF BIOGEOCHEMISTRY

Area of knowledge 10 Natural Sciences

Specialty 101 Ecology

Academic programme 101 Ecology and Environmental Protection

Faculty of Plant Protection, Biotechnology and Ecology

Developed by: Docent, Candidate of Chemical Sciences Larysa VOITENKO

(position, academic degree, academic rank)

Kyiv – 2025

# Description of the discipline
# Chemistry with the foundations of biogeochemistry

Discipline studies chemical, physical, geological and biological processes that are regulating the composition of the environment, biogeochemical cycles in their interaction with living matter through the biological systems of the Earth in time and space. The course includes the laws of the chemical composition formation of the ecosphere; principles of biogeochemical zoning, biogeochemical provinces and endemic diseases in them; theories of the origin of life, ways and types of biogenic and anthropogenic migration of chemical elements; methods for predicting chemical transformations of pollutants; mechanisms of isotope fractionation with living matter; the role of living matter in the geochemical processes of hypergenesis and crust weathering; biogeochemical patterns based on methods of chemical indication of the environmental state; transformation of xenobiotic.

| **Area of knowledge, specialty, academic programme, academic degree** | | |
|---|---|---|
| Academic degree | *Bachelor's* | |
| Specialty | *101 Ecology* | |
| Academic programme | *101 Ecology and Environmental Protection* | |
| **Characteristics of the discipline** | | |
| Type | Elective | |
| Total number of hours | 120 | |
| Number of ECTS credits | 4 | |
| Number of modules | 2 | |
| Form of assessment | *exam* | |
| **Indicators of the discipline for full-time and part-time forms of university study** | | |
| | **University study** | |
| | **Full-time** | **Part-time** |
| Year of study | 4th | |
| Term | 7th | |
| Lectures | *15 hours* | *hours* |
| Practical classes and seminars | *hours* | *hours* |
| Laboratory classes | *30 hours* | *hours* |
| Self-study | *75 hours* | *hours* |
| Number of hours per week for full-time students | *3 hours* | |

## 1. Aim, competences and expected learning outcomes of the discipline

Aim - to acquire basic concepts, principles, and techniques of modern biogeochemistry as a top level of chemistry understanding and special application for the specialists in the field of ecology, environmental protection, and sustainable development. The discipline that involves the study of the chemical, physical, and biological processes and reactions that govern the composition of the natural environment (including the biosphere, the cryosphere, the pedosphere, the atmosphere, and the lithosphere): chemical aspects of life origin. In particular, it is to study of cycles of chemical elements, such as carbon and nitrogen, and their interaction with and incorporation into living things transported through earth scale biological systems in space through time.

***Competences acquired:***

Integral competence (IC): The ability to solve complex specialized tasks and solve practical problems in the field of ecology, environmental protection and sustainable use of nature, or in studies that involve the application of basic theories and methods of environmental sciences and are characterized by the complexity and uncertainty of conditions.

General competence (GC):

GC08. Ability to conduct research at an appropriate level.
GC11. Ability to evaluate and ensure the quality of work performed.
Special (professional) competence (SC):
SC16. Ability to critically reflect on the basic theories, methods and principles of the natural sciences.

***Expected learning outcomes (ELO)***:
ELO03. Understand the basic concepts, theoretical and practical problems in the field of natural sciences, which are necessary for analysis and decision-making in the field of ecology, environmental protection and optimal nature use.
ELO21. Be able to choose the optimal methods and tools for conducting research, collecting and processing data.

## 2. Programme and structure of the discipline

| **Modules and topics** | **Number of hours** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **full-time** | | | | | | **part-time** | | | | | |
| | weeks | total | including | | | | total | including | | | | |
| | | | lec | lab | ind. | s.st. | | l | p | lab | ind. | s.st. |
| Module 1. ***Biogeochemical characteristics of the ecosphere composition*** | | | | | | | | | | | | |
| Topic 1. Introduction. The object of research and the goal of the discipline. Life origin on the Earth: hypotheses and experimental. | 1-3 | 8 | 2 | 6 | | 35 | | | | | | |
| Topic 2. The ecosphere chemical composition, the chemical elements and biogeochemical laws. | 3-5 | 8 | 2 | 6 | | | | | | | | |
| Topic 3. Biogeochemical zoning | 6 | 2 | 2 | | | | | | | | | |
| Topic 4. Endemic diseases as result of abnormal distribution of chemical elements in biosphere | 7-8 | 6 | 2 | 4 | | | | | | | | |
| Total for module 1 | | 59 | 8 | 16 | | 35 | | | | | | |
| Module 2. ***Biogeochemical cycles of the main bioactive chemical elements*** | | | | | | | | | | | | |
| Topic 1. General concepts about BGC cycles. Features of biogeochemical cycles of sedimentary and gaseous types. | 9-12 | 16 | 4 | 12 | | 40 | | | | | | |
| Topic 2. Chemistry of preservatives and psychoactive compounds | 13-15 | 5 | 3 | 2 | | | | | | | | |
| Total for module 2 | | 61 | 7 | 14 | | 40 | | | | | | |
| **Total hours** | | 120 | 15 | 30 | | 75 | | | | | | |

## 3. Topics of lectures

| No. | Topic | Hours |
|---|---|---|
| 1 | The object of research and tasks of the discipline. Applied aspects of biogeochemistry. Modern directions of biogeochemistry. The environmental protection as a social factor Theories of Life Origin | 2 |
| 2 | Vernadsky' Biosphere study. Notion of life matter, its composition. Types of bio-spherical matter of the earth. The mail biochemical components of biosphere. Conditions of the biosphere existing. Energy and matter fluxes in biosphere. Vernadsky biogeochemical principles (laws). Different types of bioelements classification. | 2 |

| | | |
|---|---|---|
| | Bioactive elements distribution in biosphere. Examples of geochemical role of life matter (calcium, iodine functions, atmospheric oxygen, formation of manganese-nickel concretions etc.). | |
| 3 | Biogeochemical zoning as an unity of geochemical environment and functioning of life matter (according to V.V. Kowalsky). Biogeochemical chains. Biogeochemical provinces and zones (taiga-forest non-chornozemic; forest-steppe and steppe chornozemic; dry-steppe; semiarid and desert; mountain) | 2 |
| 4 | Endemic diseases as a consequence of abnormal distribution of chemical elements in biogeochemical environment. History of endemic diseases studying. Endemic goiter, correlation of human iodine status and IQ level. Methods of iodine deficit prevention – pro and contra. Fluorosis as a consequence of increaser content of fluorine in drinking water. Adding of fluoride compounds in toothpastes and fluoridation of drinking water. Endemic podagra, Kashin-Bek disease (Urov), Keshan disease. Endemic diseases of farm animals. | 2 |
| 5 | The basic notions of biogeochemical cycles. Processes of cycling migration of chemical elements in environment. Fluxes and reservoirs of biogeochemical cycles. Thermodynamics laws and biogeochemical cycles. Experimental evidences of cycling (Witherspoon radioisotope experiment; Habbard-Brook experimental forest study). Exogenic and endogenic cycles. Types of ogranogenic elements cycles. Hydrological cycle. Hydrogen degasation. V. Larin theory. Global model of carbon cycle according to V. Kovda. Global carbon cycle according to R. Radkliffs as the ratio of chemical state of carbon compounds (oxiding-reducting). Detrite as biogeochemical reservoir of carbon. Fossilises. Isotope distribution of carbon. Radiocarbon analysis. | 2 |
| 6 | Nitrogen biogeochemical cycle. Biogenic and abiogenic nitrogen fixation. Phosphorus biogeochemical cycle. Ephtrofication: mechanism and prevention. Classification of biogeochemical barriers: physical, mechanical, biogenical, techogenical. Practical using of biogeochemical barrier study for the analysis and prognosis of chemical substance transformation in polluted soils. | 2 |
| 7 | General classification of psychoactive substances and food additives. Chemical structure, properties, health risks. Chemophobia. Zohnerism. | 3 |
| | Total | 15 |

## 4. Topic of laboratory classes

| No. | Topic | Hours |
|---|---|---|
| 1 | Introduction. Safe rules in chemical laboratory. Qualitative methods of environmental chemical analysis. Probe sampling, conservation and storage of samples for analysis. Principles of statistic treatment of qualitative analytical results of environmental objects. | 4 |
| 2 | Express measuring of active residue chlorine (free, total) in chlorinated drinking water by photometric method using C-401 colorimeter. | 4 |
| 3 | Determination of nitrate content in natural fresh waters and drinking water by photometrical method according to DSTU 4078-2001 Water quality; determination of nitrate; part 3: spectrometric method using sulfosalicylic acid (ISO 7890 3:1998, MOD). Statistical treatment of analysis data. | 4 |
| 4 | Determination of ammonia content in natural fresh waters and drinking water by photometrical method according to DSTU ISO 7150-1-2003 Water quality - Determination of ammonium - Part 1: Manual spectrometric method. Statistical treatment of analysis data. | 4 |
| 5 | Determination of total iron content in tap water, buvette water and surface waters according to DSTU ISO 6332:2003Water quality - Determination of iron - Spectrometric method using 1,10-phenanthroline. Statistical treatment of analysis data. | 4 |
| 6 | Determination of fluoride content in drinking water and a few sorts of leaf and packed according to DSTU ISO 10359-1:2017 Water quality - Determination of fluoride - Part 1: | 2 |

| | | |
|---|---|---|
| | Electrochemical probe method for potable and lightly polluted water. Statistical treatment of analysis data. | |
| 7 | General chemical properties of alkaloids. Sublimation method for the caffeine dry extraction from tea leaves. Qualitative test of caffeine. | 2 |
| 8 | Determination of $SO_2$ sulfur dioxide content (preservative E 220) in foodstuffs according to ISO 5521:1981 Fruits, vegetables and derived products - Qualitative method for the detection of sulphur dioxide | 6 |
| | **Total** | **30** |

## 5. Topics of self-study

| No. | Topic | Hours |
|---|---|---|
| 1 | The concept of the noosphere. The noosphere as a natural step in the development of the Earth. Characteristic features of the noosphere: a) emergence of new landscapes (cultural, man-made, agricultural landscapes); b) man as the main active force of the noosphere, man-made migration of chemical substances; c) significant increase in volumes of information, new types of information; d) use of biosphere energy. Conditions (according to V.I. Vernadsky) for the complete transformation of the biosphere into the noosphere. | 15 |
| 2 | Landscape-geochemical zoning of Ukraine. Zonal and intrazonal provinces in Ukraine, endemic diseases in Ukraine. Influence of the geochemical environment on the evolution of plants. Adaptogenic plants: indifferent to changes in the concentration of chemical elements, common and unusual concentrators, endemic plants. | 10 |
| 3 | Biogeochemistry of the Earth's gas mantle. Value of atmospheric mass transfer of water-soluble forms of chemical elements. Vegetation as an absorber of gaseous pollutants. | 5 |
| 4 | Biogeochemistry of the lithosphere and pedosphere. Chemical composition of soils and bottom sediments. Types of migration of chemical elements in the pedosphere and lithosphere (hypogenic, supergenic and anthropogenic migration). Organic matter of the pedosphere. | 5 |
| 5 | Biogeochemistry of the hydrosphere. Classification of natural waters according to the level of mineralization, type of mineral matrix. Water requirements for different types of water use (drinking, irrigation, watering animals and poultry, fish farming, recreational purposes, etc.). | 10 |
| 6 | Biochemical cycles of substances and energy in the biosphere. Cycle of elements that entered the biosphere as a result of mantle degassing (hydrogen, carbon, oxygen, nitrogen). Cycles of elements that entered the biosphere as a result of mobilization from the earth's crust (calcium, potassium, silicon, phosphorus). | 10 |
| 7 | Interaction between living and non-living nature is the basis of biogenic migration of substances. The concept of a small biological cycle of chemical elements. The energy of living matter is the driving force of the geochemical and biogeochemical circulation of substances. | 10 |
| 8 | Hydrogen (water) cycle. Chemical characteristics of hydrogen, its content in the lithosphere, atmosphere, living organisms, humus, plants. Water as a source of Hydrogen for the formation of organic substances. Water as a living environment. Total water content in the biosphere. Biogeochemical cycle of water, its duration. Provision of drinking water and the degree of its use in different countries. | 10 |
| | Total | 75 |

## 6. Methods of assessing expected learning outcomes:

- Oral or written survey;
- Interview;
- Test;

- Defending laboratory works;
- Peer-to-peer assessment.

## 7. Teaching methods*:*

- Problem-based method;
- Practice oriented studying method;
- Case method;
- Research based method;
- Learning discussions and debates method.

## 8. Results assessment

The student's knowledge is assessed by means of a 100-point scale converted into the national grades according to the "Exam and Credit Regulations at NULES of Ukraine" in force

### 8.1. Distribution of points by types of educational activities

| Educational activity | Results | Assessment |
|---|---|---|
| Module 1. **Biogeochemical characteristics of the ecosphere composition** | | |
| Lab work 1. Introduction. Safe rules in chemical laboratory. Qualitative methods of environmental chemical analysis. Probe sampling, conservation and storage of samples for analysis. Principles of statistic treatment of qualitative analytical results of environmental objects. | **ELO 02, 03** For understanding of the basic concepts, theoretical and practical problems in the field of natural sciences: to know and understand the subject area and professional activity: to be able to work and analyze scientific and educational literature on the Biogeochemistry; Gain practical skills and be able monitor and evaluate current condition of environment based on chemical concepts; to have skills for the field testing for analysis and decision-making in the field of ecology, environmental protection and balanced nature management | **5** |
| Lab work 2. Express measuring of active residue chlorine (free, total) in chlorinated drinking water by photometric method using C-401 colorimeter. | | **10** |
| On-line testing | | **10** |
| Lab work 3. Determination of nitrate content in natural fresh waters and drinking water by photometrical method according to DSTU 4078-2001 Water quality; determination of nitrate; part 3: spectrometric method using sulfosalicylic acid (ISO 7890 3:1998, MOD). Statistical treatment of analysis data. Lab Report | | **5** |
| Lab work 4. Determination of ammonia content in natural fresh waters and drinking water by photometrical method according to DSTU ISO 7150-1-2003 Water quality - Determination of ammonium - Part 1: Manual spectrometric method. Statistical treatment of analysis data. Lab Report | | **5** |
| On-line testing | | **10** |
| Module 1 control work | | **50** |
| Self-study 2 Testing via Elern | | **5** |
| **Total for module 1** | | **100** |
| Module 2. **Biogeochemical cycles of the main bioactive chemical elements** | | |
| Lab work 5. Determination of total iron content in tap water, buvette water and surface waters according to DSTU ISO 6332:2003Water quality - Determination of iron - Spectrometric method using 1,10-phenanthroline. Statistical treatment of analysis | **ELO 03, ELO 21:** For understanding of the basic concepts and principles for the analysis and decision-making in the field of ecology, environmental protection and balanced nature management; for analyzing the natural chemical | **5** |

| | | |
|---|---|---|
| data. Lab Report | composition of unpolluted and polluted environment; the methods of different laboratory and field environmental analytic techniques; to understand of the psychoactive substances and their environmental distribution; the chemical foundations of the food additives application and their safety . | |
| Lab work 6. Determination of fluoride content in drinking water and a few sorts of leaf and packed according to DSTU ISO 10359-1:2017 Water quality - Determination of fluoride - Part 1: Electrochemical probe method for potable and lightly polluted water. Statistical treatment of analysis data. Lab Report | | **5** |
| Lab work 7. General chemical properties of alkaloids. Sublimation method for the caffeine dry extraction from tea leaves. Qualitative test of caffeine. Lab work Report. | | **5** |
| Lab work 8. Determination $SO_2$ sulfur dioxide content (preservative E 220) in foodstuffs according to ISO 5521:1981 Fruits, vegetables and derived products - Qualitative method for the detection of Sulphur dioxide. Lab Report | | **5** |
| On-line testing | | **10** |
| Module 2 control work | | **30** |
| Written Essay in Biogeochemical modern problems according to individual task | | **30** |
| Self-study 2 Testing via Elern | | **10** |
| **Total for module 2** | | **100** |
| **Class work** | | **(M1 + M2)/2*0,7 ≤ 70** |
| **Exam/credit** | | **30** |
| **Total for year** | | **(Class work + exam) ≤ 100** |

**8.2. Scale for assessing student's knowledge**

| Student's rating, points | National grading (exam/credits) |
|---|---|
| 90-100 | excellent |
| 74-89 | good |
| 60-73 | satisfactory |
| 0-59 | unsatisfactory |

**8.3. Assessment policy**

| | |
|---|---|
| *Deadlines and exam retaking rules* | Works that are submitted late without valid reasons will be assessed with a lower grade. Module tests may be retaken with the permission of the lecturer if there are valid reasons (e.g. a sick leave). |
| *Academic integrity rules* | Cheating during tests and exams is prohibited (including using mobile devices). Term papers and essays must have correct references to the literature used |
| Attendance rules | Attendance is compulsory. For good reasons (e.g. illness, international internship), training can take place individually (online by the faculty dean's consent) |

## 9. Teaching and learning aids:


1. E-learning course of the discipline https://elearn.nubip.edu.ua/course/view.php?id=2314.
2. Voitenko L. Chemistry with the foundations of biogeochemistry (2019). Kyiv: Naukova stolytsa, 2019. (400 p.) (In Ukrainian).
3. Lab Manual / Voitenko, L.V. (2020). Lab workbook of Biogeochemistry for Bachelor students of Ecology, NUBIP Publ., Kyiv. (98 pp.)

## 10. Recommended sources of information


1. Аналітична хімія природного середовища: Підручник/Б.Й. Набиванець, В.В. Сухан, Л.В. Калабіна. – К,: Либідь, 1996. – 304 с.
2. Аналітична хімія поверхневих вод //Б.Й.Набиванець, В.І.Осадчий, Н.М.Осадча та ін. – Київ: Наук. Думка, 2007. – 457 с.
3. Schlesinger, William & Bernhardt, Emily. (2013). Biogeochemistry: An Analysis of Global Change, Third Edition. Biogeochemistry: An Analysis of Global Change, Third Edition. Academic Press, San Diego. 672 pp.
4. Abraham, Ralph. (2009). A Review of "Geochemistry and the Biosphere: Essays by Vladimir I. Vernadsky". World Futures. 65. 436-441. 10.1080/02604020802631709. https://www.researchgate.net/publication/249036756_A_Review_of_Geochemistry_and_the_Biosphere_Essays_by_Vladimir_I_Vernadsky
5. Samuel S. Butcher et al. (Eds.), 1992, Global Biogeochemical Cycles. Academic, ISBN-8. Global Biogeochemical Cycleshttp://www.agu.org/journals/gb/Biogeochemistry http://www.springer.com/west/home/geosciences?SGWID=4-10006-70-35757517-0. A journal published by Springer.
7. Biogeochemistry articles from across Nature Portfolio. - https://www.nature.com/subjects/biogeochemistry
8. Biogeochemistry Basics Fundamental to Earth Science www.youtube.com/watch?v=WTpkame9Sd0