

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

Chair of Analytical and Bioinorganic Chemistry & Water Quality

APPROVED

by the Dean of the Faculty of Plant Protection,
Biotechnology and Ecology
“22” June 2026

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, the Biotechnologies and Ecology

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(*position, academic degree, academic rank*)

Kyiv, 2026

Description of the discipline

Chemistry with the foundations of biogeochemistry

The discipline studies chemical, physical and biological processes that determine the composition of the biosphere, pedosphere, hydrosphere, atmosphere and lithosphere. It examines the origin of life on Earth, V.I. Vernadsky's doctrine of the biosphere, biogeochemical laws, types of matter of the biosphere, biogeochemical functions of living matter. It analyzes biogeochemical zoning, endemic diseases caused by the anomalous distribution of chemical elements. It studies in detail the global cycles of biogenic elements (carbon, nitrogen, phosphorus, sulfur, hydrogen), trace elements and toxicants. It also examines the chemistry of preservatives and psychoactive substances. Laboratory practice includes quantitative methods of environmental analysis: determination of active chlorine, nitrates, ammonium nitrogen, total iron, fluorides (photometric and potentiometric methods), extraction of caffeine from tea, detection of sulfur (IV) oxide in food products. Students master sampling, statistical processing of results, work with environmental control tools.

Area of knowledge, specialty, academic programme, academic degree		
Academic degree	<i>Bachelor's</i>	
Specialty	<i>101 Ecology</i>	
Academic programme	<i>101 Ecology and Environmental Protection</i>	
Characteristics of the discipline		
Type	Elective	
Total number of hours	120	
Number of ECTS credits	4	
Number of modules	2	
Form of assessment	<i>exam</i>	
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	<i>15 hours</i>	<i>hours</i>
Practical classes and seminars	<i>hours</i>	<i>hours</i>
Laboratory classes	<i>30 hours</i>	<i>hours</i>
Self-study	<i>75 hours</i>	<i>hours</i>
Number of hours per week for full-time students	<i>3 hours</i>	

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

composition, the chemical elements and biogeochemical laws.													
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. <i>Biogeochemical cycles of the main bioactive chemical elements</i>													
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 main biochemical components of biosphere. Conditions of the biosphere existing. Energy and matter fluxes in biosphere. Vernadsky biogeochemical principles (laws). Different types of bioelements classification. Bioactive elements distribution in biosphere. Examples of geochemical role of life matter (calcium, iodine functions,	2

	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; Hubbard-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 (oxidizing-reducing). 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. Ephrtrofication: 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	Determiration of nitrate content in natural fresh waters and drinking water by photometrical method according to DSTU 4078-2001 Water quality; determiration of nitrate; part 3: spectrometric method using sulfosalicylic acid (ISO 7890 3:1998, MOD). Statistical treatment of analysis data.	4
4	Determiration of ammonia content in natural fresh waters and drinking water by photometrical method according to DSTU ISO 7150-1-2003 Water quality - Determiration of ammonium - Part 1: Manual spectrometric method. Statistical treatment of analysis data.	4
5	Determiration of total iron content in tap water, buvette water and surface waters according to DSTU ISO 6332:2003 Water quality - Determiration of iron	4

	- Spectrometric method using 1,10-phenanthroline. Statistical treatment of analysis data.	
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.	2
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	10

	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.	
	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 6332:2003 Water quality - Determination of iron - Spectrometric method using 1,10-phenanthroline. Statistical treatment of analysis data. Lab Report	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 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 .	5	
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

<i>Deadlines and exam retaking rules</i>	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).
<i>Academic integrity rules</i>	Cheating during tests and exams is prohibited (including using mobile devices). Term papers and essays must have correct references to the literature used
<i>Attendance rules</i>	Attendance is compulsory. For good reasons (e.g. illness, international

internship), training can take place individually (online by the faculty dean's consent)
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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 stolitsya, 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. Рудишин С. Д. Біогеохімія з основами екології. – Дніпро: Середняк Т. К., 2023. – 320 с. https://pdf.lib.vntu.edu.ua/books/2024/Rudyshyn_2023_320.pdf
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 Cycles <http://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