Biogeochemistry

Working program of the discipline (Syllabus)

Details of the discipline	
Level of higher education	**The first (educational and professional)**
Branch of knowledge	*10 Natural Sciences*
Speciality	*101 Ecology*
Educational program	*Environmental safety*
Status of discipline	*Custom*
Form of training	*full-time/remote/mixed*
Year of preparation, semester	*2nd year, spring semester*
Volume of discipline	*4 ECTS credits (120 hours))*
Semester control/ control measures	*Test*
Schedule of classes	*4 hours a week (2 hours of lectures and 2 hours of laboratory classes)*
Language of instruction	*Ukrainian*
Information about course leader / teachers	*Lecturer: https://eco-paper.kpi.ua/pro-kafedru/vykladachi/shablij-tetyana-oleksandrivna.html* *Laboratory: https://eco-paper.kpi.ua/pro-kafedru/vykladachi/shablij-tetyana-oleksandrivna.html*
Course placement	*https://do.ipo.kpi.ua/course/view.php?id=4194*

Program of discipline

1. Description of the credit module, its purpose, subject of study and learning outcomes

It is known that the basis of the processes that predate the current state of the biosphere are chemical transformations of substances in the lithosphere, hydrosphere, atmosphere and living organisms. The subject of study of biogeochemistry is the process of transformation of chemical compounds of natural and anthropogenic origin into the environment. Biogeochemistry is based on basic laws and concepts of classical chemistry, but research objects are in the biosphere. Despite the fact that biogeochemistry is a relatively young area of knowledge, today it is developing intensively. One of the most important problems facing humanity is the protection of the environment. The task of biogeochemistry is to develop and improve methods for detecting and determining anthropogenic contaminants, studying and modulating chemical reactions occurring in the atmosphere, hydrosphere and lithosphere, in order to create waste-free and low-waste chemical industries, to develop ways to disinfect and dispose of industrial and domestic waste.

***The subject of the discipline "Biogeochemistry"** is the processes of circulation and transformation of chemical substances between the environment and living organisms, evaluation of mechanisms of influence of environmental pollution on living organisms.*

To successfully solve the problems of protection and preservation of natural ecosystems, specialists should be free to have information, be able to solve the tasks to reduce the anthropogenic burden on the environment.

The purpose of the discipline "Biogeochemistry"

The purpose of the discipline is to strengthen the competencies formed by students:

- The ability to critically understand basic theories, methods and principles of natural sciences;

- The ability to conduct environmental monitoring and assess the current state of the environment;

- The ability to apply up-to-date methods and means of monitoring the state of atmospheric air, natural waters, soils and biota, to determine the level of contamination of natural and industrial materials with radioactive elements, to master methods for assessing the impact of adverse factors on living organisms, to determine the adaptive capabilities of the human body in environmental conditions.

1.2. The main tasks of the discipline.

After mastering the discipline, students must demonstrate the following learning outcomes:

- To understand the basic environmental laws, rules and principles of environmental protection and nature management;

- To assess the state of the environment, to determine the level of impact of the company (production) on the environment, to determine the main pollutants of the environment of the company (production);

- To carry out laboratory researches with use of modern devices, to provide sufficient accuracy of measurement and reliability of results, to process the obtained results.

2. Prerequisitions and requisition of disciplines (place in the structural and logical scheme of training according to the relevant educational program)

*The study of the discipline "**Biogeochemistry**" is based on the principles of integration of various knowledge gained by students during the study of the following disciplines: "Chemistry and Fundamentals of Biogeochemistry", "Geodynamics of the Environment", "Biology", "Specific Topics of Biogeochemistry", "General ecology", "Analytical chemistry".*

*The discipline "**Biogeochemistry**" provides the disciplines "Normalization of Anthropogenic Load on Environment ", "Technoecology".*

3. Contents of the discipline

Chapter 1: Chemical Transformations and Evolutionary Processes on Earth.

Topic 1. Introduction to discipline.

Chapter 2: Physicochemical processes in the hydrosphere.

Topic 2. Composition of the hydrosphere. The cycle of water in nature.

Topic 3. Formula and isotopic composition of water. Condensed water composition.

Topic 4. Chemical composition of natural waters. Conditions of its formation.

Topic 5. Solubility and prevalence of macrocomponents in natural waters.

Topic 6. Composition and origin of dissolved gases in natural waters.

Topic 7. Organic substances, biogenic elements and trace elements in natural waters.

Topic 8. Carbon dioxide equilibrium in natural waters.

Chapter 3: Physicochemical processes in the atmosphere.

Topic 9. Structure of atmosphere. Temperature profile of the atmosphere.
Topic 10. Cosmic rays in the atmosphere. The formation of ions in the upper atmosphere.
Topic 11. Ozone layer of the planet.
Topic 12. Formation of radicals in the atmosphere.
Topic 13. Photochemical smog.
Topic 14. Dispersed systems in the atmosphere.

Chapter 4: Organic compounds in the pedosphere.
Topic 15. Transformation of organic matter in the soil.

Chapter 5: Migration and conversion of chemical elements to the environment.
Topic 16. Types of migrations of substances.
Topic 17. Geochemical barriers.

Chapter 6: Biogeochemical functions of living matter.
Topic 18. The main groups of biogeochemical functions of living matter.

4. Training materials and resources

Basic

1. *Богатиренко В. А. , Чорний І. Б., Нестеровський В. А. Хімія Землі: Навчальний посібник / К.: Кондор-Видавництво, 2015.– 568 с.*
2. *Мітрясова О. П.. Хімія з основами біогеохімії: навчальний посібник / К.: Кондор-Видавництво, 2016. – 384 с.*
3. *Мислюк О.О. Основи хімічної екології: Навч. пос. / К.: Кондор-Видавництво, 2015. – 660 с.*
4. *Мислюк О.О. Практикум з хімічної екології: Навч. пос. / К.: Кондор-Видавництво, 2015. – 304 с.*

Auxiliary (d)

1. *Трохимчук І.М., Плюта Н.В., Логвиненко І.П., Сачук Р.М. Біотехнологія з основами екології: навчальний посібник / К.: Видавничий дім «Кондор», 2019. – 304 с.*
2. *Бардов В. Г., Федоренко В. І., Білецька Е. М. та ін. Основи екології: Підручник / Видавництво: Нова книга, 2013 р. – 424 ст.*
3. *Шаблій Т.О., Крисенко А.Д., Крисенко Т.В., Сербіна Р.В. Основи біогеохімії: Методичні вказівки до виконання лабораторних робіт. К.:ІВЦ «Видавництво «Політехніка», 2003. – Ч.1: Визначення характеристик якості природних вод. – 44 с.*
4. *Федорова Г.В. Практикум з біогеохімії для екологів. Навчальний посібник. К.: «КНТ», 2007. – 228 с.*
5. *Клименко М.О., Кнорр Н.В., Пилипенко Ю.В. Моніторинг довкілля: Практикум. - К.: Кондор, 2010. - 286 с.*
6. *Бедрій Я.І., Канарський Ю. Екологія довкілля. Охорона природи: Навч. пос. - К.: Кондор, 2015. - 306 с.*
7. *Вишневський В.І. Малі річки Києва, К.: Інтерпрес ЛТД, 2013. – 84 с.*
8. *Набиванець Б.Й., Сухан В.В., Калабіна Л.В. Аналітична хімія природного середовища К.: Либідь, 1996г.*
9. *Radovenchyk V. Development of air quality monitoring system in Kyiv on the way of*

modernization environmental safety of sustainable development / V. M. Radovenchyk, O. I. Ivanenko, T. O. Shabliy, T. V. Krysenko, I. V. Radovenchyk // IOP Series: Earth and environmental science. 2022. P. 1-10.

Information resources on the Internet

1. *Ministry of Environmental Protection and Natural Resources of Ukraine - https://mepr.gov.ua/*
2. *Interactive map of river pollution in Ukraine - – https://texty.org.ua/water/*

2. Industrial ecology. Community of environmental specialists - http://www.eco.com.ua/

3. Professional Association of Ecologists of Ukraine (PAAU) - https://paeu.com.ua/

4. Vernadsky Library – www.nbuv.gov.ua

5. Ecological portal of Ukraine –http://www.ecolog.org.ua/ .

Educational content

5. Methods of mastering the discipline (educational component)

Lecture classes

Lectures are aimed at:

*- providing modern, holistic, interdependent knowledge in the discipline "**Biogeochemistry**", the level of which is determined by the target setting for each specific topic;*

- ensuring in the process of lecturing the creative work of students together with the teacher;

- education of students of professional and business qualities and development of their independent creative thinking;

- formation of the necessary interest in students and providing direction for independent work;

- determination at the current level of development of science in the field of modern ideas about chemical, biological processes taking place in the environment;

- display of methodological processing of the material (allocation of the main provisions, conclusions, recommendations, clear and adequate to their formulations);

- use for demonstration of visual materials, combining, if possible, them with the demonstration of results and samples;

- teaching research materials in a clear and high-quality language in compliance with structural and logical relations, explaining all the newly introduced terms and concepts;

- accessibility for perception by this audience.

No s/p	*Title of the lecture topic and list of main questions (list of didactic means, references to literature and tasks on the IWS)*	*Number of hours*
1	***The origin of the Earth and the emergence of life on Earth.*** *Subject of the course "Biogeochemistry". Theories of the Earth. The concept of the geosphere. Conditions that led to the appearance and stages of the origin and development of life on Earth. Oparin's theory.* *Literature: (1).* *IWS - Properties of the Earth and their ecological significance.*	*2*
2	***Composition of the hydrosphere.*** *The cycle of water in nature. Water resources of Ukraine.* *Literature: (2).* *IWS - Intensity of water migration of chemical elements.*	*2*
3	***Composition and structure of water***	*2*

	Formula and isotopic composition of water. Energy and heat of water formation. Size and formula of the molecule. Condensed water composition. Anomalous physical and chemical properties. *Literature: (1).* *IWS - Types of ice.*	
4	***Composition of natural waters*** *Chemical composition of natural waters and factors that determine it. Ways to express the concentrations of impurities. Formation of chemical composition. Components of the composition of natural waters and their classification.* *Literature: (5d), (7d), (8d).* *IWS - Processes of self-purification of water.*	*2*
5	***The main components in natural waters*** *Forms in solution. Solubility and prevalence of the main components of natural waters.* *Literature: (1), (8d).* *IWS – Forms of representation of concentrations of substances in aquatic environments.*	*2*
6	***Dissolved gases in natural waters*** *Composition and origin of dissolved gases in natural waters. Solubility of gases: oxygen, carbon. Redox potential in PV solutions.* *Literature: (2), (3).* *IWS – Effect of dissolved oxygen and carbon dioxide on the aggressiveness of water.*	***2***
7	***Organic substances, biogenic elements, trace elements in natural waters*** *Definition and methods of estimation of the content of organic substances in natural waters. Sources of organic matter formation, concentration of organic substances in natural waters. Biogenic and microelements in PV.* *Literature: (1), (1d).* *IWS – Forms of finding organic substances in natural waters.*	*2*
8	***Water stability*** *Carbon dioxide equilibrium in natural waters. Aggressive and free carbon dioxide in water. Aggressive action of water on concrete.* *Literature: (1).* *IWS – Non-reactent pollution of reservoirs.*	*2*
9	***Structure and composition of the atmosphere*** *Chemical composition of the atmosphere. Water in the atmosphere and its importance. Natural components of air and sources of their formation: biological, geochemical, atmospheric. Structure of atmosphere. Temperature profile of the atmosphere. Atmospheric circulation.* *Literature: (3).* *IWS - Factors of anthropogenic impact on the climate.*	*2*
10	***Processes in the upper atmosphere*** *Natural radionuclides. Cosmic rays in the atmosphere. The formation of ions in the upper atmosphere.*	*2*

	Literature: (2), (3). *IWS – Solar radiation.*	
11	***Ozone layer of the planet*** *Ozone layer of the planet. Formation and decomposition of ozone. Effects of nitrogen oxides and galagen-supply carbohydrates on the zero ozone cycle.* *Literature: (2), (3).* *IWS – The importance of ozone for the biosphere.*	*2*
12	***Organic compounds in the atmosphere*** *Hydroxyl and hydroperoxide radicals. Photochemical oxidation of methane. Benzene and its homologues in the atmosphere. Aldehydes in the atmosphere. Photochemical smog.* *Literature: (3).* *IWS – Anthropogenic and natural air pollution.*	*2*
13	***Sprays*** *Dispersed systems in the atmosphere. Origin of aerosol particles. Distribution of particles by size.* *Literature: Literature: (1), (6d).* *IWS – Infusion of aerosols on representatives of biota*	*2*
14	***Organic matter in the soil. Characteristics of the pedosphere*** *Organic matter in the soil. Proteins. Carbohydrates. Lignin. Fats. Humic substances. Humus. Biogeochymy of the pedosphere. Gases of the pedosphere.* *Literature: (2d).* *IWS - Stages of lithogenesis.*	*2*
15	***Migration of substances*** *Mechanical migration of substances. physicochemical migrations of substances. Internal migration factors: electrostatic properties of ions, the form in which the element is located, its chemical properties. External factors of migration: temperature regime, pressure, acid-basic environmental conditions, redox conditions. The intensity of migration and the classification of elements by the peculiarities of migration.* *Literature: (1), (3), (4).* *IWS – Forms of concentration of chemical elements in a living substance. Chemical composition of lithosphere and living matter. The Oddo-Harkins Rule. The Fersman Rule*	*2*
16	***Geochemical barriers*** *Intensity of biological absorption. Geochemical barriers: mechanical, physicochemical, biogeochemical. Indicators of geochemical barriers.* *Literature: (1), (3), (6d).* *IWS – Biogeochemical zoning. Ionic and sedimentary runoff as an integral part of the cycle. Biogeochemical endemias.*	*2*
17	***The main groups of biogeochemical functions of living matter*** *The concept of biogeochemical functions and biogeochemical principles of living matter. The main groups of biogeochemical functions of living*	*2*

	matter: gas, concentration, oxidative-renewable, biochemical, biogeochemical functions of man. *Literature: (1), (3), (6d)..* *IWS – Life and its biogeochemical properties (according to V.I. Vernadsky)..*	
18	***Concentrator organisms*** *Varieties of concentration of chemical elements by living matter.* *Literature: (1), (3), (6d)..* *IWS – Bioindicator animals of chemical pollution of the environment.*	*2*
	Total hours	*36*

Laboratory classes

In the system of professional training of students, laboratory classes occupy 50 % of the classroom load. Being an addition to the lecture course, they lay and form the basics of the Bachelor of Ecology qualification. The purpose of laboratory classes is to develop students' experimental skills, a research approach to the study of the subject, fixing theoretical material.

No s/p	*Name of laboratory work*	*Number of classroom hours*
1	*Determination of the main organoleptic indicators of water*	*2*
2	*Determining the color of water*	*2*
3	*Determination of turbidity and transparency of water*	*2*
4	*Determination of water mineralization*	*4*
5	*Determination of alkalinity and acidity of water*	*4*
6	*Determination of water hardness*	*4*
7	*Determination of the active reaction of water*	*2*
8	*Determination of permanganate oxidation of water*	*4*
9	*Determination of water aggressiveness*	*6*
10	*Determination of concentrations of free and aggressive carbon dioxide by nomograms*	*4*
11	*Control work from sections 1-6*	*2*
Total hours		*36*

6. Independent work of a student

Independent work takes 40 % of the time to study the credit module, including preparation for the test. The main task of independent work of students is the mastery of scientific knowledge in areas that are not included in the list of lecture issues through personal search for information, the formation of an active interest in creative approach in educational work. In the process of independent work within the educational component, the student must learn to deeply analyze modern knowledge on the transformation of chemical compounds of natural and anthropogenic origin in environmental conditions.

No s/p	Name of the topic submitted for self-study	Number of hours of IWS
Section 1. **Chemical transformations and evolutionary processes on Earth**		
1	The properties of the Earth and their ecological significance. Literature: (1).	1
Section 2. **Physicochemical processes in the hydrosphere**		
2	Intensity of water migration of chemical elements. Literature: (4d), (5d). Types of ice. Literature: (2d). Forms of finding organic matter in natural waters. Literature: (4), (8d). Processes of self-purification of water. Literature: (1d), (3). The effect of dissolved oxygen and carbon dioxide on the aggressiveness of water. Literature: (6d). Non-reactant pollution of water bodies. Literature: (5d), (7). Forms of representation of concentrations of substances in aquatic environments. Literature: (8d).	24
Section 3. **Physicochemical processes in the atmosphere**		
3	Factors of anthropogenic impact on climate. Literature: (5d). Solar radiation. Literature: (1). Anthropogenic and natural air pollution. Literature: (5d). The importance of ozone for the biosphere. Literature: (3) The infusion of aerosols on representatives of biota. Literature: Literature: (5d).	5
Section 4. **Organic compounds in the pedosphere**		
4	Stages of lithogenesis. Literature: (1).	1
Chapter 5 **Migration and conversion of chemical elements in the environment**		
5	Biogeochemical zoning. Literature: (3), (6d). Forms of concentration of chemical elements in living matter. Literature: (3), (4d). Ionic and sedimentary runoff as an integral part of the cycle. Literature: (1)	5

	Chemical composition of lithosphere and living matter. The Oddo-Harkins Rule. The Fehrsman Rule. *Literature: (1).* *Biogeochemical endemias.* *Literature: (1d).*	
Chapter 6 ***Biogeochemical functions of living matter***		
6	*Life and its biogeochemical properties (according to V.I. Vernadsky).* *Literature: (1).* *Bioindicator animals of chemical pollution of the environment.* *Literature: (1).*	*2*
7	*Preparation for the standings*	*5*
8	*Preparation for MCT*	*5*
Total hours		*48*

Politics and control

7. Policy of discipline (educational component)

Rules for attending classes and behavior in classes

Students are obliged to take an active part in the educational process, not to be late for classes and not to miss them without a good reason, not to interfere with the teacher to conduct classes, not to be distracted by actions that are not related to the educational process.

Rules for assigning incentive and penalty points

encouraging points can be credited by the teacher only for the performance of creative works in the discipline or additional passage of online specialized courses with the receipt of the appropriate certificate:

- https://www.coursary.com/course/water-quality-and-the-biogeochemical-engine-KZz04c8a?fromfld=lpads&req=wst&refsrc=gg

- https://ru. coursera. org/learn/global-warming

- https://ru. coursera. org/learn/chemicals-health

- https://alison.com/courses/diploma-in-environmental-quality-monitoring-and-analysis/content

However, their amount cannot exceed 10 % of the rating scale.

Penalty points within the discipline are not provided.

Deadline and overlay policy

In case of debts in the discipline or any force majeure circumstances, students should contact the teacher through accessible (provided by the teacher) communication channels to solve problematic issues and coordinate the algorithm of actions for working out.

Academic Integrity Policy

Plagiarism and other forms of dishonest work are unacceptable. Plagiarism includes the absence of references when using printed and electronic materials, quotes, opinions of other authors. Invalid hints and write-offs when writing tests, conducting classes; passing the credit for another student; copying of materials protected by the copyright system without the permission of the author of the work.

The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"https://kpi.ua/code.

Policy of academic behavior and ethics

Students should be tolerant, respect the opinion of others, object to formulate in the correct form, constructively maintain feedback in the classroom.

The norms of ethical behavior of students and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"https://kpi.ua/code.

8. Types of control and rating system for evaluating learning outcomes (RCOs)

Distribution of educational time by types of classes and tasks in the discipline according to the working curriculum:

Semester	School time		Training hours				Control measures		
	Loans	akad.h	Lectz.	Pract.	Lab	IWS	MCT	KR	Semester certification
4	4	120	36	-	36	48	1	--	test

The student's rating from the credit module consists of points that he receives for:

1. three control works (MCT is divided into 3 works lasting 30 minutes),

2. work in 7 laboratory classes.

System of rating (weight) points and evaluation criteria:

1. Modular control.

Weight point – 10. The maximum number of points for all control works is equal to:

10 points x 3 robots = 30 points

The task of the control work consists of test questions (20 units) to the corresponding sections of the syllabus of the credit module.

Each question of the control work is estimated at 0.5 points.

2. Work in laboratory classes.

Weight point – 10. The maximum number of points in all laboratory works is: 10 points x 7 l /r = 70 points

Criteria for assessing students' knowledge

Mark	Completeness of the answer
10	Timely full implementation of l/r, settlements according to the experiment, registration and protection of l/r
8-9	Minor deficiencies in paragraph 1
6-7	Untimely protection of l/r
4-5	Late implementation of l/r
1-3	Late implementation of l/r, shortcomings in calculations and design of l/r
0	Non-fulfillment of l/r

Thus, the rating scale of the discipline is:

*R=10*3+10*7=100 points*

According to the results of educational work for the first 7 weeks, the "ideal student" should score 40 points. At the first certification (8th week), the student receives "enrolled" if his current rating is not less than 20 points.

According to the results of educational work for 13 weeks of study, the "ideal student" should score 90 points. At the second certification (week 14), the student receives "enrolled" if his current rating is not less than 45 points.

The maximum amount of points is 100. To obtain a credit module score from the "automatic" module, you need to have a rating of at least 60 points.

Students who have a rating of less than 60 points at the end of the semester, as well as those who want to increase their grade, perform scoring control work (test). At the same time, the points received by the student during the semester are canceled.

Each question of the test (100 units) is estimated at 1 point.

Points	*Score*
95...100	*Perfectly*
85...94	*Very good*
75...84	*Well*
65...74	*Satisfactory*
60...64	*Enough*
less than 60	*Disappointing*
Uncalculated practical work or R_C<30	*not allowed*

Credit module work program (syllabus):
Compiled *prof., Doctor of Technical Sciences, Shabliy T.O.*

Approved *by the* ***Ecology and technology of plant polymers*** *(protocol No 17 from 23.05.2024)*
Approved *by the CEF Methodical Commission (protocol No.10 of 28.06.2024)*