NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

General Ecology, Radiobiology and Life Safety Department

"CONFIRMED"
Dean of Faculty of Plant Protection,
Biotechnology and Ecology
_____ Julija KOLOMIJETS
«18» May 2023, protocol № 9

"APPROVED"
at the meeting of the department of General Ecology
Radiobiology and Life Safety
Protocol № 9 dated «19» 04 2023
Head of Department
_____ Alla KLEPKO

"REVIEWED"
Program Coordinator of the educational and professional
program "Ecology and Environmental protection"
_____ (Gaychenko V.A.)

PROGRAM OF THE COURSE

"RECENT METHODS IN RADIATION RESEARCH"

Specialization:	101 - Ecology
Educational program:	«Ecology and Environmental Protection»
Faculty:	Plant protection, biotechnology and ecology
Developers:	Volodymyr Illienko , PhD in Biology, senior lecturer of General Ecology, Radiobiology and Life Safety Department Alla Klepko , PhD in Biology, docent of General Ecology, Radiobiology and Life Safety Department

Kyiv – 2023

1. Description of the course

RECENT METHODS IN RADIATION RESEARCH

(name)

Field of knowledge, specialization, educational program, educational degree		
Educational degree	*Master's*	
Specialization	*101 Ecology*	
Educational program	*"Ecology and Environmental Protection"*	
Characteristics of the course		
Mode	Compulsory	
Total number of hours	120	
Number of credits ECTS	4	
Number of meaningful modules	3	
Course project (work) (if available)	-	
Form of control	*Exam*	
Indicators of the course for full-time and part-time forms of study		
	Full-time form of study	Part-time form of study
Year of study (course)	2	-
Semester	1	-
Lectures	*20 hours*	*- hours*
Practical and seminar lessons	*20 hours*	*- hours*
Laboratory practical	*- hours*	*- hours*
Self-dependent work	*80 hours*	*- hours*
Self-dependent work	*- hours*	*hours*
Week hours for full-time education	*4 hours*	

2. Purpose, objectives, and competencies of the course

The goal of teaching "Biological Methods in Radiation Research" is to provide students with knowledge about the possibilities of using living organisms to determine the ability of radioactive isotopes migration in the environment and living organisms (income, output, accumulation) and the use of labeled isotopes in biological research.

The task is to provide opportunities for using the acquired knowledge and skills to describe, analyze and predict the accumulation of radioactive isotopes and their migration in the environment under conditions of limited information, as well as for the implementation of master's thesis.

After finishing of course students have to

The student should know the characteristics of ionizing radiation and the physico-chemical basis of the interaction of ionizing radiation with substances, methods of radiometry and spectrometry of ionizing radiation, physical and chemical properties of natural and artificial radioactive isotopes of chemical elements, the basis of statistical processing of experimental data.

Student should be able to:

- measure the specific, volume radioactivity for α-, β-, γ-radionuclides;
- carry out experimental research using the method of labeled atoms and compounds;
- conduct an autorediography;
- properly describe, analyze and formalize the results of their own experimental studies;
- formulate logical conclusions.

Acquisition of competencies:

general competencies (GC):

1. Ability to learn and acquire modern knowledge.
2. Ability to make informed decisions.
3. Ability to generate new ideas (creativity).
5. Ability to communicate in a foreign language.
6. Ability to search, process and analyze information from various sources.

professional (special) competencies (PC):

5. Ability to apply interdisciplinary approaches in critical understanding of environmental issues.

8. Ability to apply new approaches to the analysis and prediction of complex phenomena, critical understanding of problems in professional activities.

10. Ability to prove knowledge and own conclusions to specialists and non-specialists.

11. Ability to organize work related to environmental assessment, environmental protection and optimization of nature use, in conditions of incomplete information and conflicting requirements.

Program learning outcomes (PLO):

1. Know and understand fundamental and applied aspects of environmental sciences.

2. Be able to use conceptual environmental patterns in professional activity.

3. Know at the level of the latest achievements the basic concepts of natural science, sustainable development and methodology of scientific knowledge.

7. Be able to communicate in a foreign language in scientific, industrial and social spheres of activity.

9. Know the principles of personnel management and resources, basic approaches to decision-making in conditions of incomplete/insufficient information and conflicting requirements.

10. Demonstrate awareness of the latest principles and methods of environmental protection.

11. Be able to use modern information resources on ecology, nature management and environmental protection.

12. Be able to evaluate landscape and biological diversity and analyze the consequences of anthropogenic impact on natural environments.

14. Apply new approaches to production decision-making strategies in complex, unpredictable conditions.

16. Choose the optimal management and/or nature management strategy depending on environmental conditions.

17. Critically interpret theories, principles, methods and concepts from various subject areas for solutions practical tasks and problems of ecology.

18. Be able to use modern methods of information processing and interpretation when carrying out innovation activity.

3. PROGRAM AND STRUCTURE OF THE COURSE FOR:

– complete full-time (part-time) form of study

№	Topic	The topic content, recommended literature	Types of educational activity, hours.		
			lectures	practical training	independent work
Module 1. Migration of radioactive substances in the environment and microorganisms					
1.1.	Features of the radionuclides migration in the environmental objects	Foliar uptake of radionuclides into plants. Receipt of soluble radionuclides in plants from the air. Influence of physico-chemical properties of radionuclides on their transition from soil to plants through the roots. Influence of biological characteristics of plants, phases of their development and physiological state on the transition of radionuclides from the soil to plants. Features of migration of radionuclides in forest biogeocoenoses. Ways of radionuclides uptake into the body of animals. Quantitative indices of accumulation of radionuclides in the animal body: concentration factor (CF), absorption coefficient (C_a), biological elimination half-life of radionuclides (T_{biol}). The main ways of radionuclides withdrawal from the body of animals. *Literature: 1-6*	2	-	8
1.2	Metabolism of uranium and products of its disintegration in contaminated natural ecosystems	Interaction of microorganisms with elements of nuclear fuel. Extremely radio-resistant microorganisms. Mechanisms of various interactions of bacteria and uranium: bioreduction, biomineralization, biosorption and bioaccumulation.	2	4	8

		Literature: 1, 2, 4, 8-11, 23			
1.3	Features of cesium and strontium migration in the environment	Metabolism of strontium in natural contaminated ecosystems. Biogeochemistry of cesium and its interaction with soil microorganisms. Accumulation of ^{137}Cs by bacteria and their effect on the biological availability of radionuclides.	2	2	8
		Literature: 1, 4, 8, 16-20			
	Module 2. Influence of microorganisms on the state of radionuclides in the soil and their accumulation by plants				
2.1	The role of microorganisms in the fixation and migration of ^{137}Cs and ^{90}Sr in soil	Dependence between type of soil, mineral content and rate of radionuclide migration. Bacteria and actinomycetes as factors of influence on the redistribution of isotopes in the soil. Symbiosis of plants and fungi - ectotrophic and endotrophic mycorrhiza.	2	4	8
		Literature: 8, 11, 15, 21			
2.2	Changing the bioavailability of ^{137}Cs under the influence of soil microflora	Bacteria-components of bio-fertilizers and their application in agriculture. Inoculation and bacterization of seeds to reduce the accumulation of radionuclide in biomass of plants under different growing conditions.	2	2	8
		Literature: 8, 11, 21			
2.3	The method of isotopic indicators in biology and ecology	Labeled atoms. Radioactive and stable isotopes. Labeled compounds. Indicative dose. Basic ways of using isotopic indicators in research with plants. Investigation of transport and distribution of separate elements in plant. Features of the use of radioactive isotopes in vegetative and field studies. Radioautography. Features of the use of stable isotopes.	2	-	8
		Literature: 1-3, 8, 11, 19, 21			
	Module 3. Radiosensitivity of microorganisms and their diversity in territories contaminated with radionuclides				
3.1	Radiosensitivity	Extremely radioresistant bacterium	2	-	8

	of microorganisms	*Deinococcus radiodurans, Arthrobacter radiotolerans*. Isolation of strains of radiosensitive bacteria in an environment with extreme conditions of existence. Radiosensitivity of micromycetes. *Literature: 8-11*			
3.2	Classical approaches to estimating the diversity of bacterial microflora in radionuclide contaminated soil	Assessment of microbial cenosis of territories contaminated by radioactive isotopes after the Chernobyl accident. Level of radioactivity of soil and biodiversity of soil microflora. Determination of soil cellulosic activity. Dynamics of ecological and trophic groups of soil microorganisms on contaminated radionuclide territories. *Literature: 1, 8, 16*	2	-	8
3.3	New technologies in the evaluation of soil microflora diversity	Metagenomics as a complex branch of knowledge. Metageno data analysis. Sequencing metagenoids. Bioinformatics analysis of 16s rRNA metagenome data. Metadata in metagenome analysis and their integration. Determination of the main metrics of biodiversity. Check the quality of the sequencing data by the FastQC program. MetaGenom data preprocessing in the QIIME software package. Clustering metagenome data in QIIME. *Literature: 1, 8, 16, 22-25*	2	4	8
3.4	Selection of methodology for bioinformatic processing of DNA sequencing results from soils contaminated with radionuclides	Concentration of the isolated DNA. The general biodiversity of microbial soils of the Chornobyl NPP exclusion zone. Biodiversity metrics. Calculation of alpha microbioma diversity. Calculation of microbial beta diversity. Functional microbial reconstruction. Working with PICRUSt. Working with HUMAnN. Visualization of data and the construction of clusters. *Literature: 1, 8, 16, 19-21*	2	4	8
		Total:	**20**	**20**	**80**

4.Topics of seminars

№ s/n	Topic name	Number of hours
	not provided	

5. Topics of practical classes

№ s/n	Topic name	Number of hours
1	Sequential extraction method for isolation of physicochemical forms of radionuclides	2
2	Soil sampling methods for radiometric studies	4
3	Calculation of the required number of samples in the field study of radionuclide contaminated areas	2
4	Size and charge fractionation methods	2
5	Atmosphere dispersion. Discharge to the atmosphere H>2.5 H_B (CROM tool)	2
6	Measuring the width of annual rings and the length of needles using the free ImageJ software.	4
7	Data analisis from uptake experiment with Blue mussels.	4
	Total	20

6. Topics of laboratory classes

№ s/n	Topic name	Number of hours
1	not provided	-

8. Samples of control questions, tests for assessing the level of knowledge acquisition by students.

<table>
<tr><td colspan="5">National University of Life and Environmental Sciences of Ukraine</td></tr>
<tr><td>Master 2st year study Specialty Radioecology</td><td>General Ecology, Radiobiology and Life Safety Department</td><td colspan="2">Test № 1 from the course Biological methods in radiation research</td><td>Approved Head of department
_____</td></tr>
<tr><td colspan="5">Questions</td></tr>
<tr><td colspan="5">1. Radiobiological effect of radiation stimulation and its application in practice.</td></tr>
<tr><td colspan="5">2. Mechanisms of electromagnetic ionizing radiation interaction with a living cell.</td></tr>
<tr><td colspan="5">Tests</td></tr>
<tr><td>1.</td><td colspan="4">Water has _____ action
a) Radiosensitizing; b) Radioprotective; c) Both; d) There is no correct answer</td></tr>
<tr><td>2.</td><td colspan="4">What element has an antagonist with Cs?
a) Sr; b) Ca; c) K; d) Pb</td></tr>
<tr><td>3.</td><td colspan="4">What phase of cell cycle is the most radiosensitive?
a) S; b) G_1; c) M; d) G_2</td></tr>
<tr><td>4.</td><td colspan="4">Arrange the correct links on types of radionuclides distribution in animals (few radionuclide can respond to one type)
<table><tr><td>1</td><td>bone</td></tr><tr><td>2</td><td>diffuse</td></tr><tr><td>3</td><td>reticuloendothelial</td></tr></table><table><tr><td>a</td><td>Transuranic elements</td></tr><tr><td>b</td><td>Cs</td></tr><tr><td>c</td><td>Sr</td></tr><tr><td>d</td><td>Rb</td></tr><tr><td>e</td><td>Pu</td></tr></table></td></tr>
<tr><td>5.</td><td colspan="4">Critical tissue in plants are:
a) phloem; b) xylem; c) meristem; d) parenchyma</td></tr>
<tr><td>6.</td><td colspan="4">Which of the natural potassium isotopes is radioactive?
a) ^{39}K; b) ^{40}K; c) ^{41}K; d) ^{42}K</td></tr>
<tr><td>7.</td><td colspan="4">Among vertebrate animals, the highest radioresistance have:
a) fishes; b) birds; c) mammals; d) reptile</td></tr>
<tr><td>8.</td><td colspan="4">A critical organ to ^{14}C is:
a) eye lens; b) bone tissue; c) spleen; d) fatty tissue</td></tr>
<tr><td>9.</td><td colspan="4">To construct the survival curve is carried out:
a) experiments in vacuum conditions; b) experiments on the neutralization of ionizing radiation; c) experiments with irradiation in different doses;
d) experiments on irradiation in stimulating doses</td></tr>
<tr><td>10.</td><td colspan="4">The most effective way of removing ^{137}Cs from the organism of mammals:
a) through the kidneys; b) through sweat glands; c) through the mammary gland; d) through the gastrointestinal tract</td></tr>
</table>

9. Teaching methods

The main form of knowledge control is to conduct modular tests and tests. Based on the results of modular tests, the main score is derived, which is translated into rating points. To them are added points for oral knowledge in each content module.

10. Forms of assessment

According to the "Regulations on examinations and assessments at the National University of Bioresources and Nature Management of Ukraine", approved by the academic council of the National University of Bioresources and Nature Management of Ukraine on April 26, 2023, protocol No. 10, the types of knowledge control of higher education students are current control, intermediate and final attestation.

Current control of the discipline is carried out during practicals, and aims to check the level of preparedness of higher education applicants to perform a specific job.

Intermediate attestation is conducted after studying the program material and should determine the level of knowledge of higher education students in the program material obtained during all types of classes and independent work.

Form of intermediate certification - testing,

The assimilation of the program material by the student of higher education is considered successful, if its rating is at least 60 points on a 100-point scale.

Semester certification is conducted in the form of a semester exam.

Applicants of higher education are required to take exams and tests in accordance with the requirements of the working curriculum within the time limits provided by the schedule of the educational process. The content of the exam is determined by the working curriculum of the discipline.

11. Distribution of points received by students

Evaluation of student knowledge is carried out on a 100-point scale and is converted to national grades according to Table 1 "Regulations and Examinations and Credits at NULES of Ukraine" (order of implementation dated 26.04.2023)

Student rating, points	**National grade based on exam results**	
	Exams	**Credits**

90-100	**Excellent**	**Passed**
74-89	**Good**	
60-73	**Satisfactory**	
0-59	**Unsatisfactory**	**Not passed**

In order to determine the rating of a student (listener) in the discipline $\mathbf{R_{dis}}$ (up to 100 points), the rating from the exam $\mathbf{R_{ex}}$(up to 30 points) is added to the rating of a student's academic work $\mathbf{R_{aw}}$ (up to 70 points): $\mathbf{R_{dis} = R_{aw} + R_{ex}}$.

12. Educational and methodological support.

1. Choppin G. R., Liljenzin J.-O., Rydberg J. Radiochemistry and nuclear chemistry. 4th ed., Academic Press, 2013, 858 p.
2. Radiation biology: a handbook for teachers and students. International Atomic Energy Agency, VIENNA, 2010, 150 p.

13. Recommended sources of information

1. Chernobyl: 30 Years of Radioactive Contamination Legacy. Report. Lead writer and coordination of report: Prof. Valerii Kashparov, Kyiv, 2016, 59 p.
2. Climate change and nuclear power. International Atomic Energy Agency, VIENNA, 2005, 112 p.
3. Natural and induced radioactivity in food. International Atomic Energy Agency, VIENNA, 2002, 136 p.
4. Gleyzes, C., Tellier, S. & Astruc, M. Fractionation studies of trace elements in contaminated soils and sediments: a review of sequential extraction procedures. Trac-Trends in Analytical Chemistry, 21 (6-7), 2002, p. 451-467.
5. International Atomic Energy Agency Safety Standards Series No. RS-G-1.8, Environmental and Source Monitoring for Purposes of Radiation Protection for

protecting people and the environment, Safety Guide, IAEA, VIENNA, 2005, p.119.
6. He, Z. L. L., Yang, X. E. & Stoffella, P. J. Trace elements in agroecosystems and impacts on the environment. Journal of Trace Elements in Medicine and Biology, 19 (2-3), 2005, p. 125-140.
7. Lind, O.C., Salbu, B., Janssens, K., Proost, K., García-León, M., García-Tenorio, R. Characterization of U/Pu particles originating from the nuclear weapon accidents at Palomares, Spain, 1966 and Thule, Greenland, 1968. Science of the Total Environment, 376, 2007, p. 294–305.
8. Salbu, B. Fractionation of radionuclide species in the environment. Journal of Environmental Radioactivity, 100 (4), 2009, p. 283-289.
9. Tessier, A., Campbell, P. G. C. & Bisson, M. Sequential extraction procedure for the speciation of particulate trace-metals. Analytical Chemistry, 51 (7), 1979, p. 844-851.
10. Гудков І.М. Радіобіологія: підручник. – Херсон : Олді-Плюс, 2016. – 504 с.
11. Гудков І.М., Гайченко В.А., Кашпаров В.О. Сільськогосподарська радіоекологія: підручник. – К.: Ліра-К, 2017. – 268 с.
12. Моисеев А.А., Иванов В.И. Справочник по дозиметрии и радиационной гигиене. - М.: Энергоатомиздат, 1990. - 252с.
13. НРБУ-97/2000
14. Пристер Б.С., Лощилов Н.А., Немец О.Ф., В.А. Поярков. Основы сельскохозяйственной радиологии. - К.: -Урожай, 1991.- 472с.
15. Хомутінін Ю.В., Кашпаров В.О., Жебровська К.І. Оптимізація відбору і вимірювань проб при радіоекологічному моніторингу, Монографія. – К.: Український науково–дослідний інститут сільськогосподарської радіології, 2002, 160 с.
16. Радиационный мониторинг облучения населения в отдаленный период после аварии на Чернобыльской АЭС, Рабочий Документ: ТС проект RER/9/074, Вена, Австрия, 2006, 81с.
17. Паренюк О.Ю., Іллєнко В.В., Гудков І.М. Мікрофлора забруднених радіонуклідами ґрунтів. – К.: Вид-во НУБіП України, 2018. – 198 с.
18. Бондар О.І., Фещенко В.П., Гудков І.М., Гуреля В.В. Радіоекологічний термінологічий словник (україно-англійсько-російський). – Житомир: ПП Експертний центр Укреколбіокон, 2018. – 254 с.
19. Якість ґрунту. Методи відбору проб ґрунту для радіаційного контролю, СОУ 74.14-37-425:2006.
20. Якість ґрунту. Визначення щільності забруднення території сільськогосподарських угідь радіонуклідами техногенного походження, СОУ 74.14-37-424:2006
21. Якість продукції рослинництва. Методи відбору проб для радіаційного контролю, СОУ 01.1-37-426:2006.
22. Якість продукції тваринництва. методи відбору проб для радіаційного контролю, СОУ 01.2-37-427:2006.
23. Якість продукції тваринництва. Проведення прижиттєвого контролю тварин на територіях, забруднених радіонуклідами, СОУ 01.2-37-428:2006.

INFORMATION RESOURCES:

1. https://www.iaea.org/publications
2. https://web.archive.org/web/20110515164252/http://www-pub.iaea.org/MTCD/publications/PDF/INES-2009_web.pdf
3. https://www.who.int/news/item/05-09-2005-chernobyl-the-true-scale-of-the-accident
4. https://www.iaea.org/newscenter/news/fukushima-nuclear-accident-update-log-15
5. http://www.unscear.org/docs/reports/2008/11-80076_Report_2008_Annex_C.pdf
6. https://www.wright.edu/sites/www.wright.edu/files/page/attachments/radiation-safety-biological-effects-of-ionizing-radiation.pdf
7. https://doi.org/10.1016/j.jenvrad.2008.12.013
8. https://doi.org/10.1007/978-3-319-22171-7