НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ БІОРЕСУРСІВ І ПРИРОДОКОРИСТУВАННЯ УКРАЇНИ

Кафедра загальної екології, радіобіології та безпеки життєдіяльності

„ЗАТВЕРДЖУЮ”
Декан факультету захисту рослин,
біотехнологій та екології
_____ Юлія КОЛОМІЄЦЬ
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«СХВАЛЕНО»
на засіданні кафедри загальної екології,
радіобіології та безпеки життєдіяльності
Протокол №9 від “ _19 ” _04_2023 р.
Завідувач кафедри
_____Алла КЛЕПКО

«РОЗГЛЯНУТО»
Гарант ОПП Екологія
_____Віталій ГАЙЧЕНКО

РОБОЧА ПРОГРАМА НАВЧАЛЬНОЇ ДИСЦИПЛІНИ

«ЕКСПЕРИМЕНТАЛЬНА РАДІОЕКОЛОГІЯ»

Спеціальність 101 «Екологія»
Освітня програма Освітньо-професійна програма «Екологія та охорона навколишнього середовища» другого (магістерського) рівня вищої освіти
Факультет захисту рослин, біотехнологій та екології
Розробники: ст. викладач, канд. біол. наук Іллєнко Володимир Віталійович

Київ – 2023

1. Description of the course

Experimental Radioecology
(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)	1	-
Semester	2	-
Lectures	*30 hours*	*- hours*
Practical and seminar lessons	*15 hours*	*- hours*
Laboratory practical	*- hours*	*- hours*
Self-dependent work	*75 hours*	*- hours*
Self-dependent work	*- hours*	*hours*
Week hours for full-time education	*3 hours*	

2. Purpose, objectives, and competencies of the course

The purpose of teaching the discipline "Experimental Radioecology" is to study the sources of ionizing radiation in the environment, migration of radioactive substances in different ecosystems, features of physicochemical forms of radionuclides and assessment of environmental impact and risks associated with radioactive contamination. Formation of abilities and skills of carrying out radioecological researches with use of radioactive isotopes, methods of radiochemical separation and modern methods of measurement.

The task is to provide opportunities to use 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 to perform a master's thesis.

After finishing of course students should to

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.

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 autoradiography;
- 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 communicate in a foreign language.
4. Ability to search, process and analyze information from various sources.
5. The ability to motivate people and move towards a common goal.

professional (special) competencies (PC)::

1. Ability to apply interdisciplinary approaches in critical understanding of environmental issues.
2. Ability to apply new approaches to the analysis and prediction of complex phenomena, critical understanding of problems in professional activities.
3. Ability to prove knowledge and own conclusions to specialists and non-specialists.
4. Ability to organize work related to environmental assessment, environmental protection and optimization of nature use, in conditions of incomplete information and conflicting requirements.
5. Ability for self-education and training based on innovative approaches in the field of ecology, environmental protection and sustainable use of nature.

6. Ability to independently develop environmental projects by creatively applying existing ideas and generating new ideas.

7. Ability to assess the level of negative impact of natural and anthropogenic environmental hazards on the environment and humans.

Program learning outcomes (PLO):

1. Be able to use conceptual environmental patterns in professional activities.

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

3. Be able to communicate in a foreign language in scientific, industrial and social spheres of 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. Radionuclides in the environment				
1.1.	Consequences of the largest radiation accidents and prospects for the use of contaminated areas for research	**Know** main reasons and consequences of the largest nuclear and radiation accidents and incidents: the Kyshtym disaster (1957), Windscale fire (1957), Three Mile Island accident (1979), the Chernobyl disaster (1986), Fukushima nuclear disaster (2011) **Understand** how artificial radionuclides have affected the environment and human health	4	-	9
		Literature: 1-8			
1.2.	Biological effects of ionizing radiation. Assessing impacts of ionizing radiation to man and the environment (principles,	**Know** what is radiobiological effect. Dose/Effect curve. The main radiobiological effects in plants, animals and humans. Biomarkers that are sensitive to the dose of ionizing radiation. **Understand** models of risk from radiation exposure: no-threshold (LNT), Sub-linear, Threshold, Hormesis.	4	-	7

	mechanisms, biomarkers)				
		Literature: 1-5, 7,8			
1.3.	Speciation of radionuclides in the environment	**Know** the concept of speciation of radionuclides. How the speciation of radionuclides influences ecosystem transfer, biological uptake and effects. **Understand** which chemical properties would influence the mobility/migration of trace elements/radionuclides in ecosystems and biological uptake in organisms.	4	2	6
		Literature: 1-5, 7,8			
		Module 2. Experiment in radioecological research			
2.1	Field sampling and statistics in radioecology	**Know** the soil sampling methods for radiation control. Requirements for sampling devices and equipment. General requirements for the selection of test sites. Gamma survey of the surveyed area. Sampling. Soil sampling in rural settlements, on agricultural lands and in natural landscapes. Sampling in case of local emergency radioactive contamination of the territory. Marking, transportation, storage and disposal of samples. **Understand** requirements for sampling devices and equipment. Determination of homogeneity of radioactive contamination. Sampling of plant products in storage places or during its transportation, in the field.	2	3	6
		Literature: 6-10			
2.2	Particularities of radionuclide contamination measurements	**Know** requirements for error in determining the density of radioactive soil contamination. Determination of the number of soil samples to estimate the median density of radioactive contamination of the soil at the elementary site. **Understand** requirements for soil sampling and preparation and measurement of radionuclide activity in them.	2	2	6
		Literature: 6-8,11			
2.3	Radioactive particles and solid state speciation	**Know** the definition: particles - colloids - LMM species. Size categories for different physico-chemical forms of radionuclides. **Understand** mobility and bioavailability of different physico-chemical forms of radionuclides.	2	2	10

		Literature: 6-8,13			
2.4.	Modeling within radioecology	**Know** models and tools that can be used: CROM, RESRAD, HOTSPOT, ERICA. **Understand** how to use different models and software (tools) to solve specific problems in assessing environmental pollution by radioactive isotopes.	4	2	10
		Literature: 1-5, 7,8			
		Module 3. Features of studying the state of radioactive isotopes under different conditions			
3.1	Distribution, main fluxes and deposits of biologically active radionuclides (^{137}Cs and ^{90}Sr) in forest ecosystems.	**Know** the cycle and redistribution of biologically mobile radionuclides in forest stands after the Chernobyl accident in 1986. **Understand** ways to measure the parameters of forest stands and estimation the stock of above-ground biomass of forests.	2	2	7
		Literature: 1-5, 7,8			
3.2.	Radioecology of fresh and salt water	**Know** the features of radionuclide migration in water bodies. Levels of natural radionuclides in the oceans, main sources of man-made radionuclides and additional sources of natural radionuclides from man-made processes. Behavior and fate of radionuclides, distribution coefficients, speciation, sedimentation, post-sedimentation processes, processes in different marine environments. **Understand** estuarine processes, the potential long-range river transport of radionuclides. Overview of marine environmental and human dose assessments, IAEA methodology.	2	2	7
		Literature: 1-5, 7,8			
3.3	Terrestrial radioecology, transfer and countermeasures	**Know** sources of radionuclides, physical transport and biological transfer, countermeasures, summarized transfer data – IAEA TRS. **Understand** data-gap filling methodology, the goal of countermeasures, countermeasures for different isotopes	4	-	7
		Literature: 1-3, 7			

		Total:	**30**	**15**	**75**

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	3
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.	2
7	Data analisis from uptake experiment with Blue mussels.	2
	Total	15

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.

National University of Life and Environmental Sciences of Ukraine			
Master 1st year study Specialty Radioecology	General Ecology, Radiobiology and Life Safety Department	Test № 1 from the course Experimental Radioecology	Approved Head of department _____
Questions			
1. Which are the key sources contributing to doses from ionizing radiation to the population in Ukraine?			
2. How can the radionuclide speciation influence the choice of countermeasures? Give minimum 3 examples of countermeasures that can reduce the biological uptake of radionuclides in animals and humans and explain your choices.			
Tests			
1.	1 Sievert is equal to ... ber		

<table>
<tr><td>2.</td><td>What element has an antagonist with Cs?
a) Sr; b) Ca; c) K; d) Pb</td></tr>
<tr><td>3.</td><td>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>Arrange the correct links on types of radionuclides distribution in animals (few radionuclides 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>Critical tissue in plants are:
a) phloem; b) xylem; c) meristem; d) parenchyma</td></tr>
<tr><td>6.</td><td>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>Among vertebrate animals, the highest radioresistance have:
a) fishes; b) birds; c) mammals; d) reptile</td></tr>
<tr><td>8.</td><td>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>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>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 R_{dis} (up to 100 points), the rating from the exam R_{ex}(up to 30 points) is added to the rating of a student's academic work R_{aw} (up to 70 points): $R_{dis} = R_{aw} + R_{ex}$.

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

3. Chernobyl: 30 Years of Radioactive Contamination Legacy. Report. Lead writer and coordination of report: Prof. Valerii Kashparov, Kyiv, 2016, 59 p.
4. Climate change and nuclear power. International Atomic Energy Agency, VIENNA, 2005, 112 p.
5. Natural and induced radioactivity in food. International Atomic Energy Agency, VIENNA, 2002, 136 p.
6. 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.
7. 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.
8. 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.
9. 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.
10. Salbu, B. Fractionation of radionuclide species in the environment. Journal of Environmental Radioactivity, 100 (4), 2009, p. 283-289.

Supporting literature

11. 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.
12. Гудков І.М. Радіобіологія: підручник. – Херсон : Олді-Плюс, 2016. – 504 с.
13. Гудков І.М., Гайченко В.А., Кашпаров В.О. Сільськогосподарська радіоекологія: підручник. – К.: Ліра-К, 2017. – 268 с.
14. Моисеев А.А., Иванов В.И. Справочник по дозиметрии и радиационной гигиене. - М.: Энергоатомиздат, 1990. - 252с.
15. НРБУ-97/2000
16. Пристер Б.С., Лощилов Н.А., Немец О.Ф., В.А. Поярков. Основы сельскохозяйственной радиологии. - К.: -Урожай, 1991.- 472с.
17. 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.

18. Радиационный мониторинг облучения населения в отдаленный период после аварии на Чернобыльской АЭС, Рабочий Документ: ТС проект RER/9/074, Вена, Австрия, 2006, 81с.
19. Паренюк О.Ю., Іллєнко В.В., Гудков І.М. Мікрофлора забруднених радіонуклідами ґрунтів. – К.: Вид-во НУБіП України, 2018. – 198 с.
20. 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.
21. Якість ґрунту. Методи відбору проб ґрунту для радіаційного контролю, СОУ 74.14-37-425:2006.
22. Якість ґрунту. Визначення щільності забруднення території сільськогосподарських угідь радіонуклідами техногенного походження, СОУ 74.14-37-424:2006
23. Якість продукції рослинництва. Методи відбору проб для радіаційного контролю, СОУ 01.1-37-426:2006.
24. Якість продукції тваринництва. методи відбору проб для радіаційного контролю, СОУ 01.2-37-427:2006.
25. 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