NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

Radiobiology and Radioecology Department

"CONFIRMED"
Acting Dean of Faculty of Plant Protection,
Biotechnology and Ecology
_____ J.V. Kolomiets
"___" _____ 2020

CONSIDERED AND APPROVED
at the meeting of Radiobiology and Radioecology Department
Protocol №_12_ from "_17_" _June___2020 p.
Head of the Department
_____ A.V. Klepko

CURRICULUM WORKING PROGRAM

"BIOLOGICAL METHODS IN RADIATION RESEARCH"

Specialty:	101 - Ecology
Educational program:	«Ecology and Environmental Protection»
Faculty:	Plant protection, biotechnology and ecology
Developers:	Volodymyr Illienko , PhD in Biology, senior lecturer of Radiobiology and Radioecology Department
	Alla Klepko , PhD in Biology, Head of the Radiobiology and Radioecology Department

Kyiv – 2020

1. PURPOSE AND OBJECTIVE OF THE DISCIPLINE

The goal of teaching "Biological Methods in Radiation Research" is to d 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.

2. 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.

3. DISCIPLINE CONTENT AND TYPES OF EDUCATIONAL WORK

Types of educational activity	Total hours
The total laboriousness of the discipline	108
Lectures	20
Practical training	40
Independent student work	48
Type of final control	Exam

4. CONTENTS OF DISCIPLINE MODULES AND TYPES TO WORK

№	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),	2	6	6

		biological elimination half-life of radionuclides (T_{biol}). The main ways of radionuclides withdrawal from the body of animals. *Literature: 1-6*			
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. *Literature: 1, 2, 4, 8-11, 23*	2	4	6
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. *Literature: 1, 4, 8, 16-20*	2	4	6
	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. *Literature: 8, 11, 15, 21*	2	4	4
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. *Literature: 8, 11, 21*	2	6	4
2.3	The method of isotopic indicators in	Labeled atoms. Radioactive and stable isotopes. Labeled compounds. Indicative dose. Basic ways of using	2	4	4

	biology and ecology	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. *Literature: 1-3, 8, 11, 19, 21*			
	Module 3. Radiosensitivity of microorganisms and their diversity in territories contaminated with radionuclides				
3.1	Radiosensitivity of microorganisms	Extremely radioresistant bacterium *Deinococcus radiodurans, Arthrobacter radiotolerans.* Isolation of strains of radiosensitive bacteria in an environment with extreme conditions of existence. Radiosensitivity of micromycetes. *Literature: 8-11*	2	2	4
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	4	4
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	4
3.4	Selection of	Concentration of the isolated DNA.	2	2	6

methodology for bioinformatic processing of DNA sequencing results from soils contaminated with radionuclides	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*			
	Total:	**20**	**40**	**48**

5. STUDENT RATINGS

5.1 Criteria for calculating the maximum number of points in conditions of rating by hours:

Lectures - for each hour of listened and recapitulated lecture – 0.5 points.

Practical classes - for every hour of completed and assigned task of practical classes - 1 point.

Independent work - for every hour of self-prepared and assigned task - 0.5 points.

Rating (maximum) of the student by modules considering hours as a criterion

Module	**$R_{e.w.}$**	**Credits**	**Lectures**	**Practice sessions**	**Independent work**	**Total**
1	M_1	1,0	6 · 0,5 = 3	14 · 1 = 14	18 · 0,5 = 9	26
2	M_2	1,0	6 · 0,5 = 3	14 · 1 = 14	12 · 0,5 = 6	23
3	M_3	1,0	8· 0,5 =4	12 · 1 = 12	18· 0,5 =9	25
	Total	3,0	10	40	24	**74**

Rating of educational work $\mathbf{R_{e.w.}}$ = 70 %, and rating of exam $\mathbf{R_{exam}}$ = 30 % from the total number of points (according to the Regulations).

In case of 100% mastering of discipline the student can get $\mathbf{R_{e.w.}}$ - 52 points, and $\mathbf{R_{exam}}$ - 22 points.

5.2 Rating of attestation for discipline

National score	**ECTS**	**Definition ECTS**	**$R_{dis.}$, points**	**$R_{dis.}$, actual points for discipline**
Excellent	A	***Excellent*** - perfectly performance, with only a small number of errors.	(0,9 – 1,0) · $R_{dis.}$	67 – 74
Good	B	***Very good*** - above average level with several mistakes	(0,82 – 0,89) · $R_{dis.}$	61 – 66

	C	***Good*** - generally correct with some mistakes	$(0{,}75 – 0{,}82) \cdot R_{dis.}$	56 – 60
Satisfactory	D	***Satisfactory*** - not bad, but with a significant number of shortcomings	$(0{,}66 – 0{,}74) \cdot R_{dis.}$	49 – 55
	E	***Enough*** - execution satisfies the minimum criteria	$(0{,}60 – 0{,}65) \cdot R_{dis.}$	44 – 48
Unsatisfactory	FX	***Unsatisfactory*** - you need to work before getting a score (positive rating)	$(0{,}35 – 0{,}59) \cdot R_{dis.}$	26 – 43
	F	***Unsatisfactory*** - serious further work is needed	$(0{,}01 – 0{,}34) \cdot R_{dis.}$	1 – 25

5.3 Discipline rating

$$R_{dis.} = R_{e.w.} + R_{exam} + R_{add.w.} – R_{penal}$$

Assume that the student scored only 56 points, which is 75% of 3.0 credits or $\mathbf{R_{dis.}}$ of student is 2.25 credit.

6. EXAMPLE OF CONTROL TASKS

<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>Radiobiology and Radioecology Department
2019/2020 study year</td><td colspan="2">Test № 1
from the course
Biological methods in radiation research</td><td>Approved
Head of department

Gudkov I.M.</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>

7. RECOMMENDED LITERATURE

1. Choppin G. R., Liljenzin J.-O., Rydberg J. Radiochemistry and nuclear chemistry. 4th ed., Academic Press, 2013, 858 p.
2. Chernobyl: 30 Years of Radioactive Contamination Legacy. Report. Lead writer and coordination of report: Prof. Valerii Kashparov, Kyiv, 2016, 59 p.
3. Climate change and nuclear power. International Atomic Energy Agency, VIENNA, 2005, 112 p.
4. Natural and induced radioactivity in food. International Atomic Energy Agency, VIENNA, 2002, 136 p.
5. 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.
6. 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.
7. Radiation biology: a handbook for teachers and students. International Atomic Energy Agency, VIENNA, 2010, 150 p.
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.
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.