




**NATIONAL UNIVERSITY OF LIFE AND
ENVIROMENTAL SCIENSES OF UKRAINE**

Department of General Ecology, Radiobiology and Life Safety

“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
educational-professional program «Ecology»
Program Coordinator

Volodymyr BOGOLJUBOV

PROGRAM OF THE COURSE

“RADIOBIOLOGY AND RADIOECOLOGY”

Specialization 101 «Ecology»
Educational program Education-professional program “Ecology” of the first
(bachelors) level of higher education
Faculty Plant protection, biotechnology and ecology
Developers Head of the department, PhD in biology Alla Klepko
Senior lecturer of the department, PhD in biology Volodymyr Illienko

Kyiv – 2023

1. Description of the course

Radiobiology and Radioecology

(name)

Field of knowledge, specialization, educational program, educational degree		
Educational degree	<i>Bachelor's</i>	
Specialization	<i>101 - Ecology</i>	
Educational program	<i>"Ecology"</i>	
Characteristics of the course		
Type	elective	
Total number of hours	120	
Number of ECTS credits	4	
Number of content modules	3	
Course project (work) (if applicable)	-	
Form of assessment	<i>exam</i>	
Indicators of the course for full-time and part-time forms of study		
	Full-time form of study	Part-time form of study
Course (year of study)	3	3
Semester	5	5
Lecture classes	<i>30 hours</i>	<i>2 hours</i>
Practical, seminar classes	<i>-hours</i>	<i>- hours</i>
Laboratory classes	<i>30 hours</i>	<i>6 hours</i>
Self-study	<i>60 hours</i>	<i>112 hours</i>
Individual assignments	<i>- hours</i>	<i>hours</i>
Number of weekly classroom hours for the full-time form of study	<i>4 hours</i>	

2. PURPOSE, OBJECTIVES, AND COMPETENCIES OF THE COURSE

Radiobiology, or radiation biology, is a science about effects of ionizing radiations on living organisms and their groups.

During the last decades in a radiobiology next to such traditional directions as a medical radiobiology, animal radiobiology, plant radiobiology, agricultural radiobiology, radiation ecology, et al some new directions was expressly selected. They are molecular radiobiology, radiation biochemistry, radiation cytology, radiation genetics. That means that the objects of study of radiobiology are not only living organisms and their groups, but also molecules, cells and cell populations, separate processes of metabolism. And *new determination of radiobiology* appears. Now it is *the science about effects of ionizing radiations on the living systems of all of levels of organization*. This formulation is not alternative to the first are they both correct.

A basic task of radiobiology is a study of mechanism of effects of ionizing radiations on a living organism with the purpose of search of possibilities of management organisms reactions on this factor, mainly, diminishing of harmful effects. Main tasks of agricultural radiobiology as a direction which is accented in agrarian educational establishments, are: study of sensitiveness of agricultural plants and animals to the ionizing radiations, development of facilities of their protecting from a radiation defeat, search of ways of the use of ionizing radiations for an agricultural production, research of ways of migration and biological effects of the radionuclides incorporated plants and animals. However, the last task is basic for the separate section of radiobiology - radioecology.

Radioecology, or radiation ecology, is the section of radiobiology, which arose up on the joint of it with ecology. *Radioecology studies concentrations and migration of radionuclides in the environment and ionizing radiation influence on living organisms and their groups.*

Basic tasks of radioecology are: discovery of territories, contaminated by radionuclides, and determination of their concentrations; a study of migration of radionuclides in the objects of environment and ways, which they get in plants, organism of animals and man; a study of biological effects of incorporated ionizing

radioactive elements radiations on living organisms; elaboration of bases of the rational use of territories contaminated by radionuclides, in particular case agricultural lands, taking into account the specific of contamination and ground-climatic terms of regions; research of other anthropogenic factors influence which are introduced into agrosystem (ameliorator, mineral and organic fertilizers, physiological active matters, heavy metals, acid rains et al), on passing of radionuclides to the products of agricultural production, food stuffs et al; development of the scientifically grounded system of separate branches conduction which provide the permanent diminishing of level of radiocontaminant of this products.

A primary aim of these tasks is diminishing of radionuclides receipt to the organism of man by a food chain soil-plants-animals- plant-grower and animal production-man by interrupting or abatement of ecological connections on any area of this chain and decline of dose of internal radiation.

Program of course «Radiobiology and radioecology» foresees the deep study of sections of common radiobiology, including plant, animal, man, radiobiology especially related to antirad action protecting of products of agriculture from a radiocontaminant, to radiation safety in separate industries of production. Part, related to the study of radioecology is given in more generalized kind, taking into account that in subsequent students will study a separate course «Agricultural radioecology».

Primary purpose of study of discipline «Radiobiology and radioecology» is a capture thorough knowledge about influence of ionizing radiations on living organisms, mastering of the applied aspects of specialty, related to radiation safety, and also practical application of knowledge, for the solving of research and applied tasks.

As a result of radiobiology study student are:

to know: sources of ionizing radiations in the environment, mechanisms of radiations influence on living organisms, radiosensitivity of basic types of plants and animals, principles of defense of living organisms, from radiations, ways of ionizing radiations use in different spheres production, including agrarian production, theoretical bases of radionuclides application in scientific researches.

To be able: to estimate a radiation situation by the dosimetric devices of the different systems, to develop the system of radioprotective measures of radionuclides radiation defeat and contamination warning of agrocenosis, to apply radionuclides in scientific researches.

A student are to master:

1) general information about physical nature, ionization of matter under influence of physical factors, nature of corpuscular and electromagnetic radiations which are studied in the courses of «Physics» and „Biophysics”;

2) chemical elements and their basic isotopes, including radioactive, types of their co-operation one with other, compounds which appear here, that studied are in courses «General chemistry» and other chemical disciplines;

3) bases of ecology, especially sections about migration of anthropogenic origin pollutants in the objects of environment and agriculture, which are studied in courses «General ecology», «Agroecology» and other ecological disciplines;

4) systems of tillage, methods of growing and storage of agricultural cultures, basis of stock-raising, geneticists, which are studied in courses «Agriculture», „Plant-growing”, „Soil Science”, „Agricultural Chemistry”; «Bases of stock-raising», «Genetics».

Acquisition of competencies:

Integrated competency (IC): the ability to solve complex specialized problems and solve practical problems in the field of ecology, environmental protection and balanced nature management, which involves the application of basic theories and methods of environmental sciences, which are characterized by complexity and uncertainty of conditions.

General competencies (GC):

GC1. Knowledge and understanding of the subject area and professional activity.

GC8. Ability to conduct research at an appropriate level.

Professional (special) competencies (PC):

PC5. Ability to assess the impact of technogenesis processes on the environment and identify environmental and radiation risks associated with production activities.

PC11. The ability to inform the public about the state of environmental security and balanced nature management.

Program learning outcomes (PLO):

PLO9. Demonstrate skills in assessing unpredictable environmental problems and thoughtfully choosing ways to solve them.

PLO22. Participate in the development of projects and practical recommendations for environmental protection.

3. PROGRAM AND STRUCTURE OF THE COURSE FOR:

- complete full-time (part-time) form of study;
- shortened full-time (part-time) form of study.

№	Topic	The topic content, recommended literature	Types of educational activity, hours.		
			lectures	laboratory work	independent work

Module 1. Introduction. Physical basics of radiobiology and radioecology

1.1.	Introduction to radiobiology. History	Definition of radiobiology (radiation biology) and radioecology (radiation ecology). Radioecology as a component of radiobiology. Radiobiology objects of studying. Organizational structure of radiobiology. A place of radiobiology among the allied science. Directions of radiobiology development. Tasks of radiobiology and radioecology. History of radiobiology and radioecology development. A role of achievements of nuclear physics is at the end of a 19 th century in an origin and development of radiobiology. Stages of radiobiology and radioecology development. Development of radiobiology and radioecology in Ukraine. Modern problems of radiobiology and radioecology: specific of influence on the living organisms of small doses of ionizing radiations, features of influence on the living organisms of chronic irradiation, prophylaxis and therapy of sharp and chronic radiation defeats, radiation dysimmunity, remote consequences of irradiation, general influence on the organism of ionizing radiations and other factors, migration of natural and artificial radionuclides in the objects of environment, features of influence on the organism of the incorporated radionuclides, in plants, organisms of animals and man, blocking of receipt of radionuclides, in plants, organism of animals and man, leading out of radionuclide from an organism. Theoretical and practical value of	4	4	10
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radiobiology. Necessity of wide propaganda of radiobiological knowledge.

Literature: 1, 8-12

1.2 Physical basics of radiobiology	Phenomenon of radioactivity. Law of radioactive decay. Nature atoms and molecules of matter ionization. Definition of concept of ionizing radiations. Types of ionizing radiations: electromagnetic and corpuscular radiation. Types of electromagnetic ionizing radiations: x-ray photography, gamma- and slowing-down radiation. Physical descriptions of basic types of radiations: alpha -, beta-, proton and neutron radiations. Exposure, absorbed and equivalent doses of ionizing radiations. Power of dose. Types of irradiation depending on power of dose, factor of time and multiplicity of irradiation: sharp and prolonged (chronic), non-permanent and frequent (fractionating). Units of radioactivity and doses of ionizing radiations. Connection between radioactivity of matter and dose ionizing a radiation.	2	4	10
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Literature: 1, 2, 4, 8-11, 23

1.3 Sources of radioactive substances and ionizing radiation	Natural and artificial sources of ionizing radiations. Natural ionizing radiation. Space radiation and radiation of natural radioactive elements. Sun and galactic radiation. Radiation of radioactive elements from families of uranium, actinouranium and thorium. Payment of radiation of radon. Radiation of non-family natural radionuclides. Payment of radiation radioactive calcium. Radiation of cosmogenic radioactive elements. Radioactive hydrogen and carbon. Natural radiation background. Estimations of doses of irradiation of living organisms, predefined a natural ionizing radiation. The possible value of natural radiation in the processes of vital functions of organisms. Ionizing a radiation from artificial radionuclides. Sources of artificial radionuclides in environment. Radiation from radionuclides which appear as a result of tests of nuclear-powered weapon. «Global» nuclear fall-outs. Radiation of radionuclides which enter environment from	2	2	-
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the enterprises of nuclear energy. Radiation from sources which are used in medicine and everyday life.

Literature: 1, 3, 4, 7, 8, 10-13

Module 2. Biological effects of ionizing radiation

2.1	Biological effects of ionizing radiation on plants and animals	Concept of radiobiology effect. Classification of radiobiology effects. Somatic and genetic radiobiology effects. Essence of radiation stimulation. Radiation stimulation of plants and animals. Basic types of morphological changes of organs of plants under ionizing radiations influence. Animal morphological changes. Essence of teratogenic influence of ionizing radiations. Concept of radiation chimera. Carcinogenic influence of radiations. Mechanisms of morphological origin changes at the influence of ionizing radiations. Radiation illness of plants. Kinds and degrees of mammal's radiation illness. Influence of ionizing radiations is on the acceleration of senescence and life-span. Death of organisms is at the high doses of irradiation. «Death under a ray». Specific of plants radiation death. «Gamma-germs». Features of ionizing radiation influence on the forest planting. Reactions of trees on an irradiation. Unspecificity of types of mutations which arise up at the influence of ionizing radiations. Thresholdless and threshold conceptions of ionizing radiation influence. Thresholdless character of carcinogenic and genetic influence of ionizing radiations. Close and remote effects of ionizing radiations . Stochastic character of remote consequences of radiation defeat. Features of influence of small doses of ionizing are radiations on living organisms: stimulative, antiimmune, carcinogenic, genetic effects. Biological effects of radiotelemetrings.	2	2	10
<i>Literature: 1, 3, 9-12, 24</i>					
2.2	Radiosensitivity of plants, animals and other organisms	Concept of radiosensibility and radiofirmness of organisms. Effective doses: lethal, half-lethal and critical. Principles and methodology of construction of dose-effect curves. An analysis of dose-effect curves and determination of effective doses of ionizing radiations on them. Comparative radiosensibility of types of different taxonomical origin. Radiosensibility of	2	2	10

plants. Radiosensitivity of agricultural plants. Comparative radiosensitivity of vegetans plants and seed. Radiosensitivity of plants on the separate stages of ontogenesis. Radiosensitivity of animals. Radiosensitivity of agricultural animals. Radiosensitivity of other organisms: birds, fishes, amphibians, reptiles, invertebrate animals, simplest, bacteria, viruses, mushrooms. Radiosensitivity of animals is on the separate stages of ontogenesis. Radiosensitivity of biocenosis, phytogenesis, agrocenosis. Reasons of wide variability of organisms' radiosensitivity: structural and functional factors. Comparative radiosensitivity of cells is on the different phases of development. Bergon'e and Tribondo Law (rule). Genesial and interphase necrocytosis. Critical fabrics and organs of plants and animals.

Literature: 1, 7-12, 19

2.3 Radiation protection and radiosensitization	The phenomena of antagonism and synergism are at the general influence on the living organisms of ionizing radiations and other factors. Concept of modification of radiation defeat of organism. Antirad biological defense and sensibilization of radiation defeat. Physical antirad and radiosensibilization factors: composition of atmosphere, temperature, humidity, light et al. Oxygen effect. Quantitative description of oxygen effect is an oxygen amplification factor (K_{OA}). Chemical radioprotective matters and radiosensitizers. Determination of radioprotectors, radioblocators and radiodcopyrants concepts. The basic requirements to a description of radioprotective matters. Factor of changing dose (FCD) and its definition Quantitative descriptions of antirad influence. Basic classes of radioprotectors. Natural and artificial radioprotectors. Native radioprotectors of cells. Antioxidants as radioprotectors. Radioprotectors of the prolonged action. Mechanisms of action of radioprotectors: induction of the hypoxive state, «interception» of the free radicals states, formation of mixed disulfides, hypothesis of «biochemical shock». Chemical radiosensibilization matters.	2	2	-
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Mechanisms of influence of radiosensibilizers.

Literature: 1-3, 7, 10, 13, 17

2.4	Post-radiation recovery of plants and animals	Concept of postradiation renewal. Basic ways of postradiation renewal: reparation, repopulation, regeneration and compensatory renewal. Reparation of DNA and other molecules and structures of cell. Sublethal and potentially lethal damages of DNA and their reparation. Photoreactivation. Dark reparation. Postreplicative reparation. SOS- reparation. Collection of supramolecular aggregation. Reparation of the membrane system of cell. R in chromosomes. Heterogeneity of cells of critical fabrics and organs of plants and animals. Radiosensibility of cells in the different phases of cellular cycle. State of cellular rest. A role of radioresistant cells and out of cycle cells in forming of backlogs of repopulation renewal. Fabrics and organs in a spacehold. Centers of regeneration. A role of the apical dominating of plants in their regeneration renewal. Postradiation renewal in the forests. A temporal acceleration of fission critical fabricsand organs as primary reaction is on a radiation damage. Dedifferentiation of cells as a separate way of their postradiation renewal. Possibilities of management of postradiation renewal processes.	2	4	-
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Literature: 1, 7, 9-12

Module 3. Agriculture in terms of radioactive contamination

3.1	Migration of radionuclides in the environment and objects of agriculture	General ways of migration of radionuclides in the objects of environment and agriculture. Trophic, or food, chain. Sources of receipt of radionuclides in atmosphere. Ways of receipt of radionuclides in soil. A role of physical and chemical and agricultural chemistry properties of radionuclides in their migration in soil. Vertical and horizontal migration. Influence of weather-climatic terms on migration of radionuclides in soil. Ways of receipt of radionuclides are in plants: out of roots (air) and root. Quantitative indexes of radionuclides piling up by plants: coefficient of accumulation (<i>KA</i>), transition coefficient (<i>KT</i>). A specific	4	2	10
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of out of roots receipt of radionuclides from hard aerosols. There is entering of soluble radionuclides plants from air. Wind and rain getting up of radionuclides from the surface of soil as a source of the secondary contamination of plants. Influence of biological features of plants and weather terms is on the out of roots entering of radionuclides into the plants. Influence of properties of soil on the root entering of radionuclides into the plants: mechanical composition, mineral particle, organic matters, acidity, carbonate, to moisture, distributing of radionuclides, on the type of soil. Specific of entering agricultural plants of separate radionuclides. Features of radionuclides migration in forest geobiocenosis. Ways of receipt of radionuclides are in the organism of animals: peroral (through a gastrointestinal tract), inhalation (through the organs of breathing) and perkutal (through a skin and wound surface). Quantitative indexes of piling up of radionuclides in the organism of animals: a coefficient of accumulation (KA), coefficient of suction (KS , period, half-leadingout of radionuclides (Th/l)). Metabolism of radionuclides is in the organism of agricultural animals. A specific of piling up of radionuclides is in the organism of animals at the protracted receipt. Basic ways of leadingout of radionuclides from organism of animals. Determination of concept of incorporated radionuclides. Features of action of incorporated radionuclides on an organism. Features of biological action of hot particles. Methods of prognostication of radionuclides receipt in agricultural plants. Principles of prognostication of receipt of radionuclides in the organism of agricultural animals. Ways near setting of receipt norms and piling up of radionuclides in agricultural plants and organism of agricultural animals.

Literature: 1-4, 8-12, 15, 17

3.2 Measures to reduce the accumulation of radionuclides into crop and	to Basic principles of receptions application on transition of radionuclides diminishing from soil in agricultural plants. Generally accepted and special receptions of soil tilling, which reduce entering of radionuclides plants: cultivating and	4	4	10
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livestock
products

ploughing, deep ploughing, is by a trencher plough, removal of epiphase of soil, filing up of muddy layer by clean soil. Agricultural chemistry facilities of diminishing of receipt of radionuclides to plants: liming and gypsuming, application of megascopic norms of phosphoric and potassium fertilizers, use of oligoelementss, organic fertilizers. Selection of agricultural cultures, as a measure on diminishing of maintenance of radionuclides in plants. A management of irrigation regime is an effective measure of decline of receipt of radionuclides in agricultural cultures. Application of the special chemical matters and connections is for diminishing of piling up of radionuclides in plants. Phytodezactivation of soils. Land-of radionuclides contaminated meadows and pastures as a mean of diminishing of maintenance of radionuclides in sterns. Aerophare control of forages and products of stock-raising. Influence of changing of the regim of feeding and will make rations, to maintenance in the ration of alkali-earth elements and other factors on the transition of radionuclides from forages to milk, meat, eggs and other products of stock-raising. tothe rations of mineral additions and preparations which prevent the transition of radionuclides from forages to the organism of animals and acceleration of their leadingout. Radioblocators and radiodecorporants. Organizational measures. Cleaning of products of plant-grower from radionuclides washing off external contamination, receipt of oil, exception of carbonhydratess, receipt of alcohol, receipt of forage and food albumen, cleaning of grain, exception of pharmacological, bioactive and other connection, culinary treatment. Cleaning of products of stock-raising is from radionuclides: processing of milk, washing of milk products, cleaning of milk, by ion-exchanging connections and electrodialysis, culinary treatment of meat, fat and other products. Coefficient of cleaning of products.

Literature: 1, 5, 8, 10-12, 18

3.3 Application of Determination of concept of radiation
ionizing radiation biological technology. Radiation technique

6 4 -

in agricultural production and other fields of human activity and method of isotope indicators in biology and ecology which is used in radiation biological technologies. Ways of the use of ionizing radiations are in agriculture. The use in a plant-grower: a preseed irradiation of seed and presowing irradiation of vegetative reproductive and seedlings organs is in stimulant doses for a growth, development and increase of the productivity of plants acceleration; an irradiation of seed and plants for the receipt of new varieties; radiation biotechnology of fabrics incompatibility overcoming and stimulation of growth at the vegetative inoculations of plants; radiation the biotechnology of fight against the insects-wreckers of agricultural plants; radiation technology of medical plants quality improvement; radiation technologies of lengthening of shelf-lives products of plant-grower and fruit-growing, prevention of germination of tubers, root crops and bulbs; radiation pasteurization and canning. The use is in a stock-raising: an irradiation of chicken eggs and young animals in stimulant doses with the purpose of growth acceleration and development of animals; radication of products of stock-raising and sterilization of insects-higglers of illnesses of animals and man; radiation disinfestation of stock-raising products; radiation disinfestation of stock-raising complexes flow waters; radiation canning of forages and improvement of their quality; radiation sterilization of tool and materials is in veterinary medicine; radiation pasteurization and canning of products of stock-raising. The use of ionizing radiations is in medicine, food retail and pharmaceutical industry. Definition of concept of isotopic indicators, or isotope-tracers. Essence of method of isotopic indicators. Radioactive and stable isotopes. Isotopes which are used in biological researches. Methods of receipt of the marked connections.

Literature: 1, 2, 6, 10-12

Total:	30	30	60
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Structure of the course for:

- complete full-time (part-time) form of study;
- shortened full-time (part-time) form of study

Names of content modules and topics	Number of hours													
	Full-time form							Part-time form						
	weeks	total	including					total	including					
			1	p	lab	in d	sel f		1	p	lab	in d	sel f	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Content Module 1. Introduction. Physical basics of radiobiology and radioecology														
Topic 1. Introduction to radiobiology. History	1-2	18	4		4	10		13	1		2	10		
Topic 2. Physical basics of radiobiology		16	2		4	10		10				10		
Topic 3. Sources of radioactive substances and ionizing radiation		4	2		2	-		12				12		
Total for content module 1	38		8		10	20		35	1		2	32		
Content Module 2. Biological effects of ionizing radiation														
Topic 4. Biological effects of ionizing radiation on plants and animals		14	2		2	10		13	1		2	10		
Topic 5. Radiosensitivity of plants, animals and other organisms		14	2		2	10		10				10		
Topic 6. Radiation protection and radiosensitization		4	2		2	-		10				10		
Topic 7. Post-radiation recovery of plants and animals		6	2		4	-		10				10		
Total for content module 2	38		8		10	20		43	1		2	40		
Content Module 3. Agriculture in terms of radioactive contamination														

Topic 8. Migration of radionuclides in the environment and objects of agriculture		16	4		2	10		12			2	10	
Topic 9. Measures to reduce the accumulation of radionuclides into crop and livestock products		18	4		4	10		10				10	
Topic 10. Application of ionizing radiation in agricultural production and other fields of human activity and method of isotope indicators in biology and ecology		10	6		4	-		20				20	
Total for content module 3	44		14		10	20		42			2	40	
Total hours			30		30	60							
Course project (work) on _____ _____			-	-	-		-		-	-	-		-
— (if included in the curriculum)													
Total hours	120		30		30	60		120	2		6	11 2	

4. Seminar topics

№	Topic title	Number of hours
1		
2		
...		

5. Practical class topics

№	Topic title	Number of hours
1		
2		
...		

6. Laboratory class topics

№	Topic title	Number of hours
1	Radiation safety standards and basic sanitary rules of radiation protection	4
2	Determination of the flow of β -particles from the radiation source	2
3	Determination of the β -radiation half-attenuation layer	2
4	Determination of the dose rate of γ -radiation created by the reference source ^{137}Cs through protective materials	2
5	Measurement of the γ -background in the premises and on the territory using the SRP-68-01 radiometer	4
6	Measurement of the specific and volume activity of β -emitting radionuclides using the "Beta" radiometer	4
7	Express determination by γ -radiation of cesium radionuclides in water, soil, food and agricultural products using the RUB-01-P6 radiometer	4
8	Determination of ^{137}Cs contamination of the territory using the RUB-01-P6 radiometer	4
9	Determination of the content of ^{137}Cs in the human body using the RUB-01-P6 radiometer	4
	In total	30

7. Independent work topics

№	Topic title	Number of hours
1	Classification and purpose of dosimetric control devices, their components. Devices of individual dosimetric control.	10
2	Preparation for operation of general dosimetric control devices - X-ray and radiometers	10
3	Units of measurement of doses and radioactivity, their relationship and conversion	10
4	Sampling of environmental objects and their preparation for radiometry	10
5	Calculation of the level of ^{137}Cs contamination of plant products	10
6	Calculation of the level of ^{137}Cs contamination of animal husbandry products	10
	In total	60

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

National University of Life and Environmental Sciences of Ukraine			
Bachelor 3rd year study Specialty 101 «Ecology»	General Ecology, Radiobiology and Life Safety Department 2020/2021 study year	Test № 1 from the course Radiobiology and Radioecology	Approved Head of department <hr/>
Questions			
1. Factors affecting the migration of radionuclides in the atmosphere.			
2. Definition of oxygen effect concept.			
Tests			
1.	Water has _____ action a) Radiosensitizing; b) Radioprotective; c) Both; d) There is no correct answer		
2.	What element has an antagonist with Cs? a) Sr; b) Ca; c) K; d) Pb		
3.	What phase of cell cycle is the most radiosensitive? a) S; b) G ₁ ; c) M; d) G ₂		
4.	Arrange the correct links on types of radionuclides distribution in animals (few radionuclide can respond to one type)		
	1 bone	a Transuranic elements	
	2 diffuse	b Cs	
	3 reticuloendothelial	c Sr	
		d Rb	
		e Pu	
5.	Critical tissue in plants are: a) phloem; b) xylem; c) meristem; d) parenchyma		
6.	Which of the natural potassium isotopes is radioactive? a) ³⁹ K; b) ⁴⁰ K; c) ⁴¹ K; d) ⁴² K		
7.	Among vertebrate animals, the highest radioresistance have: a) fishes; b) birds; c) mammals; d) reptile		
8.	A critical organ to ¹⁴ C is: a) eye lens; b) bone tissue; c) spleen; d) fatty tissue		
9.	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		

10.	What statements are correct for α -particles: a) Have '2-' charge; b) Consists of 2 protons and 2 neutrons; c) Is a nuclei of helium d) Is the most harmful for organism	Is a nuclei
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9. Teaching methods.

When studying the discipline, the following teaching methods are used:

Depending on the source of knowledge: verbal (explanation, conversation, discussion, dialogue); visual (demonstration, illustration); practical (solving problems, business games).

According to the nature of cognitive activity: explanatory and visual problem presentation; partly search and research methods.

By place in educational activity:

- methods of organization and implementation of educational activities, combining verbal, visual and practical methods; reproductive and problem-searching; methods of educational work under the guidance of a teacher and methods of independent work of students of higher education;

- methods of control and self-control of educational activities: methods of oral and written control; individual and frontal, thematic and systematic control.

In the process of teaching an academic discipline, the following educational technologies are used to activate the educational and cognitive activity of students of higher education:

- working in small groups makes it possible to structure practical-seminar classes in terms of form and content, creates opportunities for the participation of each student of higher education in work on the topic of the class, ensures the formation of personal qualities and experience of social communication;

- seminars-discussions provide for the exchange of thoughts and views of the participants on a given topic, and also develop thinking, help form views and beliefs, the ability to formulate opinions and express them, teach to evaluate other people's proposals, to critically approach one's own views;

- brainstorming – a method of solving urgent tasks, the essence of which is to express as many ideas as possible in a limited period of time, discuss and carry out their selection;

- case method – a method of analyzing specific situations, which makes it possible to bring the learning process closer to the real practical activity of specialists and involves consideration of production, management and other situations, complex conflict cases, problem situations, incidents in the process of learning educational material;

- presentations – speeches in front of the audience, used to present certain achievements, results of the group's work, a report on the performance of individual tasks, instruction, demonstration.

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 assessments in accordance with the requirements of the work 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.

Distribution of grades 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, protocol №10)

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): $R_{dis} = R_{aw} + R_{ex}$.

11. Educational and methodological support.

1. <https://elearn.nubip.edu.ua/enrol/index.php?id=835> Radiobiology and Radioecology
2. Gudkov I. M. Radiobiology and Radioecology (in English): Textbook for students of higher educational institutions. Вид. 2-е, переробл. та допов. К.: НУБіП України, Житомирська політехніка, 2019. 384 с.
3. Gudkov I. M. Radiobiology and Radioecology / I. M. Gudkov, M. M. Vinichuk. – К. : NAUU, 2006. – 295 p.
4. Choppin G. R., Liljenzin J.-O., Rydberg J. Radiochemistry and nuclear chemistry. 4th ed., Academic Press, 2013, 858 p.

12. 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. Radiation biology: a handbook for teachers and students. International Atomic Energy Agency, VIENNA, 2010, 150 p.
7. Гродзинський Д.М. Радіобіологія. – К.: Либідь, 2000. – 448 с.
8. Гудков І.М. Радіобіологія: підручник. – Херсон : Олді-Плюс, 2016. – 504 с.
9. Гудков І.М., Гайченко В.А., Кашпаров В.О. Сільськогосподарська радіоекологія: підручник. – К.: Ліра-К, 2017. – 268 с.
10. Кічно В.О., Поліщук С.В., Гудков І.М. Основи радіобіології та радіоекології. – К.: Хай-Тек Прес, 2008 (2009). – 316 с.
11. НРБУ-97/2000.
12. 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.
13. Паренюк О.Ю., Ілленко В.В., Гудков І.М. Мікрофлора забруднених радіонуклідами ґрунтів. – К.: Вид-во НУБіП України, 2018. – 198 с.
14. Бондар О.І., Фещенко В.П., Гудков І.М., Гуреля В.В. Радіоекологічний термінологічний словник (україно-англійсько-російський). – Житомир: ПП Експертний центр Укреколбіокон, 2018. – 254 с.
15. Якість ґрунту. Методи відбору проб ґрунту для радіаційного контролю, СОУ 74.14-37-425:2006.
16. Якість ґрунту. Визначення щільності забруднення території сільськогосподарських угідь радіонуклідами техногенного походження, СОУ 74.14-37-424:2006
17. Якість продукції рослинництва. Методи відбору проб для радіаційного контролю, СОУ 01.1-37-426:2006.
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