Federal State Autonomous Educational Institution for Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA (RUDN University)

Institute of Environmental Engineering

COURSE SYLLABUS

Physicochemical methods of waste testing

Recommended by the Didactic Council for the Education Field for the specialization:

05.04.06 "Ecology and nature management"

The course instruction is implemented within the professional education programme of higher education:

«Integrated Solid Waste Management»

2025

1. COURSE GOAL(s)

The course is designed to help students to obtain knowledge, skills and abilities in the field of application modern physical and chemical methods of research of waste components; theoretical foundations of modern physical and chemical methods used in environmental studies; general laboratory and special methods for the study of waste components (including hazardous and toxic substances); principles of operation of modern analytical equipment; the basics of setting up an experiment and processing research materials; features of sampling and qualitative and quantitative analysis of chemicals, bioorganic wastes, leachate components and landfill gas; routine research; programs for environmental monitoring of waste management facilities.

- ## 2. REQUIREMENTS FOR COURSE OUTCOMES

The course implementation is aimed at the development of the following competences:

Competence code	**Competence descriptor**	**Competence formation indicators** (within this course)
GC-1	Able to carry out a critical analysis of problem situations based on a systematic approach, develop an action strategy	**GC-1.1** Knows how to solve problematic tasks and identify their components and relationships between them.
		GC-1.2 Able to search for solutions to a problematic task based on available and reliable sources of information.
		GC-1.3 Owns a strategy for solving a problem situation based on a systematic and interdisciplinary approach.
GC-6	Able to determine and implement the priorities of their own activities and ways to improve it based on self-assessment	**GC-6.1** Able to analyze large amounts of information of professional content.
		GC-6.2 Able to analyze, synthesize and optimize solutions to the tasks.

As a result of course studying, the student must:

Know:

basic terminology related to physical and chemical research methods, classification of methods; basic theories and laws underlying physical and chemical methods; physical and chemical (including spectral) methods for solving professional problems in the field of laboratory analysis of samples of various origins; theory, practice and features of combining various methods for the analysis of pollution of biosphere objects; chemical and physico-chemical methods for solving professional problems in the field of determining the structure of bioorganic compounds; essence of physicochemical methods of analysis, features of their application in modern biological research.***Be able to:***

apply methods of chemical analysis, instrumental methods of research and methods of operational analytical control; to calculate the results of quantitative analysis according to experimental data using the methods of normalization, external and internal standard and absolute calibration; interpret the results of the obtained experimental studies; independently analyze the information obtained as a result of laboratory research; use theoretical and applied knowledge of environmental safety in production activities.

Own*:*

methods for determining a rational scheme when choosing an algorithm for determining the composition and identification of compounds, depending on the nature of substances and their quantitative content; methods of systematic application of chemical reactions and instrumental

studies of ecological monitoring of the biosphere; the skills of classifying simple and complex organic compounds and reactions in the study of the functional composition; methods of using the chemical and physical and mathematical apparatus necessary for professional activities; skills in working with bioorganic objects, taking into account the features of the analysis of polycomponent mixtures.

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

Discipline ***Physicochemical methods of waste testing*** refers to the **Electives** (block 1 of the curriculum).

Within the higher education programme students also master other disciplines (modules) and / or internships that contribute to the achievement of the expected learning outcomes as results of the course.

Table 3.1

The list of the higher education programme components that contribute to the achievement of the expected learning outcomes

Competence code	Competence descriptor	Previous courses/modules, internships*	Subsequent courses/modules, internships*
GC-1	Able to carry out a critical analysis of problem situations based on a systematic approach, develop an action strategy	Undergraduate disciplines	-
GC-6	Able to determine and implement the priorities of their own activities and ways to improve it based on self-assessment	Undergraduate disciplines	-

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total workload of the discipline is **3** credit units.

Table 4.1. Types of academic activities during the period of the HE program(me) mastering

Types of academic activities		Total hours	Semester(s)			
			1	2	3	4
Contact academic hours		*34*			*44*	
Lectures		17			17	
Lab works						
Seminars (workshops/tutorials)		17			17	
Self-study		*119*			*119*	
Evaluation and assessment (exam; pass/fail grading)		*27*			*27*	
The total course workload	hours	**180**			**180**	
	credits	**5**			**5**	

5. COURSE CONTENT

Table 5.1. Course Modules and Contents

Title of Course Modules	Content	Types of academic activities

Title of Course Modules		Content	Types of academic activities
1.	Section 1. Classification of methods for monitoring and identifying of waste components	Chemical methods. Physical methods. Biological methods. The main fields of application of each group of methods.	L, S
2	Section 2. Methods of elemental analysis	Atomic adsorption analysis. Atomic emission analysis. X-ray fluorescence analysis. Neutron activation analysis. Method of mass-spectral analysis.	L, S
3	Section 3. Titrimetric methods of analysis	Types of titrimetric analysis. Titration types.	L, S
4	Section 4. Mass Spectrometry	Ionization methods: electron impact, chemical ionization, photoionization, field ionization, field desorption, fast atom bombardment, matrix laser desorption ionization (MALDI), electrospray. Ion detectors: Faraday cup, secondary electron multiplier, multichannel amplifier. Mass analyzers: operating principles, resolution. Advantages and disadvantages. Analytical possibilities of mass spectrometry. Molecular, fragmentation and metastable ions. Combinations of a mass spectrometer with chromatographs. Examples of the use of mass spectrometry.	L, S
5	Section 5. Chromatography	Chromatographic separation of a mixture of substances. Physical and chemical adsorption. adsorption-desorption equilibrium. Width and shape of the chromatographic peak. Resolution of the chromatographic column. The device and scheme of operation of the chromatograph. Dead time and retention time. Packed and capillary columns, their parameters. Optimal dimensions and resolution of the chromatographic column. Detectors.	L, S
6	Section 6. Radiospectroscopy	Magnetic moments of the electron and nuclei. NMR active nuclei. Spin in a constant magnetic field. Magnetic moment and Larmor precession. Absorption of energy of a high-frequency field. Spectroscopy of nuclear magnetic resonance. Chemical shift. Spin-spin interaction. Application of the NMR method. Spectroscopy of electron paramagnetic resonance. Hyperfine structure of the EPR spectrum. Structural and dynamic characteristics of a substance determined by EPR methods. Schematic diagram of an EPR spectrometer. Application of the EPR method.	L, S
7	Section 7. Optical spectroscopy	Classes of spectral devices. Dispersive elements of spectral instruments and their resolution. The passage of light through an absorbing medium. Absorption cross section, molar extinction coefficient. Law of Lambert-Bouguer-Beer. Spectra of absorption, emission and scattering. Luminescence and fluorescence. Spectral ranges and corresponding degrees of freedom in molecular systems. Rotational spectra and microwave spectroscopy. Vibrational spectra and infrared	L, S

Title of Course Modules		Content	Types of academic activities
		spectroscopy. Vibrations of polyatomic molecules. Electronic transitions and spectroscopy in the visible and ultraviolet ranges. Intensity of electronic-vibrational spectra: Franck-Condon principle. Spectroscopy of Raman scattering of light.	
8	Section 8. Federal Law on production and consumption waste	Basic concepts. Legal regulation in the field of waste management. Requirements for waste disposal facilities. Requirements for the handling of hazardous waste. Requirements for the transport of hazardous waste. State cadastre of waste. Production control in the field of waste management.	L, S

6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Classroom equipment and technology support requirements

Classroom for Academic Activity Type	Classroom equipment	Specialized educational / laboratory equipment, software and materials for mastering the course (if necessary)
Lecture	Classroom, equipped with a set of specialized furniture; whiteboard; a set of devices includes portable multimedia projector, laptop, projection screen, stable wireless	Classroom, equipped with a set of specialized furniture; whiteboard; a set of devices includes portable multimedia projector, laptop, projection screen, stable wireless Internet connection. Software: Microsoft Windows, MS Office / Office 365, MS Teams, Chrome (latest stable release), Skype. Microsoft Windows 7 corporate. License No. 5190227, date of issue March 16, 2010 MS Office 2007 Prof , License # 6842818, date of issue 09/07/2009
Seminars	Classroom, equipped with a set of specialized furniture; whiteboard; a set of devices includes portable multimedia projector, laptop, projection screen, stable wireless	
Computer Lab	Computer Lab for conducting classes, group and individual consultations, current control and intermediate certification, equipped with personal computers (in the amount of 12), a board (screen) and technical devices of multimedia presentations.	No
For Self-Study	Classroom for self-study (can be used for	No

Classroom for Academic Activity Type	Classroom equipment	Specialized educational / laboratory equipment, software and materials for mastering the course (if necessary)
	seminars and consultations), equipped with a set of devices includes laptop, stable wireless.	

7. RECOMMENDED SOURCES FOR COURSE STUDIES

a) **Main reading:**

1. Alastair W. Nicol Physicochemical Methods of Mineral Analysis . Springer , Plenum Press. London. https://books.google.lu/books?id=clbaBwAAQBAJ&printsec=frontcover&hl=de&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

b) **Additional reading:**

1. M.D. Kharlamova, A.I. Kurbatova. Modern technologies of waste management, recycling and environmental protection. Moscow, Peoples Friendship University of Russia, 2017 – 98 p.
2. D. Friedman. Waste Testing and Quality Assurance: Second Volume. ASTM International, 1990 – 459 p.
3. Test Methods for Evaluating Solid Waste: Physical/chemical Methods, Technical Update. U.S. EPA, 1982 – 23 p.

Internet-based sources

1. ELS of RUDN University and third-party ELS, to which university students have access on the basis of concluded agreements:

- RUDN Electronic Library System - RUDN EBS http://lib.rudn.ru/MegaPro/Web
- ELS "University Library Online" http://www.biblioclub.ru
- EBS Yurayt http://www.biblio-online.ru
- ELS "Student Consultant" www.studentlibrary.ru
- EBS "Lan" http://e.lanbook.com/
- EBS "Trinity Bridge"

2. Databases and search engines:

- electronic fund of legal and normative-technical documentation http://docs.cntd.ru/
- Yandex search engine https:// www .yandex.ru/
- Google search engine https://www.google.ru/
- abstract database SCOPUS http:// www .elsevierscience.ru/ products / scopus /

8. MID-TERM ASSESSMENT AND EVALUATION TOOLKIT

Evaluation materials and a point- rating system* for assessing the level of competence formation (part of competences) based on the results of mastering the discipline ***Physicochemical methods of waste testing*** are presented in the Appendix to this Work Program of the discipline.

DEVELOPER:

Associate professor of the ES&PQM Department		**Vasil’ev V.G.**
Position	Signature	Name, Surname

HEAD OF DEPARTMENT:

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HEAD OF PROGRAMME:

Associate professor of the ES&PQM Department		**Popkova A.V.**
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Institute of Environmental Engineering

ASSESSMENT TOOLKIT

for the course

Physicochemical methods of waste testing
course title

05.04.06 "Ecology and nature management"
field of studies / speciality code and title

«Integrated Solid Waste Management» (Network program with L.N. Gumilyov Eurasian National University)
higher education programme profile/specialisation title

master
graduate's qualification (degree)

Passport to Assessment Toolkit for Course Physicochemical methods of waste testing

Field of Studies / Speciality 05.04.06 "Ecology and nature management"

Course: Physicochemical methods of waste testing

Competences (competences in part) under assessment	Course module under assessment	Course topic under assessment	Tools to assess higher education programme mastering level															Points for topic	Points for module
			Class work								Self-studies						Ex a		
			Quiz	Test	Colloquium	Control work	Lab work	Work in class	…	…	Homework	Research essay/ Library research paper	Calculation and graphic work	Course work/project	…	…			
GC-1, CG-6,	Classification of methods for monitoring and identifying of waste components							8			4			2			4		18
GC-1 GC-6	Methods of elemental analysis							6			2			1			2		11
GC-1. GC-6	Titrimetric methods of analysis							6			2			1			2		11
GC-1. GC-6	Mass Spectrometry							6			2			1			2		11

GC-1. GC-6	Chromatography							6			2			1			2		11
GC-1. GC-6	Radiospectroscopy							6			2			1			2		11
GC-1. GC-6	Optical spectroscopy							6			2			1			2		11
GC-1. GC-6	Federal Law on production and consumption waste							6			4			2			4		16

Project work examples

1. Pulp and paper industry waste: origin, regulations, control methods, disposal;
2. Glass industry waste: origin, regulations, control methods, disposal;
3. Tire industry waste: origin, regulations, control methods, disposal;
4. Waste from the metallurgical industry: origin, regulations, control methods, disposal;
5. PET production waste: origin, regulatory documents, control methods, disposal;
6. Textile industry waste: origin, regulations, control methods, disposal;
7. Timber processing waste: origin, regulatory documents, control methods, disposal;
8. Wastes of the oil refining industry: origin, regulations, control methods, disposal;
9. Aluminum industry waste: origin, regulations, control methods, disposal;
10. Waste of the coal industry: origin, regulations, methods of control, disposal;
11. Pharmaceutical industry waste: origin, regulations, control methods, disposal;
12. Waste production of meat products: origin, regulatory documents, control methods, disposal;
13. Waste production of dairy products: origin, regulatory documents, control methods, disposal;
14. Waste from leather and shoe industries: origin, regulations, control methods, disposal;
15. Waste of cement production: origin, regulatory documents, control methods, disposal;
16. Waste production of bread: origin, regulations, methods of control, disposal;
17. Waste from galvanic production: origin, regulatory documents, control methods, disposal;
18. Sugar production waste: origin, regulatory documents, control methods, disposal;
19. Flour production waste: origin, regulatory documents, control methods, disposal;
20. Grain production waste: origin, regulations, control methods, disposal.

Questions for self-studing

1. Chemical methods of environmental control.
2. Physical methods of environmental control.
3. Biological methods of environmental control.
4. Sample incineration methods.
5. Atomic absorption analysis.
6. X-ray fluorescence analysis.
7. Neutron activation analysis.
8. Mass spectral analysis method.
9. Ion detectors in MS.
10. Methods of ionization in MS.

11. Combination of MS with chromatography.
12. Principles of chromatography.
13. Types of chromatography.
14. Combination of chromatography with other methods.
15. Principle of NMR spectroscopy.
16. NMR identification of substances.
17. NMR in quantitative analysis.
18. Features of NMR in application to waste control.
19. Spectral methods of the optical range.
20. Vibrational spectra.
21. Spectroscopy of the Raman spectrum.
22. UV spectroscopy in the analysis of substances.
23. Features of the interaction of xenobiotics with abiotic components of the environment.
24. Features of the impact of pollutants on living organisms.
25. Ecological, physicochemical and toxicological features of priority persistent organic pollutants.
26. Waste of the 1st, 2nd, 3rd, 4th, 5th hazard class.
27. Federal classification catalog of waste.
28. Classification of waste by origin.
29. Classification of waste by hazardous properties;
30. Classification of waste according to the degree of harmful effects on the environment.

Example of homework

Methods:

1. Cryoscopy, ebullioscopy
2. Optical microscopy
3. Refractometry
4. Polarimetry
5. Titrimetry
6. Electrophoresis, capillary electrophoresis
7. Spectrometry in the near infrared region
8. Spectrometry in the infrared region
9. Spectrophotometry in the ultraviolet and visible regions
10. Fluorimetry
11. Raman spectrometry

12. X-ray fluorescence spectrometry
13. Mass spectrometry
14. Chromatography
15. NMR spectroscopy
16. Atomic emission spectroscopy
17. Atomic absorption spectroscopy
18. X-ray powder diffractometry.

Place the numbers of the presented methods according to the following blocks of their use in the identification and quantitative determination of the content of elements, isotopes, ions, molecules:

1. Chemical (i.e. accompanied by a change in the composition of the analyte) methods.
2. 2.Physical methods.
3. 3.Measurement of molecular weight.
4. Measurement of magnetic properties.
5. Analysis of the atomic composition.
6. Establishment of the molecular formula.
7. Determination of functional groups of molecules.

Each method may correspond to more than one block. For the completeness of the answer, it is necessary to know both the basis of a particular phenomenon and method, as well as the measured characteristics and their relationship with the analyte data of interest.

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