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

Institute of Environmental Engineering

COURSE SYLLABUS

ENVIRONMENTAL CONTROL AND MSW MONITORING PROGRAMS

Recommended by the Didactic Council for the Education Field of:

05.04.06 "Ecology and Nature Management"

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

Integrated Solid Waste Management

2026

1. COURSE GOAL(s)

The discipline "Environmental Control and MSW Monitoring Programs" is part of the Master's program "Integrated Municipal Solid Waste Management" in the field of study 05.04.06 "Ecology and Environmental Management" and is studied in the 3rd semester of the 2nd year. The discipline is delivered by the Department of Environmental Safety and Product Quality Management. The discipline consists of 8 sections and 8 topics and is aimed at studying modern physicochemical, including instrumental, methods of control and monitoring in waste management systems.

The aim of the discipline is to familiarize students with modern physicochemical, including instrumental, methods of control and monitoring in waste management systems; the theoretical foundations of general laboratory and special modern physicochemical methods used in control and monitoring in waste management systems; the operating principles of modern analytical equipment; the basics of experimental design and processing of research materials; the specific features of sampling and qualitative and quantitative analysis of objects of various origins; and environmental monitoring programs for various waste management facilities.

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• 2. REQUIREMENTS FOR LEARNING OUTCOMES

The process of studying the discipline is aimed at the formation of the following competencies:

Competence code	Competence descriptor	Competence formation indicators
GC-1	Able to carry out a critical analysis of problem situations based on a systems approach and to develop a strategy for action.	**GC-1.1** Knows how to solve problematic tasks and to identify their components and the relationships between them;.
		GC-1.2 Able to search for possible solutions to a problematic task based on accessible and reliable sources of information;.
		GC-1.3 Possesses a strategy for resolving a problem situation based on systemic and interdisciplinary approaches.
GC-6	Able to determine and implement priorities of one's own activities and ways to improve them based on self-assessment.	**PC-6.1** Able to analyze large arrays of professional content information;
		PC-6.2 Able to conduct analysis, synthesis, and optimization of solutions to assigned tasks..
PC-13	Capable of conducting spatial, territorial, demographic, sociological, and economic investigations, together with engineering-geological and cartographic surveys.	**PC-13.1** Capable of performing analysis and evaluation of available resources and conditions required for the conduct of research;
		GPC-13.2 Capable of assessing the degree of harm and degradation to the natural environment;
		GPC-13.3 Has mastery of methods for the development of models depicting the evolution of environmental conditions under varying anthropogenic pressures.

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

Course ***Environmental control and MSW monitoring programs*** refers to the **Mandatory part** of the 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 systems approach and to develop a strategy for action.	Modern technologies for nature protection; Methodology of Scientific Creation; Research Work; Work Experience Internship;	Pre-Graduation Practice;
GC-7	Able to utilize foundational knowledge in the domain of information culture.	Philosophical problems of natural sciences; Research Work; Work Experience Internship;	Pre-Graduation Practice;
GPC-5	Able to solve the professional activity problems in ecology, environmental management and protection using information and communication, including geoinformation technologies	Research Work;	Pre-Graduation Practice;

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total workload of the course is **5** 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		*36*			*36*	
Lectures		18			18	
Lab works						
Seminars (workshops/tutorials)		18			18	
Self-study		*132*			*132*	
Evaluation and assessment (exam; pass/fail grading)		*12*				
The total course workload	hours	**180**			**180**	
	credits	**55**			**5**	

5. COURSE CONTENTS

Table 5.1. The content of the discipline (module) by type of educational work

Title of Course Modules	Content	Types of academic activities
Module 1. Classification of methods for monitoring and identifying of waste components ;	Topic 1.1. 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
Module 2 Methods of elemental analysis	Topic 2.1. Methods of elemental analysis Atomic adsorption analysis. Atomic emission analysis. X-ray fluorescence analysis. Neutron activation analysis. Method of mass-spectral analysis.	L, S
Module 3: Titrimetric methods of analysis	Topic 3.1 Titrimetric methods of analysis: Types of titrimetric analysis. Titration types	L, S
Module 4. Mass Spectrometry	Topic 4.1. 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
Module 5. Chromatography	Topic 5.1 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
Module 6 Radiospectroscopy	Topic 2.3. Radiospectroscopy basics. 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
Module 7. Optical spectroscopy	Topic 7.1 Optical spectroscopy basics. 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.	
Module 8. Federal Law on production and consumption wast	Topic 8.1. 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	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	
For Self-Study	Classroom for self-study (can be used for seminars and consultations), equipped with a set of devices includes laptop, stable wireless.	

7. RESOURCES RECOMMENDED FOR COURSE STUDY

Main reading:

1. Wastewater Monitoring and Management by Advanced Approaches//Ali Mohd Yatoo, Surendra Suthar, Maulin P. Shah. Springer Singapore. 2026 DOI https://doi.org/10.1007/978-981-95-2601-7

2. Jiachen Wang Zhen Qiao A comprehensive review of landfill leachate treatment technologies Front. Environ. Sci., 02 September 2024 Sec. Water and Wastewater Management Volume 12 - 2024 | https://doi.org/10.3389/fenvs.2024.1439128

3. Ramesha Chandrappa · Diganta Bhusan Das Solid Waste Management Principles and Practice Second Edition Environmental Science and Engineering Springer Nature Switzerland AG 2024 file:///C:/Users/user/Downloads/978-3-031-50442-6.pdf

4. Hemalatha Vegi , V.D.N Kumar Abbaraju, B.S.A Andrews, N.V.S Venugopal, Mahadi Danjuma Sani Physicochemical Properties of Soil around the MSW Dumpsite in North East Coast – A Sustainable

Waste Management Practice Pol. J. Environ. Stud. Vol. XX, No. X (XXXX), 1-9 DOI: 10.15244/pjoes/191612 2024 https://www.pjoes.com/pdf-191612-120229?filename=Physicochemical.pdf

5. Deval Jugraj Singh, Anil Kumar Dikshit, Mohan B. Dangi, George Tchobanoglous, Sunil Kumar, Performance analysis of municipal solid waste management using technical indicators, Environmental and Sustainability Indicators, Volume 26, 2025, 100693, ISSN 2665-9727, https://doi.org/10.1016/j.indic.2025.100693. (https://www.sciencedirect.com/science/article/pii/S266597272500114X)

6. Municipal Waste Management: Policies and Strategies//Sanjeev Kumar, Mohammad Badruddoza Talukder, A.K. Haghi CABI, 2025. https://www.cabidigitallibrary.org/cms/asset/52aa5b8b-c1f1-43cd-b016-d345e937e246/9781836990666.000 0.preview.pdf

7. Andrade, M. Á., Braga, R. M. Q. L., Tavares, A. d. N., & Marques, R. C. (2025). The Use of Indicators in the Regulation of Municipal Solid Waste Management: A Bibliometric Analysis (2004–2024). Sustainability, 17(4), 1348. https://doi.org/10.3390/su17041348

Additional literature:

1. Lawrence K. Wang, Yung-Tse Hung, Nazih K. Shammas Advanced Physicochemical Treatment Processes Volume 4, HANDBOOK OF ENVIRONMENTAL ENGINEERING Humana Press, Totowa, New Jersey 2006, 697 p

2. Physicochemical treatment processes / edited by Lawrence K. Wang, Yung-Tse Hung, Nazih K. Shammas.p. cm. — (Handbook of environmental engineering) Library of Congress Cataloging-in-Publication Data (2004) ; v. 3. 628p http://ndl.ethernet.edu.et/bitstream/123456789/74761/1/Lawrence%20K.%20Wang.pdf

3. 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

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. ASSESSMENT TOOLKIT AND GRADING SYSTEM FOR EVALUATION OF STUDENTS' COMPETENCES LEVEL UPON COURSE COMPLETION

The assessment toolkit and the grading system to evaluate the level of competences (competences in part) formation as results of mastering the discipline are specified in the Appendix to the syllabus.

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Federal State Autonomous Educational Institution of Higher Education
Peoples' Friendship University of Russia named after Patrice Lumumba

Institute of Ecology
(name of the main educational unit (MEU) that developed the educational program of higher education)

EVALUATION MATERIALS AND SCORE-RATING SYSTEM FOR ASSESSING THE LEVEL OF DEVELOPMENT OF COMPETENCIES IN

Environmental control and MSW monitoring programs
(name of discipline/practice)

The assessment materials are recommended by the International Union of Social Sciences for the training area/specialty:

05.04.06 Ecology and nature management
(code and name of the field of study/specialty)

The acquisition of discipline/practice is carried out within the framework of the implementation of the main professional educational program (OP VO, profile/specialization):

Integrated solid waste management
(name (profile/specialization) of the educational institution of higher education)

Assessment materials have been developed for the academic year:

2024/2025
(academic year)

Moscow

1. SCORE-RATING SYSTEM FOR ASSESSING THE LEVEL OF DEVELOPMENT OF COMPETENCIES IN A DISCIPLINE/PRACTICE

Evaluation of the level of development of competencies based on the results of studying the discipline Environmental control and MSW monitoring programs" is carried out in accordance with the Point - Rating System (PRS) in force at RUDN University . (see ***Table 1.1***) The points system is calculated and adjusted in accordance with the curriculum and the actual number of classes per semester.

Classwork : max 1 point. Grading is based on attendance and active participation in the seminar or lecture (lectures are interactive) – answering questions, taking notes, and discussing.

Independent preparation for class : maximum 5 points for each topic. The topic is prepared, a presentation is provided, calculation results are available, and the student freely answers questions – 2 points; the student is present in class, participates in the discussion, but has difficulty answering questions – 1 point. The student is absent or the assignment is not prepared – 0 points.

2. EVALUATION MATERIALS FOR CONDUCTING CURRENT MONITORING OF STUDENTS' PROGRESS AND INDEPENDENT WORK IN THE DISCIPLINE

Independent work facilitates the organization of consistent study of material assigned for independent study in accordance with the curriculum and program of the academic discipline.

Tasks for independent work:

- acquisition of skills for independent scientific research work based on the analysis of literary texts and the application of various research methods;
- developing the ability to independently and critically approach the material being studied;
- developing teamwork skills.

The SR technology ensures knowledge acquisition, consolidation and systematization, and the development of skills and abilities. The SR algorithm includes the following logically connected student actions:

- study of texts (textbooks, lecture notes, reference materials, articles, use of Internet resources);
- preparation for a business game;
- preparation and answers to test questions;
- drafting reports and electronic presentations.

Table 1.1. Point -rating system for assessing the level of development of competencies in a discipline

Code of the controlled competence or its part	Controlled section of the discipline	Controlled topic of the discipline	Name of the assessment tool					Topic points	Section points
			Work at the seminar	Independent study of the topic	Interim assessment	Lecture	Final testing		
GC-1 GC-6 PC-13	Classification of methods for monitoring and identifying waste components	Chemical methods. Physical methods. Biological methods. Main areas of application of each group of methods.	1	5		1	5		
GC-1 GC-6 PC-13	Elemental analysis methods	Sample combustion methods. Atomic absorption analysis. X-ray fluorescence analysis. Neutron activation analysis. Mass spectral analysis.	1	4		1	5		
GC-1 GC-6 PC-13	Mass spectrometry	Ionization methods: electron impact, chemical ionization, photoionization , fast atom bombardment, matrix-assisted laser desorption ionization (MALDI), electrospray . Ion detectors: Faraday cup, secondary electron multiplier, multichannel amplifier. Mass analyzers: operating principles, resolving power. Advantages and disadvantages. Analytical capabilities of mass spectrometry. Molecular, fragment, and metastable ions. Combinations of a mass spectrometer with chromatographs. Examples of mass spectrometry applications.	1	4		1	5		

GC-1 GC-6 PC-13	Chromatography	Chromatographic separation of mixtures of substances. Physical and chemical adsorption. Adsorption-desorption equilibrium. Chromatographic peak width and shape. Resolving power of a chromatographic column. Chromatograph design and operation. Dead time and retention time. Packed and capillary columns and their parameters. Optimal dimensions and resolution of a chromatographic column. Detectors.	1	4		1	5		
GC-1 GC-6 PC-13	Radiospectroscopy	Magnetic moments of electrons and nuclei. NMR-active nuclei. Spin in a constant magnetic field. Magnetic moment and Larmor precession. Absorption of RF energy. Nuclear magnetic resonance spectroscopy. Chemical shift. Spin-spin interaction. Applications of the NMR method.	1	4		1	5		
GC-1 GC-6 PC-13	Optical spectroscopy	Classes of spectral instruments. Transmission of light through an absorbing medium. Absorption cross section, molar extinction coefficient. The Lambert-Bouguer -Beer law. Absorption, emission, and scattering spectra. Luminescence and fluorescence. Spectral ranges and corresponding degrees of freedom in molecular systems. Rotational spectra and microwave spectroscopy. Vibrational spectra and infrared spectroscopy. Vibrations of polyatomic molecules. Electronic transitions and spectroscopy in the visible and ultraviolet ranges. Intensity of electronic-vibrational spectra: the Franck-Condon principle. Raman spectroscopy.	1	4		1	5		
GC-1 GC-6 PC-13	Federal Law on Production and Consumption Waste	Basic concepts. Legal regulation in the field of waste management. Requirements for waste disposal facilities. Requirements for handling hazardous waste. Requirements for transporting hazardous waste. State waste cadastre. Industrial control in the field of waste management.	2	4		2	5		

	TOTAL:	7 sections, 7 topics	8	29		8	35		80
			80 points + 20 points final assessment						

3. EVALUATION MATERIALS FOR CONDUCTING INTERIM CERTIFICATION IN THE DISCIPLINE

The final grade for the semester is the sum of the points for all student activities (see **Table 1.1**) and can be up to **80 points** . A student is considered to have successfully passed the midterm assessment if the total points for all activities at the time of assessment **exceed 51 points** .
The certification test, in the form of an exam, is mandatory and worth a maximum of **20 points.** The final score is calculated based on the exam result and the total points earned (in accordance with the adopted BRS scale). The assessment criteria are presented in **Table 3.1** .
If a student scores less than **10 points on the exam** , the test is considered failed and the student can retake it within the framework of the re-certification rules adopted by RUDN.
The final test is administered at the end of the semester and includes a list of answer options from which the student must select all the correct answers (there is no limit on the number of correct answers). The assessment is calculated as a percentage of the total number of questions assessed, with the percentages then converted into points in accordance with the approved BRS. The results of the final test are included in the total score for the semester.

Table 3.1. Scale and criteria for assessing students' responses to the certification test (exam)

Criteria assessments answer	**Points**		
	Answer Not corresponds criterion	**Answer partially corresponds criterion**	**Answer fully corresponds criterion**
The student gives an answer without leading questions from the teacher	0	1- 3	4
The student hardly ever uses the prepared answer manuscript.	0	1- 3	4
The answer demonstrates the teacher's confident command of the terminology and methodological apparatus of the discipline/module	0	1-3	4
The answer has a clear logical structure	0	1- 3	4
The answer demonstrates the student's understanding of the connections between the subject of the question and other sections of the discipline/module and/or other disciplines/modules of the educational program	0	1-3	4
TOTAL			20

QUESTIONS FOR PREPARATION FOR INTERIM CERTIFICATION

1. Chemical methods of environmental control.
2. Physical methods of environmental control.
3. Biological methods of environmental control.
4. Methods of sample combustion.
5. Atomic adsorption analysis.

6. X-ray fluorescence analysis.
7. Neutron activation analysis.
8. Mass spectral analysis method.
9. Ion detectors in MS.
10. Ionization methods 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. Raman spectroscopy.
22. UV spectroscopy in substance analysis.
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 characteristics of priority persistent organic pollutants (POPs).
26. Waste of 1st, 2nd, 3rd, 4th, 5th hazard class.
27. Federal classification catalogue of waste.
28. Classification of waste by origin.
29. Classification of waste according to hazardous properties;
30. Classification of waste according to the degree of harmful impact on the environment.

ESSAY TOPICS

1. Waste from the pulp and paper industry: 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, regulatory documents, control methods, disposal;
5. PET production waste: origin, regulatory documents, control methods, disposal;
6. Textile industry waste: origin, regulations, control methods, disposal;
7. Wood processing waste: origin, regulatory documents, control methods, disposal;
8. Waste from the oil refining industry: origin, regulatory documents, control methods, disposal;
9. Waste from the aluminum industry: origin, regulations, control methods, disposal;
10. Coal industry waste: origin, regulations, control methods, disposal;
11. Waste from the pharmaceutical industry: origin, regulations, control methods, disposal;
12. Waste from meat production: origin, regulatory documents, control methods, disposal;
13. Waste from dairy production: origin, regulatory documents, control methods, disposal;
14. Waste from leather and footwear industries: origin, regulatory documents, control methods, disposal;
15. Cement production waste: origin, regulatory documents, control methods, disposal;
16. Bread production waste: origin, regulatory documents, control methods, disposal;

17. Waste from galvanic production: origin, regulatory documents, control methods, disposal;
18. Sugar production waste: origin, regulatory documents, control methods, disposal;
19. Waste from flour production: origin, regulatory documents, control methods, disposal;
20. Grain production waste: origin, regulatory documents, control methods, disposal.

EXAMPLES OF TESTS FOR INTERIM CERTIFICATION

1. A method in which the main parameter is retention time.
   a) NMR spectroscopy.
   b) Chromatography.
   c) IR spectrometry.
   d) Titration.
2. The method makes extensive use of indicators.
   a) Mass spectrometry.
   b) IR spectrometry.
   c) Titration.
   d) Polarimetry .
3. The method is based on the separation of particles according to their mass-to-charge ratio.
   a) Refractometry.
   b) Raman spectrometry
   c) Coulometry .
   d) Mass spectrometry.
4. One of the most important characteristics of the method is chemical shift.
   a) X-ray fluorescence spectrometry.
   b) NMR spectroscopy.
   c) IR spectrometry.
   d) Polarimetry .

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