



# INDUSTRIAL ECOLOGY

## Syllabus

### Course details

Level of higher education	<i>First (bachelor's)</i>
Field of knowledge	<i>For all fields</i>
Specialty	<i>For all specialties</i>
Educational program	<i>For all educational programs</i>
Course type	<i>Selective</i>
Study mode	<i>Full-time / External</i>
Year of study/Semester	<i>2nd year / Autumn or spring semester</i>
Course total scope and hours distribution of classroom work and self-study	<i>2 credits ECTS / 60 hours: lectures – 18 hours, practical – 18 hours, self-study – 24 hours</i>
Semester assessment / control measures	<i>Final test / Modular control work</i>
Class schedule	<i>2 classes per week (1 hour of lecture and 1 hour of practical classes)</i>
Language of study	<i>English</i>
Course teachers	<i><a href="https://eco-paper.kpi.ua/pro-kafedru/vykladachi/vizytky.html">https://eco-paper.kpi.ua/pro-kafedru/vykladachi/vizytky.html</a></i>
Course location	<i><a href="https://do.ipk.kpi.ua">https://do.ipk.kpi.ua</a></i>

### Curriculum

#### 1. Course description, purpose, study subject and learning outcomes

*In modern conditions, the scale of nature management and the level of anthropogenic pressure on the environment are growing sharply. The negative impact of production on the natural environment is pollution, which has reached a critical level in many parts of the world. In the interests of preserving human civilization, there is a need to revise the priorities traditionally adopted in production. The discipline "Industrial Ecology" studies the impact of industrial emissions on the environment and the possibility of reducing this impact by improving technology and treatment facilities. It is a fundamental basis that should ensure mastering of the basics of ecology as a theoretical basis for environmental protection and further implementation of the concept of sustainable development.*

***The subject of the discipline "Industrial Ecology" is solving environmental problems of major industries such as energy, metallurgy, mechanical engineering, oil refining, chemical, pulp and paper, food industry, agriculture and construction industry.***

#### ***The purpose of the discipline "Industrial Ecology"***

*The purpose of the discipline "Industrial Ecology" is the formation of the following competencies in students:*

- *choose approaches to ensure the appropriate level of environmental safety of industrial enterprises;*
- *orientate in the directions of activity concerning protection of the environment from industrial pollution;*
- *assess the priorities of environmental protection and environmental management;*
- *master general approaches of environmental monitoring and industrial impact assessment;*
- *take into account the legal aspects of environmental safety in Ukraine.*

According to the requirements of the program of the discipline "Industrial Ecology", students must demonstrate the following **learning outcomes** after its mastering:

**Knowledge of:**

- places of industrial ecology in the system of ecological management;
- tasks facing theoretical and applied ecology;
- the structure of the industrial complex of Ukraine and environmental problems of its individual industries and industries and ways of solving them;
- causes of a complex of global environmental problems and ways of solving them.

**skills:**

- determination the level of impact of a particular production on the environment;
- using the main approaches to environmental protection in production, choose certain environmental measures;
- determination the main pollutants of the enterprise (production) based on the technological documentation of the enterprise (production),;
- applying technological processes, equipment that provide protection of water objects, atmosphere, soils and subsoil from pollution and harmful effects;
- using processes and devices that ensure effective removal and destruction of harmful impurities in water systems and gaseous media, processing and disposal of waste;
- proposing measures to reduce the anthropogenic load and, accordingly, improving the environment based on known technologies for the production of chemical products

## **2. Prerequisites and post-requisites of the course**

The studying of the discipline "Industrial Ecology" is based on the principles of integration of various knowledge acquired by students in the studying of disciplines of natural sciences, humanities and engineering. The discipline "Industrial Ecology" is fundamental basis that should ensure mastering of the basics of ecology as a theoretical basis for environmental protection and further implementation of the concept of sustainable development.

## **3. Course content**

### **Chapter 1. Features of the impact of industrial production on the environment and ways of its protection**

Topic 1. The concept of environment and its protection

Topic 2. General characteristics of modern technologies and their impact on the environment

Topic 3. Utilization and processing of solid waste

### **Section 2. Ecological aspects of rational nature management**

Topic 4. Basic principles of environmental quality rationing

Topic 5. Rational using and protection of natural resources

Topic 6. The formation of global socio-ecology and the reasons that led to its emergence and development

Topic 7. Environmental expertise and environmental audit

Topic 8. Environmental law

Topic 9. Economics of nature

## **4. Course books and supplemental resources**

1. *A Handbook of Industrial Ecology / Edited by Robert U. Ayres and Leslie W. Ayres. - Edward Elgar Publishing, Inc. - 2002. - 679 p.*
2. *Ecology of Industrial Pollution / Edited by Lesley C. Batty, University of Birmingham, Kevin B. Hallberg, University of Wales, Bangor. - Cambridge University Press. – 2010. – 350 p.*

3. *Environmental Chemistry / Edited by Stanley E. Manahan. – Tenth edition. - New York: CRC Press, Taylor & Francis Group LLC. – 2017. – 752 p.*
4. *Implementing Industrial Ecology: Methodological Tools and Reflections for Constructing a Sustainable Development / Edited by Cyril Adoue. - Taylor and Francis Group, LLC. – 2011. – 144 p.*
5. *Technotology : textbook / O. I. Ivanenko, Yu. V. Nosachova, V. O. Ovsiankina, V. V. Vember. – Kyiv : Publishing House “Condor”, 2022. – 388 p.*

#### **Additional literature**

6. *Industrial Ecology and Global Change / Edited by R. H. Socolow, Clinton Andrews, Frans Berkhout and Valerie M. Thomas. - Cambridge University Press. – 1996. – 155 p.*
7. *Industrial Ecology and Industry Symbiosis for Environmental Sustainability Definitions, Frameworks and Applications / Edited by Xiaohong Li. - Palgrave Pivot & Springer International Publishing AG. – 2018. – 143 p.*
8. *Sustainable Industrial Design and Waste Management: Cradle-to-cradle for Sustainable Developmen / Edited by Salah M. El-Haggar. - Elsevier Inc. – 2007. – 401 p.*
9. *Urban Ecology: Science of Cities / Edited by Richard T. T. Forman - Cambridge University Press. – 2008. – 480 p.*

#### **Information resources on the Internet**

9. *Ministry of Ecology and Natural Resources of Ukraine - <https://menr.gov.ua/>*
10. *Council of European Energy Regulator - <https://www.ceer.eu/>*
11. *Industrial ecology. Community of environmentalists - <http://www.eco.com.ua/>*
12. *United States Environmental Protection Agency - <https://www.epa.gov/>*
13. *World Summit on Sustainable Development (WSSD) (2002), [www.un.org/jsummit/html/basic\\_info/basicinfo.html](http://www.un.org/jsummit/html/basic_info/basicinfo.html).*

### **Course content**

## **5. Study methodology**

### **Lectures**

*Lectures are aimed at:*

- *providing modern and holistic knowledge in the discipline "Cleaner Production", the scope of which is determined by the target setting for each specific topic;*
- *determining the current level of development of science and technology in the field of environmental protection and forecasting their development in the coming years;*
- *education of students' professional and business qualities and the development of their independent creative thinking;*
- *the use of methodological features of processing the material for better understanding and perception (highlighting the main ideas and provisions, emphasizing the conclusions, repeating them in different formulations);*
- *use of visual elements for the perception of the material: a combination of a lecture with a demonstration of audiovisual materials, diagrams, tables and models;*
- *explanation of all newly introduced terms and concepts;*
- *formation of students' necessary motivation and interest in continuing their studies within the framework of independent work.*

№	<b>The title of the lecture topic and a list for self-study</b>
1	<p><b>The concept of the environment and its protection</b></p> <p>Subject, methods, tasks and structure of modern ecology. Tasks facing engineers in the preservation of the natural environment The concept of environmental protection, the task of industrial ecology.</p> <p><b>Task for self-study:</b> The Importance of Ecology for Human Civilization.</p>
2-7	<p><b>General characteristics of modern technologies and their impact on the environment</b></p> <p>Wastewater treatment and waste processing of food industry enterprises. Fundamentals of sugar production technology. Sugar production wastes and their reuse. Methods of wastewater treatment of sugar factories. Fundamentals of alcohol production technology. Wastes from alcohol production and their reuse. Alcohol production wastewater treatment.</p> <p><b>Task for self-study:</b> Classification of wastewater treatment methods: mechanical, chemical, physicochemical and biochemical treatment methods.</p> <p>Environmental problems of paper and cardboard production. Ways of solving them. General technological scheme of paper and cardboard production. Characteristics of the main fibrous semi-finished products and their paper-forming properties. Pulp and paper wastewater treatment and disposal of valuable wastewater products. Technological methods that eliminate or reduce the formation of wastewater. Cleaning and recovery of gas and dust emissions from pulp and paper production.</p> <p><b>Task for self-study:</b> Processing of secondary cellulose-containing raw materials.</p> <p>Properties, classification and characteristics of the most commonly used pesticides. Destruction of DDT. The formation of dioxins as a result of the destruction of pesticides and their impact on living systems.</p> <p><b>Task for self-study:</b> Environmental pollution associated with the using of fertilizers and pesticides. Advantages and dangers of their using.</p> <p>Environmental problems of energy and ways of solving them. Schematic diagram of NPP operation. Water treatment at nuclear power plants. Radioactive liquid waste from NPPs. Basic technological schemes of processing of liquid radioactive waste of low and medium levels of activity. Disposal of liquid radioactive waste. Radioactive gaseous waste from NPPs. Radioactive solid waste from NPPs. Wastewater from the coal industry. Using of wastewater. Technology of purification of mine, quarry and coal beneficiation waters from suspended solids. The impact of the coal industry on the air basin.</p> <p><b>Task for self-study:</b> Solid waste and the state of land resources. Environmental pollution of thermal power plants and its prevention. Using of waste from coal beneficiation, ash and slag of thermal power plants.</p> <p>The impact of ferrous and non-ferrous metallurgy enterprises on the environment and ways of its protection. Agglomerate production. Domain process. Coke production. Coking products and their using. Construction and operation of coke ovens. Wastes from coke production and their processing. Problems of organization of closed water circulation systems at coke chemical enterprises. Steel classification and its technology. Steel production in oxygen converters. Steel production in open-hearth furnaces. Electric furnaces. Rolling steel. Ferroalloy furnaces. Ferrosilicon and ferromanganese production technology. Sewage of ferrous metallurgy enterprises and ways of their treatment. Technology of copper production by pyrometallurgical method. Obtaining alumina. Obtaining aluminum from its oxide.</p> <p><b>Task for self-study:</b> Sewerage systems with minimal wastewater discharge into</p>

	<p>reservoirs. Waste disposal in ferrous metallurgy.</p> <p>Environmental problems of oil refining. Composition and properties of oil. Petroleum products. Preparation of oil for refining. Basic processing methods and equipment.</p> <p><b>Task for self-study:</b> Generation, processing and reusing of refined waste.</p>
8	<p><b>Basic principles of environmental quality rationing</b></p> <p>Tasks facing engineers in the field of environmental protection. The impact of the quality of the natural environment on human health. Hygienic criteria for environmental quality. The concept of MPC, GDS, GDV.</p> <p><b>Task for self-study:</b> Features of the impact of industrial production on the environment and ways of its protection.</p>
9	<p><b>Ecological expertise and ecological audit</b></p> <p>Objects of ecological examination and audit. Purpose and objectives. Laws of Ukraine in ecological expertise and ecological audit. General requirements for examination and audit. State regulation and management in the field of environmental expertise and audit. Expert status. Rights and responsibilities of the expert and customers of environmental expertise and audit.</p> <p><b>Task for self-study:</b> Sources and types of pollution of the atmosphere, hydrosphere and lithosphere. Ways of reduce anthropogenic pressure on the environment.</p>

### **Practical training**

Practical classes are provided as part of the teaching of the discipline. They occupy 50% of the classroom workload. Topics which are presented for practical classes cover a wide range of questions.

They allow to understand better of lecture material, to master the method of ecological calculations, to find out the impact of certain groups of pollutants on the environment and to assess the degree of ecological risks.

The content of these classes and the methods of their conduct contribute to the development of creative activity of the individual. They develop scientific thinking and the ability to use special terminology, allow you to test knowledge. This type of work is an important means of operational feedback. Therefore, practical classes perform not only cognitive and educational functions, but are designed to promote the growth of students as creative workers in the field of ecology.

#### **The main tasks of the cycle of practical classes are:**

- ✓ to help students to systematize, consolidate and deepen theoretical knowledge in the field of ecology and environmental protection;
- ✓ teach them techniques for solving practical problems;
- ✓ to teach students to work with scientific and reference literature, documentation and schemes;
- ✓ to form the ability to learn independently, to help in mastering of the methods, techniques and techniques of self-education and self-development.

<b>№</b>	<b>Name of the topic of the classes and a list of main questions</b>
<b>1</b>	<p><b>The concept of the environment and its protection</b></p> <p>Global environmental problems of the Earth's biosphere. Hierarchy of biosphere ecosystems. The cycle of matter and energy in the biosphere. Influence of anthropogenic factor on the cycle.</p> <p><b>Task for self-study:</b> The relationship of ecology with other sciences. History of formation and development of ecological knowledge in Ukraine.</p>
<b>2</b>	<p><b>General characteristics of modern technologies and their impact on the environment</b></p> <p>Sources and types of pollution of the atmosphere, hydrosphere and lithosphere. Ways of reducing anthropogenic pressure on the environment.</p> <p><b>Task for self-study:</b> Environmental problems of the largest cities of Ukraine.</p>

3	<p><b>Utilization and processing of solid waste</b></p> <p>Utilization and processing of solid waste. Formation and disposal of waste from various sectors of the economy and industrial production. Waste disposal methods. Landfills. Utilization. Secondary resources. Household waste. Waste management strategy.</p> <p><b>Task for self-study:</b> Secondary Resources. Household waste. Introduction of low-waste technologies.</p>
4	<p><b>Basic principles of environmental quality rationing. Formation of global socioecology and the reasons that led to its emergence and development</b></p> <p>Environmental monitoring. Geographic information systems (GIS) in environmental monitoring systems. Prospects for GIS development. Information technologies in the system of ecological and economic monitoring. Radioecology and ecological influence of electromagnetic radiation. Formation of global socioecology and the reasons that led to its emergence and development. Development of human relations with nature. Socio-ecosystems. The phenomenon of information and information processes in nature and society. Development and evolution of information transmission systems.</p> <p><b>Task for self-study:</b> Classification of theories of ecological development. International environmental strategy. Passive and active environmental strategies.</p>
5-7	<p><b>Rational using and protection of natural resources</b></p> <p>Natural resources, their using and protection. Protection of flora and fauna. Prospects for the preservation of animal diversity in a rapidly changing environment. Protection of soils and subsoil.</p> <p><b>Task for self-study:</b> Man-caused pollution of the lithosphere. Classification of pollution. Dependence of the degree of environmental pollution on the methods of extraction and processing of raw materials. Ways of reducing of raw materials losses at all stages of its processing.</p> <p>Air protection. Specific types of air pollution: electromagnetic, high-frequency, noise, vibration. Energy as one of the main sources of air pollution.</p> <p><b>Task for self-study:</b> Alternative energy sources, their advantages over traditional ones and disadvantages.</p> <p>Rational using and protection of water resources. Condition of water basins of Ukraine. Self-cleaning of reservoirs. Classification of methods for treatment of industrial, municipal and agricultural effluents from solid suspended colloidal particles, dissolved salts, organic impurities and petroleum products. Water treatment.</p> <p><b>Task for self-study:</b> Existing systems and schemes of water supply and sewerage of industrial enterprises. Serial and reversible water supply systems. Their advantages over direct current systems. Varieties of circulating water supply systems. Complications in the operation of existing water supply and sewerage systems of industrial enterprises.</p>
8	<p><b>Environmental law. Economics of nature management</b></p> <p>Environmental policy of different nation, environmental protection and the mechanism of its implementation. The main directions of the state policy of Ukraine in the field of environmental protection and using of natural resources. Economics of nature management. The main factors of economic development of the state. Calculation of indicators of damage caused by pollution or changes in environmental conditions. Using of systems approach to optimize nature management processes.</p> <p><b>Task for self-study:</b> The place of environmental law in the system of legal relations. Environmental rights guaranteed by the Constitution. International environmental organizations.</p>
9	<p><b>Modular test</b></p>

## 6. Self-study

Independent work of students takes 40% of the time allocation of the course, also includes preparation for writing a modular test and preparation for the final test. The main task of students' independent work is to master scientific knowledge in the field of environmental protection, which is not included in the list of lecture topics, by personal search for information, formation of active interest and creative approach in educational process.

№	Name of the topic for self-study	Number of hours
<b>Chapter 1. Features of the impact of industrial production on the environment and ways of its protection</b>		
1	<p>The concept of the environment and its protection</p> <p>The importance of ecology for human civilization. Connection of ecology with other sciences. History of formation and development of ecological knowledge in Ukraine.</p>	2
2	<p>General characteristics of modern technologies and their impact on the environment</p> <p>Classification of wastewater treatment methods: mechanical, chemical, physicochemical and biochemical treatment methods. Ecological problems of the largest cities of Ukraine.</p> <p>Processing of secondary cellulose-containing raw materials.</p> <p>Environmental pollution associated with the using of fertilizers and pesticides. Advantages and dangers of their using.</p> <p>Solid waste and the state of land resources. Environmental pollution of thermal power plants and its prevention. Using of waste from coal beneficiation, ash and slag of thermal power plants.</p> <p>Drainage systems with minimal wastewater discharge into reservoirs. Waste disposal in ferrous metallurgy.</p> <p>Generation, processing and reusing of oil refining waste.</p>	6
3	<p>Utilization and processing of solid waste</p> <p>Secondary resources. Household waste. Introduction of low-waste technologies. Secondary resources. Household waste. Introduction of low-waste technologies.</p>	1
<b>Section 2. Ecological aspects of rational nature management</b>		
4	<p>Basic principles of environmental quality rationing</p> <p>Features of the impact of industrial production on the environment and ways of its protection.</p>	1
5	<p>Rational using and protection of natural resources</p> <p>Man-made pollution of the lithosphere. Classification of pollution. Dependence of the degree of environmental pollution on the methods of extraction and processing of raw materials. Ways of reducing of raw materials losses at all stages of its processing.</p> <p>Alternative energy sources, their advantages over traditional ones and disadvantages.</p> <p>Existing of systems and schemes of water supply and drainage of industrial enterprises. Serial and reversible water supply systems. Their advantages over direct current systems. Varieties of circulating water supply systems. Complications in the operation of existing water supply and sewerage systems of industrial enterprises.</p>	2
6	<p>Formation of global socioecology and the reasons that led to its emergence and development</p> <p>Classification of theories of ecological development. International environmental strategy. Passive and active environmental strategies.</p>	1
7	<p>Ecological expertise and ecological audit</p> <p>Sources and types of pollution of the atmosphere, hydrosphere and lithosphere. Ways of reducing of anthropogenic pressure on the environment</p>	1

8	<i>Environmental law The place of environmental law in the system of legal relations. Environmental rights guaranteed by the Constitution.</i>	1
9	<i>Economics of nature management International environmental organizations.</i>	1
4	<i>Preparation for the modular test</i>	2
5	<i>Preparation for the final test</i>	6
	<b>Total hours</b>	<b>24</b>

## Attendance Policy and Assessment

### 7. Attendance policy

#### Rules of attendance and behavior in the classroom

*Attendance is a mandatory component of assessment. Students are required to actively participate in the educational process, not to be late for classes and not to miss them without a sound reason, not to interfere with the teacher to conduct classes, not to be distracted by actions that are not related to the learning process.*

#### Rules for assigning incentive and penalty points

- *incentive points can be awarded by the teacher only for the creative work in the discipline, but their amount can not exceed 10% of the rating scale;*
- *penalty points within the discipline are not provided.*

#### Policy of deadlines and repeating an examination

*In case of repeating an examination on the discipline or any force majeure, students should contact the teacher via available (provided by the teacher) communication channels to solve problems and agree on an algorithm for making-up the work. In case of absence on the day of writing of modular control work (MCW) a student who has provided a certificate of illness may write an MCW outside of classroom hours. Rewriting the MCW is not allowed.*

#### The policy of academic integrity

*Plagiarism and other forms of dishonesty are not allowed. Plagiarism includes the lack of links when using printed and electronic materials, citations, opinions of other authors. Copy-offs during control works are forbidden. Hints and copy-offs during tests, classes; passing a test for another student; copying of materials protected by the copyright system without the permission of the author of the work are unacceptable.*

*The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Details: <https://kpi.ua/code>.*

#### Policy of academic behavior and ethics

*Students must be tolerant, respect the opinions of others, formulate objections in the correct form, constructively provide feedback in class.*

*Norms of ethical behavior of students and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Details: <https://kpi.ua/code>.*



## 8. Control measures and assessment polity

*Distribution of study time by types of classes and tasks in the discipline according to the curriculum:*

Semester	Study time		Distribution of study hours				Control activities		
	Credits	acad. hours	Lectures	Practical	Lab. work	Self-study	Modular control work	Calc. work	Semester control
3/4	2	60	18	18	–	24	1	–	test

**The student's rating in the discipline consists of points for:**

- 1) presentation on a topic for practical classes or for independent work (in total 2 presentations for each student);
- 2) active participation at practical classes (provided that 10 students are examined during one class with a maximum group size of 25 students):

$$\frac{8 \text{ pract.} \times 10 \text{ stud.}}{25} \approx 3 \text{ grades;}$$

- 3) modular control work, which can be divided into two 45-minute or three 30-minute work.

Semester control is a test.

### System of rating (weight) points and evaluation criteria

#### 1. Practical work

##### 1.1. Presentation:

Weight point - 20. The maximum number of points in all practical lessons is 20 points  $\times$  2 = 40 points.

Evaluation criteria:

<b>Quality of the presentation and its assessment</b>	<b>Points</b>
The topic of the report is fully disclosed; the student thoroughly explains all aspects of the relevant topic, makes the necessary conclusions and generalizations, as well as clearly answers the questions	20
The presentation does not provide enough facts and examples; proper analysis is not performed; conclusions are insufficiently clear; the answers to the questions are unclear or have some inaccuracies	15...19
The topic of the presentation is insufficiently disclosed; there no conclusions; there are no answers to some questions	12...14
The presentation does not correspond to the formulated topic; all questions were left unanswered. The report is not credited	0

##### 1.2. Participation at practical classes:

Weight point – 10. The maximum number of points in all practical lessons is 10 points  $\times$  3 = 30 points.

Evaluation criteria:

<b>Completeness and characteristics of a response</b>	<b>Points</b>
Active participation in the discussion of all questions, correctness of answers and performance of all tasks	10
Some minor mistakes when performing tasks or discussing material	8...9
A vague answer; gross mistakes are made; there is no specific formulation of laws and terms	6...7
The answer is not valid, there is no activity or preparation for the practical classes	0

## 2. Modular control work:

Modular control work is carried out in the form of testing.

In total, students have to answer 60 questions related to different sections and topics of the discipline.

The weight point for each correct answer is 0.5. Each of the answers is evaluated separately, after which the score is summed.

The maximum number of points for writing a modular control work is equal to  $0,5 \text{ points} \times 60 = 30 \text{ points}$ .

### **Calculation of the rating scale (R)**

The rating scale of the discipline (RD) is 100 points and is formed as the sum of all rating points obtained by the student as a result of current control measures:

$$R = 20 \times 2 + 10 \times 3 + 10 \times 3 = 100 \text{ points.}$$

According to the results of education for the first 7 weeks, an "ideal student" must score 20 points. At the first calendar control (8th week) a student receives "passed" if his current score is at least 10 points.

According to the results of 13 weeks of study, an "ideal student" must score 40 points. At the second calendar control (14th week) a student receives "passed" if his current score is at least 20 points.

A necessary prerequisite for permit to the final test is the crediting of presentations, writing of MCW, as well as a score of at least 40% of the rating scale (RD), i.e. 40 points.

Students who scored less than 0.6 R during the semester, as well as those who want to increase the overall rating, should write a test work. In this case, all points obtained during the semester are canceled. Test tasks contain questions from different sections of the program. The list of test questions is given in Section 9.

To obtain a student test score, the sum of all rating points **R** obtained during the semester is transferred according to the table:

<b>Scor</b>	<b>Grade</b>
95...100	Excellent
85...94	Very good
75...84	Good
65...74	Satisfactory
60...64	Sufficient
RD < 60	Fail
Course requirements are not met	Not Graded

## 9. Additional information

### **An approximate list of questions for semester control**

1. What environmental problems are most pressing for Ukraine?
2. Formulate the main groups of global environmental problems that exist in the world today and have significant environmental consequences, as well as lead to significant economic losses.
3. Describe the pollution of heavy metals, their migration through food chains and environmental consequences.
4. Analyze the impact of military technology and aviation on the environment.
5. Assess the environmental impact of metallurgical enterprises.
6. Assess the environmental impact of the chemical industry.
7. Assess the environmental impact of refineries.
8. Assess the environmental impact of the mining industry.

9. *Assess the environmental impact of the woodworking and food industries.*
10. *Assess the environmental impact of a nuclear power plant.*
11. *Assess the environmental impact of the thermal power plant.*
12. *Assess the environmental impact of modern agriculture.*
13. *Analyze the maximum allowable concentrations, the scientific basis for determining the MPC.*
14. *Identify the types of toxic substances and their cycle in the environment. Toxic effects. Standardization of the content of toxic substances.*
15. *Analyze the dynamic balance in the natural environment and its disturbance. Conditions of ecologically safe functioning of natural and technogenic systems. Causes and consequences of intensification of dangerous processes and harmful factors in the environment.*
16. *Determine environmental safety in emergency situations. Model assessment of environmental risk. Expert assessment of environmental risk. Sociological assessment of environmental risk.*
17. *Describe the ecological approach of assessing of the state and regulating the quality of the environment. Maximum allowable environmental load.*
18. *Conduct a comparative analysis of the terms "ecosystem" and "biogeocenosis". Identify the common features and differences of these concepts. In which cases should the term "ecosystem" be used, and in which - "biogeocenosis"?*
19. *List the existing types of ecological pyramids. Analyze how the pyramid of numbers and the pyramid of products differ. Can each of these pyramids have a different (including "inverted") appearance? What is the practical significance of knowing the laws of ecosystem productivity?*
20. *What does the biotic potential reflect? What role does high reproductive potential play in the regulation of population homeostasis?*
21. *Give a list of the main components that must exist in the ecosystem to maintain the cycle of substances in it. Identify the environmental role of producers, consumers and reducers.*
22. *Carry out a comparative analysis of the content of basic nutrients in the atmosphere, hydrosphere, lithosphere and biosphere. What conclusions can be drawn from the results of the analysis?*
23. *Analyze the peculiarities of the cycle of basic nutrients in the biosphere and identify their common features and differences.*
24. *Determine which stages and stages of biological cycles are being limited and can be significantly unbalanced under the influence of anthropogenic factors.*
25. *Describe the resource cycle as an anthropogenic cycle of substances. What are the problems with its operation?*
26. *Describe the structure, gas composition and physicochemical properties of the atmosphere. Justify the value of these properties for the preservation of the Earth's biosphere.*
27. *Describe the main air pollutants and related environmental problems.*
28. *Analyze and compare different methods of protecting the atmosphere from anthropogenic pollution. What methods for cleaning and protecting the atmosphere from gas emissions do you know?*
29. *Describe the role of the ozone layer for life on Earth. What can lead to the destruction of the ozone layer and what are the possibilities of humanity to preserve it?*
30. *Assess the causes and possible consequences of global warming. What are the possibilities of humanity at the present stage to solve this problem?*
31. *Describe the preconditions for acid rain in different landscapes.*
32. *Describe the main causes and consequences of global atmospheric problems. What is the protection of the air at the present stage?*

33. Analyze the ways of pollution of the hydrosphere and give their classification. What are the global problems of the hydrosphere.
34. Carry out a comparative analysis of the methods of drinking water purification known to you. What are the problems of water treatment today?
35. Analyze the process of water treatment for different sectors of the economy. Describe the state of water basins of Ukraine and determine the state of solving the problem of providing humanity with drinking water at the present stage.
36. Describe the processes that take place in reservoirs during their self-cleaning. What can lead to pollution of water resources by nutrients?
37. Analyze the features of water using in industry, utilities and agriculture. What types of water supply systems do you know? What does the term "rational water supply" mean?
38. Describe the methods of wastewater treatment of etching production.
39. Analyze and explain the causes and consequences of salinization of surface and groundwater. Suggest ways to reduce salinization of fresh and groundwater.
40. Describe the structure and chemical composition of the lithosphere. What global problems of the lithosphere are the most urgent today?
41. Evaluate the problem of soil conservation in agriculture. Describe modern methods of agriculture. What are the consequences of man-made soil pollution?
42. Describe the pros and cons of large-scale reclamation and irrigation.
43. Describe the current state of affairs regarding the study of the Earth's interior and their protection. What are the ecological and economic significance of Ukraine's minerals?
44. Give the classification of the Earth's natural resources and analyze what types of their extraction and use are the most promising for maintaining the sustainable development of the Earth's biosphere.
45. Identify the main features of the phenomenon of stratification of the atmosphere, hydrosphere and lithosphere. Assess the ecological significance of the structure of the Earth's geospheres.
46. Identify what general engineering principles and approaches can be proposed for the rational use of nature and the development of environmentally friendly technologies.
47. Justify the forms and mechanisms of degradation of the Earth's biosphere. How does the development of industrial and agricultural production affect these processes?
48. Describe the role of VI Vernadsky in creating the doctrine of the biosphere and noosphere. Define the noosphere and analyze the current state of its formation.
49. Are there prospects for preserving the diversity of animals and plants in a rapidly changing environment? What are the consequences of anthropogenic pollution for the fauna? Justify the importance of the Red Book for biodiversity conservation.
50. Describe the main ways of regulating the number of populations in the biosphere. What type of connection is used to maintain homeostasis?
51. Determine the value of nutrients to maintain homeostasis of the biosphere. Describe the mechanisms of biogeochemical provinces and biogeochemical endemics.
52. Give a list of the main demographic problems and processes that dominate the world. Suggest ways to solve these problems.
53. Analyze the demographic situation in Ukraine. Suggest ways and means to solve demographic problems.
54. Describe the methods of processing solid waste from coke production.
55. Analyze and give a brief description of the main problems of energy supply and energy consumption in the modern world. Can alternative energy sources solve existing problems? Justify your answer.

56. Describe the methods of reducing the level of radioactive contamination of the environment and the disposal of radioactive waste. Give examples of methods of neutralization of liquid radioactive effluents.
57. Evaluate environmental monitoring. List its types and functions. Draw a diagram of environmental monitoring.
58. Describe the purpose, objectives and stages of environmental assessment.
59. Analyze the possibilities of overcoming the negative consequences of STR through the introduction of the concept of sustainable development in all spheres of modern life.
60. Describe the environmental legislation of Ukraine. Analyze the rights and responsibilities of nature users.

## **Syllabus**

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## **adopted by**

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