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КАФЕДРА РАДИАЦИОННОЙ МЕДИЦИНЫ И ЭКОЛОГИИ

ЭКОЛОГИЧЕСКАЯ МЕДИЦИНА

ECOLOGICAL MEDICINE

Лабораторный практикум
для студентов медицинского факультета иностранных учащихся

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Содержатся материалы, формирующие стойкие практические навыки изучения состояния среды обитания человека, развивающие экологическое мышление, способность научного предвидения и осуществления индивидуальной и популяционной профилактики нежелательных медицинских последствий хронического и низкодозового воздействия физико-химических средовых факторов. Прикладной характер и актуальность цели каждого практического задания, наглядность и запоминаемость результатов применения описываемых методик служат повышению мотивации обучающихся к изучению тем раздела «Экологическая медицина» дисциплины «Радиационная и экологическая медицина».

Предназначен для студентов 2-го курса медицинского факультета иностранных учащихся, обучающихся на английском языке по специальности 1-79 01 01 «Лечебное дело».

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FUNDAMENTALS OF ENVIRONMENTAL MEDICINE

Motivational profile of the theme. Comprehensive knowledge of the environmental medicine basics contributes to the formation of medical students' thinking in ecology domain, provides with understanding of the environmental triggers of morbidity and allows for the employment of appropriate therapeutic and preventive measures.

Learning objective. Comprehension of the intrinsic relationship between the immanent states of the environment, including the ones attributed to human activities, and the development of certain health disorders in humans.

Study questions:

1. Definition of the concepts «ecosystem», «trophic chains», «eco-top», «biocenosis».
2. City as ecosystem, its profile.
3. The concept of «environmental diseases».
4. Biorhythmology, «biological clock», «winter depression».
5. The concept of ultraviolet radiation, its damaging effect.
6. Human body mechanisms, protecting from ultraviolet radiation.
7. Health disorders caused by ultraviolet radiation exposure.

Ecological (environmental) medicine is a comprehensive discipline that deals with all aspects of the impact of environment on the human health with a particular focus on environmental diseases.

Gradual increase in the number of chronic diseases at the current stage of public evolution is largely determined by environmental factors (chemical, physical, biotic, social). The development of an ecologically dependent sickness in humans is induced or mediated by prolonged exposure to any environmental factor (physical, chemical, biological), which intensity level is extremely low or is recorded in a sub-threshold range.

Chronic exposure to external factors is known to initiate health disorders through the mechanisms causing:

– failure of detoxification processes;
– damage to the immune system;
– malfunction of other body systems (gastrointestinal tract, endocrine system);
– immediate damage to the target organ.

Environmental factors, that may endanger human health, are described as physical, chemical, biological etc.

It is recognized, that the visible portion of the sun's irradiance spectrum as a physical factor is crucially important for regular physiological processes. The disease, labeled «winter depression», which is associated with the relevant illumination insufficiency, is proved to be a clinical manifestation of biological rhythms disorder — dysfunction of circadian cycles, or dysfunction of the biological clock.

The effect of another physical factor — ultraviolet radiation — is related to its potency to stimulate photochemical transformations in the tissues and cells of the human body, which can induce hazardous mutations. Human natural protection system includes *the melanin synthesis mechanism, the keratinization of the skin and the uric acid excretion with sweat*. Profound knowledge of the fundamentals of dosimetry, proficiency in calculation of the minimal erythema dose (MED), subject to the skin sensitivity type and ultra-violet radiation intensity, appears to be of great importance for the prevention of the disorders, resulting from ultraviolet radiation exposure. Knowledge of the factors that can contribute to the development of skin malignancies (dysplastic nevi, tanning history, heredity, etc.) is also highly demanded in clinical medicine.

LABORATORY WORK 1. BIOLOGICAL RHYTHMS. TEMPERATURE AND PULSE DIURNAL RHYTHMS IN HUMANS

Student will master methodology of biological daily rhythm assessment related to certain human vital signs (pulse, temperature, arterial pressure).

The term «rhythm» denotes a recurring natural phenomenon. Rhythms registered in the living creatures are labeled as biological. Biorhythms are both regular quantitative changes and related qualitative alterations in biological processes that occur at different levels of biological organization: molecular-genetic, cell, tissue, organ, organism, population-biosphere. The main parameters of the rhythm are divided into ***period, MEZOR, amplitude, acrophase*** (fig. 1).

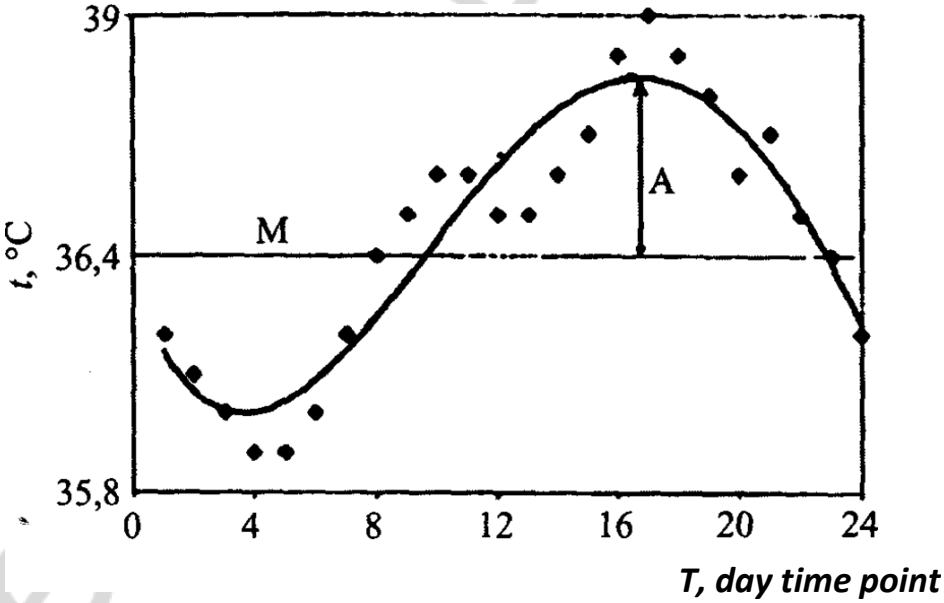

Fig. 1. Schematic representation of the rhythm and its parameters

T refers to the time points of day. The amount of cycles registered per unit time is referred to as rhythm frequency. ***M*** (MEZOR) denotes the average level of the parameters. ***A*** (amplitude) designates the divergence between the parame-

ter maximum and MEZOR. ***Acrophase*** is for the time point with the maximal value of the signal recorded.

Biological rhythms, coinciding in the time aspect with the corresponding geographical cycles are referred to as «ecological» or «adaptive». These ones include perennial (coincident, for example, with an 11-year rhythm of solar activity), annual, seasonal, lunar, tidal and daily changes in vital activity. Considering the degree of dependence on external stimuli, biorhythms are classified as exogenous and endogenous.

Exogenous, i. e. external, rhythms depend on the rhythmics of geographical and cosmic factors (photoperiodism, ambient temperature, atmospheric pressure, rhythm of cosmic radiation, gravity, etc.).

Endogenous, i. e. active, rhythms are generated under the stimuli of permanent external conditions, their biological effect does not extend beyond the limits of adaptive-compensatory reserves of the human system.

Under relative persistency of geophysical factors, oscillations of vital activity last not strictly 24 hours, but somewhat greater or shorter. These diurnal rhythms, easily synchronized with daily geophysical factors, are referred to as ***circadian rhythm***. There is a sophisticated relationship of these rhythms with the three periods: the Earth's rotation relative to the Sun, the Earth's rotation relative to the Moon, the Earth's rotation relative to the stars.

The class of *mid-frequency rhythms* (0.5 hour – 1 week) includes ultradian (30 min – 20 hours), circadian, or diurnal (20–28 hours), infradian (more than 28 hours), *circasemiseptan* (about-half-weekly), *circaseptan* (about-wekly) cycles. These patterns are highly relevant to sleep-wake cycle, body temperature, arterial blood pressure, mitosis, the secretion of certain hormones, etc.

Fundamental role of diurnal (circadian) rhythms, similar to that of the genetic code, makes these rhythms extremely significant.

Some rhythmic variations (oscillations) present internal, genetically conditioned properties of the cells. For proper interaction of these cells within the integral biological system of animals and humans, a «conductor» is required to coordinate the phase relationships. It is suprachiasmatic nuclei (SCN) which play the leading role in the circadian biorhythms implementation. In the rhythm-regulating system suprachiasmatic nuclei and ***melatonin*** hormone of epiphysis present the neurogenic and endocrine components respectively.

Studies in the domain of the physiological processes daily rhythm help organize rational activities and rest, diagnose and treat diseases, obtain scientific grounds in drug dosage, manage rational sports training and prevent premature aging.

Task for students. Perform daily measurement of temperature and pulse rate (heart rate).

Laboratory work procedure

Preliminarily, each student will measure the body temperature in axillary region and will count pulse rate at rest (if it is relevant, also — arterial blood pressure) at 7 a.m., 11 a.m., 3 p.m., 7 p.m. and 11 p.m. According to the obtained measurements, the graphs of dynamics in body temperature and pulse rate (blood pressure) will be plotted. The X-axis designates the time point of day and the Y-axis indicates the entity under consideration in its measuring units. In class, using also the measurements of the group mates, each student will fill in the table (tabl. 1).

Table 1

Daily data variations in temperature (pulse rate / blood pressure)

No.	Student Name	Temperature (or pulse rate / blood pressure) at time points specified				
		7 a.m.	11a.m.	3 p.m.	7 p.m	11 p.m.
1.						
2.						
3.						
Average value (M)						

Estimation Algorithm

Find the average quantitative value for each measured parameter at the specified time point and tabulate it. Plot the graph of the average hourly variations of temperature and pulse rate (arterial pressure). According to the graph, MEZOR, the swing amplitude, the amplitude of the oscillations (deviation from the daily average value to the peak) and the acrophase are estimated.

Based on the data obtained, draw a conclusion on the cyclic patterns of temperature, pulse rate (blood pressure) in humans.

Tasks for independent academic work

1. Study the essence of the methodology for daily biological rhythms observing.
2. Carry out measurements and calculations.
3. Evaluate your findings.

Test yourself

1. What is a «biological rhythm» phenomenon?
2. What are the types of biological rhythms in humans?
3. What anatomical structure is recognized to be the pacer of biological rhythm in the human body? Describe the immediate mechanism maintaining the circadian biological rhythms.
4. What parameters characterize biological rhythms?

LABORATORY WORK 2. ASSESSMENT OF RISK OF SEASONAL EMOTIONAL DISEASE

Student will master the methodology for assessment of a person's liability to winter depression.

Winter depression, or seasonal emotional disease (SED), also known as seasonal affective disorder (SAD), refers to human neurological disorder. It is attributed to a person's constant exposure to low light conditions due to the decrease of daylight hours in the autumn-winter season. The immediate triggering factor for the development of SAD symptoms is arising out of a longer retention of ***melatonin*** in the human body and extended effect on the endocrine system. Melatonin is synthesized as a result of the biological clock functioning.

Clinical presentation of SAD varies in wide range up to strong depression and suicidal attempts as the ultimate form of clinical presentation.

It is a direct responsibility of a medical practitioner to recognize the signs of the enhanced risk of this disorder. For this purpose one may adopt a clinical test, which has been elaborated at the University of Vienna (Austria) and is presented below.

Task for students. Test yourself, reading attentively the suggested set of questions and statements. Make notes to testify the presence or absence of characteristic features. Count the scores.

Laboratory work procedure. Accomplish the test in several steps. Once it is completed, calculate the scores using the three tables, given below (A, B and C). The score must be counted for each table separately.

Step 1: SAD identification.

Do you suffer from the following symptoms for at least two weeks within the autumn-winter period (Tabl. 2 and 3)?

Table 2

No.	Symptom	No feature	Feature is present	Total score
1	Sad, depressed, downcast mood	0	1	
2	Loss of interest in the outworld	0	1	
3	Reduced performance, easy fatigability	0	1	

Table 3

No.	Sign	No sign	Sign is present	Total score
1	Absent-mindedness, difficulty concentrating	0	1	
2	Loss of self-confidence, self-doubt	0	1	
3	Feelings of guilt, inexplicable anxiety	0	1	
4	Pessimistic thinking about the future	0	1	
5	Thoughts about the meaninglessness of life	0	1	
6	Sleep disturbances; shallow, superficial sleep, insomnia	0	1	
7	Increased appetite	0	1	

Step 2. Identification of the degree of difference in SAD manifestations.

Once you have noted the presence of one or more signs, outlined above, specify whether you observe seasonal distinctions in the grade of sign severity during a year (in particular, between summer and winter periods, tabl. 4).

Table 4

No.	Symptom	No distinction	Distinction degree				Overall score
			slight	mild	pronounced	extremely high	
1	Sleep length	0	1	2	3	4	
2	Social activity	0	1	2	3	4	
3	Mood, general state of health	0	1	2	3	4	
4	Weight alteration	0	1	2	3	4	
5	Appetite variations	0	1	2	3	4	
6	Change of performance	0	1	2	3	4	

Algorithm for the overall test results assessment

Use the following table to assess the test results:

Table 5

Test based conclusion	Table A score	Table B score	Table C score
No risk of SAD	0	0	< 7
	1	0	
Risk group for SAD development	1	1	8–10
	2	0	
Strong liability to SAD	2	2 and higher	10 and higher
	3	0	

Tasks for independent academic work:

1. Do the test according to Tables 3, 4 and 5.
2. Assess the test results.
3. Suggest a set of measures to prevent winter depression.

Self-check questions:

1. What is the effect of the visible spectrum of electromagnetic radiation on the human body?
2. What is the scheme of melatonin synthesis?
3. What are the functions of melatonin in the human body?
4. What is the role of melatonin in the presentation of winter depression?
5. What are the approaches to prevention and treatment of winter depression?

LABORATORY WORK 3. EVALUATION OF BIOLOGICAL EFFECTS OF ULTRAVIOLET RADIATION

Students will master:

1) evaluation technique of skin sensitivity to ultraviolet radiation (UVR);

2) calculation methods of the safe sun tanning time;

Brief Outline. Depending on the dose, ultraviolet (UV) radiation (UVR) can exert both positive and negative effects on the human body.

A positive effect is implemented through stimulation of vitamin D_3 synthesis in the skin. Penetrating the epidermis, UVB photons photolyze provitamin D_3 into previtamin D_3. Once synthesized, previtamin D_3 undergoes a thermally (t = +37 °C) induced isomerization to vitamin D_3. Following WHO, the daily dose of 400 IU of vitamin D_3 synthesis requires annually 60 units of minimal erythema dose (MED). According to Sanitary Rules and Regulations 11-63-PB98, for adults vitamin D_3 daily requirement is set at 100 IU, for a child of 4–6 — at 200 IU.

Nevertheless, UVR is not completely safe and can cause damage to living organisms. It is proved, that the Earth's atmosphere completely absorbs high-energy photons ($\lambda < 280$ nm). It is UVB and UVA photons that impact biota. UV rays within these energetic ranges can induce in humans both deterministic (photokeratitis, cataract, photoallergy, phototoxicity) and stochastic (skin malignant tumors) effects. Important factors to contribute to the above disorders development are as follows:

– dose of radiation;
– radiation spectral profile;
– individual sensitivity;
– frequency of exposures.

According to scientific findings, UVR of different spectral ranges has not an equal effect on human skin, for which reddening is, yet, the uniform response pattern. For example, the skin is 100 times more sensitive to UVR at 298 nm wavelength compared to that with emitted wavelength $\lambda = 319$ nm. The contribution of various UVR spectral ranges to the skin redness induction is conveyed by the so-called *erythema action spectrum* (EAS). It is measured as UV flux power per area unit (W/m^2). The 0.25 W/m^2 value is internationally accepted as EAS maximal value. Routinely, when monitoring the level of ultraviolet radiation, many countries use the *ultraviolet radiation index* (UV index), which is communicated to the public through media. The UV index is calculated as a product of the EAS and 40. Consequently, the maximal UV index at the highest recommended UVR exposure with EAS = 0.25 W/m^2 appears to be 10 ($0.25\ W/m^2 \times 40 = 10\ W/m^2$).

As per the World Health Organization (WHO), UV index values are scaled as follows:

– 1–2 — low;
– 3–5 — medium;
– 6–7 — high;
– 8–10 — very high;
– 11 and higher — extreme.

In summertime the UV index ranges from 5 to 8 on the territory of the Republic of Belarus.

It is widely acknowledged, that each person has individual skin sensitivity to UVR exposure. There exist four main types of skin sensitivity. To evaluate the type of skin sensitivity, students are suggested to carry out a special test, described further in this laboratory work.

It is the *minimal erythema dose* (MED), which characterizes the intensity of UVR impact on the skin (fig. 2).

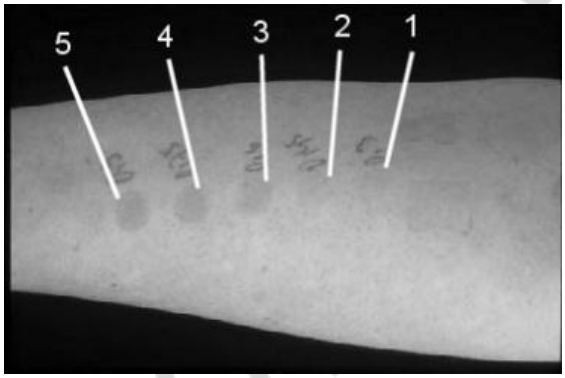

Fig. 2. UV-induced erythema:
1 — 0.3 MED; *2* — 0.45 MED; *3* — 0.6 MED; *4* — 0.75 MED; *5* — 0.9 MED

MED denotes a dose of ultraviolet radiation that produces barely perceptible redness in the previously unexposed skin within 8–10 hours following the exposure. It is estimated that one MED unit corresponds to 250 J/m^2 of energy and evokes the above response in the individuals with type II skin sensitivity. Other skin sensitivity types require their particular flux density. All the above allows calculation of UVR acceptable levels (AL) as related to the dose of UVR for type II skin sensitivity (tabl. 6).

Table 6

Acceptable levels (AL) for various skin types

Skin sensitivity type	UVR dose, J/m^2	AL
I	200	0.8 MED
II	250	1.0 MED
III	350	1.4 MED
IV	450	1.8 MED

Having compared UV index and MED values, it is easy to compute that 10 units of the UV index correspond to 4.3 MED/hour of *erythemal dose-rate* (EDR) value. Hence, a UV index unit is equal to 0.43 MED/h. Since each UV index value corresponds to a definite UV flux density, it is easy to calculate the period of the safe tanning time with regards to the skin sensitivity type.

It is internationally adopted, that for a non-pigmented (non-tanned, previously unexposed to UV) skin of all sensitivity types the UVR acceptable level equals a daily dose of 0.4 MED; for an individual with previously exposed skin of sensitivity type II UVR acceptable level (AL) corresponds to the daily dose of 1 MED. For children, an acceptable level equals 0.8 MED daily.

Calculation method of the safe sun tanning time:

Step 1. Calculation of the erythemal dose-rate (EDR) value as per certain UV index:

$$\mathbf{EDR}_{(MED/h)} = \mathbf{UV\ index} \times \mathbf{0.43}_{(MED/h)}.$$

Step 2. Calculation of the time period (expressed in hours) for the acceptable daily dose of UV radiation with regards to a given UV index value and a skin sensitivity type.

$$\mathbf{t}_{hours} = \mathbf{AL} / \mathbf{EDR}.$$

Step 3. Hour-minute conversion:

$$t_{minutes} = t_{hours} \times 60.$$

It should be taken into account that the acceptable maximal annual cumulative MED value for type II skin sensitivity is recommended to be 50, for types II and III — 70 and 90 MED respectively.

Task for students. Perform a self-test of your type of skin sensitivity to UV radiation.

To make a conclusion on skin sensitivity, a student is supposed to answer 10 questions presented below, checking ready-made answers. Each option of a response to a question is scored as follows: the 1st option — 1 point, 2nd — 2 points, 3rd — 3 points, 4th — 4 points.

I. What is the color of your un-tanned skin?

1. Pale pink, whitish-pink
2. White
3. Slightly swart
4. Swart

II. What is the natural color of your hair?

1. Red
2. Blond / blonde
3. Ranging from dark blond to brown.
4. Ranging from dark brown to black

III. What is the color of your eyes?

1. Light blue, light gray or light green

2. Blue, gray, green
3. Light brown or dark gray
4. Dark brown

IV. Does your skin bear freckles?
1. A great amount
2. A few
3. Single
4. None

V. What is the typical response of your face skin to sunlight radiation exposure?
1. Very sensitive, sunburns are often;
2. Sensitive, sunburns may occur.
3. No special sensitivity was observed, sunburns occur rarely
4. No special sensitivity was observed, sunburns occur sporadically

VI. How long can you stay in the sun at summer cloudless noon without getting sunburnt, Belarus latitude?
1. Less than 15 min.
2. From 15 to 25 minutes.
3. From 25 to 40 minutes.
4. More than 40 minutes

VII. What is the skin response to a long stay in the sun?
1. Sunburns always occur.
2. Sunburns often occur.
3. Sometimes sunburn may occur.
4. Sunburns are very rare or never at all.

VIII. What are the features of your sunburns?
1. Pronounced heavy reddening, soreness, blisters can appear, followed by skin peeling
2. Reddening, followed by peeling
3. A slight reddening, further peeling may occur
4. No reddening, no peeling

IX. Can you get tanned following a single, but prolonged stay in the sun?
1. No, this is impossible
2. Very rarely
3. Often
4. As a rule

X. What is the pattern of your tanning upon repeated sun baths exposure?
1. Feeble tan is observed or not at all.
2. Tan is produced with difficulty
3. Tan intensity gradually enhances
4. A stable tan develops instantly

Evaluation Algorithm. Sum up all the score points and divide the sum by 10. Round off the number pursuant to conventional rules. It is the final score, which signifies the type of your skin sensitivity. If, e. g., you get 2.5 as a result of division, you have an in-between type of skin sensitivity (between the 2nd and 3rd types).

Tasks for independent academic work

1. Carry out a self-test, answering the suggested questions.
2. Evaluate the test results.
3. Calculate the safe tanning time length for your skin with the UV indexes of 5 and 10.

Self-check questions

1. What types of skin are observed, depending on its sensitivity to ultraviolet radiation?
2. What is the UV index and what are the adopted values of the UV scale?
3. What is the minimal erythema dose (MED)?
4. What is the allowed MED value for an un-tanned skin?

LABORATORY WORK 4. ASSESSMENT OF RISK FOR SKIN MALIGNANCY

Students will master a technique for skin malignant tumor risk estimation.

This simplified version of the test was elaborated and proposed by the American Academy of Dermatology.

Students will perform self-testing to determine risk for skin malignancy.

Each attribute is described by a certain amount of score points, which are assigned to each answering option. Once all the seven questions are answered, all the score points are to be summed up.

1. The type of your skin sensitivity to UV radiation is:
   a) 1 (highly sensitive) — 4;
   b) 2 (sensitive) — 4;
   c) 3 (normal) — 3;
   d) 4 (insensitive) — 1.
2. Your eyes color is:
   a) blue / green — 4;
   b) gray — 3;
   c) brown — 2.
3. Describe the events, following the first one-hour episode of your tanning at summer-time:
   a) the skin reddens, further skin peeling initiates — 4;
   b) the skin reddens, later a tan does appear — 3;
   c) the skin instantly starts darkening — 1.
4. What is your total body skin count of moles?
   a) great many — 5;
   b) not so many (less than 30) — 3;
   c) single ones — 1.

5. Where do you spend most of the daylight hours, due to the nature of your professional activities?

a) outdoors — 4;
b) partly outdoors, partly indoors — 3;
c) indoors — 2.

6. Has skin malignancy been ever diagnosed in any of your relatives?

a) yes — 5;
b) no — 1.

7. Where was your main living terrain before the age of 18?

a) terrain with high insolation (Southern Ukraine, the Caucasus, Moldova, Central Asia) — 4;
b) the middle part of the European region — 3;
c) North of the European region — 2.

Table. 1.3 provides the tools to convert the score obtained to perceivable risk for skin malignancy.

Evaluation Algorithm

The testing overall score should be checked against the Table 7 data.

Table 7

Assessment of risk of skin malignancy

Risk of skin malignant tumor	Test score
Below average	10–15
Medium	16–22
High	23–25
Very high	26–30

Tasks for independent academic work:

1. Carry out a self-test, answering the proposed questions.
2. Evaluate the test results.
3. Conclude on the measures for skin malignancy prevention.

Self-check questions:

1. What are the factors, contributing to the enhanced risk of skin malignancy?
2. Make a list of risk factors in the descending order of their significance.

ECOLOGICAL AND MEDICAL CONSEQUENCES OF ATMOSPHERE POLLUTION

LABORATORY WORK 5. ASSESSMENT OF OZONE LEVEL IN AMBIENT AIR

Students will master a technique of qualitative assessment of atmospheric ozone

Students will learn to detect atmospheric ozone, employing *the Christian Friedrich Schönbein technique*.

Laboratory work procedure

1. *Principle of the technique*. Ozone in the air will oxidize the potassium iodide on the test paper to produce iodine. The iodine will react with starch, staining the paper a shade of purple. The intensity of the purple color depends on the amount of ozone present in the air. The darker the color, the more ozone is present.

$$2KI + O_3 + H_2O = 2KOH + O_2 + I_2$$

$$I_2 + \text{starch} \text{ — > blue color}$$

2. *The Schönbein test paper preparation*. Stir 2 g of starch in a vial with 50 of distilled water. While stirring with the glass rod, brew the starch until a semi translucent mixture appears. Place 1 g of potassium iodide into the vial, mix well. Pour the starch paste into the Petri dish. Soak the filter paper in it. Remove a soaked paper from a Petri dish and cut a few test strips out of it.

3. *Assessment of ozone level*. Using a paper clip or a button, hang the soaked Schönbein test strip at a data collection site of a laboratory room. Place a control strip in a test-tube, seal it. In 1.5–2.0 hours gather all the test-strips in the laboratory room and draw your conclusions about ozone levels of the air based on the test results.

Evaluation Algorithm

Observe the color of the strip and compare it with that of the control strip. If the staining is non-homogeneous, describe the stained spots of the most visible changes.

Ozone level assessment:

– low level — staining or slight color alteration of the test strip, compared to the control strip;

– medium level — pale lilac staining;

– high level — dark blue, purple or brown staining.

Tasks for independent academic work

1. Determine ozone level in other accessible locations: place the test strip in other spots of the building, and outside the window.

2. Compare and assess the results.

Self-check questions

1. What are the grounds for the Christian Friedrich Schönbein method?

2. What mode of the atmospheric ozone assessment — qualitative or quantitative — was employed in the present laboratory work?

3. Will this method work for quick assessment of the atmospheric ozone?

ECOLOGICAL AND MEDICAL CONSEQUENCES OF HYDROSPHERE POLLUTION

Motivational profile of the theme. Knowledge on the manifestation patterns of the hydrosphere detrimental factors affecting humans will facilitate timely detection of the hydrosphere hazards in the course of sanitation and hygiene monitoring, purposeful search and elimination of hydrosphere pollution sources, as well as prevention of the adverse health effects.

Objective: to teach students to see the intrinsic links between human health disorders and endangering factors of the polluted hydrosphere.

Study questions:

1. Ecological description of hydrosphere.
2. Ecological and medical consequences of hydrosphere pollution.
3. Environmental challenges due to hydrosphere pollution.

Brief outline. The following abiotic factors predetermine ecological troubles of hydrosphere:

1. **Physical factors:**

a) *heat*: nuclear power plants are recognized to be the most significant water pollution inducers;

b) *turbidity* (mines and stone-pits effluents contribute highly to water turbidity, deteriorating sunlight penetration and leading to decrease in biological production of oxygen; as a result, the bottom organisms appear to be covered with sediments stratum and rot away);

c) *altered natural flow velocity in water bodies*, due to construction of hydro-technical facilities, leading to the narrowing of river beds which results in the increased flow velocity and finally in the death of organisms and plants; on the contrary, river flow obstruction causes slowing down of the flow, water enrichment of the water with biogens, which are mineral nutritive components (nitrates, phosphate, potassium, calcium) essential for the growth and development of living organisms; the natural outcome of the above shifts leads to uncontrolled proliferation of phytoplankton — Gonyaulax, Peridinium dinoflagellates and blue-green algae from the Anabaene genus, which cause mass poisoning of birds, animals and sporadic outbreaks of gastrointestinal disorders in human beings, often referred to as «illnesses of unknown origin».

2. **Toxic Chemical Substances**. Heavy metals, all kinds of synthetic organic compounds are poisons. These compounds are soluble in water and can penetrate into the human body, where, while interacting with a number of en-

zymes, they suppress the enzymatic activity. In food chains, poisons undergo concentrating and penetrate into bodies of animals and humans. When the maximum allowable concentration is transcended, essential elements can also have toxic effects.

Fluorine. At a concentration of about 1 mg/l fluorine prevents caries and osteoporosis.

Fluorine water deficiency leads to caries (less than 0.5 mg/l). Fluorine deficiency, triggering production of a soluble form of apatite as the main substance of the tooth tissue, does stand behind the mechanism of tooth decay. This process is exacerbated upon carbohydrates redundant intake — when degrading, these ones promote synthesis of organic acids (e. g., citric acid), capable of calcium binding and apatite dissolving. Terrains like Belarus, Khabarovsk, Sochi, Kaunas, Arkhangelsk are known as caries endemic regions.

Overexposure to fluorine (more than 1.8 mg/l) leads to fluorosis. It is believed, that phosphatase activity diminishes with fluoride overload, releasing inorganic phosphorus in the ameloblast, followed by the enamel reduced mineralization. In severe cases fluorosis affects not only the teeth, but can also cause excessive deposition of fluorides in bones, inducing generalized osteosclerosis and ligaments ossification. Terrains of endemic fluorosis with severe forms of sickness in humans and animals are observed in North and South Africa, and in India.

Chlorine. Chlorine is extensively used to disinfect water from bacteria, viruses and other microorganisms. The level of residual chlorine in water after disinfection is strictly regulated: standard for maximum allowable level is set at 0.3-0.5 mg/l for free chlorine, at 0.8–1.2 mg/l — for bound chlorine. Nevertheless, there are problems, related to chlorine, dissolved in water:

– bad water taste;
– risk of bladder and rectum cancer;
– formation of chlorine-substituted methane derivatives in water, which are capable of inducing malignant tumors.

In water pipe systems, disinfection of drinking water with chlorine causes formation of dioxins — the most hazardous toxic compounds for warm-blooded organisms.

Iron. Anthropogenic sources of iron supply to the environment are sewage and sludges of metallurgy and metalworking, chemical, machine-building, petrochemical, chemical, pharmaceutical, paint and textile industries. For an adult individual the required daily dose ranges from 11 to 30 mg. It becomes significantly higher during pregnancy, breast-feeding, intense muscular activity. The major proportion of this metal is excreted with feces, a smaller amount — with urine and sweat, also iron can be excreted with breast milk.

Iron-deficient conditions in humans are the reasons for imbalance of other microelements in the whole body system:

– deficiency of fluoride leads to iron and copper utilization decrease;

– increased iron metabolism promotes a significant accumulation of magnesium in erythrocytes;

– zinc deficiency is a causative factor for a severe complex of symptoms known as iron deficiency anemia associated with hepatomegaly, dwarfism, maturation arrest and hair loss (Prasad disease);

– copper, manganese; cobalt deficiency is essential in iron deficiency development.

Fe (2+) compounds are responsible for a general toxic effect, and are involved in reactions with radicals of lipids hydroperoxides. Fe (3+) compounds are less toxic, but cauterize digestive tract mucous membrane and provoke vomiting.

Sulfates. Sulfates appear as products of a sulfur cycle in biosphere. Being an integral part of protein structures, sulfur, once these structures are decomposed, undergoes oxidation. Subsequently sulfuric acid salts (sulfates) are formed. Sulfates may be regarded as indicators of surface water pollution with animal offal. In humans sulfates affect gastric secretion and induce dyspeptic disorders.

Sulfates, diluted in drinking water, do not exert any toxic effect on humans, however, they deteriorate water taste and in concentration above 300–400 mg/l can add to water unpleasant taste. Sulfates can cause deposition of scum in water pipelines, when two water flows with different mineral composition are mixing, e.g., sulfates and calcium salts (with CaSO4 precipitation). The maximum allowable concentration for sulfates in the reservoirs, designated for domestic and drinking purposes, is 500 mg/l.

3. **Chemically necessary compounds**. These ones include biogenic elements, originating from fertilizers, atmospheric precipitation, etc. Enrichment of water bodies with these compounds is finalized in water bodies eutrophication.

The term *eutrophication* denotes overload of the water body with biogenic elements, stimulating its biological productivity (phytoplankton overgrowth).

LABORATORY WORK 6. QUANTITATIVE ESTIMATION OF SULFATES LEVEL IN WATER

Students will master the method of sulfate estimation in water.

Students will perform quantitative estimation of sulfate ion concentration in tap water.

Laboratory work procedure

The measuring of sulfates is based on the analysis of water sample turbidity caused by barium sulfate, the product of interaction of sulfate ions with barium chloride.

Sulfates concentration measurement procedure

1. Pour 5 ml of tap water into a test tube (sample test tube).

2. Add to sample test tube 0.5 ml of hydrochloric acid diluted 10 times (supplied ready-to use).

3. To plot the calibration curve, prepare a series of test tubes according to Table 8.

Table 8

Test tube serial No.	**1**	**2**	**3**	**4**	**5**
Distilled water, ml (pour a specified amount into each serial test tube)	5	4,8	4,6	4,2	3,4
Potassium sulfate, ml (stock solution, pour a specified amount into each serial test tube)	0	0,2	0,4	0,8	1,6
Obtained sulfate ion concentration, mg/l	0	20	40	80	160

Thus, you got series of test tubes with the sulfate ion definite concentration of 20, 40, 80 and 160 mg/l to plot a standard curve. Tube No. 1 is a control test tube.

4. Add 0.5 ml of diluted hydrochloric acid to each serial tube.

5. Bring into each tube (both sample test tube and serial tubes) 1 ml of 5%-barium chloride solution (supplied ready to use), mix thoroughly.

6. Operate photoelectric colorimeter to quantitatively evaluate turbidity in all the test tubes (both sample test tube and serial tubes). Wavelength of operation is 750 nm (red light filter in cuvettes with 10 mm for an optical path length) (Refer to Annex 1 for safe working practices to operate electrical equipment and Annex 2 on terms of operating of the *ФЭК—2МР* brand photoelectric colorimeter).

7. In your note-book, plot a calibration graph within the axes: OY — optical density D (at 750 nm wave length), OX — sulfate ion concentration C (mg/l). Using the calibration curve, measure the sulfate ion concentration (contaminant level) in the tap water sample.

8. **Evaluation Algorithm**. Compare the obtained sulfate ion concentration in your sample with the maximum allowable concentration of sulfates in tap water (500 mg/l) and conclude whether it is good for drinking purpose.

Tasks for independent academic work:

1. Study the principles of the method of estimation of sulfate ion concentration in water;

2. Perform measurements and plot a calibration curve;

3. Measure the level of sulfates in the tap water sample and assess the results obtained.

Self-check questions:

1. What is the definition of MAC (maximum allowable concentration)?

2. What does the level of sulfates in tap water above MAC convey?

3. What is the method of measuring sulfate level in water based on?

4. What are the main targets for sulfates in the human body?

5. Describe the photoelectric colorimeter operational procedure.

6. What is the approach in assessment of the results obtained upon water sulfate concentration measurement?

ENVIRONMENTAL AND HEALTH CONSEQUENCES OF LITHOSPHERE AND FOOD POLLUTION

Motivational characteristics of the theme: Knowledge of chronic toxic effects manifestation patterns of basic substances, which enter the human body system with food and water, helps timely isolate these substances in the course of sanitation and hygiene monitoring, provides for intentional detection and removal of pollution sources from hydrosphere and lithosphere, effective prevention of human body exposure to adverse consequences of contact with these substances.

Learning objective: Students must be able to recognize the initial signs of chronic toxic effects of substances, which enter human body with water and food.

Study questions:

1. Brief outline of food ingredients. Classification of xenobiotics in food products. Harmful chemical substances of natural origin; toxic compounds, synthetized under certain conditions in food and human organism. Biogenic amines.

2. Xenobiotics, penetrating into the human body due to food production, processing and storage («new products», «the Mallard reaction» products); possible responses of human body to chronic exposure to these types xenobiotics.

3. Substances in food products which are residues of agents used in agriculture (veterinary drugs and feed additives, toxins of food origin, mycotoxins, metals).

4. Genetically modified organisms and genetically modified food products: concept, profile, biosafety provision.

5. Metals as toxic contaminants of food products (mercury ***Hg***, copper ***Cu***, zinc ***Zn***, aluminum ***Al***, strontium ***Sr***, arsenic ***As***): description, ports of their entry into food and human system, mechanisms of action, medical consequences of the penetration into the human body.

6. Pesticides: concept, classification. Polychlorinated biphenyls and dioxins as hazardous pollutants of the environment. Sources of their release into environment. Ecological and medical consequences of their accumulation in biosphere.

7. Nitrates: sources of their entry into the body of an adult or of a child from hydrosphere and lithosphere. Variability in the content of nitrates / nitrites in food products due to the storage conditions and culinary processing. Effect of

nitrates / nitrites on the human organism. The role of nitrates in childhood pathology. Control of nitrates and nitrites content in food.

8. Methods to prevent xenobiotics exposure effects on humans: description, application characteristics.

Brief Outline. Lithosphere is an integral part of the biosphere and is a hard shell of the Earth.

Soil is a superficial layer of the lithosphere formed under the influence of climate and living organisms (plants and animals) and cultivated by humans.

Soil is a sedimentary environ, where xenobiotics accumulate well and migrate slowly. Preservation of fertile soils is the main provision for the sustainable development of the mankind.

Human body is susceptible to soil mineral composition. Excess or deficiency of elements in soil results in geochemical provinces and, as a consequence, development of endemic illnesses, e.g., endemic goiter, Kashin–Beck disease, molybdenum gout.

Consequences of soil contamination:

– inhibition of soil-formation processes;

– decrease in crop yield, degradation of agricultural products consumer qualities, excess of maximum allowable concentration (MAC) of polluting substances in food products;

– suppression of soil self-purification processes;

– accumulation of xenobiotics with further migration to food through food chains;

– geochemical provinces emergence due to human activities («artificial»).

Food products as a source of nitrates penetration into human organism. According to WHO, the permissible daily intake of nitrates for an adult is set at 5 mg/kg, of nitrites — at 0.15 mg/kg.

Plants uptake nitrates from the soil by means of the root system. Further nitrate transformation proceeds in two ways: reduction into nitrites and reduction into ammonia with nitrate reductase and nitrite reductase as enzymes respectively. Ammonia is recruited in the synthesis of amino acids and proteins in human organism. Nitrates are accumulated mainly in roots, stems, petioles, plants veins. Leaves and root crops are enriched with nitrates to much greater extent compared to that of fruit. The content of nitrates in plant depends predominantly on the nature of metabolic processes in it and derives from the attributes of a particular family, species, and variety, which each plant belongs to.

The highest potential to accumulate nitrates is proved for black radish, beetroot, leaf lettuce, sorrel, radish, rhubarb, celery, spinach, parsley leaves, dill. It is believed that cereals, fruit, berries do not accumulate nitrates in hazardous concentrations.

The nitrate content in plants is governed by a number of factors, including the availability of nitrogen in the soil (upon application of one-component —

straight nitrogen — fertilizers) and the accessibility of trace elements, in particular molybdenum and manganese, which are essential for the synthesis of enzymes involved in the conversion of nitrates to ammonia.

The level of nitrates in unprocessed meat is low, in cooled fish it is still less. A 6–10 — fold increase in nitrate concentration in cattle and swine fodder causes a 1.5–2-fold increase of nitrates level in muscles of these animals. While processing, manufacturers overburden meat and certain fish products with nitrates and nitrites for taste and smell improvement, color fixation, prevention of pathogenic microflora dissemination, especially Clostridium botulinum and for product preservation.

Nitrates are used in manufacturing of certain brands of cheese to impede the harmful microflora growth. E.g., nitrates concentration in the Kostroma cheese brand sample was reported to be 95–209 mg/kg, nitrites — 0.1–0.2 mg/kg. Cheese ripening causes nitrates concentration to decline to 30–140 mg/kg, and nitrites — to 0.1 mg/kg.

Storage of vegetables reduces nitrates content in them due to nitrates reduction to nitrites. Fresh vegetables do not reveal hazardous concentrations of nitrites, even if they contain a considerable amount of nitrates. The most vivid process of nitrate decrease due to reduction to nitrites occurs when vegetables are stored at room temperature, in filthy and damp environment, which promotes dissemination of microorganisms, converting nitrates to nitrites. Nitrates reduction to nitrites slows down substantially in vegetables kept in refrigerator, especially — when frozen.

The reduction of nitrates to nitrites increases when cooking in aluminum cookware, when grinding and grating vegetables, extracting juice from hothouse vegetables, in particular, at room temperature.

Food products cooking techniques to decrease nitrates content:

– cleaning and removal of the particular «nitrate-containing» parts (peel, petioles, upper leaves, veins, stump);
– washing and soaking the product;
– boiling in large amount of water;
– frying, stewing of vegetables (nitrates burden is reduced by about 15 %).

It is believed, that nitrates are not only washed out upon thermal processing, but also in parts are degraded to oxides of nitrogen and oxygen. Thus, cooked vegetable meals contain nitrates less by 20 to 25 % as compared to that of original product.

LABORATORY WORK 7. QUANTITATIVE ASSESSMENT OF PLANTS TISSUE NITRITE BURDEN

Laboratory work objective: to master the skills of quantitative assessment of nitrites in plant samples.

Purposes:

1) to learn the steps of quantitative determination of nitrites in plant samples;

2) to master the skills of plotting the calibration graph;

3) to learn the approaches in the results evaluation.

Method principle. The technique is based on discoloration of the neutral red in an acidic medium in the presence of potassium bromide and sodium hypophosphite, depending on the sodium nitrite content, and subsequent photoelectric colorimetry of the stained solution at 530 nm wavelength (green filter, 10 mm cuvette).

Safety precautions

1. When working with reagents, exercise caution, especially when handling a 4.25 M sulfuric acid solution. Strictly follow safe working practices.

2. In case of eye contact with reagent, immediately flush eyes with plenty of running water.

3. Should skin be exposed to reagent, the latter shall be washed off with a copious stream of water.

In case of any mishap, address the teacher for assistance.

Procedure and measurement of concentration

1. Preparation of the sample. Put 20 g of crushed vegetables (cabbage) into a flask and mix with 40 ml of distilled water preliminary heated up to 55° C. Following 10 minutes of periodic stirring at room temperature, filter the mixture through a cotton filter into a 200 ml volumetric flask; wash the sample remaining on the filter several times in water, cool the filtrate and add to the mark with distilled water.

2. Calibration graph plotting. To quantify the measurement results, it is necessary to plot a calibration curve (tabl. 9). Be advised, introduction of each reagent shall be followed by thorough mixing of the flask content.

Table 9

No.	Reagent, ml	Test tube No.							
		0	**1**	**2**	**3**	**4**	**5**	**X_1**	**X_2**
1.	$NaNO_2$ 2 ml standard stock solution	–	0.1	0.25	0.5	1.0	1.5	–	–
2.	Triethylamine (TEA) 1.5 % solution	5	4.9	4.75	4.5	4.0	3.5	–	–
3.	Neutral red 0.01 % solution	1.0 ml added to each test tube							
4.	H_2SO_4 4.25 M solution	0.5 ml added to each test tube							
5	KBr 1 % solution	0.5 ml added to each test tube							
6	NaH_2PO_2 1 % solution	0.5 ml added to each test tube							
7.	H_2O distilled	2.5 ml added to each test tube							
8.	NO_2^-, concentration, μg/ml	0	0.2	0.5	1.0	2.,0	3.0	X_1	X_2

Start introducing the reagents into the labeled test tubes according to the table, strictly observing the order and carefully mixing the contents after each reagent introduction. Use photoelectric colorimeter (having idled for 15 minutes before measurements) to measure the pigmentation of standard solutions, which is gradually fading from intense crimson to pale violet. Wave length of operation is set at 530 nm, cuvettes optical path length is 10 mm against distilled water, and measuring time is 5–10 minutes. Plot a calibration absorbance graph (D) as a function of concentration of nitrites (C, μg/ml). Basing on a plotted calibration curve, derive the content of nitrites in the samples.

Below you can find an exemplary computation procedure of nitrite-anion concentration in cabbage sample, pursuant to the equation

$$C_{mg/kg} = X \times 10$$

where 10 is a conversion factor of cabbage aqueous extract preparation, $\boldsymbol{X_{\mu g/ml}}$ refers to nitrite concentration in a given cabbage extract retrieved from the calibration graph.

To plot a calibration graph, you are provided with an exemplary table, exhibiting the chromophore (D) absorbance, as a function of the nitrite-ion amount present (C, μg/ml) (tabl. 10).

Table 10

Test tube No.	**0**	**1**	**2**	**3**	**4**	**5**	**X1**	**X2**
C, μg/ml	0	0.2	0.5	1.0	2.0	3.0		
D, relative units	0.630	0.600	0.550	0.490	0.360	0.220		

Measurement evaluation. Compare the obtained $\mathbf{C_{mg/kg}}$ value with the average nitrite contents in vegetables.

Reference information.

Since contamination of vegetables, fruit, and cereals with nitrites occurs via a natural way of nitrates reduction, it is just the level of nitrates in fresh plant products, which is under strict regulation of the sanitary and hygiene services. This regulation is implemented through enforceable standard, called *a maximum contaminant level*, or ***MCL***. The content of nitrites in fresh plant products is not subject to a particular control, but, according to scientific findings, the content of nitrites in terms of nitrite ion in vegetables and fruit is estimated to be under 0.5 mg/kg.

Processed meat, fish products and cheese exhibit a completely different case. Contamination of these products with nitrites results from immediate human involvement. That is why, in relevance to this type of products MCL is set not only for nitrates, but also for nitrites.

Students are advised to address the tutorial for nitrates-MCLs in regards of some foodstuffs.

Tasks for independent academic work:

1) Study the logic of the procedure for measuring nitrite in raw plant samples;

2) Carry out measurements and plot a calibration graph;

3) Calculate the content level of nitrites in the sample and evaluate the results obtained.

Self-check questions:

1. What is the core of the technique for determination of nitrites in plant tissues?

2. Describe the nitrates metabolism in plants.

3. What are the major targets for nitrates and nitrites in the human body?

4. What is the approach to sampling of plants, picked up for nitrates concentration assessment?

5. How do we evaluate the results of the nitrite burden measurement in plant tissues?

6. Explain reasonably, why fresh food plant products overburden with nitrogen-containing substances is regulated solely by nitrates maximum contaminant level, while contamination of processed meat, fish, cheese is controlled through standards both for nitrates and nitrites.

MEDICAL ASPECTS OF THE NON-IONIZING ELECTROMAGNETIC RADIATION (NIER) IMPACT ON THE HUMAN HEALTH

Motivational profile of the theme: comprehension of causal relationship between the pollution of the indoor environment with the electromagnetic radiation, on one hand, and the population morbidity rate, on the other hand, is necessary to correctly assess the involvement of environmental factors into the development of health disorders.

Learning objective is to attain knowledge on the basic characteristics of the electromagnetic field, mechanisms and patterns of its impact on human organism, believed to stand behind certain diseases development.

Study Questions

1. Basics of the «electromagnetic field» concept, its characteristics.
2. International classification of the electromagnetic waves by frequency
3. Electrosmog: concept and sources.
4. Mechanisms and effects of electromagnetic radiation.

The electromagnetic field (EMF) is a particular form of matter, by means of which electrically charged particles interact. EMF is described by characteristics as follows:

E denotes electric field (V/m);

H denotes magnetic field (T-Tesla, mT, μT);

λ (lambda) denotes the EMF wavelength;

F is for frequency of the electromagnetic oscillations, generated by the source.

The EMF origin physically owes to the fact that electric field E, which is changing with time flow, generates a magnetic field H, and a changing electric field generates a vortex magnetic field: both components of E and H, incessantly changing, induce each other. The EMF, originating from the uniform motion of charged particles, is inextricably bound up with these particles. Once the velocity of particles increases, EMF «detaches» from the charged particles and launches into its independent existence in the form of electromagnetic waves, which persist after the removal of the source.

For practical purposes, the NIER spectrum is classified by frequency into 3 ranges:

1. low-frequency range (3 - 3000 Hz);
2. mid-frequency range (0.3 - 3 MHz);
3. high-frequency range (> 3 MHz).

1 Hz (hertz) denotes one oscillation per second.

In the Commonwealth of Independent States they measure the electromagnetic *power density* (EPD) (W/m^2, mW/cm^2, $\mu W/cm^2$ as units), or *the Poynting Vector*, at frequencies exceeding 300 MHz. It represents the amount of energy carried by the electromagnetic wave per time unit across the unit of the surface perpendicular to the direction of wave propagation.

A combination of electromagnetic fields (EMFs) with different frequencies affecting human health (mainly in closed spaces), forms an *electrosmog*, i. e. electromagnetic pollution of an apartment, house, office etc. Devices and technologies, listed below, are known as electrosmog sources:

– mains electricity (electrical installation) — 50 Hz;
– household electrical appliances — up to 300 kHz;
– computers — up to 300 kHz;
– radiotelephones — 450–1800 MHz;
– cell phones — 400–1800 MHz;
– microwave ovens — 2.45 GHz.

Experimental studies shed light on a high biological activity of EMF in all frequency ranges. Two mechanisms behind the EMF impact are described: *thermal* (through heating) and *non-thermal* (informational). In addition, three patterns of EMF interaction with biological tissue are observed:

1. *melatonin pattern* (magnetic component of EMF suppresses the epiphysis melatonin production);
2. *tunneling pattern* (damage to membranes of the brain blood vessels, following breaking through the blood-brain barrier);

3. *resonance pattern* (the electrical component of the EMF produces potential on the surface of the human body and internal organs, which interferes with the functioning of organs and their systems).

The nervous, endocrine, immune and reproductive systems are targets of the highest susceptiblity to the NIER impact.

The EMF perennial exposure results in its effect accumulation. It enhances the risk of remote outcomes of irradiation, including central nervous system degeneration, hormonal disorders and even malignant tumors occurrence.

LABORATORY WORK 8. EVALUATION OF EMF LEVELS OF INDOOR ENVIRONMENT

Students will master:

1) technique of measuring parameters of electric and magnetic fields.

2) principle of operation of the Field Meter to quantitatively estimate the electric and magnetic fields parameters;

3) approaches to evaluate the results measured.

Students will be involved in the activities to measure and evaluate electric and magnetic field parameters with the BE-METP-AT-002 brand device (fig. 3).

Fig. 3. BE-METR-AT-002 instrument

The *BE-METP-AT-002* measuring device is designated to verify the accomplishment of standards of electromagnetic safety at terminals, equipped with video displays, as per Sanitary Standards and Regulations 2.2.2.542-96.

Measuring ranges: frequency range from 5 to 400 kHz;

the assigned frequency bands for measuring the root-mean-square value (RMSV) of the electric field strength and magnetic flux density are as follows:

- band 1 — from 5 to 2000 Hz (2 kHz);
- band 2 — from 2 to 400 kHz

electric field strength RMSV ranges:

- in band 1 — from 8 to 100 V/m;
- in band 2 — from 0.8 to 10 V/m;

magnetic flux density RMSV ranges:

- in band 1 — from 0.08 to 1 μT;
- in band 2 — from 8 to 100 nT.

The device operation principle is based on conversion of electric and magnetic fields oscillations into fluctuations in electric voltage and also on filtering of frequencies and amplification of these oscillations with subsequent decoding.

The signal, caught by the detector, is conveyed to the analog-to-digital converter and analyzed by the built-in microprocessor. The measurements are displayed on the liquid crystal display on the front panel of the instrument (fig. 3).

Laboratory work procedure

Pursuant to operator preference, either of two operational regimens of the instrument may be launched: ***1***. a continuous measuring mode of RMSV of the electric field strength and magnetic flux density (the «НЕПРЕРЫВНО» mode); ***2***. a mode to measure the absolute value of total vector, including measurements of the three components of the RMSV of the electric field strength and the density of the magnetic flux, followed by subsequent calculation of the absolute value of the electric field vector and of the magnetic flux density (the «АТТЕСТАТ» mode).

The former mode is suggested for general screening of the working premises to determine the average level of indoor electromagnetic radiation and to search for possible sources of radiation. The latter mode is expedient for certification of workplaces for operators at terminals, equipped with video displays and other electrical installation.

When measuring the electric field strength and the magnetic flux density, the device shall be attached to the dielectric rod and held only by this means, while being relocated. Should the attestation procedure be launched, the rod shall be mounted on a dielectric base.

The results of measurements of the electric field parameters in bands 1 and 2 are displayed in V/m units (volts per meter); the results of measurements of the magnetic field parameters in range 1 are presented in μT units (microtesla), in range 2 — in nT (nanotesla).

To choose the first mode, with the display indicator reading «ВЫБЕРИТЕ РЕЖИМ», press the «ВЫБОР» key until the legend «НЕПРЕРЫВНО» begins to flash to choose the continuous measurement mode. Press the «ВВОД» key to enable the mode selected.

The next step is the arrangement of the device with its front end face at the point of interest and recording of the indicator reading. Relocating the in-

strument to different points of the working area, you can measure the value of the RMSV of the electric field strength and the magnetic flux density at these points. The measuring result refers to the geometric center point at the device front end face.

To choose the second mode, with the display indicator reading «ВЫБЕРИТЕ РЕЖИМ», press the «ВЫБОР» key until the legend «АТТЕСТАЦИЯ» begins to flash to choose the mode (measurement of the total field). Press the «ВВОД» button to enable the selected measurement mode.

Arrange the geometric center of the front end panel of the instrument at the measurement point (at 5 m distance from the screen of the video display terminal on the perpendicular to its center). With the initial orientation of the device, the arrow on the front panel shall be located horizontally, i.e. perpendicularly to the plane of the screen of the video display terminal. Press the «ВВОД» key to activate the measurement.

After the beep, proving the measurement start, reorient the instrument: with the arrow remaining in the horizontal plane, arrange the device to the arrow directed parallel to the plane of the video display terminal screen. Press the «ВВОД» button to activate the measurement.

After the beep, signaling the measurement start, reorient the device to have the arrow on the face panel vertically directed. Press the «ВВОД» key to activate the measurement.

Following the beep, signaling the measurement start, press the «ВВОД» key. The results of the completed measurements will be automatically processed by the device processor and the absolute values of the electric field strength and the magnetic flux density vectors within the two frequency ranges will be displayed on the device indicator.

Once the measurements are completed, the results should be recorded in the measurement report. Press the «ПИТАНИЕ» key to switch the device off. The indicator on the meter panel will fade out. Criteria for evaluation of measurements are presented in Table 11.

Table 11

Allowable Values of NIER Parameters

Parameter Name, effective as from 01.01.1997	**Allowable level**
Electromagnetic field intensity at a 50 cm distance, around the video display terminal for the electrical component shall not exceed: within the frequency range 5 Hz — 2 kHz within the frequency range 2 Hz— 400 kHz	 25 V/m 2,5 V/m
Magnetic flux density shall not exceed: within the frequency range 5 Hz — 2 kHz within the frequency range 2 — 400 kHz	 250 nT 25 nT
Surface electrostatic potential shall not exceed	500 V

Tasks for independent academic work:

1. Learn the basics of the technique to measure the parameters of electric and magnetic fields in a residential building.

2. Learn the principles of operation of the **BE-METP-AT-002** brand instrument, designated for electric and magnetic field parameters quantification.

3. Evaluate the measurement results.

Self-check questions

1. What are the purposes of **BE-METP-AT-002** brand instrument employment?

2. Describe the principle of the device operation, keeping in focus the range of frequencies and values of the measuring parameters.

3. Describe the algorithm for indoor electric and magnetic fields parameters evaluation with the **BE-METEP-AT-002** brand instrument.

MONITORING OF THE ENVIRONMENT AND POPULATION HEALTH STATE

Motivational profile of the theme. Knowledge of the monitoring system framework and of the assessment stages of morbidity risk, arising from environmental factors exposure, allow to elaborate valuable pragmatic recommendations on lifestyle, which is in compliance with environment, and on public health preservation.

Learning objective is to master the approaches in assessment of the human health risks, related to environmental alterations or pollution, and to gain skills in application of methods to assess and control environment quality.

Study Questions

1. Monitoring: concept, levels, types.

2. Socio-hygiene monitoring: purposes, objectives.

3. Steps of risk assessment due to the exposure to unfavorable environmental factors.

Brief Outline. Environmental monitoring covers a set of observation, estimation and forecast systems, applied to the natural environment and phenomena, as well as to biological responses to environmental alterations, exerted by natural and man-made factors.

The elaborated levels of monitoring are as follows:

– *local monitoring* — the scope of terrain observation does not exceed tens of kilometers;

– *regional monitoring* — the magnitude of the observation terrain approximates thousands of square kilometers;

– *global monitoring* provides for global processes tracking in the biosphere and the Earth's ecosphere.

Types of monitoring fall within biological, ecological, socio-hygiene approaches. *Biological* monitoring determines the state of the biota and response of the latter to anthropogenic intervention. *Environmental* monitoring does assess the state of the human habitat and that of biological communities. *Socio-hygiene* monitoring presents a system of special observations, assessments and forecasts of the population health status in its subordinate relation with the habitat state and life conditions of humans

Within the framework of socio-hygiene monitoring, environmental risk factors, which endanger human health, are assessed through certain consecutive stages. They are: hazard identification, impact assessment, identification of the effect dependence on the dose, calculation of a particular risk.

Hazard identification implies the consideration of the factors that might impair the human health.

Impact assessment is designated to study the population affected by the factor, periodicity and factor exposure time length. The above information is based on the laboratory monitoring and the calculation results.

The impact assessment encompasses three sub-stages:

– the environment in-depth study with the focus being on the essential parameters in the study field;

– the identification of the impact pathways and of possible expansion routes;

– the quantitative evaluation of the factor exposure to measure magnitude, frequency and duration of exposure, estimated for every single pathway identified in the course of the previous sub-stage.

Quantitative relationship between dose and response denotes the factor toxicity value. It is estimated by experiment through hefty doses employed, which unconditionally cause apparent effect; the final conclusion on the hazard magnitude of the actual factor exposure is achieved through extrapolation.

For *non-carcinogenic* substances, a threshold model is employed. Following this model, there is a believed risk-free dose threshold, below which the substance under consideration pose no probability of producing a carcinogenic response. According to the worldwide adopted opinion on the *non-threshold carcinogens*, even the minimal concentration of genotoxic / carcinogenic xenobiotic can give rise to cell malignant transformation.

The risk assessment conveys the occurrence probability for a particular health disorder.

The final stage is elaborated to generalize the outcomes of the previous studies. Besides the quantitative assessment of the risks, it contains analysis and characteristics of the uncertainties, pertaining the assessment, and generalizes all information on the risk assessment.

LABORATORY WORK 9. COMPUTATION OF CARCINOGENIC RISK FROM THE EXPOSURE TO CHEMICAL FACTORS OF ENVIRONMENT POLLUTION

Students will master:

1) environment quality assessment tools;

2) characteristics of the basic values for carcinogenic risk computation;

3) assessment of the level of environmental factors involvement in the development of oncological disorders.

Students will accomplish computation of carcinogenic risk, resulting from both oral and inhalation exposure to environmental factors.

Laboratory work procedure

1. Carcinogenic risk computation, using the following equation:

$CR = AAD \times PICR \text{ (or } PCRI)^* \times \alpha,$

where **CR** is a carcinogenic risk; **AAD** is an average absorbed daily dose for each route under consideration (*inhalation* or *ingestion*), mg/kg; PICR — potential inhalation carcinogenic risk, $(\mu g/kg)^{-1}$; PCRI is a potential cancer risk through ingestion, denotes a cancer potency factor from a daily oral exposure to an agent, $(mg/kg)^{-1}$; **α** is a ratio of a pollutant exposure duration (years) to an average life expectancy (70 years):

$$AAD = C \times V / M,$$

where **C** is the xenobiotic concentration in water (mg/l) or in air ($\mu g/m^3$); **V** — daily average volume of air inhaled (22 m^3) or daily average volume of water consumed (3 liters); **M** is the average body weight (70 kg).

2. Computation of extra number of oncological cases N using the equation:

$$N = CR \times P,$$

where P is population size; N, ranging from 1 to 10 per 1 million people, is qualitatively described as an acceptable lifetime cancer risk — one-in-a-million extra risk (10−6 risk) to one-in-a-hundred-thousand extra risk (10−5 risk).

A model task to evaluate carcinogenic risk via ingestion exposure to pollutant

Compute an expected extra number of oncological cases to be diagnosed per 1 million people after having permanently lived (i.e. 70 years) in a terrain with arsenic compounds concentration in drinking water 0.05 μg/l.

Computation steps:

1. conversion of μg/l into mg/l: 0,05 μg /l = 0,00005 mg/l;
2. $AAD = C \times V / M = = 0{,}00005 \text{ mg/l} \times 3 \text{ l} / 70 \text{ kg} = 0.0000021 \text{ mg/kg};$
3. $\alpha = 70/70 = 1$ (permanently living in the task specified terrain);
4. $CR = AAD \times PCRI \times \alpha = 0.0000021 \text{ mg/kg} \times 1.5 (mg/kg)^{-1} \times 1 = 0.0000032;$

---

* For the PICR and PCRI factors refer to table «Prioritized Chronic Dose-Response Values …», Annex 3, page 37.

5. $N = CR \times P = 0.0000032 \times 1000000 = 3.2$;

6. Conclusion:

a) new extra cases of malignances per 1 million people will develop in the particular terrain due to drinking water pollution, as it is specified by the task;

b) new extra cases of malignances per 10^6 people is regarded as the level of acceptable cancer risk.

A model task to evaluate combined carcinogenic risk via ingestion and inhalation simultaneous exposure to pollutant*

Calculate an expected extra number of oncological cases per 1 million people to be diagnosed in population after having lived for 40 years in a terrain with drinking water lead contamination at 0.015 mg/l and with chloroform polluted air at 0.000023 mg/m^3.

Calculation

1. Calculation of cancer risk via lead contaminated water intake, CR_{intake}:

$CR_{intake} = AAD \times PCRI \times \alpha$

$AAD = C \times V / M = 0.015$ mg/l $\times$ 3 l / 70 kg = 0.000643 mg/kg;

α = 40 years /70 years = 0.57 (for a 40-year living in the terrain);

$CR_{intake} = 0.000643$ mg/kg $\times$ 0.0085 (mg/kg)$^{-1}$ $\times$ 0.57 = 0.0000031.

2. Computation of cancer risk via inhalation of chloroform-polluted air, CR_{inhale}:

$CR_{inhale} = AAD \times PICR \times \alpha$

$AAD = C \times V/M$

AAD = 0,000023 mg/m^3 $\times$ 22 m^3 / 70 kg = 0,023 **µg**/m^3 $\times$ 22 m^3 / 70 kg = 0,00723 **µg**/kg

α = 40 years / 70 years = 0.57 (for a 40-year living in the terrain specified);

$PICR_{chloroform} = 0.019$ (**µg**/m^3)$^{-1}$

CR_{inhale} =0,00723 **µg**/kg $\times$ 0.019 (**µg**/m^3)$^{-1}$ $\times$ 0.57 = 0.0000783.

3. Computation of the combined carcinogenic risk CR:

$CR = CR_{intake} + CR_{inhale} = 0.0000031 + 0.000078 = 0.0000811$

4. Computation of the expected extra number N of malignancies to be diagnosed per 1 million people, exposed to a combination of pollutants:

$N = 0.0000811 \times 1000000 = 81$ extra cases per 1 million people

5. Conclusion: 81 extra cases of malignances per 1 million people is regarded as a level of unacceptable cancer risk.

Tasks for independent academic work

1. Compute the expected number of extra cases of malignancies per 1 million people to be newly diagnosed in population after having permanently lived

* Note, that to avoid erroneous calculation of CR, the concentration of the actual xenobiotic ***C*** shall be expressed **solely in µg/m^3**, if, given the conditions of the task, the pollutant is found in the **atmospheric air**, and **solely in mg/kg** — if you deal with a **drinking water** pollutant.

in a terrain with polychlorinated biphenyls (PCBs) polluted atmospheric air at 0.0018 mg/m^3.

2. Calculate the expected number of extra of malignancies per 1 million people to be newly diagnosed in population after having lived for 30 years in a terrain with alachlor-polluted drinking water at 0.004 mg/l.

3. Compute the expected number of extra malignancies per 1 million people to occur in population after having permanently lived in a terrain with chloroform-contaminated atmospheric air and drinking water at 0.00002 mg/m^3 and 0.07 mg/l accordingly.

Self-check questions

1. Describe the algorithm to compute carcinogenic risk via inhalation exposure to xenobiotic.

2. Describe the algorithm to calculate carcinogenic risk via ingestion exposure to xenobiotic.

3. Describe the algorithm for combined carcinogenic risk estimation.

4. Describe the algorithm to calculate the number of new extra cases of oncological diseases expected to develop in human population in consequence of exposure to chemical substances.

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Annex 1

SAFETY RULES FOR WORKING WITH ELECTRICAL EQUIPMENT

To prevent electric shock, the student shall not

– switch on, adjust or control the electrical instrument, contacting the grounded objects or metal parts of the installation with the other hand.

– relocate instruments, which are under the electrical voltage;

– replace blown fuses with one or both terminals energized;

– leave the equipment switched on without appropriate attendance;

– when going out of the room, leave unattended electric installation (heaters included), connected to power supply.

Before switching on the electrical devices, make sure the effective grounding is applied. Inspect portable cord-and-plug connected equipment, extension cords, power bars, and electrical fittings for damage or wear before each use. Make sure that there are no open live parts, that protective screens and devices are installed. Do not use water pipes, heating and sewerage tubes for grounding.

Once the instrument malfunction is encountered, the student shall stop any activity, communicate the problem to the teacher and the department executives.

Should the tools ignition occur, provide disconnection to achieve lockout, take measures to extinguish the fire with a carbon dioxide fire extinguisher, report to the department executives.

Safety requirements in emergency situations

Stop working if the situation might lead to an accident or mishap. In emergency, disconnect the equipment, notify the teacher and the department executives. When shortcut circuit, grounding or power supply system breakage or other damages occur, or smell of burning, unusual noise appear, immediately disconnect the mains switch in the room, call for a person responsible for the operation of the electrical equipment.

Safety requirements to terminate the job

Disconnect and lockout the power supply upon work completion, have your workplace cleaned-up.

Annex 2

TERMS OF OPERATING OF THE ФЭК-2МР BRAND PHOTOELECTRIC COLORIMETER

1. Following the device connection to the mains, switch on the tumbler on the rear panel. Be advised to idle the instrument for 15 minutes (fig. 4).

Fig. 4. The ФЭК-2МР brand photoelectric colorimeter

2. Set the value of the optical density (wavelength, nm), according to the guidelines of the laboratory work to be performed. Toggles are located at the lower front of the unit.

3. Press the «START» key on the digital panel. In response, flashing comma and indicator «P» will flare up on the scoreboard.

4. With the lid open, make measurement and save the benchmark value by pressing «Ш (0)» key. The regular benchmark value ranges from 0.001 to 1.0.

5. Cuvettes with solutions shall be mounted in the sample compartment. The cuvette with the control solution shall be placed in the farthest (rear) cuvette jack, the cuvette with any other solution — in the nearest (front) one.

6. Switch the handle located in the foreground and designated for cuvette change to «1» position.

7. Close the lid of the cuvette compartment and press the «К (1)» key. Digital display shows the «1» symbol. Switch the cuvette change handle to «2» position. For optical absorbance measurement press «Д (5) » key.

8. The figure on the digital display on the right shows the optical density of the solution, which is currently under test.

9. Open the lid of the sample compartment, remove the cuvette solution, fill the cuvette with another solution to study its optical density and repeat the measurement.

Annex 3

PRIORITIZED CHRONIC DOSE-RESPONSE VALUES FOR SCREENING RISK ASSESSMENTS (U.S. EPA Standards)

Chemical Name	Chemical Abstracts Service (CAS) Registry Number	Potential Inhalation Cancer Risk (PICR) $(\mu g/m^3)^{-1}$	Potential Cancer Risk through Ingestion (PCRI) $(mg/kg)^{-1}$	Non-cancerogenic risk oral reference dose (oral Rfd, µg/kg)	Carcinogenic risk from external exposure to ionizing radiation (risk/year)/(pCi/g)
Chromium	7440473	0,012		0,005	
Arsenic compounds	7440382	0,0033	1.5	0,0003	
Chloroform	67663	0,019	0,031	0,01	
Chlorine	7782505	—		0,1	
Fluorine	7782414	—		0,06	
Copper	7440508	—		0,037	
Barium	7440393	—		0,07	
Aluminum	7429905	—		0,1	
Cadmium compounds	7440439	0,0018		0,0005	
Strontium-90	10098972	0,0000000000594 risk level/pCi	0,0000000000409 risk level/pCi		
Cesium-137	10045973	0,0000000000191 risk level/pCi	0,0000000000316 risk level/pCi		0,00000209
Aldrin	309002	0,0049	17	0,00003	
Polychlorinated biphe-nyls (PCBs)	1336363	0,00057	5	0,00002	
Thiourea	62566	0,000021	0,072		
Nickel compounds	7440020	0,00026		0,02	
Hydrazine	302012	0,0049	3		
Formaldehyde	50000	0,000006		0,2	
DDT	50293	0,000097	0,34	0,0005	
Benzene	71432	0,000029	0,1		
Alachlor	15972608	0,000016016	0,056	0,01	
Lead compounds	7439921	0,000012	0,0085	0.0000785	

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