MINISTRY OF HEALTH OF UKRAINE
O.O. BOGOMOLETS NATIONAL MEDICAL UNIVERSITY

"Approved"
at the methodological conference of hygiene and ecology department
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GUIDELINES
FOR STUDENTS

Subject	Hygiene and ecology
Module № 1	Assessment of the environment and its impact on the population health
Submodule №1	General questions of hygiene and ecology
Topic of the lesson	Hygienic significance of ultraviolet radiation and application of its constituents for the disease prevention and air, water and objects sanation.
Course	6
Faculty	medical
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Kiev

1. Learning objective

1.1. Become familiar with physical and biological characteristics of ultraviolet radiation (UVR). Master the methods of measuring the ultraviolet radiation intensity. Master the measures of the ultraviolet radiation intensity and the calculations of the exposure to it using the different measuring methods.

1.2. Strengthen and to supplement knowledge about the biological effect and hygienic significance of the ultraviolet radiation (UVR). Master the methods of organization of the UV irradiation (UVI) for the purpose of the UV deficiency prevention and the control of it. Master the methods of air sanation by the UVR and its efficiency assessment.

2. Basics

2.1. You should know:

2.1.1. Nature, physical characteristics and spectral distribution of the solar radiation. Physical characteristics, spectral distribution and biological effect of the ultraviolet radiation (UVR). Dosimetric units and measuring methods of the UVR.

2.1.2. Main biological effects of the UVR. Deficiency and excess of the UVR and its effect on health. Types of the artificial UVR sources. Photaria. Methods of measuring and estimation of the UVR intensity.

2.2. :You should have the following skills:

2.2.1. Working with ultravioletmeter (uphymeter) according to its instruction. Determination of the reagent titre and substance concentration by volumetric titrimerty methods. Using the mathematical methods of the UVR intensity and dose assessment.

2.2.2. Usage of the UVR for disease prevention and air sanation at the patients' care institutions, child institutions and workplaces. Calculation of the preventive dose and selection of the UV irradiation procedure. Planting the microorganisms into the air samples using the Krotov's device. Calculation of the number of colonies on beef-extract agar (BEA) in Petri dish before and after the air UV irradiation for the determination of the microbial air pollution and air sanation efficiency.

3. Self-training questions

3.1. The nature of the solar radiation, basic constituent elements of corpuscular and electromagnetic portions of the solar radiation.

3.2. Spectral distribution of the ultraviolet diapason of the solar radiation at the edge of the atmosphere and earth surface (regions A, B, C). The ozone layer and its hygienic significance.

3.3 Artificial ultraviolet radiation sources, their physical and hygienic characteristics.

3.4. Main effects (biogenic and non-biogenic) of the UVR and their particularities for each of the UVR region separately.

3.5. Measuring methods of the UVR intensity – physical, photochemical, biological, mathematical (calculation).

3.6. Ultraviolet intensity measures used with these methods and their interrelation.

3.7. Erythemal, physiologic and preventive ultraviolet radiation doses.

3.8. Types and mechanisms of the UVR effects: biogenic – general-stimulatory, vitamin D forming, chromogenic and non-biogenic – bactericidal, virulicidal, cancerogenic etc..

3.9. Distinctive characteristics of biological effects of the UVR band (regions A, B, C).

3.10. Erythemal, physiological, preventive doses of the UV radiation. Quantitative determination of the UVR intensity using different measuring methods.

3.11. The UVR disadvantage and its effect on health.

3.12. Main symptoms of "solar insufficiency" and cases requiring the preventive UV irradiation.

3.13. Usage of the UVR for primary and secondary prophylaxis of different diseases.

3.14. Artificial UVR sources, principles of their functioning, main technical characteristics. Photaria.

3.15. Excessive exposure to natural and artificial UVR sources.

3.16. "Ozone holes" as a hygienic problem. UVR as an occupational hazard.

3.17. Methods and means of protection from the excessive UVR exposure.

4. Self-training assignments

4.1. Forearm skin was locally exposed to the LE-30 lamp during 5 (five) minutes. Barely perceptible reddening (erythema) appeared under the second window of Gorbachov's biodosimeter after 20 hours. Calculate the UVR intensity in biological, photochemical, physical measures. What are physiological and preventive doses in these measures?

4.2. Erythemal ultraviolet dose is reached by the exposure to the LE-30 lamp during 4 minutes at a distance of 2 m from the source. Calculate the exposure time required to receive the preventive dose at a distance of 4 meters from the source?

4.3. The preventive UVR dose is reached by the exposure to the beacon irradiator with 10 LE-30 lamps (capacity of 30 Wt) at the distance of 0.5 m during 2 minutes. What is a distance (using the same source) for a group of the children of kindergarten age to receive a preventive dose during 5 minutes of exposure?

4.4. An irradiator with БУВ-30 (BUV-30) lamps was used for the air sanation in the school class rooms (area was 50 m^2, height was 3.5 m, time of irradiation was 1 hour) during the influenza epidemic. Planting of the air was done on BEA in Petri dishes in Krotov's device before and after the UVR irradiation (planting speed was 20 l/min during 10 minutes). 65 colonies were grown before the sanation, 12 – after the sanation in Petri dishes on BEA. State a hygienic value of the air sanation efficiency.

5. Structure and content of the lesson (duration of the lesson 160 min + 10 min break)

5.1. Preamble – 10 min.

5.2. Theoretical training – 40 min

5.2.1. Curriculum questions (see page 2)

5.2.2. Solar radiation, its basic constituent elements and characteristics.

5.2.3. Biological effect of the ultraviolet radiation (UVR).

5.2.4. Measuring methods of the UVR intensity.

5.2.5. Usage of the UVR prophylaxis of different diseases.

5.2.6. Determination of the efficiency of the air sanation by the UV irradiation.

5.3. Typical situational tasks “Krok-2” solution – 30 min.

5.4. State hygiene exams situational tasks solution – 30 min.

5.5. Test control for assessment of students’ knowledge final level – 30 min.

5.6. Final part – 20 min.

The solar radiation, its physical characteristics and spectral distribution.

The solar radiation is an integral corpuscular flow (consisting of protons, alfa-elements, electrons, neutrons, neutrinos) and electromagnetic (photon) radiation.

Electromagnetic portion of the solar radiation
(according to R.F.Donnelly, O.R.White, 1980)

	Wave lenght λ, nanometers
Frequency band	> 100 000
Far-infrared region	100 000 – 10 000
Infrared region	10 000 – 760
Visible (optical) region	760 – 400
Ultraviolet region	400 – 120
Terminal ultraviolet region	120 – 10
Soft X-rays	10 – 0,1
High-energy (gamma) rays	< 0.1

The solar ultraviolet radiation wave length less then 290 nm is completely absorbed by oxygen and ozone of the upper atmosphere. Atmospheric pollution by factory waste helps the ozone layer destruction resulting in appearance of “ozone holes”. The shortest and the most harmful UV waves reach the earth surface through these “ozone holes”.

Artificial UVR sources:

- direct mercury-quartz lamps (MQL), mercury-arc lamps (MAL) generate UVR wave lengths of 240 – 380 nm;
- erythemal lamps (LE-15, LE-30, LE-30) – wave lengths of 285-380 nm;
- bactericidal lamps (LB-30) – wave lengths of 240-380 nm.

The solar and artificial UVR band consists of three regions:

- region A – long-wave ultraviolet radiation: λ = 315-400 nm;
- region B – middle-wave ultraviolet radiation: λ = 280-315 nm;
- region C – short-wave ultraviolet radiation: λ = 10-280 nm.

Spectral distribution and the main characteristics of the ultraviolet radiation are shown in figure 2.1.

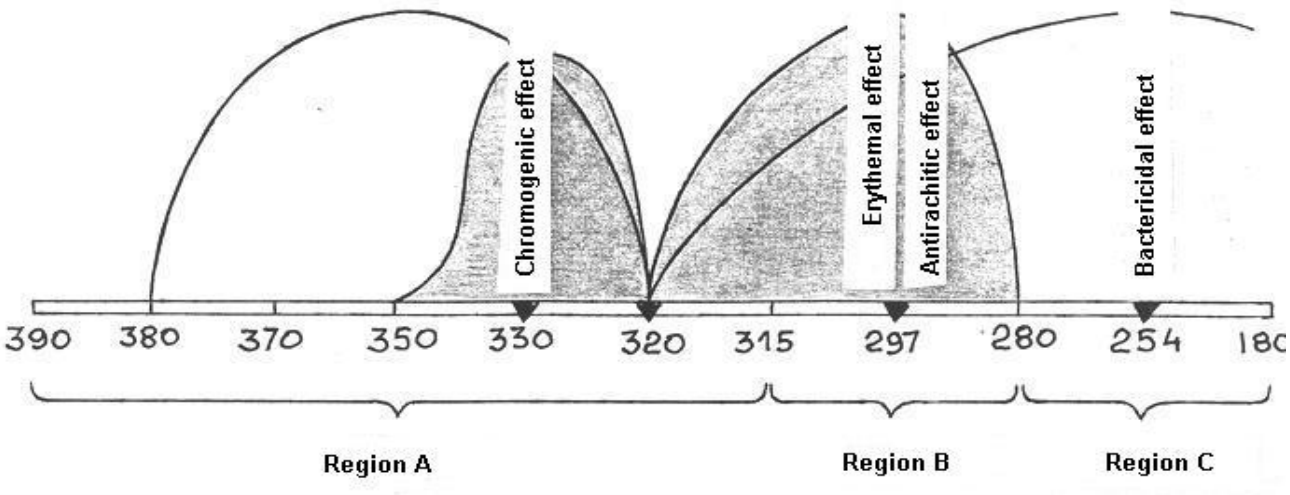

Fig. 2.1. Spectral distribution and the main characteristics of the ultraviolet radiation (UVR)

Biological effects of the ultraviolet radiation may be biogenic (general-stimulatory, vitamin D formation, chromogenic) and non-biogenic (bactericidal, carcinogenic, etc.).

1. General-stimulatory (erythemal) effect of the ultraviolet radiation is typical for the wave length of 250-320 nm, reaching the maximum at 250 and 297 nm (double peak) and the minimum at 280 nm. This effect results in the photolysis of skin proteins (the UV rays may penetrate the skin as deep as 3-4 mm). The following toxic products of photolysis are generated during this process: histamine, choline, adenosine, pyrimidine etc. These substances are absorbed by blood, they can stimulate metabolism, reticuloendothelial system (RES), marrow, rise the levels of haemoglobin, erythrocytes and leucocytes, increase enzyme activity and liver function, stimulate the activity of the nervous system etc.

The UVR general-stimulatory effect is emphasized by its erythemal effect, which consists in reflex dilation of capillary vessels, particularly when exposed to the intensive infrared radiation. The erythemal effect may result in the skin burn if exposed to the extensive radiation.

2. Vitamin D forming (antirachitic) effect of the UVR is typical for the 315-207 nm wave length (region B), reaching the maximum at 280-297 nm. This effect consists in the decomposition of calciferols: ergosterin (7,8-dehydrochplecterol) of the skin fat (in sebaceous glands) turns into the vitamines D_2 (ergocholecalciferol), D_3 (cholecalciferol), and the provitamin 2,2-dehydroergosterin – into the vitamin D_4 under the UVR influence due to the decomposition of the benzene ring.

3. Chromogenic (tanning) effect of the UVR is typical for regions A, B with wave lenght of 280-340 nm, reaching the maximum at 320-330 nm and 240-260 nm. Transformation of tyrosine (amino acid), dioxyphenilalanine and the products of adrenaline decay helps to generate the black pigment melanin under the influence of the UVR and the enzyme tyrosinase. This pigment protects the skin and the whole body from the ultraviolet, optical and infrared radiation surplus.

4. Bactericidal (non-biogenic) effect of the UVR is typical for regions C and B with wave lenght from 300 to 180 nm, reaching maximum at 254 nm (according to some other sources – 253.7-267.5 nm). First, the irritation of bacteria under the influence of the UVR

activates their metabolism, then a dose increase provokes the bacteriostatic effect and further - photodecomposition, protein denaturation and microorganisms death.

5. Photo-ophthalmic effect of the UVR (the inflammation of the eye mucous membrane) may be observed high in the mountains ("snow disease" among the alpinists), and also among the electric welders and physiotherapists that don't follow the security rules during the work with the artificial UVR sources.

6. Cancerogenic effect of the UVR is more evident in hot tropical climate conditions and during an exposure to high levels and long-term action of the UVR technical sources (electric welding etc.).

Measuring methods of the ultraviolet radiation intensity

1. An integral (total) flow of the solar radiation is measured by pyranometer (e.g. Yanishevskiy's pyranometer). The measure units are $\frac{mcal}{cm^2 \cdot \min}$. The solar constant is 2 $\frac{mcal}{cm^2 \cdot \min}$ at the upper atmosphere and 1 $\frac{mcal}{cm^2 \cdot \min}$ near the earth surface.

2. *Biological method* – an erythemal dose determination using the Gorbachov's biodosimeter (fig. 2.2). *A minimal erythemal dose (MED) or biodose* is the shortest exposure time to the UVR (minutes), which causes the barely perceptible reddening (erythema) on non-tanned skin 15-20 hours after the exposure (for children - 1-3 hours).

Gorbachov's biodosimeter is 6-window (1.5×1.0 cm) plane-table with the sliding cover, that may close all or some of the windows. This device (biodosimeter) is fixed on the non-tanned skin (the internal surface of the forearm) to determine the biodose. It is useful to mark the window numbers and locations on the skin. After warming up of the lamp (10-15 minutes), a student is exposed to an artificial source of the UVR at the distance of 0.5 m. Then the window #1 is opened, and after that we open a new window every minute. This way, the window #1 is irradiated for 6 minutes, #2 – 5 minutes, #3 – 4 minutes, #4 – 3 minutes, #5 – 2 minutes, #6 – 1 minute. The exposure time and distance may be different depending on a power of the UVR source and other conditions.

The skin is checked for the reddening 18-20 hours after. An erythemal dose is the exposure time of a window with the smallest erythema.

A physiological dose is 1/2 - 1/4, and a preventive dose is 1/8 of erythemal dose.

A preventive dose for the exposure distance, required for the patient can be calculated using the following formula:

$$X = \left(\frac{B}{C}\right)^2 \cdot A \cdot 1/8 \ \min$$

where B is a distance from the lamp to the patient in meters;

C – a standard distance for the determination of a preventive dose in meters, (0.5 m);

A – an erythemal dose at a standard exposure distance in minutes.

Comment: As it's above mentioned, students will only perform the first phase of the biological method measuring during this lesson. They will irradiate the forearm skin of each other using the Gorbachov's biodosimeter and indicate numbers of windows on the skin. Students will be able to determine the erythemal dose after 18-20

hours. Then they should write it down in the protocol and prepare the calculations of the physiological and preventive doses for themselves for the next lesson.

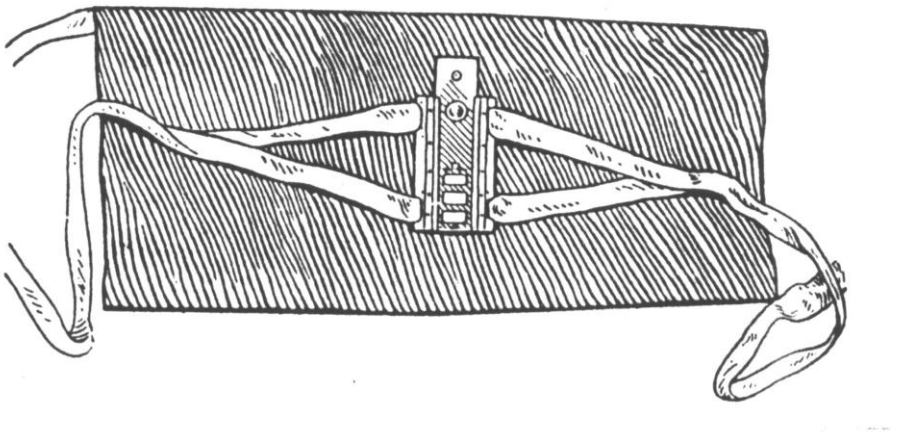

Fig. 2.2. Gorbachov's biodosimeter.

3. *Photochemical (Oxalic Acid) method* was elaborated by Z.N. Kylichkova. It is based on the oxalic acid decomposition being in proportion with the intensity and duration of the UV irradiation in the presence of nitrate uranil.

Measuring result is the mass (in milligrams) of the decomposed oxalic acid per 1 cm^2 of the solution surface. An erythemal dose is 3.7 – 4.1 mg/cm^2 of the decomposed oxalic acid, a physiological dose is 1 mg/cm^2, a preventive dose is 0.5 mg/cm^2.

Intensity of the ultraviolet radiation can be determined using this method as the mass (in milligrams) of the decomposed oxalic acid per 1 cm^2 of the solution surface per certain amount of time (day, hour).

Reagents: 0.1 n. oxalic acid solution (6.3 g per liter of distilled water); effecting 0.1 n. solution of potassium permanganate (3.16 g $KMnO_4$ per liter of distilled water): effecting 0,1 n. solution of the oxalic acid and nitrate uranil (6.3 g of oxalic acid and 5.02 g of nitrate uranil per liter of distilled water); 6 % solution of sulphuric acid (60 ml of concentrated acid per liter of distilled water).

Order of testing:

1. The titer of 0,1 n. solution of potassium permanganate $KMnO_4$ by 0.1 n. solution of the oxalid acid (T) has to be determined. For this the following should be done: 25 ml of H_2SO_4 and 25 ml of 0.1 н. solution of the oxalic acid are poured into the volumetric flask, then it is warmed up to 70^0C on a bain-marie, and titrated by 0.1 n. solution of $KMnO_4$ from a burette until the appearance of the minimally perceptible pink color, that remains visible for 1 minute. The titer is calculated by dividing the volume of the oxalic acid by the volume of the $KMnO_4$ solution, used in the procedure.

2. An initial volume of $KMnO_4$ solution on effecting solution of oxalic acid with uranil (V_1), which will be exposed to the UVR is determined. For this, the solution of pure oxalic acid is replaced by 25 ml of the effecting solution of oxalic acid with nitrate uranil. The titration process is similar.

3. This solution is exposed in a desired place to determine the UVR intensity there. 25 ml of the effecting solution of oxalic acid with nitrate uranil is poured into a quartz test-tube. This test-tube is overshadowed by black paper with light-window of a certain size.

A closed test-tube is exposed to the sun for a day (to determine the intensity of the Sun or the sky UVR) or to an artificial source of the UVR for an hour (LE-30 lamp, MQ etc). The test-tube is kept in a light-tight case after this exposure.

Comment: Student are provided with pre-made solution to speed up the work.

4. The volume of $KMnO_4$ solution by solution of oxalic acid with nitrate uranil after an exposure (V_2) is determined similarly. The difference between an initial volume of $KMnO_4$ solution and a volume of oxalic acid solution after an exposure to the UVR is the volume of decomposed oxalic acid.

Intensity of the UVR is determined as the mass (in mg) of the decomposed oxalic acid per 1 cm^2 of the surface of solution during the exposure time (hour).

Intensity of the UVR may be calculated by this formula:

$$X = \frac{(V_1 - V_2) \cdot T \cdot 6{,}3}{S \cdot t},$$

where:

T – a titer 0.1 n. solution of $KMnO_4$ determined by oxalic acid;

V_1 and V_2 – volumes of $KMnO_4$, used for titration of oxalic acid with nitrate uranil, before and after an exposure of the UVR, in ml;

6.3 (mg) – the mass of oxalic acid per 1 ml of 0.1 n. solution;

S – a light-window area of quartz test-tube, cm^2;

t – the time of a test-tube exposure to the source of the UVR, in hours (to the sun) or minutes (to the artificial source of the UVR).

Comment. The result of the UVR measuring is determined as a mass (in mg) of decomposed oxalic acid per 1 cm^2 per minute (from artificial source) or per hour (from the sun).

Conclusion (example). The intensity of the solar UVR, determined by this method is 1.3 $\frac{mg}{cm^2 \cdot hour}$ of decomposed oxalic acid. This is 0.3 of an erythemal dose. A man needs to receive at least 1/8 of an erythemal dose every day, for this he is required to spend 24 minutes each day outdoors.

4. *Physical (photoelectrical) method* measures the intensity of the UVR with the ultravioletmeter (short form is uphymeter). Uphymeter is a device containing the magnium (for length range of 220-290 nm) or stibium-caesium (290-340 nm) photoelement. Results of the measuring are represented in mW/cm^2 or mcW/cm^2.

Due to the erythemal effect being different at various wave length, and being maximal one when λ=297 nm, a special unit – microer is introduced. 1 mcer =1 mcW/cm^2 when λ= 297 nm. The results in mcW/cm^2 have to be multiplied by the relative biological effectiveness (RBE) (tabl.1) if the wave length is different.

E.g., the intensity of the UVR, measured by an uphymeter, is 6 mcW/cm^2, of which 4 mcW/cm^2 at λ=297 nm, and 2 mcW/sm^2 at λ=310 nm. Radiation dose is: 4×1+2×0,03=4,06 mcer. It has been determined, that 1 MED=700-1000 mcer; and 1 preventive dose – 100 mcer.

Table 1

Relative biological effectiveness of the UVR different bands

Wave lenght, nm	320	310	300	297	280	250	180
Relative biological effectiveness	0.01	0.03	0.5	1.0	0.75	0.43	0.18

Similarly to the above mentioned, the bactericidal effect is maximal at the wavelength of 254 nm and decreases if the wave lenght is different, so microbact has been introduced.

1 microbact = 1 mcW/cm^2 at λ=254 nm. A result in mcW/cm^2 is to be multiplied by the relative bactericidal effectiveness (RBcE) coefficient (tabl.2) if the wave length is different from 254 nm.

Table 2

Relative bactericidal effectiveness

Wave length, nm	320	300	280	254	220	180	100
Relative bactericidal effectiveness	0.02	0.08	0.45	1.0	0.84	0.76	0.74

There are several types of uphymeter. The instructions on using the automatic UVR dosimeter ДАУ-81 (DAU-81) for measuring the intensity of the UVR and radiation dose are given below.

A dosimeter measures an energy (band to 500 W/m^2) and dose (band from 10 J/m^2 to 15 MJ/m^2) of radiation at the exposure angles between +80° and - 80° from the artificial sources: bacteridcidal diapason UVR-DB from 0.22 to 0.28 mcm (region C); lamps LUV-40, LUV-80 with band from 0.32 to 0.40 mcm (optical region).

A dosimeter ДАУ-81 (DAU-81) consists of a measuring block and converters – primary (UV-C) with F-29 photoelement for wave length 0.22 – 0.28 nm (region C); primary (UV-A) with F-26 photoelement and UV and C2C23 color filters for wave length 0.32 – 0.40 mcm (region A); primary (FAR) with F-25 photoelement and C3C25 and ZC4 color filters for wave length 0.38 – 0.71mcm (optical region).

Dosimeter setup. Connect the primary converter for the selected region (C, A or optical region) to the measuring block and a cable of radiation source (UV lamp) to a control system.

Plug the device into the electrical supply network. Press the “Power” button. The device is ready when the pointer is not at 0 immediately after that.

Order of testing. Press “Power” and switch on the dosimeter.

Press the radiation wave band of energetic illumination switch button (“10”) (the primary converter is closed), after that press the “Уст. 0” (Set 0) button to set the microampermeter pointer to zero.

Press the “500” button. Take the deck off the primary converter. Check the data of the ampermeter. Select a more sensitive mode if the pointer shows less than 1/5 of the scale.

Set necessary dose of irradiation according to the sensor.

Press the “Reset” button. The counter has to show zero.

A chime will make a sound and the radiation source (UV lamp) will be switched off when the necessary dose has been reached.

Write down the data, and press “Reset”. The counter has to show zero.

Dosimeter is ready again after a necessary dose of radiation is set according to the sensor.

2.5. *Calculation methods* of determination of the UV radiation intensity.

2.5.1. The following formula is used for the calculation of erythemal flow from a movable source of the UVR

$$\mathcal{F}_{\text{source of radiation}} = 5.4 \cdot S \cdot H/t,$$

where:

$\mathcal{F}$ is the general (integral) flow of irradiation device, $\frac{mer}{m^2 \cdot \min}$;

5.4 – safety factor;

S – area of the room, m^2;

t – the duration of the irradiation source work, min;

H – dose of the preventive UV irradiation, $\frac{mer}{m^2 \cdot \min}$.

Values of **H**: - if 1 MED = 800 mcer (mcW/cm^2) = 5000 $\frac{mer}{m^2 \cdot \min}$;

- if $^1/_2$ MED = 400 mcer (mcW/cm^2)=2500 $\frac{mer}{m^2 \cdot \min}$;

- if $^1/_4$ MED = 200 mcer (mcW/cm^2) = 1250 $\frac{mer}{m^2 \cdot \min}$;

- if $^1/_8$ MED = 100 mcer (mcW/cm^2) = 625 $\frac{mer}{m^2 \cdot \min}$.

Comment: The calculation of the preventive UVR dose during the exposure to the sun or the open air with the tables is shown in the topic #3 - “Usage of the UV radiation for disease prevention and air sanation”.

Usage of the sun and artificial UVR sources for primary and secondary prophylaxis of chronic cardiovascular diseases

Considerable amount of material on the preventive doses of the natural (solar) and artificial UVR slowing down the development and the clinical course of cardiovascular diseases has been accumulated by practical medicine and special researches (V.G. Bardov, 1990). Toning up of cerebral (brain) cortex, normalization of the reactions of stimulation and inhibition, improvement of the state of vegetative nervous system, activisation of some enzymes, increase of erythrocyte amount in blood, normalization of lipid composition and cell membrane permeability, stimulation of anticoagulant system, mineral metabolism (especially phosphrus and calcium metabolism), blood pressure reduction, decrease of hypertention stroke frequency and severity, cardiovascular fitness ascension, angina pectoris, cardiac infarctions and cerebral strokes reduction are registered after preventive UV irradiation.

Aerosolaria (sun-air bathes) and medicinal beaches are used for primary and secondary helioprophylaxis of the diseases and health conditions listed above. These facilities must not cause overheating or cooling (they must be protected from wind). Chaise

longues or the beach sand is used often for sun bathes. Special tables, accounting for the sun climate of different places (see table 1) determine the insolation time.

Common scheme of cardiovascular diseases (CVD) UV prevention

For primary and secondary prevention of CVD is recommended courses of UV irradiations 3-4 times a year with duration of each course of 1 month and with intervals between them – 2-3 monthes. In Ukraine (taking into account seasonality of CVD) preventive courses of UV prevention better to conduct in october, december, february and april. In summer it is enough to spend 30-60 minnutes on open air for receiving preventive dose of UVR because of UVR intensity and not much clothes. In case of time limitation of natural UV prevention by summer monthes, UVR of antropogenic origin is used for this order. After determination of erythemal dose for concrete human under concrete irradiation conditions courses of primary and secondary prevention will be conducted according table 4.

In time of UV irradiation vitamin C and D, Ca and P should be prescribed.

Indications and contra-indications for UV prevention

Primary prevention prescribes for practicaly healthy people of different age, with serious risk factors of hypertension, chronuc ischemic disease, miocardial infarction, cerebral blood circulation disorders. Contra-indications for it are acute stage or exacerbation of all internals diseases, active tuberculosis of lung and kidneys, acute eczema, susceptibility to bleeding, nephritis, malaria, blood circulation insufficiency, malignant tumors, marked cachexy, heightened sensibility to UVR.

Secondary prevention prescribes for pationt in remission. Contra-indications for it are exacerbation or complication of disease is form of hypertension stroke, acute strokes of angina pectoris, acute period of cerebral stroke, miocardial infarction, state of health worsening, headache, and contra-indications for primary prevention.

General principles of UV prevention:

1. rational clinical examination
2. doctor’s control of irradiation
3. in time stoppage of irradiations in case of complicatioms appearance
4. optimization of labour and rest
5. rational nutrition
6. drug treatment in out-patients departments

Table 3.

Calculation (mathematical) method of the determination of preventive doses of the UV irradiation during solar and celestial bathes using the tables (49°- 51° of North latitude, Northern regions of Ukraine).

Irradiation duration in minutes.

Serial number of the sun bath	Irradiation dose (portion of erythemal dose)	April		May, June, July						August		September	
		Time of the day											
		11-12 16-17		10-11 17-18		11-12 16-17		12-13 15-16		11-12 16-17		12-13 15-16	
		Bath											
		solar	unsolar	solar	unsolar	solar	unsolar	solar	unsolar	solar	unsolar	solar	unsolar
Children from 6 months to 4-year-old													
1-3	1/12	3	6	2	4	2	4	2	3	2	4	3	6
4-6	1/10	4	8	3	6	3	5	2	4	3	6	4	8
7-9	1/8	5	10	4	8	3	6	3	5	4	8	5	9
10-12	1/6	6	12	5	10	4	8	3	6	5	10	6	12
13-15	1/5	8	16	7	13	5	10	4	8	6	12	8	16
16-18	1/4	10	20	9	17	6	12	5	10	8	16	10	19
Children of pre-school (4-7) and primary school (7-12) age													
1-2	1/10	5	10	5	10	3	6	3	5	4	8	5	10
3-4	1/8	7	14	6	12	4	8	4	7	5	10	7	13
5-6	1/6	9	18	8	16	5	10	5	9	7	14	9	17
7-8	1/5	11	22	10	19	7	13	6	11	9	18	11	21
9-10	1/4	13	27	12	23	9	17	7	13	11	22	13	26
11-12	2/7	16	31	14	274	10	20	8	16	13	25	16	30
13-14	1/3	19	36	16	31	12	23	9	19	15	29	19	36
15-16	2/5	23	44	20	38	14	27	11	23	18	35	23	43
17-18	1/2	28	55	25	48	17	34	14	28	23	44	28	54

Serial number of the sun bath	Irradiation dose (portion of erythemal dose)	April		May, June, July						August		September	
		Time of the day											
		11-12 16-17		10-11 17-18		11-12 16-17		12-13 15-16		11-12 16-17		12-13 15-16	
		Bath											
		solar	unsolar	solar	unsolar	solar	unsolar	solar	unsolar	solar	unsolar	solar	unsolar
Children of middle (12-15), senior (15-18) school age and adults													
1-2	1/10	7	13	6	11	4	8	4	7	6	10	7	13
3-4	1/8	9	17	8	14	5	10	5	9	7	12	9	16
5-6	1/6	11	23	10	19	7	14	6	11	9	18	11	21
7-8	1/5	14	28	12	23	8	16	7	14	11	22	14	26
9-10	1/4	17	34	15	29	10	21	9	17	14	27	17	32
11-12	2/7	20	39	17	33	12	24	10	20	16	31	20	37
13-14	1/3	23	46	20	38	14	28	12	23	19	36	23	43
15-16	2/5	28	55	26	46	17	34	14	28	23	44	27	52
17-18	1/2	35	69	30	58	22	43	18	35	29	55	34	65
19-20	5/8	44	86	37	72	27	53	22	44	36	68	43	81
21-22	3/4	53	104	45	87	33	64	27	53	43	83	52	98
23-24	7/8	62	121	53	101	38	75	31	62	50	97	60	115
25-26	1	71	138	60	116	43	86	36	71	58	111	69	131

UV irradiation scheme for primary and secondary prevention of cardiovascular diseases (number of erythemal doses in total on front and body surface)

days	Primary prevention of cardiovascular diseases	Secondary prevention of arterial hypertension	Secondary prevention of miocardial infarction	Secondary prevention of cerebral blood circulation disorders	Secondary prevention of chronic ischemic disease	Secondary prevention of miocardial inflamations
1	1/2	1/8	1/8	1/10	1/8	1/6
2	1/2	1/8	1/8	1/10	1/8	1/6
3	1/2	1/8	1/8	1/10	1/8	1/6
4	1/2	1/8	1/8	1/10	1/8	1/6
5	1/2	1/8	1/8	1/10	1/8	1/6
6	rest	rest	rest	rest	rest	rest
7	1	1/6	1/6	1/8	1/4	1/4
8	1	1/6	1/6	1/8	1/4	1/4
9	1	1/6	1/6	1/8	1/4	1/4
10	1	1/6	1/6	1/8	1/4	1/4
11	1	1/6	1/6	1/8	1/4	1/4
12	rest	rest	rest	rest	rest	rest
13	1-1/2	1/4	1/4	1/6	1/2	1/2
14	1-1/2	1/4	1/4	1/6	1/2	1/2
15	1-/12	1/4	1/4	1/6	1/2	1/2
16	1-1/2	1/4	1/4	1/6	1/2	1/2
17	1-1/2	1/4	1/4	1/6	1/2	1/2
18	rest	rest	rest	rest	rest	rest
19	2	1/2	1/2	1/4	3/4	3/4
20	2	1/2	1/2	1/4	3/4	3/4
21	2	1/2	1/2	1/4	3/4	3/4
22	2	1/2	1/2	1/4	3/4	3/4
23	2	1/2	1/2	1/4	3/4	3/4
24	rest	rest	rest	rest	rest	rest

25	2-1/2	3/4	1/2	1/2	1	1
26	2-1/2	3/4	1/2	1/2	1	1
27	2-1/2	3/4	1/2	1/2	1	1
28	2-1/2	3/4	1/2	1/2	1	1
29	2-1/2	3/4	1/2	1/2	1	1
30	rest	rest	rest	rest	rest	rest

Air sanation effectiveness assessment

The artificial UVR sources for preventive irradiation – different irradiators and photaria are equipped with erythemal lamps LE-15, LE-30. These lamps don't generate undesirable short-wave UV radiation, shoter than 285 nm (fig. 3.1, 3.2). The direct mercury-quartz lamps (MQL) have to be restricted by special filters for this.

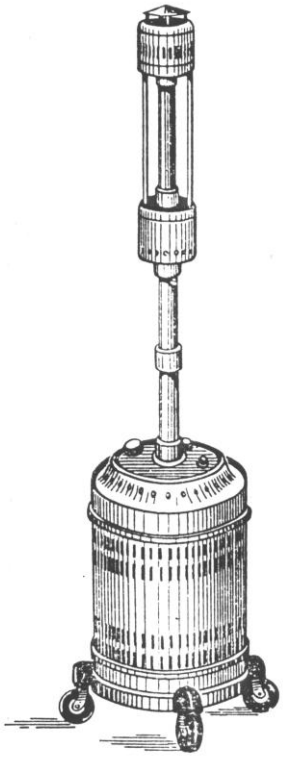

Fig. 3.1. Beacon irradiator

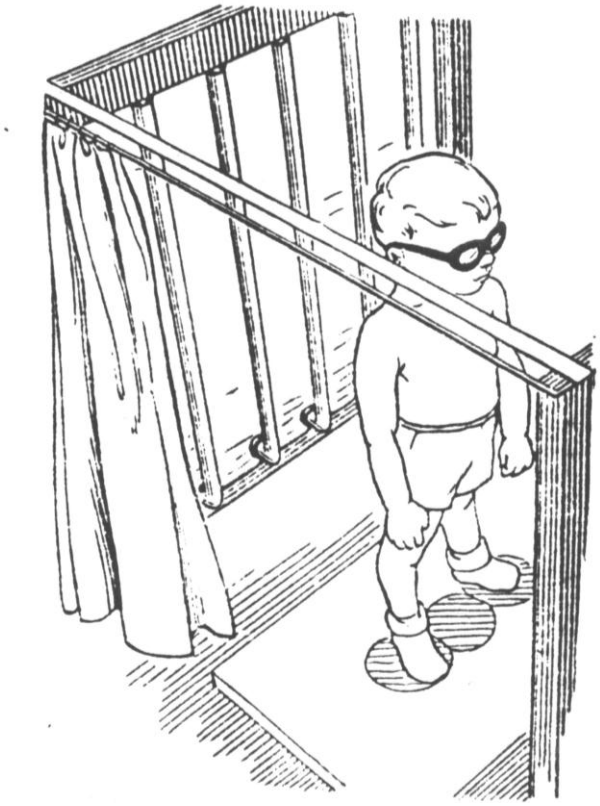

Fig. 3.2. Photarium with erythemal lamps in bilateral rows

An erythemal dose (biodose), and then the exposure time and distance (using table 2) are determined before the irradiation.

Table 4

Coefficients for exposure time modification on different distances from the lamp to the exposure place.

Initial distance from the lamp, cm	*New distance, cm*					
	100	70	50	40	30	20
100	1.00	0.49	0.25	0.16	0.09	0.05
70	2.04	1.00	0.51	0.32	0.18	0.12
50	4.00	1.96	1.00	0.64	0.36	0.25
40	6.25	3.06	1.56	1.00	0.56	0.39
30	11.10	5.44	2.77	1.77	1.00	0.69
20	16.00	7.84	4.00	2.56	1.44	1.00

Instruction on the determination of the efficiency of the air sanation by the UV irradiation

Planting of the air is performed on beef-extract agar or special agar in Petri dish in Krotov's device (fig. 3.3) before irradiation (exposure) to estimate the air sanation efficiency. The irradiation is performed using the bactericidal lamps LB-30 or mercury-quartz lamps in accordance with the pre-calculated exposure. Replanting (secondary planting) of the air in Petri dish is done after the exposure. Dishes are incubated in the thermostat during 24 hours at the temperature of 37^0C. The number of colonies after the incubation is calculated in both Petri dishes before and after the exposure.

The air contamination with the microbes is estimated by determination of microbe air contamination index (microbe number) (the number of microorganisms per 1 m^3 of the air) and the Staphylococcus hemalyticus population.

Microbe number is calculated using the following formula:

$$\text{M.n.} = \frac{A \cdot 1000}{T \cdot V}$$

where: M.n. – number of microbes in 1 m^3 of the air;

A – number of colonies in Petri dish;

T – duration of air sampling in minutes.;

V –air transmission speed of Krotov's device, l/min.

Efficiency degree and efficiency coefficient characterize the bactericidal effect of the UVR. Efficiency degree represents the percentage of decrease in the number of microbes. Efficiency coefficient represents by how many times the microbe number has decreased in the same air volume (colonies number disparity in Petri dishes before and after air exposure).

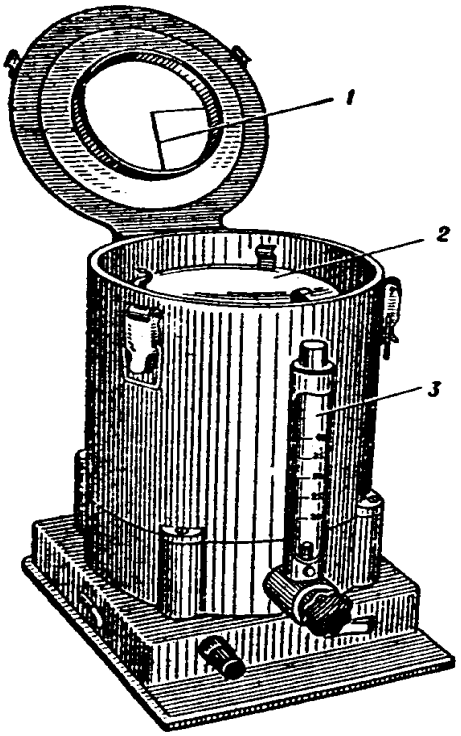

Fig. 3.3. Krotov's device for bacterial research of the air

(1 – cone crack; 2 – rotating disk; 3 – rheometer)

Sanation is considered effective if the efficiency degree is 80%, and the efficiency coefficient is not less than 5. (*Efficiency degree* is the ratio of microbe number difference before and after exposure to microbe number before exposure in %. *Efficiency coefficient* is the number, which represents by how many times the number of colonies has decreased after the exposure).

Microbe number after the air exposure is compared to the allowed air contamination index for premises (table 3)

Table 5

Approximate indices for the estimation of microbe air contamination (air clearance) for different premises.

	Microbe number, on m^3		*Air description*
	General microbe number	including Staphylococcus haemolyticus	
Residential premises	up to 2 000	up to 10	Very pure
Social premises	2 000-4 000	11-40	Sufficiently pure
Preschool institutions (children's homes, schools etc.)	4 000-7 000 >7 000	40-120 >120	Moderate contaminated High contaminated
Operating-room :			
a) before operation	up to 500	Must be none	Pure
b) after operation	up to 1 000	Not more than 3	
Dressing-room			
a) before the procedures	up to 500	Must be none	Pure
b) after the procedures	up to 2 000	Not more than 3	
Manipulation room	up to 1 000	up to 16	Very pure
	up to 2 500	up to 16	Sufficiently pure
Hospital ward	up to 3 500	up to 100	Pure

The artificial UVR sources are widely used for medical treatment of rheumatism, neuralgic pain, cutaneous tuberculosis (scrofuloderma) and in surgery to speed-up operative, traumatic, war, purulent (septic) wound regeneration and their complications. The UVR effect on the wound consists of bactericidal properties, the speed-up of the purulent discharges rejection, kerato-plastic skin function stimulation, and general analgetic effect. Artificial UVR sources of wide band (such as the direct mercury-quartz lamps) are used for this purpose.

The wound hydration, scarring and epithelization period (wound regeneration) are sped up during exposure of both the wound surface and the healthy structure around injury, which is the source of the regeneration process, to the UV radiation.

7. Literature

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6.1.6. Lecture materials.

6.2. Additional:

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6.2.3. Пивоваров Ю.П., Гоева О.Э., Величко А.А. Руководство к практическим занятиям по гигиене. – М., Медицина, 1983. – С. 199-210.

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3. Medicine of emergency situations: textbook for students of higher medical institutions / V.V. Chaplyk, P.V. Oliynyk, S.T. Omelchuk, V.V. Humenyuk. – Vinnytsia: Nova Knyha, 2012. – 344 p.

4. General nutrition: Study guide for the 4th accreditation level Medical School Students / edited by S.T. Omelchuk, O.V. Kuzminska. – Kyiv, 2016. – 146 p.

5. Гигиена и экология: учебник для студентов высших медицинских учебных заведений. – Винница: НОВА КНИГА, 2008ю – 720 с.

8. Equipment required for the lesson

1. The ultravioletmeter (uphymeter) DAU-81 or another type.

2. Gorbachov's biodosimeter.

3. Tape-line or tape-measure.

4. Artificial UVR sources: direct mercury-quartz lamp (MQL), mercury-arc lamp (MAL), erythemal lamp (LE-30), bactericidal lamp (LB-30).

5. Reagents: 0.1 n. oxalic acid solution (6.3 g per liter of distilled water);

0.1 n. solution of the oxalic acid and nitrate uranil 5.02 g/l;

0.1 n. solution of potassium permanganate KMnO4 (3.16 g per liter of distilled water);

6% solution of sulphuric acid (60 ml of concentrated acid per liter of distilled water).

6. Quartz test-tubes covered by black paper with a window of 3 – 4 cm^2 area – 2.

7. Tables for determination of preventive doses of the UV irradiation during solar bathes.

8. Erythemal lamp (LE-30), bactericidal lamp (LB-30).

9. Krotov's device.

10. Petri dishes with beef-extract agar planted with indoor air before and after the sanation performed with LB-30.