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ГРОМАДСЬКА ОРГАНІЗАЦІЯ

RADIATION SAFE KIROVOHRAD REGION

The impact of the uranium mining industry and natural factors on the environment and human health in the Kirovohrad oblast Analytical review

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Analytical review

Kropyvnytskyi 2021

Analytical report “Radiation safe Kirovohrad region. Current state and perspectives of development of the civic radiation protection system”.

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The analytical report was prepared based on the results of the analysis of the current state of the radiation safety system of Kirovohrad oblast. Data obtained from open sources, responses to requests for information, as well as expert opinions and results of laboratory and sociological research were used to collect information. The report presents the material from the results of relevant scientific research conducted in domestic and foreign scientific institutions, gives examples of functioning of certain elements of the system of radiation and radon protection of the population of some developed countries. Based on the obtained data, the authors provide a list of recommendations that should be considered when modernizing the system of protection from excessive ionizing radiation of the population of Kirovohrad oblast.

This report will be useful for the heads of structural units of the Kirovohrad Oblast State Administration, employees of local governments, employees of institutions involved in counteracting radiation pollution, scientists, journalists and civil society activists.

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CONTENTS

I. Legal regulation of protection of the population of Kirovohrad oblast from excessive ionizing radiation

Protection of the population from ionizing radiation, including that caused by the decay products of radon-222, is required due to the significant negative impact of radon on human health. The World Health Organization notes that the proportion of radon-induced cases of lung cancer in the overall structure of this pathology reaches 14% [1].

In addition, daughter products of the breakdown of this gas can cause leukemia in children. Studies show an increase in the number of cases of leukemia in children by 34% for every additional 100 Bq/m^3 [2].

One of the basic profile documents, which directs the efforts of the Member States of the European Union to achieve standards of well-being in the context of protection against ionizing effects, including radon-222, is Council Directive 2013/59 / Euratom of 5 December 2013 (hereinafter - Directive 2013) / 59 / EURATOM). The document establishes the basic standards of protection against the dangers arising from ionizing radiation [3]. One of the requirements of the Declaration is the obligation of Member States to develop sound strategies to implement these standards.

According to the Association Agreement between Ukraine, of the one part, and the European Union, the European Atomic Energy Community and their Member States, of the other part (hereinafter - the Association Agreement), the provisions of the Directive were to be implemented in Ukraine within 2 years of the entry into force of the Agreement [4]. Therefore, the Directive was to be fully implemented in our country in November 2016. According to the final provisions of the Directive, the enactment of laws, regulations and administrative provisions was to take place by February 6, 2018.

In order to implement the Directive, in 2015 the State Nuclear Regulatory Inspectorate of Ukraine developed a plan for its implementation, which was approved by the order of the Cabinet of Ministers of Ukraine dated February 18, 2015 №110-r [5]. This plan provided for "Development of a national action plan (state target program) to reduce the risks of long-term exposure to radon products" in 2016. In 2018, "radon radiation databases of representative groups of the population as a part of the state system of accounting and control of radiation doses of the population of Ukraine" were to be created. However, there is no national action plan, nor are databases.

In 2017, the Cabinet of Ministers approved an updated action plan for the implementation of the Association Agreement (hereinafter - the updated action plan, Resolution №1106) [6]. The updated action plan, paragraph 738 provides for "Development and approval of an action plan to reduce population exposure to radon and

its decay products, minimize long-term risks of radon spread in residential and non-residential buildings, workplaces, from any source of radon penetration - from the soil, building materials or water". This item was to be fulfilled during 2018-2019. Therefore, on November 27, 2019, the order of the Cabinet of Ministers of Ukraine № 1417-r approved a plan of measures to reduce population exposure to radon and its decay products, minimize long-term risks of radon spread in residential and non-residential buildings, workplaces for 2020-2024 (hereinafter - radon plan) [7].

According to this plan, in 2020 the Procedure and Methodology for radon monitoring in Ukraine and notification of radiation risks were to be developed and approved. As of the beginning of 2021, there is no Procedure and Methodology.

In addition, paragraph 3 provided for the establishment of a system of control over the quality and effectiveness of anti-radon measures at the state level. The entity responsible for monitoring radon levels is local government administrations.

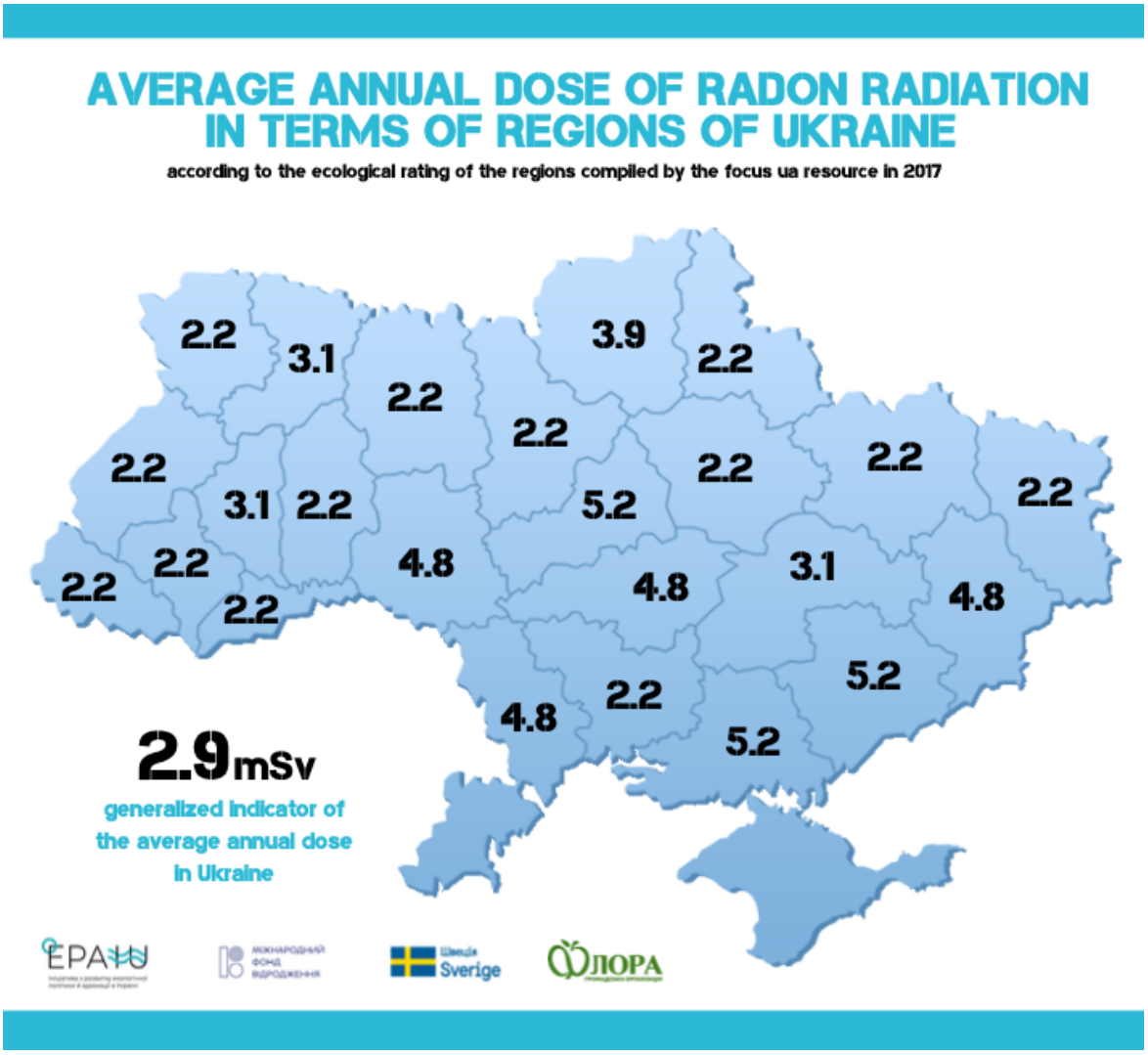
Thus, in Kirovohrad oblast, the main entity responsible for the coordination and implementation of measures to monitor and counteract radon radiation is the Kirovohrad Oblast State Administration.

However, since 2018, Kirovohrad oblast has not adopted any program document on the protection of the population from ionizing radiation, in particular from excessive concentrations of radon. The need to develop and implement comprehensive measures to protect the population of Ukraine, including Kirovohrad oblast, from excessive ionizing radiation and radon, is also due to other factors.

II. Current state of radiation pollution in Kirovohrad region

According to the geological map, which records the location of radioactive rocks, all parts of the country have uranium potential, except the southern (Crimean-Black Sea basin) and north-eastern part of Ukraine (Dnieper-Donetsk basin, Donetsk folded region). But the central part of Ukraine, namely the regions located on the surface of the Ukrainian crystal shield: Kherson, part of Rivne, Chernihiv, Vinnytsia, part of Khmelnytskyi, Cherkasy, Kirovohrad, Dnipropetrovsk and Zaporizhzhia regions have the highest potential, and consequently, radon sources. The influence of radon sources is quite clear in the indicators of the average annual dose of radon radiation at the regional level. For example, in a study conducted by the portal Focus.ua in 2017, it was determined that residents of six regions, including Kirovohrad have the largest average annual dose of radon radiation [13]. In more detail, the indicators of the average annual dose of radon radiation in terms of regions are presented in Figure 1.

Figure 1.



Kirovohrad oblast, in comparison with other regions of Ukraine, has a high additional level of irradiation of the population with natural radionuclides of a number of uranium, including radon-222 and its daughter decay products. The main reasons for this are two types of factors - natural and man-made. The first is due to the fact that almost half of the region is located on the Ukrainian crystal shield with a high content of natural radionuclides.

One of the regional geological faults runs almost on the territory of Kropyvnytskyi. This determines the existence in the region of large areas with radiogeochemical features, characterized by the presence of areas with abnormal concentrations of radon in groundwater and ground air, as well as areas with abnormal concentrations of uranium in groundwater.

Uranium and thorium, which are present in the rocks of the crystalline shield, cause increased release through the soil layer into the atmosphere and premises of buildings of radioactive gases radon and toron. These gases create the basic dose (about 75%) of irradiation from all natural sources of irradiation of the population of region. According to

the information provided by the head of the radiology laboratory of the state enterprise "Kirovohrad Laboratory Center of the Ministry of Health of Ukraine" Babirad I.Y., according to many studies conducted in Kropyvnytskyi and region, according to preliminary calculations under standard conditions, the values of effective doses of radon and its daughter products can reach 39.1 μSv/year.

The presence of elevated levels of radon-222 in the air of Kirovohrad oblast is constantly confirmed by the results of numerous studies.

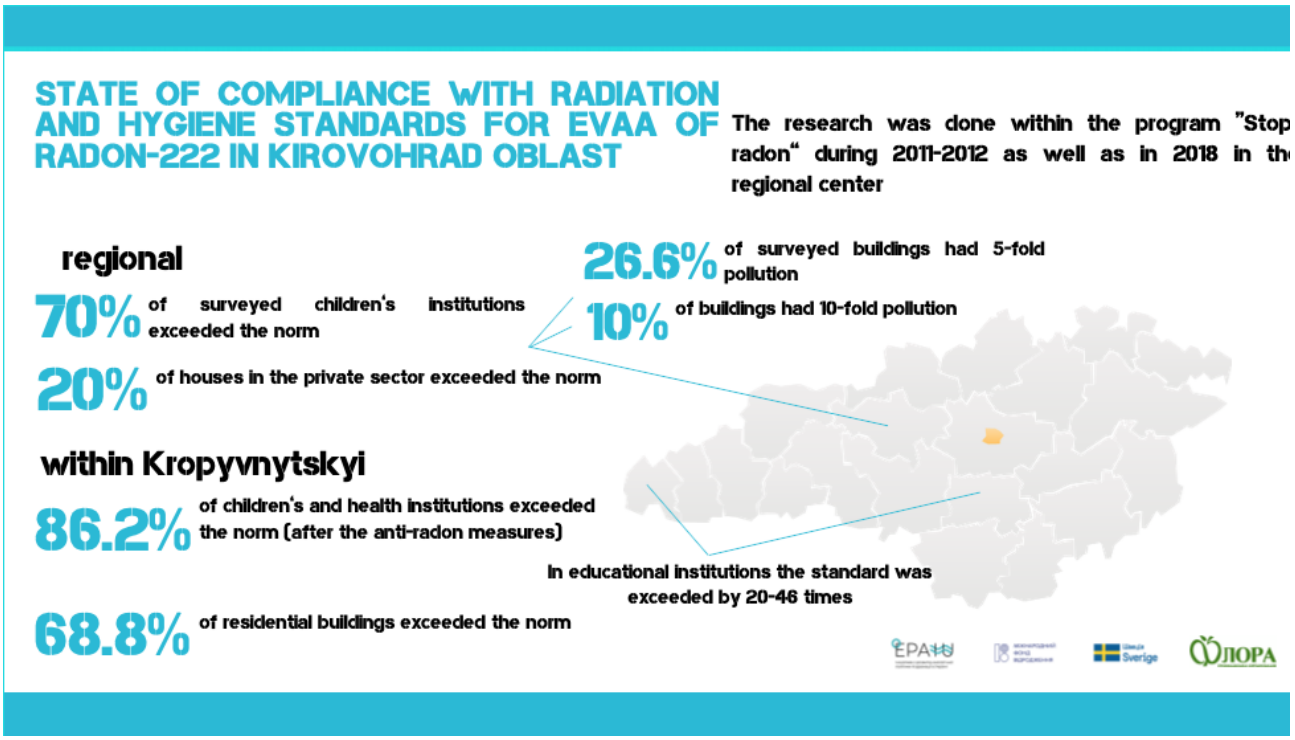
Thus, within the Stop Radon program during 2011-2012, relevant research was conducted in almost 700 preschool and children's institutions. The obtained results testified to the excess of the radiation-hygienic standard for equivalent equilibrium volume activity (hereinafter - EEVA) of radon-222 in 70% of the surveyed children's institutions. Out of 30 surveyed buildings in Mala Vyska raion, 23 were exceeded, while in eight buildings there was a five-fold excess of pollution above the standard and three - ten-fold. In Kompaniyivka and Haivoron raions, radon activity indicators in educational institutions of more than 1000 Bq/m3 and 2300 Bq/m3 were determined, respectively, which is a 20-46-fold excess of the normalized limit values.

Approximately the same situation was observed in other raions of the region and the regional center. In the private sector, one in five buildings was exceeded.

Similar studies were conducted in 2018. At that time, the average annual EEVA of radon-222 was measured in the air of the premises of educational and medical institutions of Kropyvnytskyi, where anti-radon measures were performed in the previous year. As a result, the radiation-hygienic standard for EEVA of radon-222 (50 Bq/m3) was detected in 86.2% of the investigated premises (which indicates the ineffectiveness of the implemented anti-radon measures). At the same time, in residential buildings the standard of 100 Bq/m3 was exceeded in 53.6% of buildings, the level of more than 200 Bq/m3 - in 15.2% of premises. Of all the studied objects, only one met the standard of 50 Bq/m3.

In more detail, the state of compliance with the radiation-hygienic standard for EEVA radon-222 in the Kirovohrad oblast is presented in Figure 2.

Figure 2.

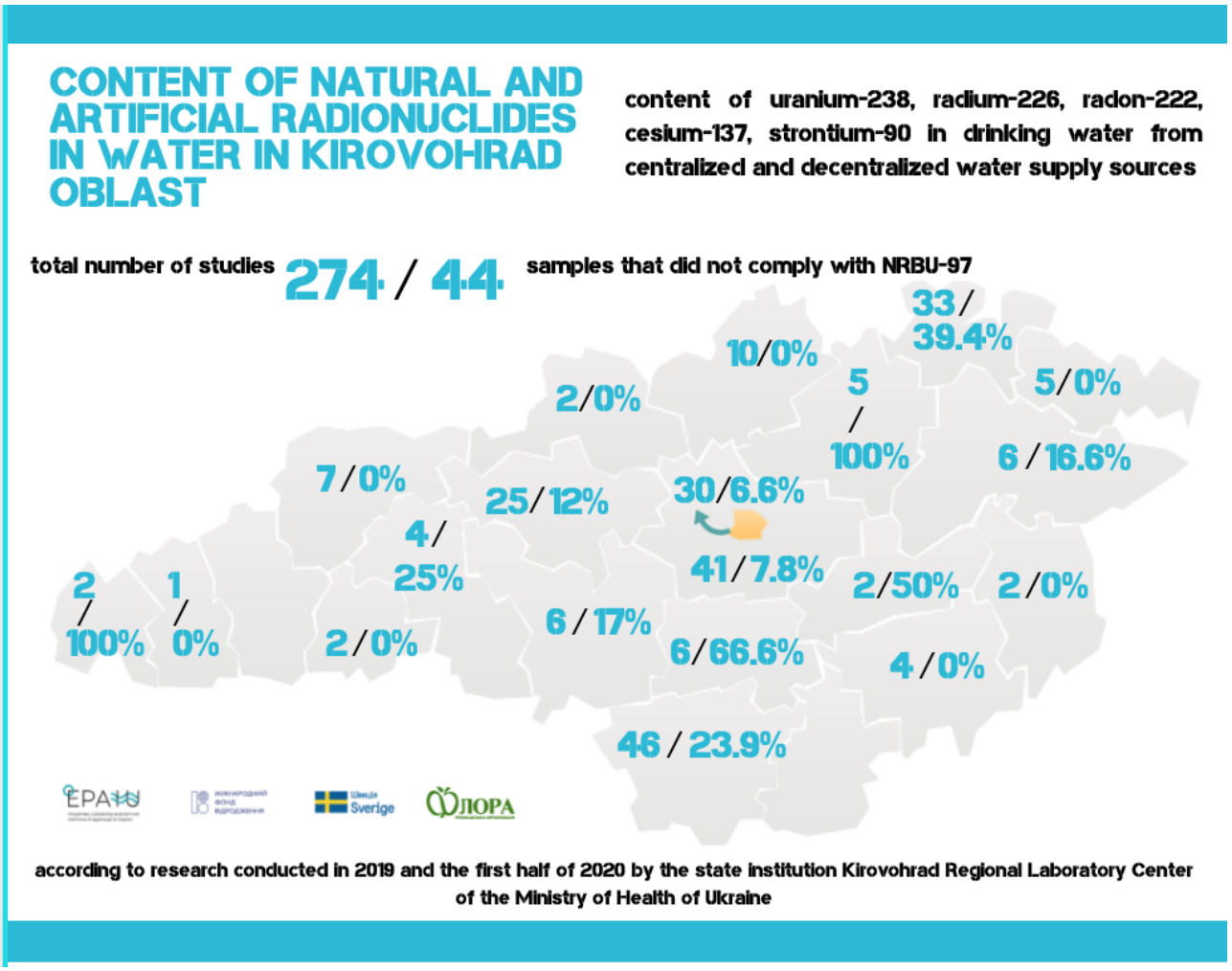


In addition, specialists of structural subdivisions of the Main Department of the State Food and Consumer Service of Kirovohrad oblast and the State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine" conducted research of water supply sources for radon-222 content in educational institutions of the region. In selected samples of drinking water, which were tested for compliance with the requirements of State sanitary rules and regulations 2.2.4-171-10 "Hygienic requirements for drinking water intended for human consumption", specific radon activity up to 326,5 Bq/m3 at a rate of 100 Bq/m3 was found. This excess was detected in six raions of the region, namely: Svitlovodsk, Novhorodka, Novomyrhorod, Golovanivs, Gaivoron and Bobrynets.

In general, according to the results of research conducted during 2019-2020 by the State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine", 16.3% of water samples from decentralized sources of the region had an excess of natural radionuclides, including radon-222.

The content of natural and artificial radionuclides in water in Kirovohrad oblast is presented in Figure 3.

Малюнок 3.



The state of radiation pollution of underground sources of the Kropyvnytskyi city and wastewater of the Inhulska mine, in particular with regard to the content of natural uranium, is presented in Figure 4.

Малюнок 4.

The problem of over-irradiation of the population of the region is also complicated by man-made factors. Namely, the practice of using local mineral raw materials with a high content of natural radionuclides of the uranium-thorium series, as well as the consequences of uranium mining. Today Kirovohrad oblast is the only region of the country where uranium ore mining is carried out. Three uranium mines are concentrated within the region: Inhulska, operating on the border of Kropyvnytskyi, Smolinska and Novokostiantynivska, located at a distance of up to 100 km from the regional center. Extraction leads to the accumulation of a significant amount of solid waste, as well as to the pollution of some rivers by discharges of mine waters.

Therefore, for Kirovohrad oblast it is important to protect the population from the consequences of uranium ore mining, including from uranium that enters surface waters. Emissions of untreated mine water, including uranium contaminated, were recorded by the State Environmental Inspectorate of Ukraine in 2020 and 2019. As well as by the NGO "Flora", which in early 2021 analyzed the chemical composition of mine waters of the Inhulska mine (see Fig. 4) [15].

Thus, residents of some areas of the region are at risk of consuming water and products with high uranium content. The health risks of uranium have been confirmed by a number of scientific studies. Here are some of the results of such studies over the past five years.

• Uranium can alter immune function and cause asthma in humans. This is the conclusion of a study of the relationship between the presence of uranium in the urine and asthma in adults. A retrospective cross-sectional study was conducted with 3425 subjects aged 20 years and older in the US National Health and Nutrition Study (NHANES) [8].

• Uranium can adversely affect the thyroid gland. A national study on health and nutrition (USA) found that significant uranium activity and high concentrations of uranium in water adversely affect thyroid health - in particular, increase the risk of cancer [9].

• Prenatal exposure to uranium has adverse effects on the baby. This was confirmed by a study that evaluated the relationship between uranium concentrations in the urine of women preparing for childbirth and adverse birth effects such as preterm birth, low birth weight, and premature birth. The study found that the effects of uranium on the mother during pregnancy leads to a decreased length of gestation and an increased risk of premature birth [10].

• Uranium may be a risk factor for the development of circulatory system diseases. This conclusion was confirmed by the results of a study of cases of circulatory system diseases (CSD) in persons who from 1960 to 2005 worked in the nuclear production of the French company AREVA NC Pierrelatte. The purpose of the analysis was to assess the risks of these diseases taking into account the main risk factors for CSD (smoking, blood pressure, body mass index, total cholesterol and glycemia) and the obtained external dose of gamma radiation. The results showed that uranium exposure may be an independent risk factor for circulatory diseases and mortality [11].

• Low doses of radiation can be an equivalent factor in cancer, as can atomic bomb explosions in Japan. These findings were obtained by comparing the health status of low-dose workers commonly found in the nuclear industries of France, the United Kingdom, and the United States with the effects of radiation received by survivors of the atomic bomb blast in Japan [12].

Despite the lack of practice of conducting such studies in Kirovohrad oblast, today there is a significant amount of relevant information, which confirms the presence of significant health problems in the population of the region. A clear indication of this is the growing incidence of cancer, the development of which is significantly affected by excessive concentrations of radon-222.

Numerous scientific studies directly link the effects of radon-222 and the increase in morbidity and mortality from cancer. For example, studies conducted in the United States of America and the United Kingdom show that about 21,000 and more than 1,000 people die each year from lung cancer directly from radon-222, respectively. It is impossible to determine the exact number of deaths and cases of lung cancer caused by the effects of radon-222 in Kirovohrad oblast due to the lack of relevant studies. At the same time, statistics on oncological pathology in the region indicate the presence of problems caused by excessive exposure to ionizing radiation in the region. According to official data, over

the past twenty years the incidence of cancer in Kirovohrad oblast is higher than the national one. Thus, in 2006, Kirovohrad oblast had 411 cases per 100 thousand population, which is 23% more than in Ukraine, in 2016 the excess over the national level was 35.9%, in 2020 - more than 30%. At the same time, in some territories of the region (Kropyvnytskyi, Oleksandriya and Bobrynets districts) the excess of this indicator over the all-Ukrainian one is about 50%.

Measures taken to protect the population of the region from excessive ionizing radiation are:

1) sanitary and hygienic monitoring of environmental objects.

2) Radioactive dumps are filled up in the spent cavities of uranium mines, other radioactive wastes are transferred for disposal.

3) during the preparation for the school year in all educational institutions of the region anti-radon activities are carried out (sealing of communication outlets, bricklaying of seams between slabs, cracks of concrete walls and floors, installation of permanent exhaust ventilation, etc.).

However, most such measures are not systemic in nature and are not evaluated in the context of their effectiveness. After all, in Kirovohrad oblast there is no equipment for measuring the EEVA of radon-222. The last time such studies (139 measurements) were carried out at the end of 2018 exclusively on the territory of the regional center.

For the region, the active search for sources of ionizing radiation and radioactive waste that can be detected outside the places of authorized disposal remains relevant. For example, in places of concentration of the population of cities and territorial communities, points of gathering of scrap metal, at the enterprises on extraction and processing of minerals (quarries), etc.

The need for such measures is confirmed by the results of radiation background research conducted by the research and analytical center of the public organization "Flora" in the city of Kropyvnytskyi and the region. During January-April 2021, the organization's specialists conducted about 20 such studies, as a result, several places were identified where gamma radiation reached almost 3.00 μSv. In particular, on the dumps of the Inhulska mine, as well as from abandoned cores scattered on the territory of Hyrnyche selyshche in Kropyvnytskyi [14].

The importance of protecting the population from radiation risks is confirmed by the results of a sociological survey conducted by the NGO "Flora". The survey was conducted from 04.13.2021 to 04.23.2021. A total of 400 respondents, permanent residents of Kropyvnytskyi, were interviewed. Type of sampling - quota, representative for the adult population of the city (from 18 years old) by sex, age and territorial-administrative district.

With a confidence probability (p) = 0.95, the error (Δ) is +/- 4.9%. The survey method is an individual standardized interview at the place of residence. The study was performed by the Central Ukrainian Sociological Laboratory.

The vast majority of Kropyvnytskyi residents surveyed identified poor drinking water quality among the most important problems of the regional center. The number of such respondents was 83%. This problem took the first place in the corresponding rating of problems that concern the residents of Kropyvnytskyi. The residents gave the third place to a high level of radiation. The number of people who identified this problem as the most urgent was 44.8%.

Radiation pollution worries most respondents. Almost half of the respondents - 45.3% answered that this indicator is "rather disturbing" and 24.3% said that it is "very disturbing".

Answering the question "What to your opinion is the level of radiation background in Kropyvnytskyi?", the vast majority of respondents rated the radiation level as high. Namely, 37.3% of respondents chose the answer - "rather high", 28% chose the option - "very high". In fact, every fifth resident of the regional center who took part in the survey said that it was "difficult to answer" this question.

In the city of Kropyvnytskyi, there is a significant public demand for constant measurement of the level of radiation background. 52.3% of respondents agreed that it was "rather necessary" and 39.3% chose the answer - "very necessary".

In the survey, we paid special attention to assessing the level of public awareness about various aspects of radon pollution. It turned out that more than half of the respondents (50.5%) do not know that radon gas damages the upper respiratory tract. At the same time, almost every second respondent (48.2%) believes that his airways are either completely or rather invulnerable.

Even more respondents (78%) are unaware of how to protect themselves and their children from radon radiation.

The vast majority of respondents said they needed information on how to protect themselves from radon radiation. Answering the question "How much do you need the information about methods of protection against radon radiation?", 49.3% chose the answer - "very necessary" and 41% - "rather necessary".

Assessing the effectiveness of the government's activities to protect the population of Kropyvnytskyi from radon radiation, 42.5% of people answered - "completely ineffective" and 30% - "rather ineffective."

Thus, it is necessary to immediately develop a comprehensive program for Kirovohrad oblast to protect the population from the risks of excessive ionizing radiation. At

the same time, in order to achieve maximum efficiency, it is necessary to combine domestic experience in combating excessive ionizing radiation, including radon-222, with the best practices of developed countries. To find the best proposals for the draft Comprehensive Program, a comparative analysis of the experience of protecting the population from radon-222 in the United States, Germany and Poland was conducted.

III. Comparative analysis of certain anti-radon measures in the United States, Germany and Poland

The experience of these countries proves the effectiveness of a program approach to protect the population from excessive ionizing radiation.

The United States of America's experience

The beginning of the development of state policy to protect the population from radon in the United States can be considered the early 1990s. During this period, Standards and protocols for measuring and mitigating the effects of this hazardous gas were developed and published. These Standards and Protocols have been recognized and integrated into the licensing and certification system, the activities of the US Environmental Protection Agency (EPA), as well as into national training programs - the National Radon Training Program AARST-NRPP and the National Radon Safety Board (NRSB). But, as it turned out, the established mechanism was imperfect and in early 2010 in the United States there was a need to modernize anti-radon policy.

The main impetus for the renewal of the state system for counteracting ionizing radiation caused by the decay of radon-222 was far from the processes in government. In the mid-2000s, America was hit by a construction boom. Combined with insufficient voluntary action to implement radon measures, many American homes found themselves

at significant risk, which in 2010 was estimated to be commensurate with the year 1986 levels. It was then that the EPA launched its latest National Radon Risk Assessment Campaign at the national level.

Recognizing the problem, nine federal agencies began looking for new solutions and set up a working group. The Department of Agriculture, The Department of Defense, the Department of Energy, the Department of Health and Social Services, the Department of Housing and Urban Development, the Department of the Interior, the Department of Veterans Affairs, the Environmental Protection Agency, the Agency and the General Services Administration joined the development of the Federal Radon Action Plan.

The activity of the working group resulted in 33 commitments, which each of the subjects accepted and undertook to fulfill and monitor. That's how a powerful document appeared in the United States in 2010 - A National Strategy for Saving Lives. The strategy was based on four approaches: a) testing and implementing measures to reduce radon levels through professional services; b) providing financial incentives and direct support in situations where measures to reduce radon levels are needed; c) introduction of construction practices using approaches aimed at preventing radon risks; d) awareness raising (information and educational component). The main goal of the Strategy was to prevent 3,200 deaths from lung cancer caused by radon each year by detecting and reducing the concentration of this gas in 5,000,000 American buildings. Subsequently, other entities joined the implementation of the Strategy.

For example, in 2013, twelve leaders of national organizations representing the Government teamed up with nonprofits and industry to expand efforts to eliminate radon-induced lung cancer. Thanks to the implemented approaches in the USA the really effective system of counteraction to excessive amount of radon in buildings is created. The mechanism is especially effective for ordinary residents. There are five radon hotlines in the United States. At the same time, one National Hotline operates exclusively for Spanish-speaking people. There is an open access radon map of the United States, where the entire territory of the country is divided into territories according to the level of radon concentration. In total, there are three zones with high radon concentrations. Every citizen also has the opportunity to buy special equipment for measuring radon levels in their homes.

There are two types of such equipment. The first is for quick measurements, which costs about $ 10-15, the second for a longer study (radontestkits). The citizen receives

such equipment by mail. After receiving the results, the person can contact the consultants, who will provide explanations and offer recommendations. If it is necessary to take measures to reduce the level of radon in the home, in the US there is a special portal, where for each area is a list of certified companies that can carry out such measures (radon mitigation contractor).

There is quite a number of such companies in each state. For example, there are 19 in Nevada and 125 in Wisconsin. In the United States, there is a detailed list of 13 measures that such companies can take in buildings to reduce radon levels. Thanks to such techniques it is possible to reduce the level of radon by 99%. Such work costs from $800 to $2,500, but, as a rule, on average - $1,200.

In order to increase the awareness of the importance of reducing radon concentration, in the United States, January is celebrated annually as the National Radon Action Month.

Germany's experience

As a member of the European Community, Germany has an obligation to implement the regulatory standards imposed on the states of the European Union. Including in the field of protection of the population from excessive ionizing radiation. One of the basic profile documents that directs the efforts of EU member states to achieve standards of well-being in the context of protection against ionizing effects, including radon-222, is Council Directive 2013/59 / Euratom [3]. The document sets the basic standards for protection against ionizing radiation. One of the requirements of the Declaration is the obligation of Member States to develop sound strategies to implement these standards.

For Germany, the need to counter radon, as proclaimed in the Declaration, was not new. Since 1995, the country has been conducting constant research to determine the level of radon concentration in the premises and soil. As a result, in the early 2000s, Germany had a national map that presented the concentration of this gas in the soil. Scientifically based approaches have led to further development in this area. Later, another map of radon potential was created in the country. Radon potential is the amount of radon that potentially enters the building from the ground.

At the same time, the Declaration was the impetus for finding even more effective approaches to protect the population from ionizing radiation and visualization of relevant

data. In pursuance of the requirements of the Declaration, on December 31, 2018, the relevant Radiation Protection Act was enacted in Germany. In addition, the implementation of the law led to the development and implementation of a national Radon action plan.

One of the main components of this plan is the measurement of radon concentration and updating the estimated amount of this gas in the country. The accumulation of such became the basis for further updates of visualized services, i.e. maps.

German scientists worked synchronously with the national anti-radon action plan. A group of scientists led by Eric Petermann carried out scientific work "Mapping the geogenic radon potential for Germany by machine learning".

The result was a third map of the radon potential of Germany. However, this resource is unique in that it takes into account not only the results of 4448 field measurements of radon concentration levels, but also some other data. For example, the so-called predictors. In particular, the physical characteristics of the soil, such as the concentration of clay, sand, silt, as well as soil chemical parameters, pH level, concentrations of various chemical elements. In addition, the level of precipitation and atmospheric temperature fluctuations generalized for the period 1981–2010 are taken into account. In total, 36 such factors were taken into account in the scientific work, which to varying degrees affect the concentration of radon that potentially enters the premises from the soil.

In order to "create an accurate map of the geogenic radon potential with a high degree of accuracy (in the scale - 1kmX1km)" to visualize the obtained data, scientists used special algorithms. Namely, multivariate adaptive regression splines, random forest and support vector machines.

These algorithms have made it possible to build complex relationships between exposure factors, which have made it possible to obtain the most accurate data on the predicted concentration of radon in the room at virtually anywhere in Germany. Thanks to the available maps, anyone can get information online about the possible concentration of radon-222, which could potentially get into a building in a certain area of Germany. If it is necessary to carry out accurate measurements EEVA of radon-222, there are 16 laboratories in the country, which for 30-50 €, allow any person to take measurements indoors.

Thus, the German approach to the practical interaction of scientists and government institutions provides a unique and effective experience for protecting the population from ionizing radiation caused by the decay of radon-222.

Poland's experience

In the summer of 2020, during the implementation of the National Anti-Radon Strategy, Poland began a large-scale implementation of the provisions of Directive 2013/59/EURATOM [3]. As part of this activity, the Chief Sanitary Inspectorate has launched a nationwide radon survey, which will take place over the next four years. Given the volume of EEVA measurements of radon-222 that will be carried out, this study is one of the largest ever implemented in Europe. The Swedish laboratory Radonova, which is a world leader in the measurement of radon-222 and the distribution of relevant equipment, was involved. Radonova provides Poland with 15,000 detectors for the detection EEVA of radon-222.

In addition, a broad information and education campaign is being launched in the country to raise public awareness of radon and its impact on human health. Currently, the Ministry of Climate and Environment together with the Atomic Forum Foundation (a non-governmental organization that includes scientists) is implementing a large national educational project - the "Radon School Map". This is the largest project of its kind to map radon concentrations in schools.

Students from 48 carefully selected high schools from across the country are participating in this project. Under the supervision of an expert from the Radonova laboratory, students are responsible for placing detectors to determine the level of EEVA of radon-222, as well as for analyzing additional factors that may affect the results. To help the teams, the Atomic Forum Foundation has prepared training materials, handbooks, and detailed instructions on how to perform and understand radon measurements. In addition, a series of online seminars on radon for both teachers and students will be held to support the project.

In general, the above experience of civilized countries may indicate the need for a comprehensive approach to the protection of the population from radon, as well as provide examples to be implemented in Kirovohrad oblast. In particular: a) introduction of the practice of carrying out as many measurements of EEVA of radon-222 as possible in various types of buildings and further creation of an appropriate interactive map; b)

introduction, with the participation of scientists and civil society organizations, of relevant educational courses and a broad information and educational campaign, including the introduction of the practice of celebrating November 7 as the National Radon Day, which has been practiced in all European countries since 2015; c) assessment of the quality of anti-radon measures to be implemented in buildings where excessive concentrations of EEVA of radon-222 have been recorded, by measuring EEVA of radon-222, immediately after the implementation of such measures.

Given the high levels of cancer and the excess of radon content over the standards in many rooms, Kirovohrad oblast urgently needs to develop and implement a comprehensive approach to protecting the population of the region from excessive ionizing radiation. The first step should be the development and implementation of a comprehensive program to protect the population of Kirovohrad oblast from the effects of ionizing radiation for 2021-2025.

The aim of the program should be to reduce the incidence of cancer in Kirovohrad oblast to the national level by creating safe conditions for human life and health, introducing the necessary protection of the population from excessive ionizing radiation of natural and man-made nature and related harmful factors.

IV. Main measures to be implemented within the program approach (the program)

The most optimal option for the implementation of the program is carrying out comprehensive organizational, technical and sanitary-hygienic measures that will ensure compliance with the requirements of Radiation Safety of Ukraine and provide the population of the region with sanitary and radiation well-being.

At the same time, today in the region there is an unsatisfactory situation for the implementation of a systematic program approach to the organization of radiation safety of the population.

The fact is that as a result of the restructuring of public authorities, territorial institutions of ministries and departments, redistribution and change of powers, there is currently some inconsistency between the relevant institutions. Therefore, first of all, it is necessary to coordinate the actions of all relevant and interested institutions for the preparation, implementation, control and analysis of the effectiveness of measures to protect the population from the effects of ionizing radiation.

Radiological measurements, analysis of indicators and quality of research are very complex and specific measures. Therefore, the availability of appropriate trained and

experienced professionals, instrumentation, methods, licenses, certificates, certification in the areas of research and measurement is an important prerequisite in the implementation of the program.

Currently, the only organization in the region that can monitor the health of the population, carry out and support instrumental radiological research, as well as establish correlations and support research in the territory, is the state institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine" which has extensive experience of cooperation with both national and foreign partners.

However, as it turned out, this institution is not provided with the necessary fleet of laboratory equipment and a sufficient number of staff on the development and implementation of radon measures.

The only solution to the identified problem is to create on the basis of the state institution "Kirovohrad Laboratory Center of the Ministry of Health of Ukraine", a system of environmental and radiation monitoring in Kropyvnytskyi and Kirovohrad oblast with its mandatory correlation with public health indicators, including: a) bringing the existing radiological laboratory of the state institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine" to the modern technological level, taking into account international requirements; b) mandatory conducting of instrumental research in the selection of land for any construction; c) introduction of anti-radon measures at the design stage, which in such cases are more cost-effective; d) mandatory performance of annual EEVA tests of radon-222 in the air of educational and sports facilities, libraries, boarding schools, colleges, universities and health care facilities, radon-222 content in water from underground water supply sources, control measurements after implementing anti-radon measures; e) conducting scientific research that will contribute to the solution of socio-economic, environmental, medical and biological issues of the region.

Thus, in order to implement the program approach, in the framework of a comprehensive program to protect the population of Kirovohrad oblast from the effects of ionizing radiation for 2021-2025, measures should be implemented that will meet the basic requirements of Directive 2013/59/EURATOM, in particular on public protection from excessive concentrations of radon-222. In general, the directions of implementation and the list of such measures are presented below.

DIRECTIONS OF IMPLEMENTATION AND MEASURES
to be introduced within regional Comprehensive program of protection the population of Kirovohrad oblast from the effects of ionizing radiation in 2021-2025

№ In numerical order (unit)	**Name of direction of implementation** (priority tasks)	**The list of program's measures (paragraph)**	**Implementers**	**Expected result**
1.	Search and identification of sources and ways that cause the impact of ionizing radiation on humans.	1. Organization of work on active search (using dosimetric measurements) of sources of ionizing radiation and radioactive waste that can be detected outside the places of authorized placement, in institutions of preschool, general secondary, out-of-school education, higher and professional higher education and professional (professional-technical) education of the region.	Department of Civil Defense, Defense Work and Interaction with Law Enforcement Bodies of the Regional State Administration, State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine", relevant licensed research institutions, certified laboratories.	Detection and removal of sources and neutralization of pathways that cause the impact of ionizing radiation on people, preventing the uncontrolled spread of radioactive materials.
		2. Detection of radioactive anomalies in the building structures of residential buildings and social facilities in order to remove them.	Department of Civil Defense, Defense and Interaction with Law Enforcement Bodies of the Regional State Administration, State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine", Main Directorate of the SES of Ukraine in the region, relevant licensed research institutions, certified	Ensuring radiation safety of the population of the region during the use of residential buildings and social facilities.

№ In numerical order (unit)	Name of direction of implementation (priority tasks)	The list of program's measures (paragraph)	Implementers	Expected result
			laboratories, raion state administrations, local governments	
		3. Carrying out radiation monitoring and control over the implementation of regulations on discharges, emissions of Inhulska, Smolinska and Novokostiantynivska mines and in the area of the tailings pond of the Shcherbakivska gully.	State Environmental Inspectorate of Prydniprovskyi District (Dnipropetrovsk and Kirovohrad Oblasts), State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine", SE "East GOK".	Prevention of radiation pollution of the environment.
		4. Conducting radiological monitoring of radon-222 content in the air of educational institutions.	Department of Civil Defense, Defense Work and Interaction with Law Enforcement Bodies of the Regional State Administration, research institutions, licensed institutions, certified laboratories.	Reduction of radon-222 concentration to acceptable level in the air of premises of regional subordination after the implementation of anti-radon measures.
		5. Providing radioecological support of: land plots allotted for construction, construction, construction materials and control of radiation-hazardous factors during the acceptance of buildings into operation, recording of real radiological indicators during the execution of contracts of sale and lease of buildings and premises;	Raion State Administrations, local governments, State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine", institutions and organizations of the region, research institutions, licensed institutions, certified laboratories.	Prevention of use of land plots, construction materials and buildings that exceed the radiation values given in Radiation Safety Norms of Ukraine (NRBU-97).

№ In numerical order (unit)	Name of direction of implementation (priority tasks)	The list of program's measures (paragraph)	Implementers	Expected result
		carrying out dosimetric control of gamma radiation; taking into account the level of escalation of radon from the soil and radiometric control of EEVA of radon-222 in indoor air.		
		6. Carrying out of system researches of water of artesian wells and wells of the region - performance of measurements of volume activity of radon-222 in water.	Raion State Administrations, local governments, State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine", relevant research licensed institutions, certified laboratories.	Prevention of negative impact on human of the water of artesian wells and wells of the region due to ionizing radiation.
		7. Studying of the average annual EEVA of radon-222 in the air of multi-storey residential buildings in Kropyvnytskyi and other settlements of the region.	Specialized research licensed institutions, certified laboratories.	Determination of the level of radon-222 content in the air of residential premises and the need to perform anti-radon work to reduce its content to a safe, less than 100 Bq/m3, concentration.
		8. Carrying out of dose-metric monitoring at the enterprises and establishments where the work with open sources is carried out (once a year).	State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine", heads of enterprises.	Generalization of radiation characteristics of a separate object or territory, as well as to assess the state of radiation protection of personnel and the population.

№ In numerical order (unit)	Name of direction of implementation (priority tasks)	The list of program's measures (paragraph)	Implementers	Expected result
2.	Implementation of measures to neutralize sources and ways that cause the impact of ionizing radiation on humans, and (or) protect against this human impact	1. Implementation of state sanitary supervision over radiation safety of use of ionizing radiation sources in medicine.	Main Department of State Service of Ukraine on Food Safety and Consumer Protection in the region, State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine", Department of Health of the Regional State Administration	Avoidance of unwarranted exposure by taking into account the results of previous diagnostic procedures related to the planned medical exposure
		2. Transfer for burial or storage to specialized enterprises on a contractual basis of radioactive waste of spent sources of ionizing radiation, devices for remote gamma therapy AGAT with a source of gamma radiation Cobalt - 60: communal non-profit enterprise "Alexandria Oncology Dispensary of Kirovohrad Regional Council" - 1 set; municipal non-profit enterprise "Kirovograd Clinical Oncology Center of Kirovohrad Regional Council" - 2 sets.	Department of Civil Defense, Defense Work and Interaction with Law Enforcement Bodies of the Regional State Administration, State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine".	Protection of life and health of personnel, population and the environment from the effects of radioactive waste in accordance with Radiation Safety Norms of Ukraine (NRBU-97).
		3. Carrying out reasonable anti-radon measures of unconditionally justified intervention (countermeasures) in case of exceeding the average annual EEVA	Raion State Administrations, local governments, Department of Civil Defense, Defense Work and Interaction with Law Enforcement	Reduction of EEVA content of radon-222 in the air of educational institutions to values less than

№ In numerical order (unit)	Name of direction of implementation (priority tasks)	The list of program's measures (paragraph)	Implementers	Expected result
		of radon-222 in the air of premises of preschool, general secondary, out-of-school education and medical institutions of the region, on the basis of prepared design and estimate documentation.	Bodies of the Regional State Administration, research licensed institutions, certified laboratories.	100 Bq/m3 in accordance with the Sanitary Regulations for general secondary education institutions, approved by the order of the Ministry of Health of Ukraine from September 29, 2020 № 2205.
		4. Organization and supervision of compliance with special conditions of licenses and sanitary passports of business entities that have sources of ionizing radiation.	Main Department of State Service of Ukraine for Food Safety and Consumer Protection in Kirovohrad oblast	Ensuring radiation safety of the region's population.
		5. Carrying out of the state inventory of radioactive waste and sources of ionizing radiation at the enterprises, in establishments and the organizations of the region.	Structural subdivisions of the regional state administration, local governments, Main Department of State Service of Ukraine for Food Safety and Consumer Protection in the region, enterprises, relevant institutions and organizations of the region, Dnipropetrovsk State Interregional Special Plant of the Ukrainian State Association "Radon".	Control over the use of sources of ionizing radiation, detection of radioactive waste, ensuring control over their accumulation and movement, timely transfer to a specialized enterprise for storage and disposal.

№ In numerical order (unit)	**Name of direction of implementation** (priority tasks)	**The list of program's measures (paragraph)**	**Implementers**	**Expected result**
		6. Restoration of protective forest belts on the outer border of sanitary protection zones:		Reduce the amount of radioactive dust flying from the territories of mines.
		6.1. Around the Inhulska mine - 9.4 km;	SE "East GOK".	Reduce the amount of radioactive dust flying from the mine territory to Kropyvnytskyi.
		6.2. Around the Novokostyantynivska mine 3.8 km;	SE "East GOK".	Reduce the amount of radioactive dust flying from the mine territory to Oleksiivka village.
		6.3. Carrying out actions for greening of human settlements.	Raion State Administrations, Executive Bodies of Administrative-Territorial Communities, local governments.	Reduction of solar radiation and radioactive dust in settlements.
		7. Bringing to 100% the state of readiness of protective structures of civil protection of the population.	Department for Civil Defense, Defense Work and Interaction with Law Enforcement Bodies of the Regional State Administration, Raion State Administrations, Executive Bodies of Administrative-Territorial Communities, local governments, Territorial Bodies of Ministries and Departments of Ukraine, Business Entities.	100% readiness of civil protection structures for radiation protection of the population.

№ In numerical order (unit)	**Name of direction of implementation** (priority tasks)	**The list of program's measures (paragraph)**	**Implementers**	**Expected result**
		8. Elimination of off-balance ore dumps near uranium mines and the Severynivsky ore mine by moving them to the spent cavities of mines.	Department of Civil Defense, Defense Work and Interaction with Law Enforcement Bodies of the Regional State Administration, local governments, Department of Education and Science of the Regional State Administration, Raion State Administrations, Department of Health of the Regional State Administration, Department of Ecology, Natural Resources and Fuel and Energy Complex of the Regional State Administration.	Disposal of a sufficiently powerful source of radionuclides that are dispersed in the environment.
		9. Preparation for bringing the territories of uranium mines into a radiation-safe state after the cessation of operation (Smolinska, Inhulska).	Management of Inhulska and Smolinska mines, SE "East GOK".	Prevent free access to a powerful source of radionuclides that are dispersed in the environment.
		10. Ensuring the protection of a temporary storage place for radioactively contaminated materials in the "Veselivsky clay quarry" until their reburial.	Main Department of the National Police in the region.	Prevention of unauthorized disclosure of temporary disposal of radioactive materials in the "Veselivsky clay quarry".

№ In numerical order (unit)	Name of direction of implementation (priority tasks)	The list of program's measures (paragraph)	Implementers	Expected result
3.	Introduction of radiation control points for food products in the markets and other places of their mass sale	Update of necessary equipment, appliances and devices of radiological control.	Main Department of State Service of Ukraine for Food Safety and Consumer Protection in the region, Department of Civil Defense, Defense and Interaction with Law Enforcement Bodies of the Regional State Administration, Raion State Administrations, city executive committees, State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine".	Preventing the sale of radiation-contaminated food in markets and other places of their mass sale.
4.	Organization of dosimetric control posts in accordance with the standards set by the relevant	1. Carrying out of individual dosimetric measurements on the posts established by separate divisions of "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine". 2. Implementation of measures of the unified state system of control and accounting of individual radiation doses.	State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine", Department of Health of the Regional State Administration, Raion State Administrations, local governments, relevant licensed research institutions.	Protection against the negative effects of radiation on the health and safety of people who, by their nature, are exposed to high levels of radiation, work with sources of ionizing radiation, or are exposed to radiation due to special medical procedures.

№ In numerical order (unit)	Name of direction of implementation (priority tasks)	The list of program's measures (paragraph)	Implementers	Expected result
	central executive bodies			
5.	Providing the population with free consultations on protection against ionizing radiation, radiation control, decontamination of household items	1. Annual training of employees of advisory points of the main department of the SES of Ukraine in the region and arrangement of points for providing free consultations to the population of the region on protection against ionizing radiation, radiological control, decontamination of household items.	Main Department of the State Emergency Service of Ukraine in the region, Department of Civil Defense, Defense Work and Cooperation with Law Enforcement Bodies of the Oblast State Administration, State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine", Department of Health of the Regional State Administration, Raion State Administrations, local governments.	Ensuring awareness of the population of the region on issues of protection against the effects of ionizing radiation, radiological control, decontamination of household items.
		2. Introduction of systematic information and scientific-educational work with the population:	Department of Civil Defense, Defense Work and Cooperation with Law Enforcement Bodies of the Regional State Administration, local governments, Department of Education and Science of the Oblast State Administration, Raion State Administrations, Department of Health of the Oblast State Administration, Department of	Ensuring awareness of the population of the region on radiological indicators of the state of territories and methods of protection against the effects of ionizing radiation.

№ In numerical order (unit)	Name of direction of implementation (priority tasks)	The list of program's measures (paragraph)	Implementers	Expected result
			Ecology, Natural Resources and Fuel and Energy Complex of the Oblast State Administration, Department of Public Communications and Information Activity of the Oblast State Administration.	
		2.1. Production and distribution of informational, methodical and cognitive materials on protection against radon exposure.	Department of Civil Defense, Defense Work and Cooperation with Law Enforcement Bodies of the Oblast State Administration, local governments, Department of Education and Science of the Oblast State Administration, Raion State Administrations, Department of Health of the Oblast State Administration, Department of Public Communications and Information Activity of the Oblast State Administration.	Ensuring awareness of the population of the region on radiological indicators of the state of territories and methods of protection against the effects of ionizing radiation.
		2.2. Speech on regional television by scientists on the promotion of protection against radiation factors under the heading - "Life in the land of high radiation."	Department of Civil Defense, Defense Work and Cooperation with Law Enforcement Bodies of the Oblast State Administration, Department of Education and Science of the Oblast State Administration, Raion State Administrations,	Ensuring awareness of the population of the region on radiological indicators of the state of territories and methods of protection against the effects of ionizing radiation.

№ In numerical order (unit)	**Name of direction of implementation** (priority tasks)	**The list of program's measures (paragraph)**	**Implementers**	**Expected result**
			Department of Health of the Oblast State Administration, Department of Public Communications and Information Activity of the Oblast State Administration.	
6.	Repair, certification and maintenance of household radiation monitoring devices	Organization of repair, calibration, verification, attestation and maintenance of devices for radiological measurements used by control bodies and civil defense forces in the territorial subsystem of the emergency management.	Main Department of the State Emergency Service of Ukraine in the region, Raion State Administrations, local governments, State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine", structural subdivisions of the regional state administration, enterprises and institutions of the region.	Providing metrological support of radiological measurements.
7.	Carrying out dosimetric inspections, radiometric and deconta mination works at	1. Bringing to the population the addresses of institutions that can perform dosimetric examinations to order. 2. Bringing to the population the addresses of institutions that can perform decontamination work to order.	Department of Civil Defense, Defense Work and Cooperation with Law Enforcement Bodies of the Oblast State Administration, Main Department of the State Emergency Service of Ukraine in the region, Raion State Administrations, local governments, State Institution "Kirovohrad Regional Laboratory Center of the Ministry of Health of Ukraine".	Providing metrological support of radiological measurements, protection against ionizing radiation.

№ In numerical order (unit)	**Name of direction of implementation** (priority tasks)	**The list of program's measures (paragraph)**	**Implementers**	**Expected result**
	the request of the population			

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