**Department for Mitigation of the Consequences
of the Catastrophe at the Chernobyl NPP of the Ministry
for Emergency Situations of the Republic of Belarus**

A Quarter of a Century after the Chernobyl Catastrophe: Outcomes and Prospects for the Mitigation of Consequences

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National Report of the Republic of Belarus "A Quarter of a Century after the Chernobyl Catastrophe: Outcomes and Prospects for the Mitigation of Consequences" was produced to present unbiased information on the consequences of the Chernobyl catastrophe for the republic, the efforts of the government in mitigation of these consequences, achieved results and outstanding problems. The information in the report shows both the immensity of the effects of the Chernobyl catastrophe and the complexity of the situation that the Republic of Belarus faces in decision making and choosing specific action to cope with them.

The Report is based on the findings of scientific research and practical works commissioned by the Department for Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP of the Ministry for Emergency Situations of the Republic of Belarus as part of State Programmes on Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP, Union State Programmes of Joint Action to Mitigate the Consequences of the Chernobyl Catastrophe, other programmes and projects, including international.

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PREFACE

On April 26, 2011 it is twenty five years after the Chernobyl catastrophe. The events of that fatal day split the fates of millions of people into BEFORE and AFTER.

How do the people affected by the catastrophe live today? How does the young generation perceive the Chernobyl tragedy? How should one assess the accident at the Chernobyl NPP in the context of providing the mankind with energy and conservation of the environment and climate change? How should we preserve the natural and spiritual riches of the affected territories and pass them over to the next generations? Answers to all these questions play a prominent role for the self-awareness of the Belarusian nation.

Twenty-five years have passed. A quarter of a century is a significant milestone in the history of a country. Belarus has acquired the involuntary experience of living and working in the conditions of a long-term radioactive contamination of vast areas. Today we have the well-established schools of thought in the area of radiology and radiation medicine; advanced production of radiometric equipment; well-elaborated systems of legislation, health and social protection, radiation control, agriculture and forestry management on contaminated territories. Belarus is making a qualitative transition from the country most severely affected by Chernobyl to the state, which has accumulated an invaluable research, practical and managerial experience. The summarized experience of our country in overcoming the consequences of the Chernobyl catastrophe can serve the entire mankind.

Today the Republic of Belarus has confidently passed onto the stage of sustainable development of the affected regions. "We must revive, renew this land so that it is nice to live here for you and your children", these words were said by the President of the Republic of Belarus A. Lukashenko when visiting Bragin District in Gomel Oblast in 2009. In talking to the local people Alexander Lukashenko expressed his confidence that it was not for nothing that the funds were invested into these regions.

Department for Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP of the Ministry for Emergency Situations of the Republic of Belarus

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INTRODUCTION

Twenty-five years ago an accident at the Chernobyl NPP occurred – it was the worst radiation accident in the world's history.

The effects of the accident in a varying degree affected many countries, which fact makes it possible to speak of it as a global disaster. Ukraine, Belarus and Russia suffered the most. That being said the relative burden of the effects of the accident for Belarus turned out to be much worse as compared to its neighbours. That is why the aftermath of Chernobyl for Belarus is more adequately characterized as 'catastrophe' or 'national environmental disaster'.

Mitigation of the consequences of the Chernobyl catastrophe has become a matter of national importance for the Republic of Belarus. The issues of living on the affected territories are in the focus of attention of the legislative and executive power and the President of the Republic of Belarus. All practical work is carried out within the framework of state programmes on the mitigation of the consequences of the catastrophe at the Chernobyl NPP, and financing of these programmes takes a considerable portion of the country's budget.

About USD 19 billion have been channelled for the mitigation of the consequences of the catastrophe during these years - considering all economic problems, which makes approximately two annual budgets of the republic.

A sufficient regulatory and legal environment and the system of social protection for all categories of the affected people have been established in the republic.

Due to the improved level of medical services, a large-scale programme of resort treatment and health recuperation a considerable increase in the morbidity of the affected population and, first of all, children has been prevented.

Protective measures in the agro-industry and forestry secure production of standard clean produce.

The system of radiation monitoring and control has been established and is operating effectively, the instrumentation for measuring ionizing radiation is in place, and is constantly developing.

All necessary works are carried out to manage the alienation territories, including the 30-kilometre zone around the NPP.

The system of training and retraining of specialists and informing the population on the issues of radiation safety has been put in place.

The Law "On Social Protection of People Affected by the Catastrophe at the Chernobyl NPP, other Radiation Accidents" protects the interests of all categories of the affected population. The established benefits and compensations to the population and cleanup workers (liquidators) are based on the principle of compensating for the damage and health risk arising from participating in cleanup works, working and living on the radioactively contaminated territory.

The issues of the preservation of health of the cleanup workers and the affected population are of utmost importance in the mitigation of the consequences of the catastrophe.

The existing system of medical screening, preventive medical examination, diagnostics and treatment of diseases, health recuperation and sanatorium-resort therapy allow to some extent to compensate the damage to the health caused by the Chernobyl disaster.

The basis for the provision of medical services to the affected population is preventive medical examination, which ensures early disease detection and timely treatment. Over 1.4 million people affected by the catastrophe in the republic, among them over 212,000 children, are under medical supervision.

For the time the registry of the population exposed to radiation has existed, data about more than 1.7 million people, including over 360 thousand children and adolescents, have been entered in the registry.

One of the major components of the preservation and promotion of the health of children in the contaminated districts has been in place – well-balanced free meals at school. Over 127 thousand students of primary and secondary education establishments are entitled to free meals.

Sanatorium-resort treatment and recuperation of the affected population play a significant role in health promotion.

Over 170 thousand people, including over 165 thousand children and adolescents are entitled to free treatment or health recuperation.

Subprogramme "Children of Chernobyl" of the Presidential Programme "Children of Belarus" has been completed successfully. Additional medical protection, social and psychological rehabilitation and health recuperation of children have been ensured due to this programme, the construction and reconstruction of a number of medical and preventive treatment facilities has been accomplished.

The efforts of the government are primarily aimed at reducing the radiation health risk of the population and securing normal living conditions in the contaminated environment. The collective internal and external radiation doses have been diminished considerably due to the protective measures.

The resettlement of people from the areas where safe living was not guaranteed has been completed. In total 137.7 thousand people have been resettled. Over 66 thousand flats and cottages in 293 settlements with the necessary infrastructure and service facilities have been built for these people. All

necessary comprehensive schools, kindergartens, day nurseries, policlinics, outpatient clinics and hospitals have been constructed to cover the needs of the relocatees.

The task of supplying the population with clean fuel and high-quality water has been addressed in a planned manner.

Over 1 million hectares of cropland in the republic demand special attention to ensure standard clean produce. A package of special protective measures funded from the republican budget has been implemented for this end. These include supplies to the contaminated districts and application of the required amounts of phosphorus and potash fertilizers. Lime treatment of acid soils and application of weedicides have been carried out in full.

The population in the rural areas is provided with cultivated grassland and mixed feeds with caesium binding adsorbent.

These measures allowed to reduce the amounts of products with radionuclide content above permitted standard by several times as compared to the initial post-accident period. At the same time, the established standard for radionuclide content in food and raw materials have been stiffened repeatedly in the republic.

Upon the instruction of the President of the Republic of Belarus re-specialization programmes have been implemented since 2002 in the agricultural organizations, where protective measures do not allow obtaining standard clean produce, provided that the existing economic specialization were preserved. The transition to the production of goods meeting sanitary and hygienic requirements is underway. Beef cattle breeding, seed farming of grain crops, potatoes, permanent grasses and cultivation of technical crops refer to these areas.

At the same time the problem of raising the efficiency of economy in the conditions of radioactive contamination, and ensuring the profitability of production are addressed. Agricultural production will remain a very important factor contributing to employment in the contaminated districts also in the long term. That is why the need for concentrating financial and material resources and attracting investments into this sphere is evident.

Today, twenty-five years after the catastrophe, some paramount tasks have been solved but there are a number of long-term challenges. Since 2011 the fifth State "Chernobyl" Programme designed for 2011-2015 and for the period up to 2020 has been implemented. Its adoption is the best evidence that Chernobyl problems are still in the focus of prime attention of the government.

This report serves to provide an objective insight into the consequences of the Chernobyl catastrophe in the Republic of Belarus, efforts of the government in the mitigation of these effects and the outcomes of the performed activities as well as outstanding problems.

The first section of the report gives a summary of the radiological effects, the assessment of radiation exposure doses and the damage caused by the catastrophe. The second section dwells on the approaches to mitigating these consequences. The third section describes main results achieved by the Republic of Belarus in overcoming the effects of the catastrophe; and the fourth gives an outline of prospective activities in the remote post-Chernobyl period.

1. EFFECTS OF THE CHERNOBYL CATASTROPHE

1.1 Radioactive Contamination

The accident at the Chernobyl NPP was accompanied by a thermal explosion of the reactor core of Unit 4 of the power plant resulting in the release of a virtually full range of radionuclides which had accumulated in the reactor by the time of explosion.

During the first weeks after the catastrophe a significant increase of gamma-ray emission was registered almost on the entire territory of Belarus due to short-lived isotopes, first of all, iodine 131-135. In some settlements radiation dose rate amounted to 500 μS/h, which is several thousand times greater than the natural background radiation. The negative effect on human health was most of all due to iodine-131 (half-life period is 8.04 days).

According to the Hydrometeorology Department of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus the levels of iodine-131 fallout in April-May 1986 in Bragin, Khoiniki, Narovlya Districts of Gomel Oblast amounted to 37,000 kBq/sq.m (1,000 Ci/sq.km) and over. In Vetka District of Gomel Oblast its content in soil amounted to 20,000 kBq/sq.m. In Mogilev Oblast maximum contamination was recorded in Cherikov and Krasnopolye Districts (5,550–11,100 kBq/sq.m). The districts lying in the south-west of Gomel Oblast – Yelsk, Lelchitsy, Zhitkovichi, Petrikov - as well as Pinsk, Luninets, and Stolin Districts of Brest Oblast were also exposed to significant levels of contamination.

The adverse effect of iodine isotopes is associated with the fact that upon entering the body they concentrate in the thyroid gland and are responsible for its internal exposure. That is why contamination with radioactive iodine led to significant thyroid exposure doses in virtually all people of Belarus (the so-called "iodine shock") and a large increase in the frequency of its abnormalities, especially in children.

The amount of the available experimental evidence based on the measurements of iodine-131 activity in fallouts is limited, so the reconstruction of iodine radioactive contamination based on the designed theoretical models was performed to reconstruct the overall picture of the contamination.

The peculiarities of meteorological conditions in the period from April 26 to May 10, 1986 as well as the composition and the dynamics of the emergency emission of radioactive substances, determined the complex nature of the contamination of the territory of the republic, which has an uneven, mosaic character. There are several major areas of contamination distinguished. This is the near zone of the Chernobyl NPP, including the 30-kilometre zone around the plant. The levels of soil contamination with Caesium-137 in this area are extremely high and at some points amount to over 14,800 kBq/sq.m (400 Ci/sq.km), at the same time contamination values within some spots do not exceed 185 kBq/sq.m (5 Ci/sq.km).

A part of the contamination is defined as a north-west trail. Southern and south-western parts of Gomel Oblast, central parts of Brest, Grodno and Minsk Oblasts pertain to it. Levels of contamination in this trail are considerably lower than in the near zone of the Chernobyl NPP.

The third spot is located in the northern part of Gomel Oblast and the centre of Mogilev Oblast.

Caesium-137 accounts for the most long-term contamination and radiation exposure.

Exhaustive data on the contamination of Europe with radioactive Caesium are given in the Atlas of Caesium Contamination of Europe After the Chernobyl Accident [1], which was produced by the European, Russian, Belarusian and Ukrainian scientists under the aegis of the European Commission. About 35 per cent of the fallout of this radionuclide occurred on the territory of Belarus.

Twenty three per cent of the territory of the republic with area over 46.45 thousand sq.km were exposed to over 37 kBq/sq.m Caesium-137 radioactive contamination. The density of soil contamination with Caesium-137 over the area of 136.5 thousand sq.km exceeded 10 kBq/sq.m (0.27 Ci/sq.km).

Maximum level of soil contamination with caesium-137 after the Chernobyl disaster – about 60,000 kBq/sq.m (1,622 Ci/sq.km) was recorded in some settlements both in the near (Bragin District of Gomel Oblast) and the far zones (Cherikov District of Mogilev Oblast.

Currently the area of radioactive contamination in the Republic of Belarus is considered such portion of its territory, where long-term contamination of the environment with radioactive substances following the catastrophe at the Chernobyl NPP occurred with density of soil contamination with caesium-137 or Strontium-90 or Plutonium-238, - 239, - 240 equal to respectively 1.0, 0.15; 0.01 Ci/sq.km and over, as well as other areas where the annual mean effective exposure of the population could exceed 1.0 mSv above the natural and technogenic background, and the areas where it is impossible to produce goods with radionuclides content below the republican permitted levels (Article 3 of the Law of the Republic of Belarus On the Legal Status of the Territories Which Suffered Radioactive Contamination Resulting from the Catastrophe at the Chernobyl NPP [2]).

Table 1. Contamination of the territory of the Republic of Belarus with caesium-137 resulting from the catastrophe at the Chernobyl NPP (as of 01.01.2010)

	Contaminated		Out of them with contamination levels, thousand sq.km			
	thousand sq.km	in per cent to the total area	1-5 Ci/sq.km	5-15 Ci/sq.km	15-40 Ci/sq.km	40 and over Ci/sq.km
Republic of Belarus	30,10	14,5	20,86	6,6	2,22	0,42
including oblasts:						
Brest	2,37	7,23	2,3	0,07		
Vitebsk	0,01	0,03	0,01			
Gomel	18,33	45,37	11,7	4,72	1,54	0,37
Grodno	0,61	2,41	0,6	<0,01		
Minsk	0,90	2,25	0,9	<0,01		
Mogilev	7,88	27,08	5,35	1,8	0,68	0,05

There are contaminated territories in all oblasts, but Gomel, Mogilev and Brest Oblasts suffered the most. There are soils with Caesium-137 contamination density over 1 Ci/sq.km in 21 districts of Gomel Oblast, 13 districts of Mogilev, 4 districts of Brest, 10 districts of Minsk, 3 districts of Grodno and one district of Vitebsk Oblast.

Within the period from 1986 to 2010 the territory of the republic with caesium-137 contamination level over 1 Ci/sq.km decreased by 1.6 times due to its natural decay, and as of January 1, 2010 it amounted to 14.5 per cent (Table 1). The area of contamination of Gomel Oblast is 18.33 thousand sq.km, Mogilev – 7.88 thousand sq.km, Brest – 2.37 thousand sq.km, it means that about 45.37%, 27.08% and 7.23% of the territory are contaminated respectively.

Depending on the density of soil contamination with radionuclides and the extent of the impact (the effective dose) of the radiation on the population the territories are divided into the following zones (Table 2) [2]:

— exclusion zone (alienation) is the territory around the Chernobyl NPP, from where people were evacuated in 1986 in line with the then in effect safety radiation levels (30-kilometre zone and the territory from which people were evacuated additionally due to soil contamination with strontium-90 over 3 Ci/sq.km and Plutonium-238, -239, -240 over 0.1 Ci/sq.km);

— zone of primary evacuation is the territory where the density of soil contamination with caesium-137 is 40 Ci/sq.km or Strontium-90 or Plutonium-238, - 239, - 240 equal to respectively 3.0; 0.1 Ci/sq.km and over;

— zone of subsequent evacuation is the territory where the density of soil contamination with caesium-137 is 15-40 Ci/sq.km or Strontium-90 is 2-3 Ci/sq.km, or Plutonium-238, - 239, - 240 is 0.05 - 0.1 Ci/sq.km, where the annual mean effective exposure of the population could exceed 5.0 mSv above the natural and technogenic background, and other territories with lower density of contamination

Table 2. Zoning of the territories of the Republic of Belarus affected by radioactive contamination resulting from the catastrophe at the Chernobyl NPP

Zone	Effective exposure dose, mSv/year	Density of contamination, kBq/sq.m (Ci/sq.km)		
		Caesium-137	Strontium-90	Plutonium-238, -239, -240
Habitation with periodic radiation control	less than 1	37–185 (1–5)	5,55–18,5 (0,15–0,5)	0,37–0,74 (0,01–0,02)
With the right to resettle	1–5	185–555 (5–15)	18,5–-74 (0,5–2,0)	0,74–1,85 (0,02–0,05)
Subsequent resettlement	over 5	555–1480 (15–40)	74–111 (2,0–3,0)	1,85–3,7 (0,05–0,1)
Primary resettlement	–	over 1,480 (over 40)	over 111 (over 3.0)	over 3.7 (over 0.1)
Exclusion (alienation)	Territory around Chernobyl NPP, from which population was resettled in 1986			

with the abovesaid radionuclides where the annual mean effective exposure of the population could exceed 5.0 mSv;

— zone with the right for resettlement is the territory where the density of soil contamination with caesium-137 is 5-15 Ci/sq.km, or Strontium-90 is 0.5 - 2 Ci/sq.km, or Plutonium-238, - 239, - 240 is 0.02 - 0.05 Ci/sq.km, where the annual mean effective exposure of the population could exceed 1 mSv above the natural and technogenic background, and other territories with lower density of contamination with the above radionuclides where the annual mean effective exposure of the population could exceed 1.0 mSv;

— zone of habitation with periodic radiation control is the territory where the density of soil contamination with caesium-137 is 1-5 Ci/sq.km, or Strontium-90 is 0.15 – 0.5 Ci/sq.km, or Plutonium-238, - 239, - 240 is 0.01 - 0.02 Ci/sq.km, where the annual mean effective exposure of the population should not exceed 1 mSv.

As of 01.02.2010 the proportion of caesium-137 contaminated areas as compared to the area of the Republic of Belarus were: zone of habitation with periodic radiation monitoring – 10.0 per cent, zone with the right to resettle – 3.2 per cent, zone of subsequent resettlement – 1.1 per cent, zone of primary resettlement – 0.2 per cent.

The list of settlements and other sites located in these areas is determined based on the radiation situation and other factors and is reviewed by the Council of Ministers of the Republic of Belarus at least once in five years.

The List of Settlements and Sites Located in the Radioactively Contaminated Areas was adopted by the Enactment of the Council of Ministers of the Republic of Belarus No. 132 dated February 1, 2010. According to the List there are currently 2,402 settlements in the areas with radioactive contamination where 1,141,272 people live (Table 3).

It is anticipated that by 2056 the number of settlements pertaining to the zones of radioactive contamination would decrease to 1051.

The contamination of the territory of the republic with Strontium-90 is of a more localized nature as compared to caesium-137 [3]. Levels of soil contamination with this radionuclide above 5.5 kBq/sq.m (0.15 Ci/sq.km) were discovered on the area of 21.1 thousand sq.km, which makes 10 per cent of the entire territory of the republic. Maximum levels of strontium-90 amounted to 1,800 kBq/sq.m (48.6 Ci/sq.km) within the 30-km zone around the NPP (In Khoiniki District of Gomel Oblast). Maximum activity level of strontium-90 in the far zone was detected 250 km away from the NPP – in Cherikov District of Mogilev Oblast and equals 29 kBq/sq.m (0.78 Ci/sq.km), as well as in the northern part of Gomel Oblast, in Vetka District amounting to 137 kBq/sq.m (3,7 Ci/sq.km).

Supertransuranic radionuclides predominantly fell out in the near zone (30-km zone) of the NPP.

Currently alpha-ray emitting radionuclides of Chernobyl origin are mostly represented by long-lived isotopes of plutonium-238, -239, -240 and americium-241.

Soil contamination with isotopes of plutonium-238, -239, -240 with density over 0,37 kBq/sq.m covers about 4.0 thousand sq.km, or about 2 per cent of the territory of the republic. These territories are mostly situated in Gomel Oblast (Bragin, Narovlya, Khoiniki, Rechitsa, Dobrush and Loev Districts) and Cherikov District of Mogilev Oblast. Contamination with isotopes of plutonium with high density is characteristic for the 30-km zone around the Chernobyl NPP. Highest levels of contamination with isotopes of plutonium-238, -239, -240 and americium-241 (above 37 kBq/sq.m or 1 Ci/sq.km) were recorded on the territory of the former settlements of Masany (Khoiniki District) and Kulazhin (Bragin District).

It has been established that plutonium and americium stay mostly in the top 10 cm deep layer of the soil, and only in sand varieties of sod-podzolics – in the 20 cm deep layer. Plutonium and americium in soils are largely immobile. For mineral soils a greater content of mobile and biologically available

Table 3. Distribution of settlements of the Republic of Belarus per radioactive contamination zones, as of February 1, 2010

Oblast	Zone of habitation with periodic radiation control	Zone with the right to resettle	Zone of subsequent resettlement	Total
Brest	114	5	-	119
Vitebsk	1	-	-	1
Gomel	950	352	13	1315
Grodno	106	-	-	106
Minsk	117	1	-	118
Mogilev	616	122	5	743
Republic, total	1904	480	18	2402

forms of radionuclides is characteristic as compared to organic soils. The reserves of americium in mobile and biologically available forms are higher than plutonium. The share of transuranium radionuclides in soils in a water-soluble and reversibly bound forms is between 1.1 and 9.4 per cent, and in biologically available form it is between 2.7 – 29 per cent.

The peculiarity of the radioactive contamination of the territory of the near zone around the Chernobyl NPP is the so-called presence of "hot" particles in the soil, which are made of finely dispersed nuclear fuel and fission products which condensed on the products of combustion of the reactor, dust particles, etc. Such condensation "hot" particles destroyed gradually by environmental factors are the source of secondary radioactive contamination. As a rule released radionuclides enter the environment in ionic form, which determines their high mobility and intensive uptake by plants. For example, the release of "hot" particles of strontium-90 is one of the reasons for the anomalously high contamination of plants with this radionuclide, which is comparable or exceeds the levels of caesium-137 contamination, while the density of soil contamination with caesium is considerably higher.

1.2 Assessment of Radiation Exposure

Radiation Exposure of Liquidators

In 1986 a basic standard of 250 mSv was introduced for the participants of the cleanup after the Chernobyl disaster, which ensured the absence of deterministic effects of radiation. Despite the measures to limit the exposure a part of liquidators suffered radiation exposure about the ultimate level, although mean exposure per the entire cohort of Belarusian liquidators is estimated as much lower (Table 4) [4].

Thyroid Gland Radiation Exposure (according to the materials of [5])

In May-June 1986 direct measurements of iodine-131 concentration in the thyroid gland of the population of the most contaminated districts of Gomel and Mogilev Oblasts and the city of Minsk (200 thousand people) were performed. The limited amount of this sample and the insufficient direct measurements of soil and plant contamination levels with radioactive iodine did not allow for a veritable assessment of the thyroid gland exposures of the population.

A large-scale reconstruction of the mean thyroid gland exposure for 9.5 million people in 19 age categories who lived in 1986 in 23,325 settlements of the Republic of Belarus – virtually the entire population affected by the disaster – depending on the age and residence area was performed in the Republic of Belarus. The highest collective thyroid gland exposures in two age groups were registered in the inhabitants of Gomel Oblast and the city of Gomel (70 per cent of the collective exposure for the entire Republic of Belarus), and the lowest level – for the inhabitants of Vitebsk Oblast.

The junior age group accounts for the greatest amount of people with maximum thyroid exposure levels (above 1 gray) (Table 5). With age increase the number of people with maximum radiation exposure decreases considerably. The category of children and adolescents (about 30 per cent of the total number of people for whom the reconstruction of the thyroid exposure doses was performed) covers over 97 per cent of maximum radiation exposure.

The assessment of mean exposure for the age category under 18 years demonstrated that children and adolescents who lived in Bragin, Khoiniki, Narovlya and Vetka Districts of Gomel Oblast suffered the maximum exposure burden. The levels of thyroid radiation exposure for adults turned out significantly lower.

Effective Exposures of the Population

During the first year after the disaster the dominating factor contributing to the effective exposure was the external radiation of people by radionuclides deposited onto the soil and plants. An exclusion was a number of settlements situated on the territories with the density of caesium-137 contamination up to 555 kBq/sq.m (15 Ci/sq.km), where the exposure was formed predominantly due to the consumption of contaminated food. Starting from summer 1986 the internal radiation dose was

Table 4. Distribution of exposure doses of the cleanup workers at the Chernobyl NPP

Period of works	Number of participants of salvage works	Share of people for whom exposure doses are unknown, %	Effective dose, mSv			
			average	median value	75-percentile	95-percentile
1986	68 000	8	60	53	93	138
1987	17 000	12	28	19	29	54
1988	4 000	20	20	11	31	93
1989	2 000	16	20	15	30	42
1986–1989	91 000	9	46	25	70	125

Table 5. Distribution of population of various age groups according to the range of thyroid exposure doses

Age group (at the moment of accident)	Specific weight [%] of people according to thyroid exposure doses, Gy					Number of inhabitants, mln. people
	0–0,05	0,05–0,1	0,1–0,5	0,5–1	>1	
Children and adolescents	60,1	19,3	16,3	3,2	1,1	2,7
Adults	81,4	7,3	10,6	0,69	0,01	6,8
Total	75,5	10,6	12,2	1,4	0,3	9,5

mainly due to the intake of radioactive caesium with food. The contribution of strontium-90 to the internal exposure dose of the population makes just several per cent. The contribution determined by the inhalation intake of the isotopes of plutonium and americium makes less than one per cent.

In 2009 the mean annual effective exposure exceeded 1 mSv/year in 191 settlements where over 48 thousand people lived (Table 6)[6]. There were no settlements where the mean annual effective exposure would exceed 5 mSv/year (in 2004 there were 3 such settlements). These settlements are situated on the territories with caesium-137 contamination density over 555 kBq/sq.m (15 Ci/sq.km). The proximity of the exclusion zone, which is the source of contaminated forest products and fodder for the cattle can be considered additional contributing factors of the increased radiation exposure.

For the overwhelming majority of the population residing permanently on the radioactively contaminated territories the accumulated effective exposure over the period from 1986 to 2005 does not exceed the values specified in the current hygienic regulations (70 mSv during life). According to the data of the radiation and hygienic certification natural sources of ionizing irradiation and irradiation for health care purposes (medical procedures, X-ray diagnostics) account for maximum contribution to the buildup of the population collective exposure dose.

1.3 Medical Aspects of the Chernobyl Disaster Effects (according to the materials of [7])

The activities on the organization of long-term monitoring of the people who suffered radiation exposure due to the Chernobyl disaster were began in the Soviet Union in June 1986 at the Medical Radiological Scientific Centre of the Russian Academy of Medical Sciences (Obninsk of Kaluga Oblast).

In the Republic of Belarus the State Registry of Population who suffered radiation exposure due to the catastrophe at the Chernobyl NPP was established in 1993 at the Belarusian Centre for Medical Technologies, Information Science, Management and Economics of the Ministry of Health of the Republic of Belarus.

In conformity with the programme of cooperation to overcome the consequences of the Chernobyl disaster within the framework of the Union of Belarus and Russia a unified Chernobyl Registry of Russia and Belarus was established in 1998. The combination of the medical and dosimetric information accumulated in the national radiation and epidemiological registries ensures assessment of the risk of developing radiation induced pathology and identifying the cohort of the people who need permanent medical surveillance, and providing high-tech medical aid in case of detecting a disease (groups of increased radiation risk).

According to the radiation and epidemiological research performed since 1993 by the State Registry there has been no increase of leucaemia cases in children in the most contaminated districts of Gomel and Mogilev Oblasts. But at the same time there is increase of all forms of chronic leucaemia in the population of these regions on the whole.

By far, based on the twenty-five-year long

Table 6. Distribution of the number of settlements (S) and inhabitants according to annual mean effective dose (AMED) range

AMED range, mSv/year	S	Number of inhabitants, thousand people
>1 - <2	165	45,4
≥2 - <3	21	2,2
≥3 - <4	3	Less than 0.01
≥4	4	0,5
Total:	191	48,1

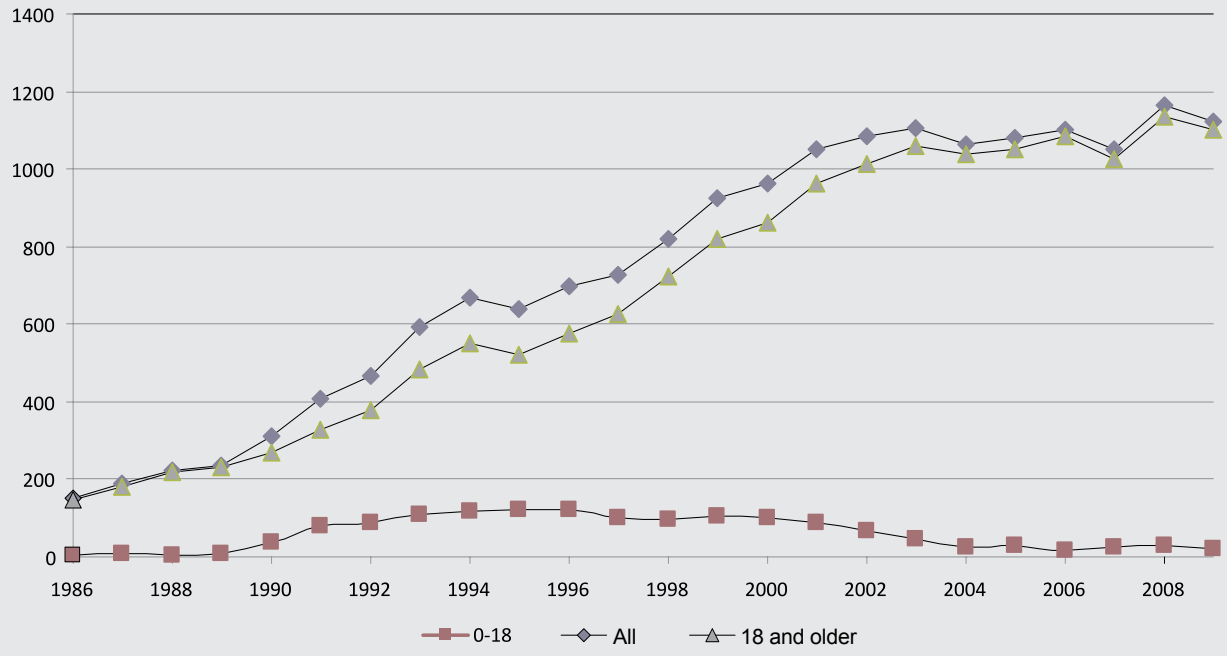


Fig.1. Dynamics of thyroid cancer morbidity in the Republic of Belarus (per 100,000 inhabitants)

monitoring of the cohort[1] of the affected population one can state the following.

The radiation induced nature of the excessive incidence of thyroid cancer in the people exposed to iodine radionuclides in childhood and adolescence has been substantiated (Figure 1).

The incidence of thyroid cancer among adults has increased greater than by 6 times. The peak morbidity of children (0-14 years in 1986) was registered in the period between 1995–1996, when the incidence rate increased by 39 times as compared to 1986.

Convincing data on the radiation genesis of malignant neoplasms not only in children and adolescents but also in adult population, as well as non-neoplastic thyroid pathology in the people exposed to radiation in childhood have been obtained (Figure 2).

As a result of early detection and timely medical

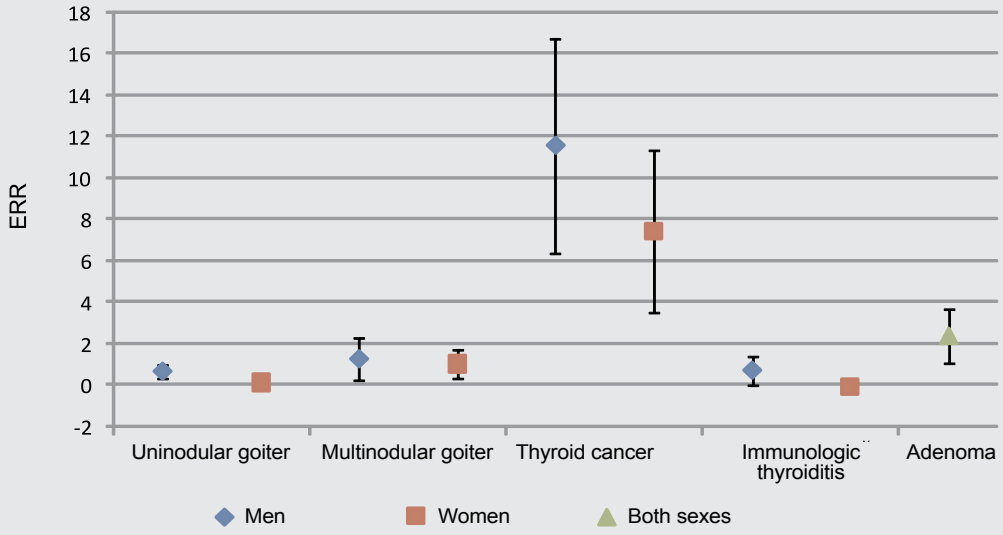


Fig. 2. Excess Related Risk[2] of thyroid pathology in the age group of 0–3 years

[1] A cohort in epidemiological surveys is a group of people possessing initially some common feature (for example, in contact with an exposure source due to their profession) and observed during a certain period of time

[2] Excess Related Risk (ERR) is the difference between the observed (observed cohort) and expected (comparison cohort) occurrence in proportion to the occurence expected in the absence of the surveyed influencing factor. If relative risk is 1, this is the evidence of the lack of difference between the compared cohorts.

intervention potential fatalities due to all incidents of thyroid cancer were minimized.

The research performed up to date has yet not been successful in associating the incidence of other – apart from thyroid cancer – localizations of malignant neoplasms - to the effect of disaster radiation (Figure 3). This being said one has to take into account that not so much time passed since the end of the theoretical minimum latent period.

The analysis of information on the group of persons who were in the evacuation zone in the early post-accident period; persons aged 0–18 years at the moment of the disaster, shows an express but statistically insignificant due to the extremely low number of diseased people increase of the incidence of breast cancer in young women (Figure 4).

Since 1993 and until now cancer morbidity among liquidators has been comparable to the average republican level and did not show tendency for outrunning growth either in men or women. Within the entire analyzed period relative risk as regards all malignant neoplasms amounted to 1.05 in men, and 1.07 in women. The slight excess of the relative risk both in men and women is associated with the growth of incidence of thyroid malignant neoplasms. Within the same period the risk of thyroid cancer in men amounted to 5.95, and in women to 2.95. The said values of relative risk are determined to a great extent by the morbidity in the group of persons exposed to radiation in childhood. The relative risk in persons younger than 15 years for the moment of the onset of the disease amounted to 22.4 in boys and to 17.2 in girls.

During the last five years the increase of general morbidity among all affected categories of the population of the Republic of Belarus has been noted with average annual growth rate amounting to 2.0 per cent while there has been no explicit increase of primary morbidity (growth rate is less than 1.0 per cent). As a consequence, the ratio of general and primary morbidity increased from 2.4 in 2004 to 2.6 in 2009, which is an evidence of the dynamic accumulation of chronic pathology associated with the aging of monitored cohorts. The structure of primary morbidity within these five years was identical to the structure of the morbidity of the entire population of the Republic of Belarus. Injuries and intoxication (8.5 per cent) and the diseases of bone and muscular tissue (6.2 per cent) have demonstrated maximum specific weight after respiratory diseases.

1.4 Evacuation and Resettlement of the Inhabitants

Starting from the first days after the accident the Government of Belarus organized and conducted activities aimed at the evaluation of the radiation situation and the protection of the population.

The guidance of the protective measures and the cleanup of the effects of the accident at the Chernobyl NPP in April-May 1986 was implemented by the Government Committee of the Council of Ministers of the USSR and the Ministry of Health of the USSR. First there was a decision taken about the evacuation of the population from the territory where the exposure dose rate exceeded 25 mR/h (territory approximately within a radius of 10 km from the Chernobyl NPP). In fact, the evacuation of the population of this zone

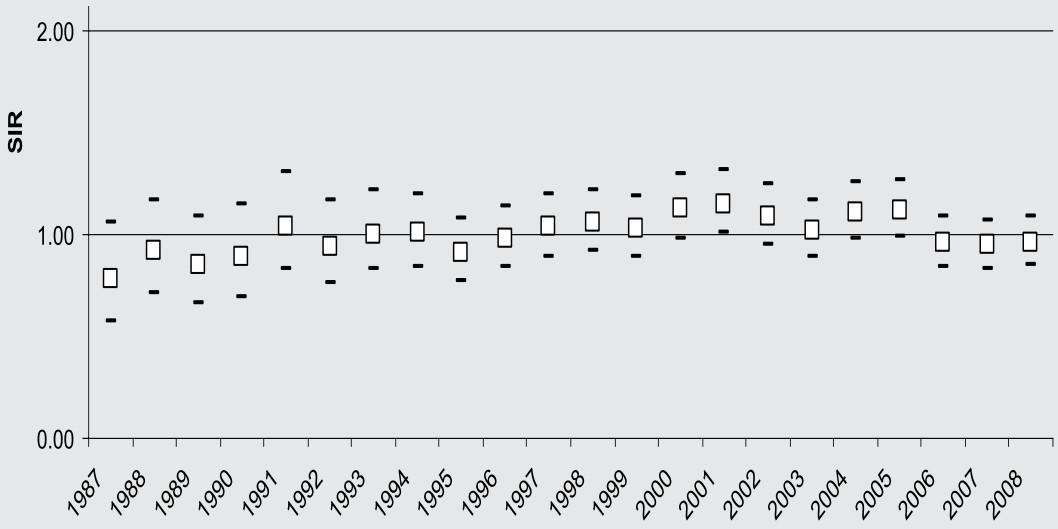


Fig. 3. Relative risk[1] dynamics, primary registration groups 1–3, men, solid neoplasms without thyroid cancer

[1] Standardized Incidence Ratio (SIR) is the ratio of the observed occurrence to what might be expected estimated for a certain number of man-years based on the cancer morbidity of the population. When SIR is >1 the risk of falling ill for the radiation exposed population is highher than for the non-exposed population.

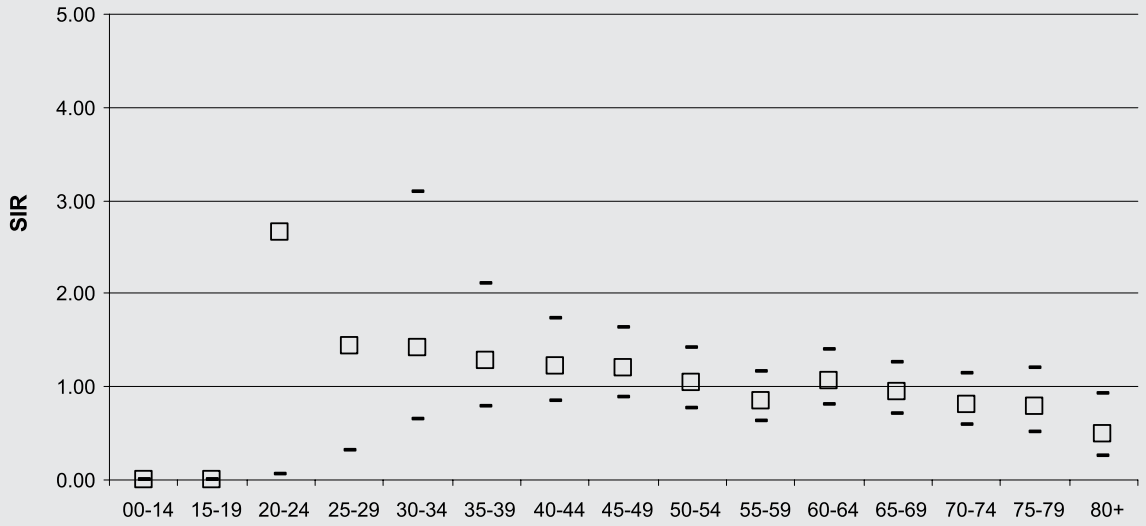


Fig. 4. Relative risk level depending on the age at the moment of disease, primary registration groups 1–3, women, breast cancer

in the Belarusian portion started on May 2 (first only children and pregnant women). Then it was decided to reduce the dose limit to 5 mR/h, which approximately corresponded to the zone within the 30 km radius. All in all, during the first stage 50 villages (11,035 people) were evacuated on May 2-5 from Bragin, Khoiniki and Narovlya Districts. Between 2nd and 9th of June 28 villages were additionally resettled (6,017 people), and at the end of August – 29 villages (7,327 people). Therefore, 24.7 thousand inhabitants from 107 most affected settlements were evacuated during 1986 from the Belarusian zone of the accident.

By mid June 1986 the issue of arranging thousands of evacuees on a new place of residence emerged. In this regard the Central Committee of the Communist Party of Belarus and the Council of Ministers adopted on June 11, 1986 Resolution No. 172 "On Job Placement and Provision with Housing and Social Amenities of the Population of Gomel Oblast Evacuated from the Chernobyl NPP Zone". Oblast Party Committees and Oblast Executive Committees were assigned with the task to ensure during June 1986:

— temporary accommodation of citizens evacuated from the dangerous zones of the accident at the Chernobyl NPP, their feeding, medical, and consumer services;

— job placement of the evacuated citizens with providing them with permanent job in line with their professional qualification in collective farms, soviet farms and other agricultural enterprises as well as in establishments and organizations.

When necessary, issues of job retraining of these workers and organization of their training with preserving their mean salary at the previous place of work had to be addressed.

Providing the said people with housing by Ocober 1986 at the latest in residential buildings belonging to various departments was the responsibility of the Ministry of Rural Construction, Belarusian authority for rural construction and, Glavpolessievodstroi. The task was set to construct residential buildings, cultural facilities and social amenities, shops and communal facilities in the settlements of Gomel Oblast chosen as places of permanent residence of the evacuated population. In total it was planned to construct 3,970 detached cottages, and 90 million roubles were allocated for this. Pre-fabricated wooden houses with total area of 180 thousand sq.m and sets of wooden parts for the construction of houses with walls made of local materials in the amount of 70 thousand sq.m, which were received by the republic from the Union fund were passed to the Gomel Oblast Committee.

Oblast Executive Committees and the State Agro-Industry Committee of the BSSR were assigned with the task to ensure:

— provision of land plots to the people evacuated to rural settlements and assistance in tilling these plots;

— sale of cows to the evacuated people, allocating plots for cattle grazing and haymaking, and when necessary also fodder at the expense of farms.

A number of resolutions of the Council of Ministers touched upon issues related to compensation payments to the people affected by the catastrophe at the Chernobyl NPP. Organizationally this issue was further developed in the Enactment of the Council of Ministers dated June 26, 1986 No. №194-13 "On Compensating Material Damage to the Population Evacuated from Settlements in the Evacuation Zone of the Chernobyl NPP". This Enactment established compensation payments for the household property, fruit and berry plantations and crops, uninsured farm animals, and constructions (residential houses, cabins, summer cottages, garages, household outbuildings).

The State Bank was permitted to issue interest free loans to the evacuated people for arranging their new homes. Meals for the evacuated children in children's pre-school institutions had to meet sanatory standards.

Mothers with children of pre-school age faced most difficulties, as in the majority of cases they stayed at recreational establishments together with their children. In this regard the Council of Ministers adopted on August 13, 1986 Instruction No. 645-rs, according to which women workers with children of pre-school age and evacuated from the Chernobyl NPP zone and accommodated in trade unions' health resorts, recreation institutions of ministries and agencies or other temporary housing would be paid their average salary and their service would be considered uninterrupted for the period starting from the moment they stopped working because of the accident at the Chernobyl NPP and until their return to the previous place of residence or obtaining residential space and job in other districts. Oblast Executive Committees, ministries and administrative entities, heads of enterprises, organizations and institutions were assigned with the responsibility to ensure job placement of these women by October 1, 1986 along with providing places for their children in pre-school institutions out of turn.

At the same time the analysis of the radiation situation indicated the necessity of performing additional relocation of citizens. On August 26, 1986 The Central Committee of the Communist Party of Belarus and the Council of Ministers adopted a joint resolution No. 266-17 "On Additional Measures to Ensure Job Placement, Provision with Housing and Social Services for the Population Evacuated from Settlements due to the Chernobyl NPP Disaster and Compensating Material Damage Incurred by Them". As a top priority task the Gomel Oblast Executive Committee was commissioned with the task to ensure temporary accommodation of the evacuated citizens, organizations of their meals, provision of medical and consumer services; ministries and administrative entities – with the task to ensure their job placement before October 1, 1986. In view of the beginning of a new school year on September 1, it was commissioned to return children to the places of residence of their parents. Instructions were issued on the development of documents and implementing the whole body of work on the timely completion of the construction of residential buildings, cultural and consumer facilities for the relocated people. Amounts of compensation payments for fruit and berry plantations and for uninsured farm animals were established. A lump sum benefit payment was introduced for employed persons and members of their families, payment for the transportation of the property, payment of salaries for the days when they were preparing for travelling to a new place and for the days of arranging in a new place of residence.

The completion of the evacuation of population from the most affected settlements – this was the focus of attention in the period from May to August 1986 – made it possible to face the problems of other contaminated territories where hundreds of thousands of people were living. In this regard the Council of Ministers adopted on August 28, 1986 Enactment No. 267-18 "On Improving the Material Situation of the Population Living in Settlements with Limits for the Consumption of Locally Produced Agricultural Products in the Context of the Chernobyl Disaster". This enactment established payment of a money allowance in the amount of 30 rubles per month for each member of the family, free preschool institutions services and meals in 116 settlements. The damage to people's property caused by decontamination activities had to be compensated in full. Ministries and administrative entities were assigned with the responsibility to secure supplies of milk, meat and other foodstuffs, systematic monitoring of the quality of potable water, local agricultural produce and goods produced in smallholdings, as well as products brought from other districts. In order to prevent consumption of contaminated milk and milk products oblast executive committees and State Agro-Industry Committee were commissioned with the responsibility to organize stable keeping of cows belonging to citizens' smallholdings and provide these smallholdings with the necessary amount of non-contaminated fodder before September 1, 1986.

Further on, right until the adoption of the Law "On Social Protection of People Affected by the Catastrophe at the Chernobyl NPP" the Council of Ministers more than once turned its attention both to the issues related to the social protection of the affected population and the issues of referring settlements to this or that contamination zone with further evacuation or establishing respective benefits to citizens. So, on August 19, 1987 Enactment No. 273-20 was adopted "On Additional Measures to Ensure Public Health and Improve Economic Activity in the Districts of Gomel and Mogilev Oblasts Affected with Radioactive Contamination". On July 12, 1989 under Instruction No. 339 it was envisaged to relocate inhabitants of 52 settlements affected by radioactive contamination as a result of the accident at the Chernobyl NPP, where decontamination and agromelioration activities did not guarantee the observance of the individual life exposure dose as stipulated by the Ministry of health of the USSR. On December 22, 1989 Instruction No. 578r adopted the list of settlements where consumption of locally produced milk was partially limited and if necessary other locally produced foodstuffs and products of smallholdings; it envisaged payment of money

allowance in the amount of 15 rubles per month for each family member.

By now resettlement of people from the zones of primary and subsequent resettlement has been completed. The said territories now represent a vast region defined as the "zone of resettlement". In total 137.7 thousand people have been resettled from 471 settlements (295 in Gomel, 174 in Mogilev and 2 in Brest Oblast), and 75 per cent of them are the inhabitants of Gomel Oblast.

Simultaneously with organized resettlement and evacuation about 200 thousand people left radioactively contaminated territories independently.

1.5 Economic Damage (according to the materials of [8])

The nature and the amount of the damage caused by the catastrophe at the Chernobyl NPP turned out powerful destabilizing factors as regards the social and economic development of the republic. As a result all major sectors of the national economy in the areas of radioactive contamination faced an extremely harsh economic situation.

The agricultural economy suffered the worst. 265 thousand hectares of agricultural lands were removed from agricultural production. The cultivated area and the gross yield of agricultural crops declined sharply, livestock population decreased considerably.

Fifty-seven deposits of minerals, raw materials and other resources turned out to be in the zone of contamination above 555 kBq/sq.m (15 Ci/sq.km), including: 9 deposits of sand with the overall stocks of 196 million cub.m; 19 deposits of ceramic clay (6 million cub.m); 6 of heat-resistant clay (46.5 million cub.m); 8 of cement raw products (835 million t); 14 chalk for lime (853.5 million t); and 1 glass and molding sands deposit (16.6 million t).

Because of the radioactive contamination exploration of the southern part of the Pripyat oil-and-gas bearing area with estimated resources of 25.3 million t oil was limited.

The forest sector suffered a huge loss. About a quarter of the forest reserves of Belarus – 20.1 thousand sq.km of forests were exposed to radioactive contamination. Around 340 industrial plants were located within the contaminated area, and their operation conditions deteriorated significantly. Due to the resettlement of inhabitants from the most affected districts operation of a number of industrial plants and social facilities stopped. At the same time others suffered great losses from the decline of production, incomplete return on investment into buildings, constructions, equipment and reclamation works. Losses of fuel and raw materials were considerable.

According to the estimates by the Institute of Economy of the National Academy of Sciences of Belarus the aggregate damage incurred by the republic due to the Chernobyl catastrophe with a view to the 30-year mitigation period is estimated as USD 235 billion, which makes 32 budgets of the republic as of 1985. It includes losses related to the deterioration of public health; damage caused to the industry and the social sphere, agriculture, construction sector,

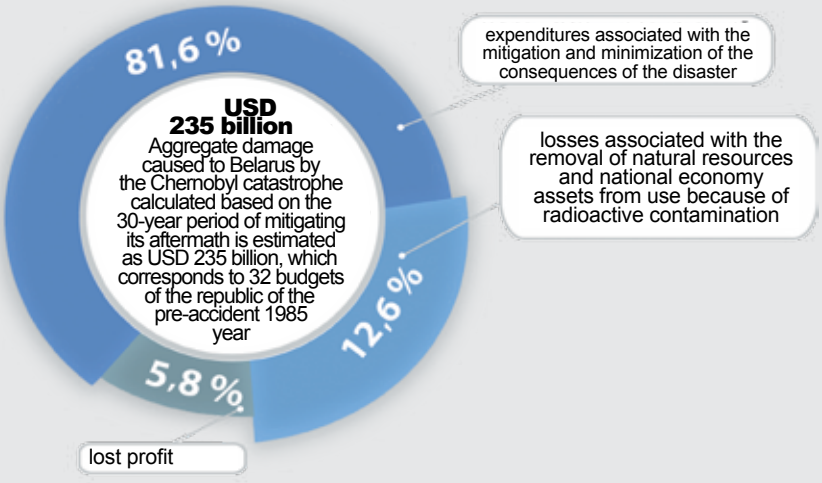


Fig. 5. The structure of damage to the Republic of Belarus resulting from the catastrophe at the Chernobyl NPP for the period up to 2015
1 – Additional costs associated with maintaining the operation, production and implementation of protective measures – USD 191.7 billion
2 – Direct and indirect losses – USD 29.6 billion
3 –Loss of profit – USD 13.7 billion

transport and communication, community facilities; contamination of mineral, raw, land, water, forest and other resources; as well as additional costs of the measures for the cleanup and minimization of the effects of the catastrophe and providing a safe living environment for the population.

The costs related to maintaining of the industry and implementation of protective measures, which amount to USD 191.7 billion account for the major share (81.6%) in the structure of the total damage. Direct and indirect losses account for about USD 30.0 billion (12.6%). Loss of profit is estimated as USD 13.7 billion (5.8%).

Direct losses include the cost of the component part of the national wealth of the republic removed from use: basic production assets and stock, social infrastructure facilities, residential space and natural resources.

The following are referred to indirect losses: losses determined by the influence of economic and social factors (living conditions, way of life, health status of the population), which caused disturbance or termination of production, reduced labour productivity, increase of the cost and the difficulty of provision of other objects of state, cooperative and personal property, as well as losses from the migration of the population from contaminated districts.

The integral components of the loss of profit expressed in monetary form are: decrease of the quantity of output, works and services on contaminated territories; cost of products unfit for consumption because radioactive contamination; additional costs for the compensation of short received produce; costs for the compensation of the lost quality of produce; losses from termination of contracts, cancellation of projects, credit freeze, payment of fines, penalties, forfeits and suchlike.

Additional costs are expenses for the mitigation of the effects of the accident and ensuring normal operation of various sectors of the national economy in the areas of radioactive contamination, including creating safe living conditions for the population. To these also relate expenses on the compensation for the consequences of the impact of negative factors; cost of additional resources attracted for the compensation of losses and lost profit; costs of decontamination activities and organization of radiation monitoring (Table 7).

The performed assessment of the damage is not conclusive as the causal relationships reflecting the impact of the radioactive contamination of the territory on different aspects of life are quite complex. Scientists do not yet have exhaustive information on the medical and biological, social and environmental effects of the Chernobyl disaster.

In summary, Chernobyl contaminated territories faced an especially complex socio-economic situation. In such conditions one can only speak about the long-term rehabilitation process, which implies gradual introduction of the lost potential into the sphere of national economy along with creating safe living conditions and provisions for the development of the economy sectors, which may operate safely without damage to public health in the conditions of radioactive contamination.

Table 7. Sectoral breakdown of the socio-economic damage to the Republic of Belarus resulting from the Chernobyl catastrophe (USD bln.)

Sectors of national economy	Years				
	1986–1990	1991–1995	1996–2000	2001–2015	1986–2015
Public health	4,05	16,77	18,13	54,32	93,27
Agro-industry	18,3	20,0	15,6	18,1	72,0
Forestry	0,58	0,68	0,70	2,15	4,11
Industry	0,06	0,13	0,11	0,33	0,63
Construction sector	0,15	1,25	0,32	0,96	2,68
Mineral, raw materials and aquatic resources	2,00	0,12	0,15	0,40	2,67
Transport and communication	0,93	1,20	0,36	0,90	3,39
Social sector	2,84	5,45	2,96	6,45	17,70
Decontamination of contaminated areas	0,04	4,19	22,48	10,12	36,83
Radioecological monitoring	0,05	0,21	0,19	1,27	1,72
Total	29,00	50,00	61,00	95,00	235,00

2. DEVELOPMENT OF APPROACHES TO THE MITIGATION OF THE EFFECTS OF THE CHERNOBYL CATASTROPHE

2.1 Scientific Basis for the Mitigation of the Effects of the Chernobyl Catastrophe

In 1986 there were practically no scientific teams specializing in radioecology, radiobiology, radiation medicine or agricultural radiology in the Republic of Belarus. Considering this, one must do justice to the scientific manpower of the Soviet Union who were able to quite realistically assess the new situation and suggest recommendations, which allowed to reduce radiation impact on the population of the republic to the extent possible.

The first priority tasks after the catastrophe were the assessment of the radiation situation and developing urgent measures and suggestions for the Government Committee on the Problems of the Consequences of the Chernobyl Catastrophe in order to reduce the negative impact of the radiation on population. The scientists of the National Academy of Sciences of Belarus, Ministry of Health, State Agro-Industry Committee, Ministry of Higher and Post-Secondary Education and other administrative entities of Belarus were also involved in tackling the problems.

The results of research obtained during first years after the catastrophe became the basis for taking government decisions on the resettlement of the inhabitants of the most affected districts, selection of construction sites for new housing developments, stiffening of the standards of radionuclides content in foodstuffs and potable water, prohibition or restriction of a number of economic activities.

However, it was evident that in order to eliminate the effects of the accident, both urgent measures and also the development of long-term theoretically grounded approaches were necessary. That is why the Government had to establish without delay specialized scientific institutions and arrange training of personnel. The Institute of Radiobiology and the Institute of Radioecology Problems of the Academy of Sciences of Belarus (city of Minsk), Research Institute of Radiation Medicine of the Ministry of Health (city of Minsk), its Vitebsk, Gomel and Mogilev branches, the Belarusian Research Institute of Agricultural Radiology (city of Gomel) of the Ministry of Agricultural Production (now – the Republican Research Unitary Enterprise "Institute of Radiology" of the Ministry for Emergency Situations of the Republic of Belarus) were established in the republic. Virtually all scientific institutions and universities, possessing necessary experts and material support joined their efforts in solving the problems: These were the Institute of Nuclear Engineering of the Academy of Sciences, Belarusian State University, Belarusian Research Institute of Soil Science and Agrochemistry and many others.

The international experience of the cleanup of the effects of nuclear incidents available at the time did not allow for developing unequivocal recommendations on dealing with such a large-scale problem. The Programme of Integrated Research on the Problems of the Cleanup of the Effects of the Chernobyl Disaster was developed and adopted. It envisaged research and development along four priority areas:

- examination of the radioactive contamination of ecological systems, genetic, physiological and biochemical assessment of its potential effects;
- developing farming technology and methods in the conditions of radioactive contamination of the environment;
- study of the influence of radiation on the functional systems of the human body, incidence and course of the disease in humans, development of diagnostics and treatment methods;
- development of technologies for reducing radioactive contamination of the environment and individual objects, methods and tools of radiometric and dosimetric control.

Coordination of efforts of scientific institutions within the framework of this programme allowed switching from operative tasks to system research. Programme assignments were carried out by 18 institutes of the Academy of Sciences and over 20 scientific institutions and universities of the Ministry of Health, State Agro-Industry Committee, Ministry of Higher and Post-Secondary Education and other administrative entities of the republic. Further on, based on this inter-republican programme the Comprehensive Programme of Scientific Research on Overcoming the Effects of the Catastrophe at the Chernobyl NPP in Belarus was elaborated.

Simultaneously the programme of monitoring and forecasting radiation situation in the republic was developed and adopted.

A comprehensive assessment of the radiation and ecological situation was performed, forms of radionuclides presence in different eco-systems, and their major migration paths were determined; first findings on the impact of the existing situation on the functional systems of the human body and population morbidity rate were obtained, a package of remedial and preventive measures implemented; a number of recommendations on farming in the conditions of radioactive contamination, conservation of nature, methods of decontamination

and cleanup of environment sites from radionuclides were proposed, the dynamics of the radioactive contamination of the territory of Belarus for the upcoming years was predicted.

These results served as the basis for implementing protective measures, development of the concept of living on contaminated territories, adopting stiffer permissible levels for the content of radionuclides in foodstuffs and potable water, prohibition or restriction of some types of economic activity on the affected territories. All this became the ground for developing the State Programme of the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP for 1990-1995.

There is a special section in the Programme, which envisages scientific support to practical work. The Steering Board was established for coordinating scientific research, which was adopted 13.12.1989 by the Committee of the Presidium of the Council of Ministers of Belarus on Technical Advance.

Scientific research performed in 1990–1995 allowed to estimate radioecological, radiobiological, economic and social effects of the Chernobyl disaster, which was used as a basis for adopting necessary protective measures. In 1992 the Catalogue of Exposure Doses of the inhabitants of the settlements situated on contaminated areas was created, which made it possible to clearly determine basic areas of protective healthcare and hygiene activities.

The implementation of the programmes on the mitigation of the consequences of the catastrophe at the Chernobyl NPP as well as the adopted laws "On Social Protection of Citizens Affected by the Catastrophe at the Chernobyl NPP" and "On the Legal Status of the Territories Which Suffered Radioactive Contamination Resulting from the Catastrophe at the Chernobyl NPP" allowed the establishment of the system of radiation monitoring of the Republic of Belarus, which in its turn revealed new requirements to the instrumentation of radiation measurements. This was because the existing stock of instrumentation for measuring ionizing radiation was not oriented at radiation monitoring on radioactively contaminated territories. There emerged new tasks of mass radiation monitoring of foodstuffs, raw materials, water as regards content of caesium and strontium radionuclides.

In order to solve these tasks the Republican Research and Technology Programme on Creating and Production of Equipment for Radiometric and Dosimetric Monitoring (RNTP 18.02 r) was adopted in 1990. The Programme was designed for the period 1991 - 1995.

The main idea of the Programme was the development and production of the equipment, which would secure addressing three primary objectives of radiation monitoring in the republic:

- radiation monitoring of all types of food raw material and products, including mass monitoring of the amount of alpha, beta, gamma radiating radionuclides of natural and technogenic origin in potable water, foodstuffs, agricultural produce, crude drugs, etc.;
- comprehensive radiation monitoring of the natural environment;
- control of internal and external human exposure doses.

The equipment designed within these programmes allowed both for mass radiometric measurements and spectrometric measurements in low activity samples of any origin.

According to the Programme about 4 thousand gamma and beta radiometers, over 200 professional gamma radiation dosimeters, more than 10 highly sensitive spectrometers were designed, their manufacture was organized and this equipment was supplied to the radiation monitoring network of the republic; a mobile radiologic laboratory for mass examination of people was put in commission,and a car based radiometric monitoring post for live measurement of specific activity of caesium radionuclides in the muscular tissue of large farm animals established. A large portion of the equipment was sold to Russia, Baltics, Austria and other countries. The new class of scintillators designed within the framework of the programme are now used on a competitive basis at the European Organization for Nuclear Research (CERN, Geneva) in large-scale experiments to obtain information on the structure of the material.

The implementation of the tasks set in the scientific section of the State Programme for 1996–2000 brought a number of principally new scientific and practical results for the domestic and international science:

— the status and migration of radionuclides in various ecosystems was studied, which demonstrated the need to review the models of radionuclide behavior in the environment existing in the international science, including their inclusion in food chains, which allowed to develop a set of proposals on the conservation of nature and lay the grounds for taking managerial decisions;

— assessment of the health status of the affected population was performed, methods and tools for the diagnostics, treatment and prevention of diseases were developed;

— scientific substantiation was given for radiation protection activities aimed at reducing individual and collective exposure doses, regulatory documents specifying permissible levels of radionuclide content in foodstuffs and potable water, forestry products were elaborated.

RPL-96 (Republican Permissible Levels) were adopted to limit internal exposure, agriculture technologies included into the "Guidelines

on Agriculture in the Context of Radioactive Contamination of Lands in the Republic of Belarus for 1997–2000" were improved.

A set of regulatory and organizational and methodological documents, which specify the organization, procedure and safety measures for decontamination and handling radioactive waste were elaborated ("Regulations on Decontamination and Handling Radioactive Waste Generated as a Result of the Cleanup of the Effects of the Chernobyl Disaster", "Classification of Decontamination Waste of Chernobyl Origin", "Sanitary Rules for Handling Decontamination Waste").

Research and development has been completed ready for direct practical employment: a plant for immobilization of radioactive waste and decontamination products with preprocessing (concentration and solidification) of liquid radioactive waste of low and medium activity level; a complex of forest area automated remote infrared fire monitoring system; a retrofit KSK-100 fodder harvester with a multi-fuel environmentally friendly MF-4RTA engine for operating in the contaminated regions of Gomel Oblast; fire-extinguishing chemical formulations for localizing and extinguishing peat (underground) fires, allowing to considerably reduce peat bog burn-out areas and decrease the transfer of radionuclides with combustion products and contamination of adjacent territories; a laboratory technology of manufacturing assay kits for enzyme-linked immunoassay for organ-specific antigens in blood serum and plasma for screening of thyroid pathologies, and other.

The research allowed to considerably reduce exposure doses, improve medical provision for the affected population; forecast the development of the radiation and environmental situation and medical and biological effects of the Chernobyl disaster; introduce most efficient equipment and technologies; ensure information support of the population; perform operative adjustment of priority areas and funding of the State Programme to Mitigate and Overcome the Consequences of the Catastrophe at the Chernobyl NPP.

The results of this comprehensive research allowed to create the Concept for the rehabilitation of the population and the territories affected by the catastrophe at the Chernobyl NPP and the Concept of the Programmes for the Rehabilitation of the Regions and Settlements Contaminated with Radionuclides, which were used as the grounds for elaborating the State Programme of the Republic of Belarus on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP for 2001–2005.

Since 1997 the State Research and Technology Programme (SRTP) "Develop and Implement Methods and Instruments to Ensure Radiation and Environmental Safety" ("Radioecology"), which focused on the technical and methodological support for the system of environmental monitoring and radiological security, has been implemented in the republic. Major outcomes of the programme are: development and production of new series of equipment for the system of prevention of emergency situations, development of equipment for the system of ecological monitoring of the natural environment; design and production on a commercial scale of equipment for the radiation monitoring network, including equipment for control of alpha-radiation and beta-emission spectrometers, production of new series of equipment for monitoring X-ray (impulse and continuous) and gamma radiation for medical dosimetry.

In total, 20 types of preproduction equipment models and 12 methods used in the system of radiation monitoring were developed under the assignments of "Radioecology" SRTP.

About 2000 devices of 28 items were produced. Their total cost amounted to more than USD 1.5 bln., which paid for the performed research and development.

In 2001–2005 "Radiation Safety" SRTP was implemented in the republic, which was the logical continuation of SRTPs 18-02r and "Radioecology". The purpose of this programme was the establishment of the equipment and methodological basis for addressing the tasks specified by the Law of the Republic of Belarus "On Radiation Safety of the Population". The tasks, which emerged in the course of the implementation of the above law are characteristic of any developed country. For Belarus, which was most affected by the Chernobyl disaster these are extremely important. As a result of the programme implementation 2 unique units were designed: an "Expert Beta-Gamma Human Radiation Counter and a reference facility for measuring volumetric activity of radon in the air, 4 new generation apparatuses and 4 methods. The implementation of this cycle of scientific and technological programmes allowed establishing in the Republic of Belarus of a new production branch – nuclear instrumentation, maintain scientific and production potential, form the material and technical, methodological and metrological basis of the radiation monitoring system, secure the equipment and methodologies for solving new tasks in the sphere of radiation safety.

The transition to the stage of long-term effects of the Chernobyl catastrophe imposed new requirements, considerably broadened the goals of the scientific support section of the State Programme for 2001–2005 and determined the following areas of development:

- scientific support to the rehabilitation of radioactively contaminated territories and protective measures in agricultural production;

• scientific support to solving medical issues of the Chernobyl disaster effects;

• dealing with the long-term problems of radiobiological and radioecological effects of the Chernobyl disaster.

Based on the performed research a number of fundamental documents were elaborated, adopted and are widely used, including the "Concept for the Rehabilitation of the Population and Territories Affected by the Catastrophe at the Chernobyl NPP", "Recommendations for Agro-industry in the Context of Radioactive Contamination of the Lands of the Republic of Belarus", "Recommendations for the Production of Food in Smallholdings Contaminated with Radionuclides".

Implementation of these recommendations made it possible during 2001-2005 to reduce production of milk with caesium-137 content in excess of the permissible level: in the public sector by 5.5 times, in the private sector by 1.7 times, and return of cattle from meat processing plants by 2 times.

New approaches were defined for obtaining standard clean and profitable agricultural produce, methodology and a number of programmes for comprehensive rehabilitation were elaborated (Chechersk, Bragin and Vetka Districts of Gomel Oblast and Bykhov, Klimovichi, Krasnopolye, Kostiukovichi, Slavgorod and Cherikov Districts of Mogilev Oblast). The implementation of the designed re-specialization programmes for most contaminated farms of Gomel and Mogilev Oblasts allowed both to tackle the radiological problems and enhance the economic efficiency of agricultural production.

The optimization of the location of cereal crops for food production between fields and sites in the group of "critical" farms made it possible to considerably reduce volumes of production of food grain with strontium-90 content above RPL-99.

Complex monitoring research of the radiation and ecological status of soils, hydrologic systems, air, flora and fauna has been organized and carried out annually based on the established reference network. Principal patterns of the distribution, accumulation and migration of caesium-137, strontium-90, transuranium elements in ecosystems have been identified. Maps of the contamination of the republic with caesium-137, strontium-90 and plutonium-239, -240 are periodically improved. Forest exploitation systems for zones of radioactive contamination have been developed and implemented, which ensured the production of standard clean timber and wooden articles for the domestic and external markets.

A Concept for the Organization of Medical Provision of the Population Affected by the Catastrophe at the Chernobyl NPP has been developed. It was based on the restriction of surveyed cohorts according to the dose principle with distinguishing groups of higher radiation risk to optimize the health survey performed, enhance its efficiency and cut costs.

Elaborated methods for the treatment of patients with localized thyroid cancer allowed to reduce the incidence of disease return up to 3.2 per cent. Use of radioiodine therapy in patients with distant metastases of thyroid cancer leads in 55.5 per cent of cases to remission and reduces mortality up to 0.9 per cent.

In pursuance of the instruction of the President of the Republic of Belarus dated 14.04.2003 No 09/124-228 the scientific potential and funds of scientific programmes were concentrated in the city of Gomel. Research in the sphere of the rehabilitation of contaminated territories is performed by Republican Research Unitary Enterprise (RRUE) Institute of Radiology; a territorial department of the Institute of Soil Science and Agrochemistry of the National Academy of Sciences of the Republic of Belarus was established at the institute. Health-oriented scientific research is concentrated at the Republican Scientific and Practical Centre for Radiation Medicine and Human Ecology. Fundamental research in radiobiology and radioecology are entrusted with the Radiobiology Institute, which according to the resolution of the Presidium of the National Academy of Sciences of the Republic of Belarus dated 17.04.2003 was transferred to Gomel.

Among important issues addressed by the science one should mention the creation of a cycle of recommendations on agro-industry, the observation of which ensures production of products with radionuclide content within permissible levels on the contaminated territories, as well as the elaboration of the issue of rehabilitation of contaminated territories on the level of a concept and methodology. The social and radiation certificates of the contaminated districts of Gomel (13 districts), Mogilev (12 districts) and Brest (3 districts) Oblasts are updated annually based on the created databases.

Performance analysis of the implemented developments was performed based on the application of the generally accepted concept of a prevented collective dose and comparing difference between expired costs on protective measures and gained public benefit [9]. Thus, as a result of performed activities the value of the accumulated dose of the affected inhabitants of Belarus in 1986-2005 amounted to 24,000 man-Sieverts instead of the anticipated 176,000. The prevented collective dose amounted to 152,000 man-Sieverts. Considering the international coefficient of the probability of cancer incidence per unit of effective dose for the population, data of the Ministry of Statistics and Analysis on the value of the annual death-rate coefficient of the inhabitants of Belarus from all causes, amount of monthly average wages in USD,

cost of one year of life of a typical inhabitant, the amount of prevented damage for human health due to reducing irradiation doses as a result of carrying out scientifically grounded protective measures amounted to money's worth of USD 45.2 bln. Within the calculated period about USD 18 bln. have been spent on mitigating the effects of the catastrophe at the Chernobyl NPP. Thus the economic effect from preventing radiation impact on the health of the population amounted to more than USD 27 bln.

The social effect of the research is revealed in the reduced level of radionuclide contamination of the goods produced in the public and private sectors, increased awareness of the population on the rules of safe living on contaminated territories, improved planning and enhanced efficiency of the measures of the State Programme by state governing bodies and - in the long run – reduction of population exposure doses.

Considering the need to enhance the efficiency and practical output of scientific research within the State Programme on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP 2006-2010 it was focused along the following areas:

- ensure rehabilitation of territories contaminated with radionuclides and carrying out protective measures in agriculture;
- addressing health effects of the catastrophe;
- addressing long-term problems of radiobiological and radioecological consequences of the catastrophe.

Parent organizations on these areas of research were Institute of Radiology RRUE, Republican Scientific and Practical Centre for Radiation Medicine and Human Ecology, Institute of Radiobiology of the National Academy of Sciences of Belarus. Among main tasks the following objectives were defined:

- elaboration and scientific support of the target oriented programmes for the production of competitive agricultural produce on the radioactively contaminated territories;
- further elaboration of agrochemical, agronomic activities and technologies aimed at the production of various types of standard clean agricultural produce;
- elaboration of methodological approaches for justification of regional programmes of adaptive land use;
- elaboration of the strategy for the maintenance and possible use of lands of the resettlement zone and the lands removed from agricultural production;
- further streamlining of the radiation control system with due regard to the radiation situation and performing protective measures;
- determining basic trends in health indexes (morbidity and mortality) and revealing their relation to catastrophe factors;
- further increase of the efficiency of treatment of radiation induced diseases;
- improvement of dose monitoring through the optimization of the volumes of instrument measurement of the content of radionuclides, distinguishing critical territories and groups of population with assessment of the dose forming structure;
- post-evaluation and reconstruction of irradiation doses from all sources related to the catastrophe;
- elaboration of a scientifically substantiated system of measures to optimize land use on contaminated territories.

Among most significant developments there are:

- The Concept of the State Programme on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP 2011-2015 and up to 2020;
- Recommendations on Agro-industry in the Context of Radioactive Contamination of the Lands of the Republic of Belarus 2011-2015;
- Agrochemical protective measures on the contaminated lands of Belarus for the period 2011-2015;
- Catalogue of mean annual effective radiation doses of the inhabitants of settlements located in the radioactive contaminated zones;
- prognosis of the fate of thyroid cancer patients;
- instructions on the treatment of patients with thyroid cancer relapse, and diagnostics of thyroid carcinoma;
- development of a State Registry of Persons Exposed to Radiation Due to the Catastrophe at the Chernobyl NPP.

Out of the findings of scientific research developments in the area of agricultural production were most widely used. Thanks to the implementation of these findings governing bodies have the possibility to organize production and obtain produce within the limits of the current standards with minimum costs and maximum effect.

The scientific support to the State Programme on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP 2011-2015 and Towards 2020 the following is envisaged;

- elaboration of new methods of diagnostics, treatment and rehabilitation of the affected people;
- improving methods of predictive appraisal of population irradiation doses in the long-term period after the catastrophe at the Chernobyl NPP for carrying out radiation protection measures;
- justifying indices of soil quality, which ensure minimum intake of caesium-137 and strontium-90 in the products crops with due regard of the principles of economic expediency of using agrochemical protective measures;
- obtaining new knowledge in the area of radiobiology and radioecology to improve the principles of safe living on contaminated territories.

By now the necessary scientific areas have been formed, there is own personnel, the material and technical basis for research has been established. The scientists of Russia and Ukraine recognize the existence of the Belarusian school of thought on the issues of rehabilitation of affected territories.

The overall goal of scientific support is the scientific substantiation of managerial decisions aimed at forming target oriented assignments and activities on overcoming the consequences of the Chernobyl disaster, which are then to be approved by the Council of Ministers of the Republic of Belarus.

The mitigation of the consequences of the Chernobyl disaster is related to long-term and comprehensive problems of the protection of population and areas, which are unique in the world practice; and from this comes the necessity of a strict scientific approach to continuous control of the situation, setting tasks and determining the ways for solving them, and also planning of specific activities. The complexity and diversity of problems recognized by the world scientific community dictate the necessity of performing scientific research on the high level.

Therefore, the science during all years after the disaster has been and is still the backbone instrument for the development, planning, implementation and operative adjustment of the activities on mitigating the consequences of the catastrophe at the Chernobyl NPP (Table 8).

2.2 «Chernobyl» Legislation. Transformation of the System of Social Protection of the People Affected by the Catastrophe at the Chernobyl NPP

At the moment of the accident at the Chernobyl NPP there were no legislative acts in the Soviet Union, which would regulate issues of the social protection of citizens, legal regulation of the territories, evacuation of population, compensation payments, etc. in case of a radiation accident of such scale. Considering the acute need for prompt action to protect people, evacuate population and property, grant benefits and

Table 8. Major stages and peculiarities of the scientific support to the mitigation of the consequences of the catastrophe at the Chernobyl NPP in the Republic of Belarus

Period	Organization of scientific support	Peculiarities
1986–1987	Performance of immediate tasks	Emergency measures. The international experience in mitigating the aftermath of nuclear accidents available at that time did not allow to elaborate well-defined recommendations for dealing with such large-scale problems
1988–1992	Adoption of the Programme of Integrated Research on the Problems of the Cleanup of the Effects of the Chernobyl Disaster	Establishment of specialized scientific institutions Transition to systematic planned research Ensuring scientific support for all aspects of life and economy on contaminated territories
1993–1995	A special scientific section of the State Programme, which is a tool for the planning and implementation of activities	Accumulation of a considerable data array and unique facts Assessment of the radioecological, radiobiological, economic and social consequences of the Chernobyl catastrophe
1996–2000	Development and adoption of methods and instruments for securing radiation and environmental safety, decontamination techniques, methods of nuclear waste conversion and disposal, manufacture of special medicines and food additives	Focus on radiation protection and preservation of the health of the population Large-scale practical application of R&D results
2001–2005	Considerable enlargement of the objectives of scientific support Elaboration and implementation of programmes for the adoption of R&D results	Transition to the long-term effects stage New requirements to the scientific support as regards economic and social effectiveness Identifying new approaches to producing standard clean and profitable agricultural produce (re-specialization programmes)
2006–2010	Mobilization of the scientific potential and financing for research as part of the State Programme in Gomel Oblast (city of Gomel), which was most severely affected by the Chernobyl disaster	Bundling of activity areas Increasing the efficiency of research and development Gaining experience in the organization and implementation of measures in case of a nuclear accident to reduce its adverse effects

compensations, these issues were addresses through adopting regulatory acts of the Central Committee of the Communist Party of the Soviet Union, the Council of Ministers of the USSR, All-Union Central Council of Trade Unions, and suchlike. These decisions were duplicated by the respective entities of the Belorussian SSR. Such crucial decisions, as for instance, evacuation of people – in view of the need to be adopted literally in several hours – were taken at the level of the Government Committee of the Council of Ministers of the USSR, the Central Committee of the Communist Party of the Soviet Union, the Council of Ministers of the BSSR, Gomel Oblast Executive Committee.

Just within the period 1986-1987 about 90 regulatory acts were adopted, dealing with the mitigation of the effects of the catastrophe at the Chernobyl NPP, which were valid on the territory of our republic. And their amount grew from year to year, and it was only in 1991 when in the BSSR – for the first time in the history of the Soviet Union and most affected soviet republics (RSFSR, USSR) – the laws were adopted, which built upon the entire accumulated body of existing regulatory acts. In February 1991 the Law of the Republic of Belarus "On Social Protection of People Affected by the Catastrophe at the Chernobyl NPP" [10] was adopted, and afterwards the Law of the Republic of Belarus "On the Legal Status of the Territories Which Suffered Radioactive Contamination Resulting from the Catastrophe at the Chernobyl NPP" [2]. In 1998 the National Assembly of the Republic of Belarus adopted the Law of the Republic of Belarus "On Radiation Safety of the Population" [11].

An abnormal situation caused by the immense disaster demanded unconventional approaches to be employed in handling new problems, and it was also true for elaborating legislative acts. This is why, for example, the Law "On Social Protection of People Affected by the Catastrophe at the Chernobyl NPP" (hereinafter referred to as the Law) introduced a number of standards, which there had not been before. It was the basic law for the elaboration of other Chernobyl oriented legislative acts. The entire system of the social protection of the population affected by the effects of the catastrophe was grounded on this law. All consequent legal acts were adopted in line with this act. With the course of time the natural transformation of the legislation takes place. There appeared laws, which governed individual relations differently, some statutory provisions began to be duplicated and transformed with due regard to the current situation. Some provisions of the law still failed to come into effect, as the budget of the republic could not accommodate them. As, for instance, the provision about the reduction of the generally established retirement age for the people living on the contaminated territories.

In 2007 the system of social protection of people was considerably modified on the whole due to the adoption of the law of the Republic of Belarus "On State Social Benefits, Rights and Guarantees for Certain Categories of Citizens". Providing targeted social assistance to the people (families) facing difficult situations, and creating conditions for the social and labour activity of the population, which have the possibility to secure their own well-being independently was identified as the main task of the social policy.

In 2009 the Law of the Republic of Belarus "On Social Protection of People Affected by the Catastrophe at the Chernobyl NPP, and Other Radiation Accidents" [12] came into effect. This law did not change the fundamental approaches to the social protection of the population affected by the catastrophe at the Chernobyl NPP. The provisions stipulated by this law have been brought in line with all regulatory acts relating to this issue and effective as of the day of its adoption.

2.3 Programme Specific Approach to Overcoming the Effects of the Catastrophe

State Chernobyl Programmes: Tasks and Priorities at Various Stages of Mitigation

The working experience gained at the initial stage demanded the need to systematically address the problems of the effects of the Chernobyl catastrophe. On March 22, 1989 the Central Committee of the Communist Party of Belarus and the Council of Ministers of the BSSR adopted the resolution on the elaboration of the State Programme for Overcoming the Effects of the Catastrophe at the Chernobyl NPP in the BSSR for the years 1990-1995 and up to 2000. This programme was elaborated in July 1989 and was approved by the XI session of the Supreme Council of the BSSR. At the same session the republic was declared a zone of national environmental disaster. The Programme was finally adopted at the XII session of the Supreme Council in October 1989. The following activities formed the core of the programme:

- a package of measures to reduce the radioactive exposure dose to the extent possible;
- maintaining health of the people due to medical prevention, health promotion, social provision and relocation from settlements where the criteria of safe living are not met;
- creating safe living conditions in the radioactively contaminated districts;
- improving the quality of life of the population of these districts;
- scientific research into the issues related to the impact of radiation on humans, ecosystems and suchlike.

In April 1990 the Supreme Council of the USSR adopted the State Union-Republican Programme of

Immediate Measures for 1990-1992 to mitigate the effects of the catastrophe at the Chernobyl NPP. The costs for its implementation took a considerable part of the republican budget: in 1991 – 16.8 per cent, and in 1992 – 12.6 per cent. The republic channelled large funds to secure the living conditions of the population, including various payments (benefits and compensations), which made 30-40 per cent of the total expenses spent on the mitigation of the effects of the catastrophe. In 1992 these constituted 24 per cent of the funds allocated for the implementation of the programme.

Following the disintegration of the Soviet Union the Republic of Belarus had to handle the whole set of Chernobyl problems on its own. On July 28, 1992 the Presidium of the Council of Ministers of BSSR adopted the State Programme on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP for 1993-1995 and up to 2000.

The State Programme of the Republic of Belarus on the Mitigation and Overcoming the Effects of the Catastrophe at the Chernobyl NPP for 1996-2000, which built upon the analysis of the work performed between 1990 and 1995 and the findings of the long-term forecast of the radiation and environmental situation, further focused on the development and implementation of a package of technical, social, remedial and recreation measures to reduce dose loading of the population. It envisaged measures to improve the system of medical services, provision of people with medicines and environmentally clean foodstuffs, implementation and improvement of the radiation and environmental monitoring of the territory of the republic, providing the public with veritable information on the radiation and environmental situation on the territories of living and associated medical and biological risk factors. Planning and implementation of these measures required a deep scientific study of the existing radiation, environmental, medical and biological situation, discovering causative relations and development of scientifically substantiated forecasts.

The priority areas of this state programme was the implementation of the measures to create normal conditions for living and economic activity on the contaminated territories, construction of social and consumer facilities in the newly built settlements, large scale implementation of the set of activities to reduce the exposure doses to the extent possible.

According to the instruction of the President of the Republic of Belarus dated June 16, 1999 No. 188rp and based on the order of the Government of the Republic of Belarus dated August 10, 1999 No. 04/115 the State Programme on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP for 2001-2005 and up to 2010 was elaborated.

The overall purpose of the State Programme was reducing the damage to the health of the affected population, adverse social and psychological effects of the catastrophe at the Chernobyl NPP, socio-economic and radiation and environmental rehabilitation of the contaminated territories and return to normal operating conditions.

As an outcome of the implementation of this Programme socio-economic conditions on the contaminated territories were improved, a package of measures to enhance the level of medical services was implemented, health monitoring established, and reduction of internal and external exposure doses secured. The world community assesses the activities on the mitigation of the effects of the Chernobyl catastrophe positively. In particular, such assessment is given in the World Bank's document Belarus: Chernobyl Review [13], where the following outcomes are cited as major success points:

- minimizing collective dose of the population through resettlement and implementation of special measures;
- development of farming and processing technologies, which reduce radioactive contamination of food;
- effective treatment of patients with thyroid cancer and other diseases.

A similar assessment was given in the Recommendations to the governments of the Republic of Belarus, Russian Federation and Ukraine of the Chernobyl Forum (2003-2005) [14], and conclusions of the largest in the past years International Conference "20 Years After Chernobyl. Strategy for Recovery and Sustainable Development of the Affected Regions" (2006, Minsk-Gomel) [15].

The goal of the fourth State Programme on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP for 2006-2010 were socio-economic and radioecological rehabilitation of the contaminated areas, creating conditions for economic activity without restrictions as per radiological factor, and further reduction of health risk for the affected population.

The State Programme consolidated the mechanism of the implementation of state policy in what concerns protection of population and territories from the effects of the catastrophe at the Chernobyl NPP and was a well coordinated set of activities - as per resources, main implementing entities and execution periods – aimed at reducing the adverse effects of the catastrophe. The state policy on the radioactively contaminated territories was defined as rehabilitation oriented.

The programme envisaged addressing the following primary objectives:

- improvement of specialized medical care to the affected population;
- establishment of an effective system of social protection and social and psychological rehabilitation

of the population living on contaminated territories, liquidators, evacuees and resettled people;

• concentration of capital investment for the provision of gas and water supply and the arrangement of utilities in the contaminated territories, first of all, zones of subsequent resettlement and zones with the right to resettle, completion of the programmes of resettlement of people from the zones of subsequent resettlement;

• ensuring radiation protection of the population;

• ensuring the operation of the system of radiation control of agricultural and forestry products, food and potable water;

• improving regulatory legal acts governing the issues of overcoming the consequences of the catastrophe in order to create beneficial economic conditions for the development of the affected territories and guarantee that specialists in health, education, agriculture and forestry would stay to work there;

• creating conditions for the radioecological and economical rehabilitation of the territories of Gomel, Mogilev and Brest oblasts which suffered radioactive contamination;

• implementation of special measures in agriculture and forestry on the contaminated territories aiming to obtain produce within the permissible limits as for radionuclide content;

• further development of scientific and applied research and adopting their findings;

• broadening international cooperation;

• stage-by-stage rehabilitation of the radioactively contaminated territories and the affected population;

• optimization of the medical provision to the affected population based on scientific recommendations;

• implementation of protective measures to reduce radiation exposure doses;

• production of marketable products meeting republican and international requirements as per radiological quality.

In 2011 the State Programme on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP for 2011-2015 and for the period up to 2020 was launched. Its purpose is further reduction of the risk of adverse health effects for the people affected by the catastrophe at the Chernobyl NPP, promotion of the transition from the rehabilitation of territories to their sustainable socio-economic development provided that the requirements of radiation safety are absolutely met.

Union Chernobyl Programmes

During the first years after the dissolution of the USSR basic measures to mitigate the consequences of the accident at the Chernobyl NPP were implemented within the framework of the programmes of the affected countries. However both the common character and the complexity of the problems it brought about served as a precondition for joining financial resources, organisational experience, scientific and practical potential of Belarus and Russia for addressing them. In 1993-1995 the governments of the two countries entered into an agreement on join action to mitigate and overcome the consequences of the Chernobyl catastrophe. In

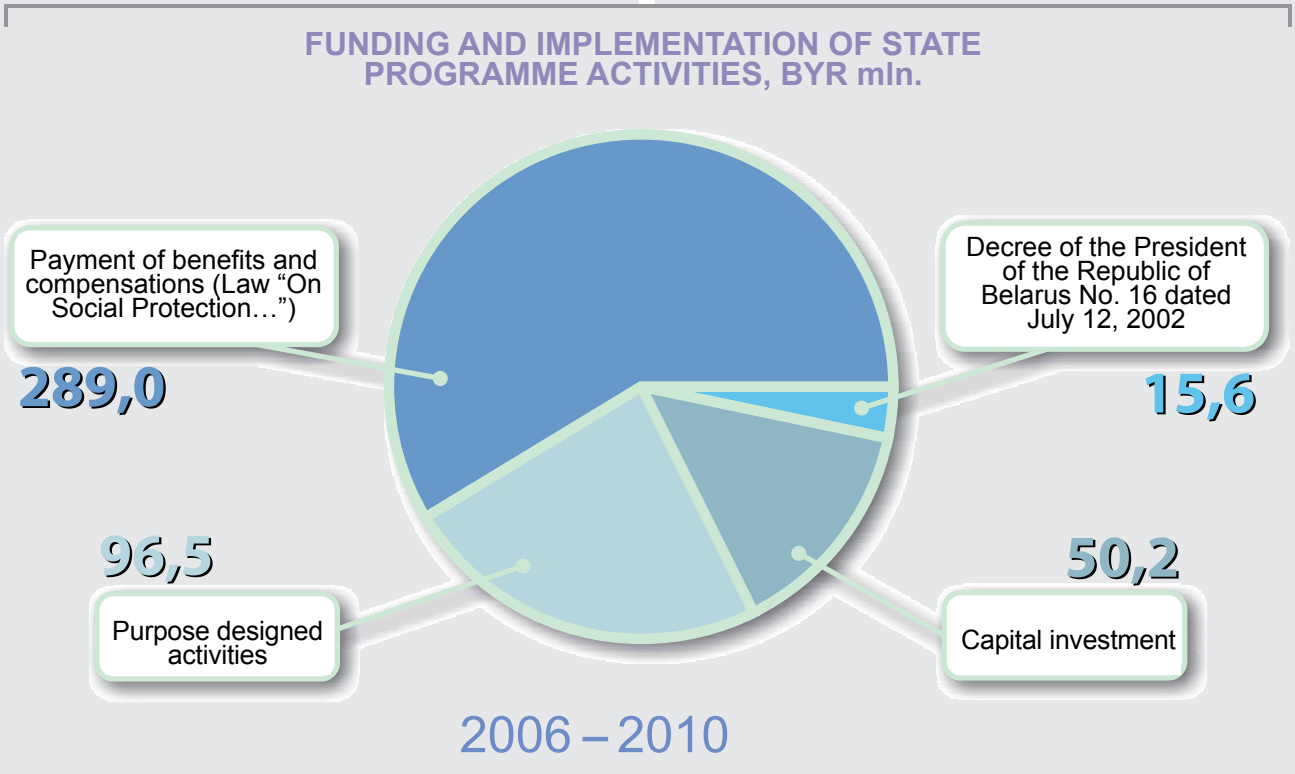


Fig. 6. Expenditures pattern within the State Programm

the process of implementing the provisions of the Agreement on the Union of Belarus and Russia and the Statute of the Union State, the Council of Ministers of the Republic of Belarus adopted resolution No. 725 dated June 16, 1997 "On Organizing the Implementation of the Programme of Primary Action to Realize the Provisions of the Agreement about the Union State and the Regulations of the Union of Belarus and Russia in 1997", according to which the ministries for emergency situations and protection of the population from the consequences of the catastrophe at the Chernobyl NPP, health, labour and social protection of the Republic of Belarus were commissioned with the task to prepare along with the interested ministries of the Russian Federation propositions on creating a consistent legal environment for the medical, radiation and social protection of the people affected by the radiation as a result of the accident at the Chernobyl NPP. From that moment the work started on organizing joint action to mitigate the consequences of the Chernobyl catastrophe of Belarus and Russia.

The Agreement on establishing the Union State dated December 8, 1999 envisages joint policy as regards the prevention and mitigation of the effects of natural and technogenic catastrophes, including consequences of the accident at the Chernobyl NPP, as well as formation of the common information space.

In the context of the Union State of Belarus and Russia it was possible to address "Chernobyl" problems jointly, by employing a programme specific method. Union Chernobyl programmes have been implemented along with the state programmes of both countries. By far three Union Programmes have been implemented, and the fourth one is under way.

The source of funding of the programmes of joint action to mitigate the consequences of the Chernobyl catastrophe in the context of the Union of Belarus and Russia is the budget of the Union State. The funds from the budget of the Union State allocated for the programme activities are distributed equally between Russia and Belarus.

The first Union Chernobyl programme for 1998-2000 was adopted by resolution No.1 of the Executive Committee of the Union of Belarus and Russia dated June 10, 1998 and was extended to 2001 by resolution No.34 of the Council of Ministers of the Union State dated December 21, 2000. For the funding of the Programme RUR 344.8 million were allocated (about USD 17 million) (Figure 7).

The Programme united material, financial and intellectual resources of Belarus and Russia to solve most topical problems. The priority of the Programme is the construction and equipping of specialized health institutions. Considerable work was performed to create the physical infrastructure of the unified system of specialized aid for the citizens of Belarus and Russia. About 90 per cent of the total funding was allocated for this end. The grounds have been laid for bringing closer the regulatory, legal and methodological approaches in the area of the protection of population and rehabilitation of territories.

The Second Union Chernobyl Programme for 2002-2005, adopted by resolution No. 17 of the Council of Ministers of the Union State dated April 9, 2002 ensured the integration of the efforts by the Republic of Belarus and the Russian Federation in overcoming the consequences of the Chernobyl catastrophe through establishing the foundations of the unified legal environment, introduction of universal standards and most effective technologies. For the funding of the programme RUR 980 million were allocated (about USD 32 million).

The overall goal of the Programme was forming the unified policy of the two states for the mitigation of the consequences of the Chernobyl catastrophe

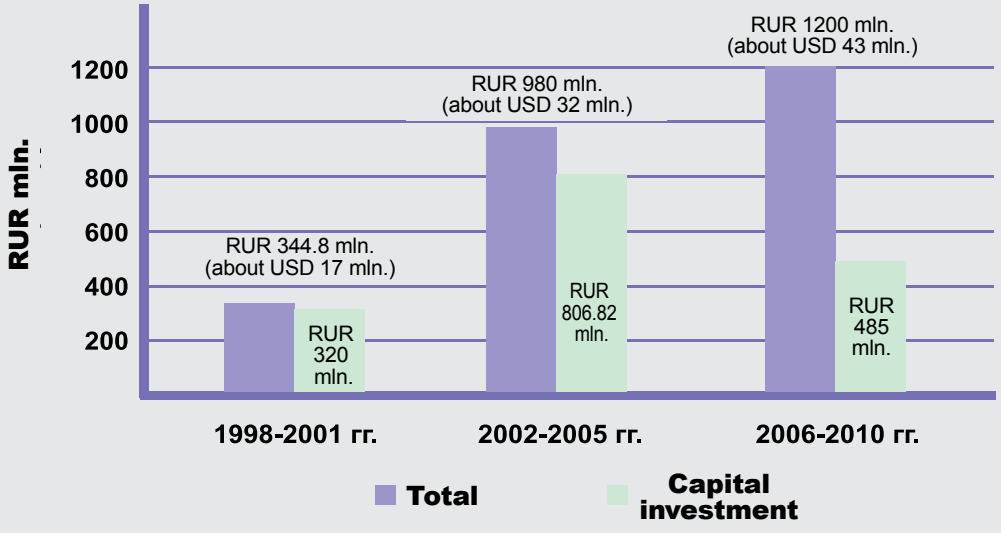


Fig. 7. Union programmes funding

and ensuring its implementation. Main objectives were the development, improvement and ensuring operation of the unified system of rendering specialized medical aid to the people of Belarus and Russia affected by the Chernobyl catastrophe; elaboration and adoption of the most effective technologies and implementation of economically safe activities; scientific, information and analytical, organizational and technical support to the joint activities to overcome the consequences of the Chernobyl catastrophe.

The overall goal of the third Union Chernobyl Programme for 2006-2010 adopted by resolution No. 33 of the Council of Ministers of the Union State dated September 26, 2006 was forming and improving of the coordinated elements and mechanisms of the joint activity of the Russian Federation and the Republic of Belarus in overcoming the consequences of the Chernobyl catastrophe. For the financing of the Programme RUR 1200 million (about USD 43 million) were channelled. Works were implemented in three areas: joint activity to create elements of the system of targeted specialized medical aid to the affected population; formation of the unified requirements and elements of normative and technical regulation of works intended to make farming lands and forest reserves lands safe and return them to the economy; implementation of the general information policy on the problems of mitigating the consequences of the Chernobyl catastrophe.

The large portion of funds within the framework of the Union programmes (especially two first ones) was allocated for establishing the physical infrastructure of the public health service. Two facilities were put into operation - the Republican Scientific and Practical Centre for Radiation Medicine and Human Ecology in the city of Gomel and the Grodno Plant of Healthcare Products in the town of Skidel.

International Cooperation

During the twenty-five years since the Chernobyl catastrophe the Republic of Belarus has passed a long way from the country – recipient of humanitarian assistance to the equal partner and an expert country possessing the experience, which may be applied in other countries.

Organizational fundamentals of the international cooperation on Chernobyl catastrophe issues were established by Resolution 45/190 "International Co-operation to Address and Mitigate the Consequences of the Accident at the Chernobyl Nuclear Power Plant" adopted at the 45th Session of the UN General Assembly (1990). Based on the Resolution Belarus initiated the creation of coordination mechanisms on the issues associated with the mitigation and minimization of the effects of the Chernobyl catastrophe, and these were the Interagency UN Committee for the Response to Nuclear Accidents and the Four-Party Coordinating Committee at the ministry level. The Interagency Committee included organizations and institutions of the UN system (UNDP, UNICEF, IAEA, UNFPA, UN HABITAT, UN ECE, UNSCEAR, IOM, UNIDO, UNESCO, WHO, WMO) and the World Bank. The Four-Party Coordinating Committee united the interested governing bodies of Belarus, Russia, Ukraine and UN agencies.

In the period from 1990 to 2001 Chernobyl related international cooperation was of a humanitarian and scientific and technical nature. The main programmes in the Republic of Belarus were the programme of technical cooperation by IAEA and the UNDP country programme for Belarus. Along with them there were some other initiatives, such as Chernobyl Humanitarian Assistance and Rehabilitation programme (CHARP) of the International Federation of the Red Cross and Red Crescent societies, International Programme on the Health Effects of the Chernobyl Accident of the World Health Organisation, TACIS-93 Programme, UNESCO-Chernobyl Programme, one-off projects of UNIDO, UNICEF, UN Office for the Coordination of Humanitarian Affairs. Besides, numerous projects and humanitarian programmes were implemented by nongovernmental organizations.

All in all, according to UN estimates the assistance to the Republic of Belarus within 1990-2001 from UN organizations amounted to about USD 45 million, through the TACIS Programme of the European Union – over USD 2 million, through the Humanitarian Office of the European Union – USD 6.5 million.

Starting from 2001 there was a shift in international post-Chernobyl cooperation as regards the organization of activities on the rehabilitation of the contaminated territories.

During this time international organizations carried out a number of missions and assessments in the area of management of post-Chernobyl situation in the post-accident period. Based on their results some reports were prepared, which represented an unbiased outlook on the environmental, health, socio-economic effects of the Chernobyl catastrophe, and a review of projects and programmes on overcoming them. Nowadays the findings of these reports are also used in determining the topical areas of international post-Chernobyl cooperation.

One of such initiatives was a mission completed in 2001 upon the initiative of the UN system in order to obtain reliable information on the living conditions of the affected population fifteen years after the accident at the Chernobyl NPP. The mission performed the analysis of the impact of the Chernobyl catastrophe and its aftermath on the socio-economic and environmental situation, and

the health of the population of the affected territories of the Republic of Belarus, Russian Federation and Ukraine. Special emphasis was placed on the issues of the welfare of people and provision of public services and amenities in the settlements directly affected by the catastrophe. Human Consequences of the Chernobyl Nuclear Accident. A Strategy for Recovery report was prepared based on the results of the mission.

In 2001-2002 the experts of the World Bank performed the analysis of the programmes and documents of the Government and the organizations rendering assistance to the Republic of Belarus in overcoming the consequences of the Chernobyl catastrophe, studied the opinion of the people living on contaminated territories as well as other categories of the affected population. The produced report [13] identifies major challenges Belarus faced following the accident at the Chernobyl NPP and proposes possible ways of dealing with them. Experts recommended placing more emphasis on highly contaminated areas, find new ways of informing people on healthy lifestyles, review approaches to the economic development of the affected districts, and optimize state programmes of assistance to the population.

Within the framework of the Chernobyl Forum initiated by the IAEA in cooperation with WHO, UNDP, FAO, UNEP, UN OCHA, UNSCEAR, the World Bank and the governments of the Republic of Belarus, Russian Federation and the Ukraine in 2003 scientific research was performed into the medical, environmental and socioeconomic consequences of the Chernobyl catastrophe. The findings of the Forum reflect the outcomes of the research and provide recommendations to the authorities of the three most affected countries on the issues of health care, environment protection, and implementation of the social and economic policy.

The mentioned assessments performed approximately at the same time by different organizations and participants came up with similar conclusions, the idea is as follows. The time has come for employing a new approach to the recovery and development, which should be comprehensive and include health, socio-economic development, conservation of nature, production of food, education and culture to meet the urgent and long-term needs of the affected population and the civil society. The participants of the activities should therefore coordinate their activity in order to ensure that their support reaches the most affected people and communities and brings expected results.

Thus the change of priorities occurred – there was a transition from humanitarian assistance to long-term socio-economic rehabilitation and securing sustainable development of the affected districts with active involvement of the inhabitants of the contaminated districts into the improvement of their living conditions. In this regard the assistance of the international community in overcoming the consequences of the catastrophe is considered as an important and essential precondition for the transition of the affected districts and the country on the whole to sustainable development.

In this context the Republic of Belarus along with international partners initiated and tested in practice a new approach through the implementation of the International Programme "Cooperation for the Rehabilitation of the Living Conditions in the Chernobyl Affected Areas of Belarus" (CORE, 2003-2008). The Programme was implemented in the four most affected districts of the Republic of Belarus: Bragin and Chechersk Districts of Gomel Oblast, Slavgorod District of Mogilev Oblast and Stolin district of Brest Oblast. The main goal of the programme was the active engagement of the affected people and local experts, all stakeholders into the processes of rehabilitation and recovering the living conditions on the territories. This goal was achieved through the implementation of topical projects in the area of ecology and agriculture, medicine, education, radiological quality, preservation of the cultural heritage initiated by the local communities. The programme made it possible to test new approaches to the rehabilitation of the affected territories, such as the introduction of the microcrediting mechanism, initiating alternative production, adoption of educational models on fostering practical radiological culture and publication of practical guides, preservation of the memory about the catastrophe through establishing memorials and monuments, etc. The inhabitants of the affected districts developed 146 projects, out of which 80 have been implemented for the total amount of €4.3 million with support and involvement of a large number of partners from many countries and organizations.

In 2006 the Republic of Belarus came forward with the initiative to declare the third decade after Chernobyl (2006-2016) the UN Decade on Recovery and Sustainable Development of the Affected Regions. This proposal was accepted at the 62nd session of the UN General Assembly in 2007. The UN Development Programme (UNDP) was delegated with the authority to elaborate the action plan for the UN system agencies to implement this proposal. The provisions of the plan aim to create by 2016 the conditions for the active involvement of the local population in the rehabilitation and recovery of the affected territories. The long-term action plan of the UN on Chernobyl serves to secure most efficient employment of the objectively limited resources allocated for the international assistance in the Chernobyl area, and also prevent the duplicating of efforts with optimum use of the advantages of the mandates and competencies

of each international stakeholder of the international Chernobyl cooperation.

Within the UN Decade the implementation of large-scale international technical assistance projects coordinated by the UNDP were launched:

"Area Based Development of the Chernobyl Affected Areas of Belarus" (budget over € 1.5 million). The project aims to enable the engagement of the local population in solving specific socio-economic tasks in the Chernobyl affected areas, and support to the most vulnerable groups of population. The main objective of the project was a working model of interaction and cooperation between the rural residents, the local authorities and other local organizations and institutions aimed at resolution of specific socio-economic problems in the target settlements and the region through the development and implementation of specific community project initiatives.

"Enhancing Human Security in the Chernobyl Affected Areas of Belarus" (budget over USD 1.6 million). The project aims to create conditions for improving income security, minimizing internal radiation exposure and practicing healthy lifestyles by the population of the five target districts (Bragin, Luninets, Slavgorod, Stolin and Chechersk).

"Development of International Chernobyl Research and Information Network (ICRIN)" (the project is implemented within the framework of the regional programme covering Belarus, Russia and Ukraine, the Belarusian part of the budget amounts to USD 330 thousand). The goal of the project is to support local initiatives on creating favourable conditions for the economic and social development of the regions affected by the Chernobyl catastrophe. The programme includes dissemination of information through the educational system, trainings for journalists, teachers and health workers as well as through the establishment of resource centres with access to the Internet in the affected rural areas. Four UN agencies are involved in the implementation of the project (UNDP, WHO, UNICEF, IAEA).

Other forms of cooperation with international organizations, which are principally new for the Republic of Belarus, are also implemented. A Loan Agreement has been signed with the International Bank for Reconstruction and Development within the framework of the joint project of the World Bank and the Republic of Belarus on the rehabilitation of the areas affected by the Chernobyl Catastrophe worth USD 50,0 million. The project covers two socially sensitive topics: increasing the energy efficiency and provision of gas supply to individual houses from the existing gas pipelines. Borrowing loan funds allows to streamline implementation of state programmes, reduce load on the budget, and channel released budget funds for addressing other objectives.

Within the framework of interaction with the International Atomic Energy Agency a number of national and regional technical assistance projects have been accomplished. Among them are national projects within the international technical cooperation programme by IAEA "Rehabilitation of the Territories Contaminated by the Chernobyl Accident" (project budget is USD 342 thousand), "Recovery of the contaminated territories with the help of innovative ecological technologies" (budget is USD 321,495); project "Supporting Forest Management in the Chernobyl Affected Territories" is under implementation. The country took part in the regional (Belarus, Russia, Ukraine) projects "Radiological Support to the Rehabilitation of Territories Affected by the Catastrophe at the Chernobyl NPP" (project budget is over USD 1 million, the goal of the project is to develop recommendations on the support in decision making regarding the maintenance of the areas exposed to radioactive contamination), "Training of Specialists and Support to Nuclear Technologies".

International Scientific Cooperation with the North-Atlantic Treaty Organisation NATO within the "Science for Peace" programme has been established. Since 2008 a project has been implemented on the territory of the Polessie State Radiation and Environmental Reserve worth € 300 thousand aiming to get comprehensive information on the radioactive contamination of the territory of the reserve; elaboration of the model of trans-boundary transfer of radionuclides beyond the borders of the near zone and creation of the prospective forecast of the change of the radiation situation due to wind and water transfer; assessment of the total content of radionuclides in the near zone of the Chernobyl NPP.

During the 25-year period following the Chernobyl catastrophe humanitarian assistance in the form of goods and money has been coming to the Republic of Belarus through public associations and private sector; children from the most affected districts of Belarus have been going for recuperation. Among the humanitarian partners of our country Austria, Great Britain, Belgium, Germany, Ireland, Spain, Italy, Canada, PRC, Luxemburg, USA, France, Sweden, Switzerland, Japan, etc. take a special place.

Along with the active work of international organizations on the rehabilitation and recovery of the Chernobyl affected areas, there is constant work going on to find and adopt new approaches to the state policy of the rehabilitation and recovery of the country with due consideration of the experience of implementing joint initiatives.

The Republic of Belarus expresses sincere gratitude to the organizations and countries, which actively participated in the rehabilitation and recovery of living conditions in the Chernobyl affected districts of Belarus. Thank to the joint effort the country

has crossed the line from receiving humanitarian assistance to the partnership of equal parties and sustainable development. The main work on the rehabilitation of the affected territories is done within the State Programme on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP, while attracting international experience in this area successfully complements the efforts of the state and is of special importance. The Republic of Belarus invites all interested stakeholders to the effective and fruitful cooperation.

2.4 State Management of the Mitigation of the Consequences of the Catastrophe

The management of protective measures and the mitigation of the consequences of the Chernobyl accident in April-May 1986 was the responsibility of the Government Committee of the Council of Ministers of the USSR and the Ministry of Health of the USSR.

The practical work on overcoming the effects of the Chernobyl catastrophe has been carried out within special state programmes funded from the budget.

The dissolution of the USSR, the establishment of the Belarus statehood and the three-year experience of overcoming the aftermath of the Chernobyl catastrophe demanded the necessity of establishing a special public governing body responsible for the mitigation of the effects of the catastrophe. In September 1990 the State Committee on the problems of the Consequences of the Catastrophe at the Chernobyl NPP was established by the Resolution of the Council of Ministers of the Belarusian SSR. In 1995 it was transformed into the Ministry for Emergency Situations and Protection of the Population from the Consequences of Chernobyl NPP, and in 1997 – into the Ministry for Emergency Situations, and in 1998 – into the Committee on the Problems of the Consequences of the Catastrophe at the Chernobyl NPP at the Ministry for Emergency Situations (Komchernobyl), and in 2001 – into a similar committee but this time under the Council of Ministers of the Republic of Belarus (Table 9).

The first Chairman of the Committee was appointed Vice-Prime Minister of the Government of the republic Ivan A.Kenik, who in the subsequent years also headed other governing bodies responsible for mitigating the consequences of the catastrophe up to 2000, that is for 14 years.

Currently the functions of the governing body dealing with Chernobyl problems are performed by the Department on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP of the Ministry for Emergency Situations of the Republic of Belarus.

Acting in the capacity of the state customer under the assignment of the Ministry for Emergency Situations the Department organizes and coordinates the implementation of the State Programme of the Republic of Belarus on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP.

Table 9. Reorganisation of the state governing body responsible for the mitigation of the consequences of the catastrophe

Resolution adopted, date	Name of the state governing body
Resolution of the Council of Ministers of the Belarusian SSR No. 277 dated September 11, 1990	State Committee on the Problems of the Consequences of the Catastrophe at the Chernobyl NPP
Resolution of the Council of Ministers of the Republic of Belarus No. 19 dated January 11, 1995 Resolution of the Council of Ministers of the Republic of Belarus No. 86 dated February 13, 1995	Ministry for Emergency Situations and Protection of the Population from the Consequences of Chernobyl NPP
Resolution of the Council of Ministers of the Republic of Belarus No. 674 dated June 10, 1997	Ministry for Emergency Situations of the Republic of Belarus
Resolution of the Council of Ministers of the Republic of Belarus No. 1862 dated December 4, 1998	Committee on the Problems of the Consequences of the Catastrophe at the Chernobyl NPP at the Ministry for Emergency Situations (Komchernobyl)
Resolution of the Council of Ministers of the Republic of Belarus No. 1578 dated October 31, 2001	Committee on the Problems of the Consequences of the Catastrophe at the Chernobyl NPP under the Council of Ministers of the Republic of Belarus
Edict of the President of the Republic of Belarus No. 756 dated January 29, 2006	Department for Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP of the Ministry for Emergency Situations of the Republic of Belarus

3. RESULTS OF THE ACTIVITIES ON OVERCOMING THE CONSEQUENCES OF THE CHERNOBYL CATASTROPHE

3.1 Organization of the System of Social Protection of People Affected by the Catastrophe at the Chernobyl NPP

The legislation in effect establishes the system of benefits, rights and guarantees for the people: who participated in the cleanup works after the catastrophe; evacuees, relocatees and those who moved to a new pace of residence from the radioactively contaminated territories; residing currently on the said territories; who participated in the cleanup or suffered from accidents and their effects at other nuclear civilian or military facilities; were affected during trials, manoeuvres and other works associated with nuclear plants, including nuclear weapons.

As of 01.01.2011 in the Republic of Belarus there were:

- people who fell ill and suffered from radiation sickness; disabled persons for whom the catastrophe at the Chernobyl NPP was established the cause of the disablement – 10,655 people;
- participants of the cleanup works at the Chernobyl NPP in 1986-1987 in the evacuation zone – 66,225 people;
- participants of the cleanup works at the Chernobyl NPP in 1988-1989 in the evacuation zone, in 1986-1987 in the zones of primary and subsequent resettlement – 37,706 people;
- people residing on contaminated territories – 1,114.3 thousand people;
- people resettled from the most contaminated territories – over 137.7 thousand people.

The dynamics of the number of settlements located in the zones of radioactive contamination and the number of population residing in these zones is shown in Fig. 8.

The most affected group is represented by the people who fell ill and suffered from radiation sickness; invalids for whom the catastrophe at the Chernobyl NPP was established the cause of the invalidity.

The funds channelled annually for the social protection of the population under the State Programme on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP for 2006-2010 amounted to about 60 per cent (Fig. 10).

The main areas of the state social policy regarding the population affected by the catastrophe

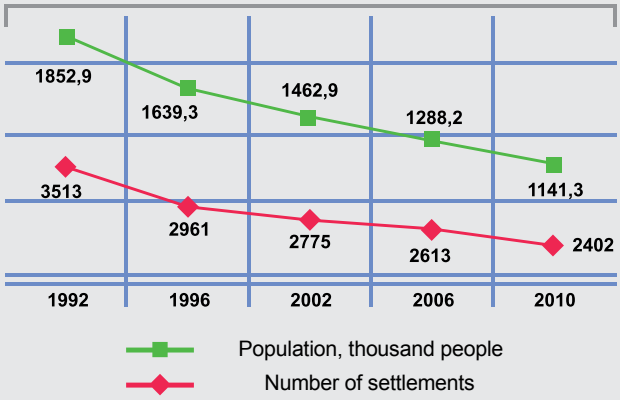


Fig. 8. Number of settlements on contaminated territories and the number of people residing in these settlements

Fig. 9. Funds allocated for the implementation of the Law of the Republic of Belarus "On Social Protection of People Affected by the Catastrophe at the Chernobyl NPP"

at the Chernobyl NPP are: rendering maximum assistance to the socially vulnerable categories of the population and implementation of top-priority state programmes, which envisage measures on maternal health, reducing the risk of the loss of health, and creating conditions for the socio-economic development of the regions affected by the catastrophe at the Chernobyl NPP.

The laws of the Republic of Belarus "On State Social Benefits, Rights and Guarantees for Certain Categories of People" and "On Social Protection of People Affected by the Catastrophe at the Chernobyl NPP, Other Radiation Accidents" envisage benefits as regards provision of medicines, sanatorium-resort treatment and recuperation, provision with technical rehabilitation means, payment for communal services and travelling by passenger transport for the categories of people, who in the view of their physical and social status need state support – for the disabled persons of categories I and II, people who fell sick and suffered from acute radiation sickness caused by the consequences of the catastrophe at the Chernobyl NPP.

Relevant social support for the children residing in the zones of radioactive contamination is

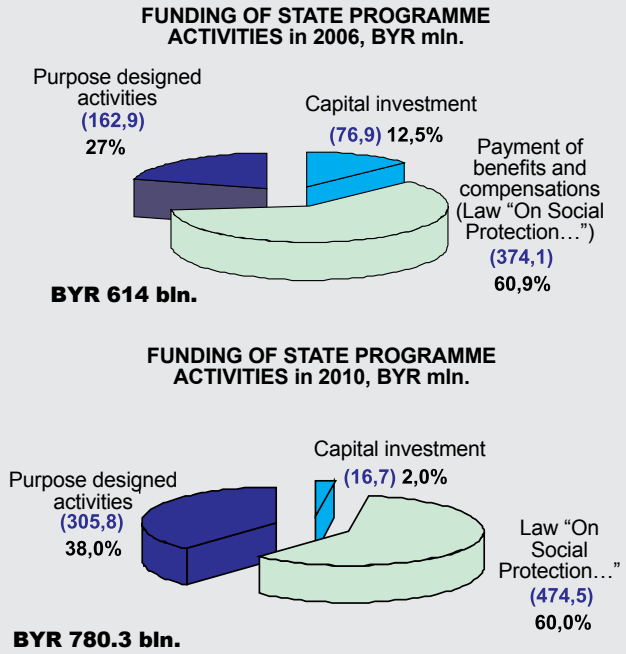


Fig. 10. Expenditures from the republican budget for the activities of the State Programme in 2006-2010

sanatorium and resort treatment and recuperation, free meals.

A number of additional guarantees and benefits to other categories of citizens are established. So, for instance, for the people who participated in the cleanup works after the Chernobyl accident in 1986-1987 in the evacuation (exclusion) zone or who were employed at that time in operation or other works of the said power plant (including those temporarily appointed or on business trips), including military men and obligated volunteers called out for special training and engaged in works associated with the cleanup of the effects of the said catastrophe, the retirement benefit is elevated by 50 per cent of the minimal retirement pension, and to those who participated in the cleanup works after the catastrophe at the Chernobyl NPP in 1988-1989 in the said zone or were employed at that time in operation or other works of the power plant - by 25 per cent of the minimal retirement pension.

For the people for whom the catastrophe at the Chernobyl NPP, and other radiation accidents were established as the cause of their invalidity an increment to their pension is paid at the following rates of the minimal retirement pension:

- disabled persons of category I, disabled children under 18 years – 100 per cent;
- disabled persons of category II – 75 per cent;
- disabled persons of category III – 50 per cent.

For the evacuees, relocatees, those who moved independently from the radioactively contaminated territory from the evacuation (exclusion) zone, primary resettlement zone and subsequent resettlement zone (including children of gestational age), except for those who arrived in the said zones after January 1, 1990, pensions are elevated by 25 per cent of the minimal retirement pension.

The people residing permanently (predominantly) on the radioactively contaminated territory in the zones of subsequent resettlement and with a right to resettle are entitled to a maternity benefit for mothers with children under three years of age in the amount of 150 per cent of the allowance stipulated by the legislation of the Republic of Belarus.

Those who work on the radioactively contaminated territory in the zones of primary resettlement and subsequent resettlement are entitled to temporary disability benefit at the rate of 100 per cent of the average daily (hourly) wages for the workdays (hours) according to the work schedule of the employee from the first day of temporary disablement, maternity leave to the women starting from the 27 weeks of pregnancy with the duration of 146 calendar days (in case of complicated delivery or in case of giving birth to two or more children – 160 calendar days) independently of the number of days actually used before childbirth.

Those who work in the evacuation (exclusion) zone are entitled to 35-hour working week and free hot meals three times a day, and in case it is impossible to organize such meals, they are entitled to packed meals or a monetary compensation.

Additional guarantees are established in order to engage and secure staying of certain categories of workers and specialists in the organizations located in the radioactively contaminated zones. In accordance with the Resolution of the Council of Ministers of the Republic of Belarus No. 1842 dated November 30, 1998 "On introducing contract-based employment for pedagogical, medical and pharmaceutical workers, arts and culture workers, including managers of these workers, specialists and managers of the specialized training and sports institutions, specialists in agriculture and housing and utilities, workers and specialists of the system of consumer cooperation in the districts exposed to radioactive contamination as a result of the catastrophe at the Chernobyl NPP" the said categories of workers who arrived and concluded a contract for employment in the organizations located in the radioactively contaminated zones, increments to their position salaries (rates) are established with due regard to the conditions, amount and quality of performed work, and a lump sum benefit is paid, the amount of which is determined depending on the rate of contamination of the territory and the duration of contract.

Graduates of post-secondary and higher education establishments who were sent for work or service (military service) to the radioactively contaminated territories, to the zone of subsequent

resettlement and to the zone with the right to resettle are entitled to annual payments at the rate multiple to the base rate of the first category established by the Council of Ministers of the Republic of Belarus for payments to the employees of state organizations funded from the budget and benefiting from state subsidies. 10 base rates – after the first year of work; 12 – after the second year of work; 15 – after the third year of work (Resolution of the Council of Ministers of the Republic of Belarus No. 1516 dated October 1, 1998 "On Establishing Payments to the Graduates of Post-Secondary and Higher Education Establishments Sent to Work or Serve (Military Service) to Radioactively Contaminated Territories").

3.2 Medical Provision of the Affected Population, Health Status

The health of the Chernobyl accident cleanup workers and the population living on the contaminated territories is the issue of maximum social significance. It is the centre of attention in the activity of the government in overcoming the consequences of the catastrophe at the Chernobyl NPP.

Since the catastrophe a comprehensive set of activities has been implemented in the Republic of Belarus to maintain the health of the affected population.

In 1993 a system for the registration of the people affected by the Chernobyl catastrophe was established and has been operating in the Republic of Belarus in the form of a State Registry in accordance with the "Regulations on the State Registry of the People Exposed to Radiation Caused by the Catastrophe at the Chernobyl NPP, Other Radiation Accidents" as adopted by the resolution of the Council of Ministers of the Republic of Belarus No. 773 dated 11.06.2009.

The State Registry, which ensures collection and analysis of personal health and dosimetric information about the population exposed to the impact of the radiation, is an essential tool and an information basis for shaping up the targeted approach to rendering specialized medical aid to the people affected by the Chernobyl catastrophe.

The data of the State Registry of the People Exposed to Radiation Caused by the Catastrophe at the Chernobyl NPP, Other Radiation Accidents are used for studying the structure and dynamics of morbidity, disablement, mortality, for performing comprehensive radiation, epidemiological and statistical analysis, elaboration of methods and criteria for determining the groups of elevated radiation risk, as well as the analysis and control of the periodic medical examination of the population.

The database of the State Registry contains personalized data of registration nature about diseases, their treatment and fates, about the performed monitoring, exposure doses, including individual absorbed doses and accumulated effective doses.

Currently information about the following categories of people has been accumulated and has been constantly updated in the database of the State Registry:

- participants of the cleanup works at the Chernobyl NPP and other radiation accidents;
- evacuees, relocatees, those who moved independently from the radioactively contaminated territory within the evacuation zone, primary resettlement zone and subsequent resettlement zone (including children who were not born yet), except for those who arrived in the said zones after January 1, 1990.
- people who fell ill and suffered from acute radiation sickness caused by the consequences of the catastrophe at the Chernobyl NPP, other radiation accidents, disabled persons for whom the catastrophe at the Chernobyl NPP, and other radiation accidents were established as the cause of their injuries or disease leading to disablement.
- disabled children under 18 for whom the catastrophe at the Chernobyl NPP, and other radiation accidents were established as the cause of their injuries or disease leading to disablement;
- children of the people affected by the catastrophe at the Chernobyl NPP, and other radiation accidents;
- people who permanently (predominantly) reside on the radioactively contaminated territories in the zones of subsequent resettlement, with the right to resettle, and partially about the people residing in the zone of periodic radiation control.

In accordance with the statutory requirements [12] the registration of people who resided in the radioactively contaminated territory in the zone with a right to resettle, zone of habitation with periodical radiation control, as well as residing (those who resided before) permanently (predominantly) in the settlements removed from the list of the said zones according to the procedure stipulated by the legislation of the Republic of Belarus, except for those who arrived to this territory after January 1, 1990 is going on.

At the district level 209 groups of state health care institutions of the system of the Ministry of Health, Ministry of the Interior, KGB, Ministry of Defence, and Ministry of Transport contribute information to the State Registry.

Organizational and methodological guidance, analysis, testing and verification of data are performed by 7 Oblast Divisions of the State Registry and one division of the State Establishment Republican Scientific and Practical Centre of Radiation Medicine and Human Ecology. By the beginning of 2010 there

was information about 390 thousand people subject to inclusion into the State Registry in the district databases, and about 280 thousand people in the republican database.

The establishments of the system of the Ministry of Health based on the findings of individual radiation counter measurements[1] assess individual internal irradiation doses of the population, analyze and interpret data for subsequent decision making on the expediency and feasibility of the social, medical and radiation protection measures.

Currently 36 fixed and mobile individual human counters operate within the system of the Ministry of Health. Annually data on the individual human counter measurements of caesium-137 content in the body are sent to the State Dosimetry Registry, based on which the doses of internal irradiation are calculated for over than 100,000 people.

Out of all examined population there are 0.3-0.4 per cent with the internal irradiation dose exceeding 1 mSv. These are the people who regularly eat the "gifts" of the forest, and wild fowl. Health workers work individually with these people to raise their awareness.

To ensure permanent medical surveillance of the people affected by the Chernobyl catastrophe special periodic medical examination of the this category of people is carried out, a special system of medical provision has been put in place, including priority services of the medical and preventive treatment facilities and pharmacies, free medicines according to doctor's recipes, provision with food at a higher standard when under therapy, etc These tasks are implemented by territorial medical and preventive treatment facilities, as well as with the aid of specialized field medical teams and medical personnel working on the contaminated territories on a rotational basis.

The periodic medical examination of the affected population is the basis for the treatment and preventive measures aiming to reduce the health consequences of the Chernobyl catastrophe. During the periodic medical examination the following objectives are pursued:

- dynamic health surveillance of the affected population;
- active detection of diseases at early stages, adjustment of the diagnosis, arrangement of therapy;
- identifying persons with risk factors contributing to the emergence and development of diseases;
- implementation of preventive and rehabilitation and recuperation activities.

The periodic medical examination of the population affected by the catastrophe at the Chernobyl NPP as well as the operation of inter-agency expert councils on establishing the causative relation between diseases and the consequences of the catastrophe are funded from the republican and local budgets, out of the resources allocated for the implementation of the assignments of the State Programme.

The record keeping of the people subject to periodic medical examination, planning, medical examinations and their analysis, provision of medical aid and treatment and rehabilitation activities are performed at medical and preventive treatment facilities at their place of residence or work.

Medical examinations of the population are mandatory on the whole territory of the republic. During periodical medical examinations preventive oncologic examinations and preventive tuberculosis screening are performed.

All people subject to periodic medical examination are distributed between 7 primary registration groups (1-7 PUG) and into four risk groups. People of all seven registration groups undergo medical examinations annually, once a year.

People of the first primary registration group (subgroup 1.1 – those who took part in the cleanup of the effects of the catastrophe at the Chernobyl NPP in 1986-1987 within the evacuation (exclusion) zone; subgroup 1.2 – in 1986-1987 in the zones of primary and subsequent resettlement, and in 1988-1989 within the evacuation zone), and second primary registration group (evacuees, relocatees or those who independently left the evacuation zone in 1986) are obligatorily examined by a therapeutist, endocrinologist, ophthalmologist, otolaryngologist, neurologist, gynaecologist, oncologist, as well as undergo examination including blood test with thrombocytes count, ECG, thyroid gland ultrasonic scanning.

The persons of the third primary registration group (residing on the radioactively contaminated territories in the zones of primary and subsequent resettlement, relocatees or those who left these zones independently after the catastrophe, including children and adolescents) are examined by a paediatrician, therapeutist and endocrinologist, have their blood tested (blood sedimentation test, leucocytes, haemoglobin) and undergo dosimetric control.

For the people of the fourth primary registration group (born to persons of the 1-3 primary registration groups and their subsequent generations) only undergo a complete blood cell count. Examinations by specialists depend on the age group: adults are examined by a therapeutist; children and adolescents are examined by a paediatrician and an endocrinologist.

To the children of the fourth and fifth primary

[1] WBC whole-bodies counter measurements for internal exposure, meant for measure of gamma-emitting radio nuclides within human body.

registration group obligatory medical examinations are performed in accordance with the regulatory legal acts, which govern regular medical check-ups of children.

People of the fifth primary registration group (residing in the zones with the right to resettle and periodic radiation control, as well as those for whom the causative relation of the disease leading to disablement has been established, and those who left), referred to the B risk group, undergo annually mandatory radiation control (blood sedimentation test, leucocytes, haemoglobin), and a therapeutic examination.

For the people of the sixth primary registration group (those who participated in the cleanup works or affected by the accidents at other nuclear facilities) and the seventh primary registration group (children and adolescents with acute leukemias, thyroid adenoma and carcinoma and other malignant diseases; disabled persons whose disablement was caused by the catastrophe at the Chernobyl NPP, who did not have the status of "affected by the catastrophe at the Chernobyl NPP" before) a general blood cell count and an annual therapeutic examination (or a paediatrician) are performed obligatorily.

Consultations by other specialists and additional tests are performed for all registration groups as necessary.

Besides, three groups of elevated radiation risk are distinguished to render targeted medical aid and in-depth study of the medical consequences of the catastrophe:

Risk group A – people of the 1st and 2nd PUG who were in the evacuation zone in 1986.

Risk group B – people from the 3rd and 5th PUG aged 0-18 at the moment of the accident at the Chernobyl NPP (born 1968-1986).

Risk group C – people with repeated - within 2 or more years – levels of internal irradiation over 1 mSv/year.

As of 01.01.2010 there were 1,429,570 people, including 1,160,297 adults, 57,204 adolescents, 212,069 children undergoing periodic medical examination on the territory of the Republic of Belarus.

In 2009 1,406,524 persons (98.4 per cent) underwent medical examinations, in particular: adults – 1,137,253 (98%), adolescents – 57,204 (100%), children – 212,067 (100%).

In order to improve the quality of examination and treatment of the affected people 402 items of medical equipment worth BYR 23.5 billion were procured with the funds of the local budgets in 2006-2010. In addition to this, BYR 22 billion were channelled from the republican budget for the procurement of medical equipment.

To supply healthcare institutions situated on radioactively contaminated territories with healthcare manpower, a contract-based employment system for healthcare professionals has been introduced, and a medical institute has been opened in the city of Gomel. Admission of students to the medical institutes on condition of guaranteed placement after graduation in the areas in question has been widely used.

Activities implemented as part of Union Chernobyl programmes made a considerable contribution into the improvement of targeted medical aid to the people affected by the Chernobyl catastrophe. In 2002-2005 the construction and equipping of the Grodno Plant of Healthcare Products was completed to supply population of the affected districts of Belarus and Russia (Skidel) with medicaments. For the implementation of this activity RUR 323.7 million were allocated, including RUR 161.2 from the budget of the Union State, and RUR 162.5 million from the budget of the Republic of Belarus. Production units (pills, theca and drug products) were commissioned.

Based on the use of the substances of highly purified amino acids the production of drug products was organized with the capacity of 200 million pills and 50 million theca a year. Altogether 11,641 thousand packs of pills and 431 thousand packs of theca were produced in 2004. The plant adopted production of 10 drugs.

Under the same programme the construction and equipping of the specialized radiological dispensary in Gomel has been completed. For the implementation of this activity the Union programme envisaged RUR 1,470.4 million, including RUR 234.1 from the budget of the Union State, and RUR 1,236.3 million from the budget of the Republic of Belarus. Under the instruction of the President of the Republic of Belarus and for improving the efficiency of the scientific and practical activities aiming to mitigate the consequences of the Chernobyl catastrophe, by the order of the Ministry of Health of the Republic of Belarus the Republican Scientific and Practical Centre for Radiation Medicine and Human Ecology was established at the Gomel specialized dispensary. The centre included:

- a specialized radiology dispensary;
- an in-patient clinic for 450 patients;
- scientific units.

The opening of the Republican Scientific and Practical Centre for Radiation Medicine and Human Ecology allowed to bring medical aid closer to the most Chernobyl affected region of the Republic of Belarus – Gomel Oblast. At the same time the system of scientific and practical institutions dealing with the health problems was cardinally reorganized. The Centre is a unique complex for rendering qualified medical aid to the citizens of Belarus and Russia affected by the Chernobyl catastrophe.

As part of the State Programme 2006-2010 27

projects for the development and promotion of high-end medical technologies and best practices in providing specialized medical aid to the people have been implemented at national medical centres and Belarusian healthcare institutions. Among them there are: technologies of binocular entoptoscopy, 2D and 3D eyebulb scanning, optical coherence tomography, fluorescent angiography, funduscopic examination, eye bulb surgery, endolaser surgery, automated cytogenetic monitoring of chromosomal aberrations, detection of "sentinel lymph nodes" in case of breast malignant tumours; a multiparameter immunophenotypic evaluation and monitoring of treating acute leukemias and lymphomas in children. The technology of remote on-line and off-line telemedicine consultations is introduced. The technology allows to receive consultations from the leading specialists of the Republic of Belarus, in certain cases replace direct consultations, which imply the need to visit the consultant considerably enhances the process of transmitting necessary diagnostic materials. Within the project the effective telemedicine consultations network has been established, which embraces the leading medical scientific and practical centres of the republic and 15 healthcare institutions of oblast and district level in Brest, Gomel and Mogilev oblasts. The system ensures at least 1000 consultations in oncology and cardiology annually.

High-tech medical equipment was procured to implement medical projects.

Considerable aid is also rendered by the world community.

In 2004 Belarus was included into the Japanese government's programme Grant Assistance to the Grass Roots Human Security Projects, which envisages implementation of humanitarian projects on the supplies of high-tech medical equipment to district hospitals and training personnel in Chernobyl affected districts. As part of the programme grant assistance has been allocated to the medical institutions of Gomel and Mogilev oblasts for implementing projects on the safety of population residing on contaminated territories. All in all, projects for the amount of USD 2 million have been implemented during the period from 2004-2010.

Republican Scientific and Practical Centre of Radiation Medicine and Human Ecology

Since 2006 the Government of the People's Republic of China donated to the Republic of Belarus for the districts affected by the catastrophe at the Chernobyl NPP medical equipment worth USD 2.4 million. The works on the reconstruction of the healthcare institution Gomel Oblast Clinical Cardiologic Dispensary involving surgery unit enlargement and equipping the facility with medical equipment worth USD 4.5 million were financed.

A project on establishing the International Scientific and Practical Centre for Thyroid Pathologies has been completed. Project budget amounted to €1.14 million. The project aim was to provide the insufficient scientific basis infrastructure and knowledge for further improvement of the diagnostics and treatment of thyroid diseases and achieve sustainable improvement of the state of health of the population affected by the catastrophe. The project included research aiming to enhance knowledge on radiation induced thyroid pathologies; establishment and equipping of the International Scientific and Practical Centre for Thyroid Pathologies designed to perform the diagnostics, treatment and dynamic surveillance of the patients, as well as dissemination of corresponding knowledge among healthcare professionals and patients.

Generally there is no considerable deterioration of the state of health observed for the entire affected population. This is to a great extent due to the smoothly run system of dynamic regular medical surveillance of the population. Cancer morbidity of the affected adult population does not exceed similar figures in the respective age and sex groups of the population of the Republic of Belarus. According to the majority of other figures the morbidity of this category of people is also within the average republican values.

3.3 Development of the System of Recuperation and Sanatorium-Resort Treatment of the Affected People

An essential role for the preservation of health of the affected population and maintaining it on the adequate level pays free sanatorium-resort treatment and recuperation.

According to the current legislation underage children residing on the radioactively contaminated territory; children residing on clean territories but going to school in the contaminated areas; and non-working disabled persons of categories I and II whose disablement was caused by the catastrophe at

the Chernobyl NPP are entitled to free sanatorium-resort treatment or recuperation.

In recent years vouchers have been issued to all children who displayed willingness of going for sanatorium-resort treatment and recuperation.

Children of pre-school age and disabled children are sent to resort institutions accompanied by one of the parents, schoolchildren go for recuperation and sanatorium-resort treatment mainly in organized groups accompanied by pedagogues.

Average annual coverage of the children affected by the catastrophe at the Chernobyl NPP with recuperation and sanatorium-resort treatment has been increasing from year to year (from 56.7 per cent in 2001 to 66.8 per cent in 2010) (Table 10).

Over 50 sanatoriums, resort and recreational institutions admit children from radioactively contaminated areas.

For the recuperation of the children going for treatment and recuperation in organized groups, a network of specialized resort institutions – children's rehabilitation and recuperation centres (CRRC) - has been established; these facilities feature everything necessary for the organisation of treatment and recuperation, academic process, social and psychological rehabilitation, and arrangement of children's leisure. Recuperation and sanatorium-resort treatment are implemented all year round.

In 2010 about 56.0 thousand children underwent sanatorium-resort treatment and recuperation at CRRCs, or 53.6 per cent of the total amount of those recuperated. In 2011 children's rehabilitation and recuperation centres will accept about 60 thousand children from the affected districts; others will be treated and recuperated at sanatorium-resort institutions.

CRRCs are located in the environmentally favourable districts of Belarus (Fig. 11), at a distance from major industrial plants, as a rule, close to reservoirs.

All CRRCs are equipped with modern medical equipment, which allows both treatment and diagnostics of the children. Physiotherapeutic rooms in CRRCs along with usual inhalation, oxygen cocktails and baths offer electrotherapeutics, phototherapy, thermotherapy, air, phyto and laser therapy, massage, circular douche, underwater massage douche.

During the recuperation of children preference is given to non-drug treatment methods, children are offered herbal teas made of medicinal herbs, oxygen cocktails, mineral water.

There is everything necessary for ensuring a continuous academic process at CRRCs. There are classrooms, and in many CRRCs there are whole schools with specialized chemistry, biology, ecology classrooms. Classes are organized in accordance with the curriculum for sanatorium-resort and recuperation facilities.

Much emphasis is placed onto the psychological aspect, which helps create favourable environment for the adaptation of the children who are far away from their families, and promotes creative development, self culture, self-actualization of the personality and a healthy lifestyle.

The duration of children's stay at CRRCs is 24 days, which is optimal for the complete course of treatment and recuperation.

Since 2002 funds for the organization of treatment and recuperation of children from Russia and Belarus residing in Chernobyl contaminated areas have been allocated from the Union State budget. These funds serve as a complement to the financing from the budget of the Republic of Belarus and do not only contribute to the enhanced coverage of the children affected by the Chernobyl catastrophe with treatment and recuperation, improvement and enhancement of their health, but it also plays a positive role in forming friendly ties between the young people of both countries within the Union State.

All in all, 3.5 thousand Belarusian children from the districts affected by the catastrophe at the Chernobyl NPP have undergone treatment and

Table 10. Information on the sanatorium-resort treatment and recuperation of children

Years	Subject to recuperation	Recuperated	Coverage, %
2001	405 926	229 883	56,7
2002	397 885	222 370	55,9
2003	357 912	212 220	59,3
2004	334 788	208 563	62,3
2005	275 196	177 011	64,3
2006	258 462	138 982	53,8
2007	213 099	138 524	65,0
2008	195 118	128 365	65,8
2009	174 418	115 003	65,9
2010	156 876	104 856	66,8

recuperation at the expense of the Union State.

Foreign countries render substantial aid to Belarus in recuperation of children. During the period from 1990 to 2010 827,000 Belarusian children went for recuperation abroad. The following countries received most people for recuperation: Italian Republic (over 399,000), Federal Republic of Germany (about 186,000), and Spain (about 75,000).

In 2010 the President of the Republic of Belarus and the Government assumed a number of additional measures aiming to improve the organization of sanatorium-resort treatment and recuperation of children residing on radioactively contaminated territories. Among them: entitling children to free travel to recuperation as part of organized groups; provision of parents who accompany children of pre-school age for treatment with vouchers at reduced price, free sanatorium-resort treatment and recuperation of schoolchildren residing on clean territories but going to schools on radioactively contaminated territories; provision of children when at recuperation with medical procedures and suchlike.

3.4 Organisation of Radioactive Contamination Monitoring

Monitoring of the radioactive contamination of water bodies, soil and air, updating information on the radiation situation at the Belarusian sector of the Chernobyl 30-km zone, control of radioactive contamination of the territories of settlements and sites to assess conditions for living and production activities on the territories contaminated as a result of the catastrophe at the Chernobyl NPP are performed by the subdivisions of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus (Fig. 12). State Establishment Republican Centre for Radiation Control and Environment Monitoring (RCRCEM) of the Hydrometeorology Department is the leading organization in this activity.

Fig. 11. A sketch map of the location of CRRCs

Zhdanovichi CRRC (Minsk Oblast, Minsk District, Zhdanovichi settlement)

Nadezhda CRRC (Minsk Oblast, Vileika District, Budischa village)

Considering the specific character of radioactive contamination of certain regions, their landscape and geochemical peculiarities the network of permanent monitoring of the environment has been organized in the Republic of Belarus (Fig. 13), which includes 121 reference sites and 19 landscape and geochemical grounds.

In 15 posts of continuous monitoring situated in Gomel Oblast (Bragin, Gomel, Zhitkovichi, Zhlobin, Lelchitsy, Mozyr, Narovlya, Khoiniki, Chechersk), Mogilev Oblast (Klichev, Kostiukovichi, Mogilev, Slavgorod) and Brest Oblasts (Drogichin, Pinsk) gamma-radiation dose rate (DR) is measured on a daily basis.

The analysis of the measurements of gamma-radiation dose rate collected in the radiation and environmental monitoring network currently demonstrates that average annual levels exceeding pre-accident values are registered in the following towns within the radioactively contaminated zones: in Bragin – 0.57 μSv/h, in Narovlya – 0.48 μSv/h, in Khoiniki – 0.24 μSv/h, in Chechersk – 0.23 μSv/h, in Slavgorod – 0.22 μSv/h. On the rest of the territory the DR did not exceed the natural background gamma radiation (up to 0.20 μSv/h). At other observation posts DR levels are comparable to the pre-accident values.

Upon the introduction of automated control systems the system of radiation monitoring of the environment currently in effect secures a high level of the national response system in case of technogenic emergencies.

At 11 posts (Bragin, Gomel, Lelchitsy, Mozyr, Narovlya, Khoiniki, Chechersk, Kostiukovichi, Mogilev, Slavgorod, Pinsk) radioactive fallout from the atmosphere is monitored (horizontal panels are mounted). The content of radioactive aerosols in the air is monitored daily in Mogilev, Gomel, Mozyr and Pinsk with filter installations.

The activity of radionuclides in the atmospheric

Zhemchuzhina CRRC (Vitebsk Oblast, Lepel District, Borovka village)

Ptich CRRC (Gomel Oblast, Petrikov District, Kopatkevichi settlement)

Lesnaya Polyana CRRC (Grodno Oblast, Smorgon District, Zhodishki village)

ground level is to a great extent determined by the content of dust in the air, that means processes of secondary wind uplift, while precipitation reduces activity of radioactive aerosols in the atmospheric air by 3-4 times. Content of caesium-137 and aggregate beta-activity in the atmospheric air corresponded to the established longstanding values (control levels of aggregate beta-activity of radioactive aerosols when protective measures are undertaken are 3,700x10-5 Bq/cub.m) Activity of natural radionuclides in the ground layer corresponded to the average annual values recorded during many years.

Radiation monitoring of surface waters is performed on six Belarusian rivers which flow through Chernobyl contaminated territories: the Dnieper (Rechitsa), the Pripyat (Mozyr), the Sozh (Gomel), the Iput (Dobrush), the Besed (Svetilovichi village), the Lower Braginka (Gden village).

The existing system of monitoring radioactive contamination of surface waters allows to perform an operative assessment of the content of radionuclides in water and their carry-over through controlled section lines during flood tides.

If during the first days following the catastrophe at the Chernobyl NPP the increase of radionuclide concentration in water was preconditioned by the direct fallout onto the water surface, now contamination of water systems is determined by secondary processes:

- outwash of radionuclides from the river watershed area with rain, snowmelt and floods;
- radionuclide exchange in the "bed silt – water" system;
- radionuclide redistribution along the riverbed by means of transport with the water flow in soluble form or deposited on suspended matter.

Nowadays, when the radiation situation has become stable there is considerable washout of radionuclides from the watershed areas only of those rivers, whose watersheds lie partially or fully in the Chernobyl NPP exclusion zone.

Currently average concentrations of caesium-137 and strontium-90 in all monitored rivers except for the Lower Braginka (village of Gden) were much lower the republican permissible levels for potable water (as for caesium-137 – 10 Bq/l, for strontium-90 – 0.37 Bq/l). For example, caesium-137 content in the Pripyat (Mozyr) was between 0.008 and 0.012 Bq/l, in the Sozh (Gomel) – between 0.008 and 0.052 Bq/l, the Besed (village of Svetilovichi) – between 0.01 and 0.064 Bq/l. Content of strontium-90 in the Pripyat river (Mozyr) was between 0.006 and 0.018 Bq/l, the Sozh (Gomel) – between 0.019 and 0.043 Bq/l, the Besed (village of Svetilovichi) – between 0.021 and 0.040 Bq/l. One should note that these values of caesium-137 and strontium-90 activity are still higher as compared to the pre-accident values.

Content of strontium-90 in the Lower Braginka (village of Gden) exceeds RPL-99 hygienic regulations (by 2.5-15 times). An elevated content

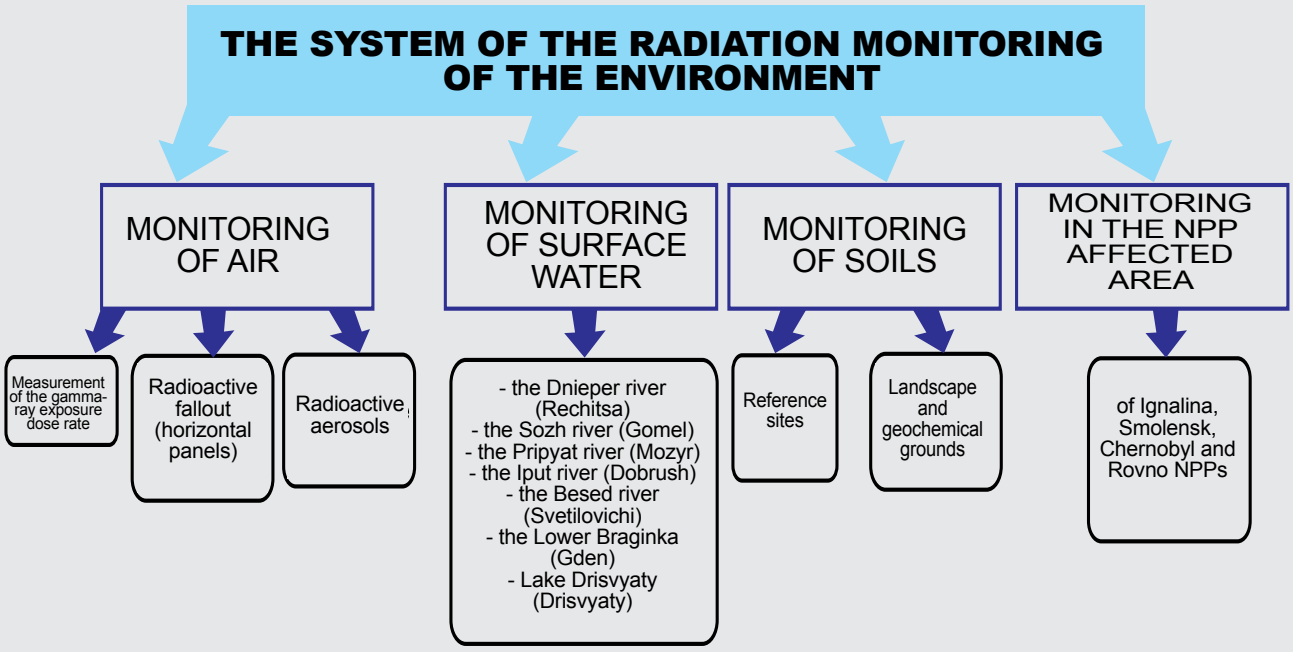


Fig. 12. Radiation monitoring system in the Republic of Belarus

of radionuclides in the surface waters of this river is predetermined by their washout from the watershed area, which lies partially within the Chernobyl NPP exclusion zone.

The assessment of the transfer of radioactive contamination through trans-boundary section lines is done on the Pripyat, Iput and Besed rivers.

According to the data obtained during radiation monitoring at the Pripyat river (section line at the Belarusian-Ukrainian border) trans-boundary carry-over of caesium-137 has reduced greatly with the course of time. The aggregate carry-over of this radionuclide by the surface waters of the Pripyat river (section line at the Belarusian-Ukrainian border) within the period from 1987 to 2009 amounted to 36.89 TBq (a terabequerel is 1012 Bq).

The trans-boundary carry-over of strontium-90 depends on the extent of the annual flooding of the shores of the Pripyat river. The aggregate carry-over of this radionuclide by the Pripyat river (section line at the Belarusian-Ukrainian border) within the period from 1987 to 2009 amounted to 69.63 TBq.

Iput and Besed rivers are the largest tributaries of the Sozh river, which flow over the Belarusian-Bryansk "caesium spot", where area contamination with caesium-137 varies from 1 to 60 Ci/sq.km.

If in the first years following the catastrophe at the Chernobyl NPP considerable carry-over of caesium-137 by the surface waters of these rivers was recorded, nowadays the trans-boundary carry-over of caesium-137 with the waters of the Iput (Dobrush) and Besed (village of Svetilovichi) is minor and does not exceed 1 per cent of its entire resource in the watershed.

Concentrations of caesium-137 in large and medium rivers have decreased considerably by means of dynamic processes of water carrying over, sedimentation of suspended matter onto the bottoms of water bodies and natural decay. The main factor for the reduction of caesium-137 concentration in the surface waters of the said rivers is significant decrease of radionuclide washout from the watershed surface associated with the reduced amount of its exchange forms in soils.

In closed and slowly running aqueous systems of lake type the activity concentration of caesium-137 and strontium-90 in surface waters approaches, and in a number of cases exceeds (in the Chernobyl NPP exclusion zone) sanitary and hygienic standards of the Republic of Belarus. Lakes, closed type reservoirs and reclamation works are characterized by high levels of caesium-137 accumulation in bed silt (up to 49,000 Bq/kg).

A network of landscape and geochemical grounds (LGG) operates to study the processes of radionuclide migration in the soil.

One of the essential issues is study of the vertical migration of radionuclides. Identifying the character of this process allows to establish the consistent patterns of soil self-purification of various genesis, and assess the potential for radionuclides getting into ground waters.

Now the intensity of migration processes has reduced.

The reduction of the linear velocity of radionuclides migration – those which migrate

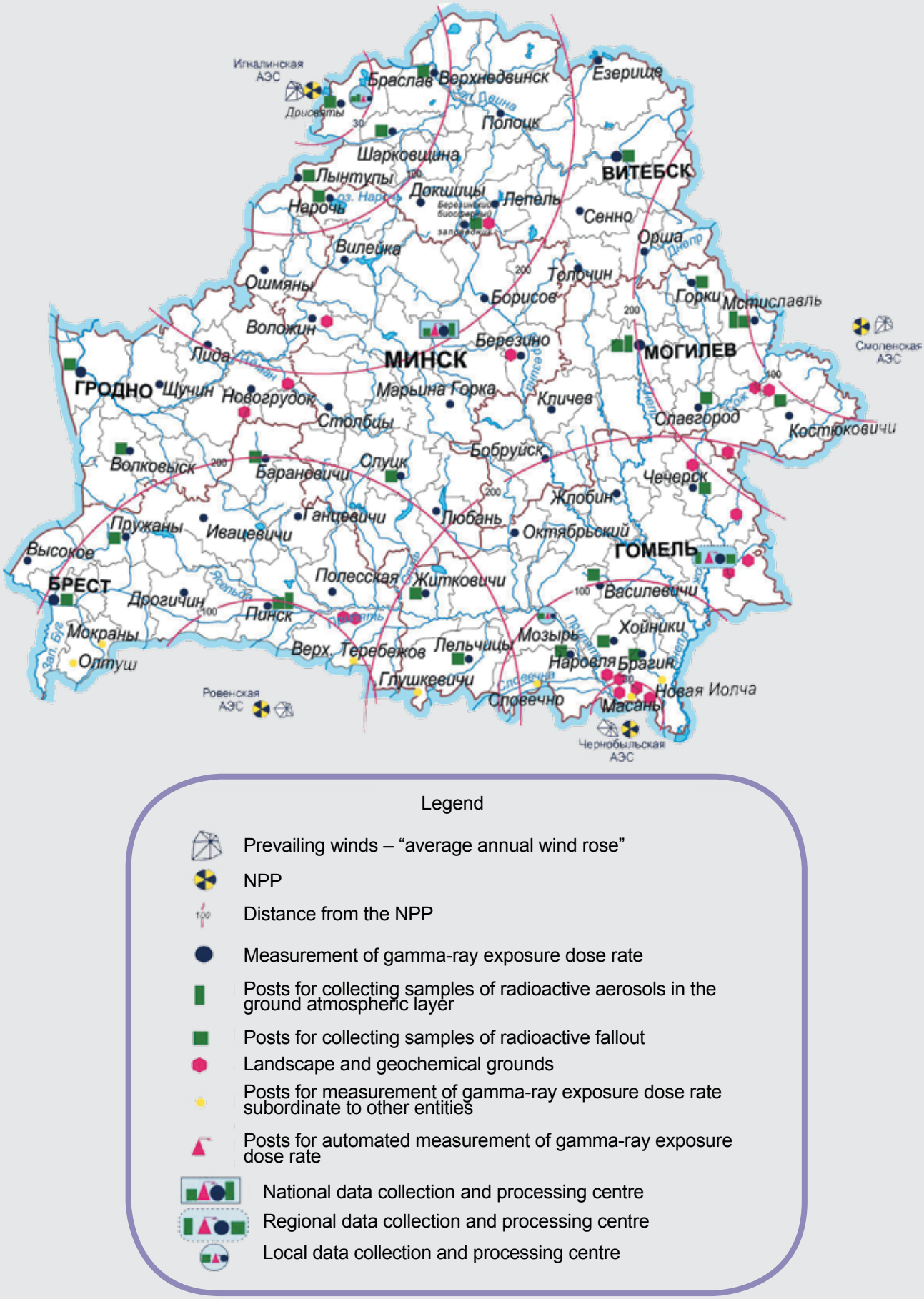


Fig.13. Nationwide network of the radioecological monitoring of the environment

deep into the soil with the moisture flow as part of colloid particles – has been registered in soils with various hydromorphic features. If during the first years after the catastrophe at the Chernobyl NPP convective diffusion played a noticeable part in the redistribution of the mobile portion of radionuclides along the vertical soil profile, now the main mechanism determining migration is diffusion. In this regard there is stabilization of the parameters of vertical migration observed, linear velocity of caesium-137 migration has practically become equal in various types of soil within the period of observation (since 1993) and is equal to 0.2-0.35 cm/year. Similar trends, though to a lesser extent, are characteristic also of strontium-90.

This is explained by the fact that most radionuclides which fell out onto the surface of soil and started interreacting with the soil adsorbing complex are in the immobilized form, and this does not let caesium-137 penetrate soil profile along with colloid particles. The presence of geochemical barriers (thick layers of grass sod, humus horizons, layers of clay minerals, which immobilize radionuclides and hinder their penetration into deeper soil layers) also determines the reduced intensity of migration processes. The major share of radionuclides of caesium-137 and strontium-90 lie in the upper root layer of the soil.

Radiation situation on agricultural lands is updated by oblast chemicalization survey and design stations periodically, once in every four years. Soil samples are collected from every elementary site (average size of the site is 9 hectares). The analysis of the findings of radiological survey shows that today the radiation situation on farming lands has stabilized and shows a tendency to improve. Thus, since 1992, considering the decrease of the land use area by 2.6 per cent, the area of caesium-137 contaminated territories (contamination over 1 Ci/sq.km) has fallen by 25.8 per cent, and for strontium-90 contaminated areas (contamination over 0.15 Ci/sq.km) – by 34.6 per cent.

As a result of the catastrophe at the Chernobyl NPP forestland on a large part of the territory of the Republic of Belarus was exposed to radioactive contamination (20 per cent of the total forest resources of the republic).

During the period since the Chernobyl catastrophe forest ecosystems – possessing the capability of retaining radioactive isotopes and preventing their migration beyond the contaminated territory - acted as a kind of a barrier to the spread of radionuclides

The radiation situation in forests is monitored within the monitoring network which is a part of the system of the Ministry of Forestry of the Republic of Belarus; this network was established in 1993-1995 and it comprises 89 permanent observation stations. In 2003 the network was complemented with another 20 permanent sites in the district forestries of the Gomel and Mogilev State Production Forestry Associations and the neighbouring forestries of Bryansk Oblast of the Russian Federation. The contamination of soil with forest cover and live ground cover, trees of the main layer and their parts (timber, bark, branches, needles, leaves), young growth, shrub layer, plants of the live ground cover, mushrooms are monitored. Besides, over 100 control grounds were established in 2003 to study the contamination of mushrooms and berries. The changes of the radiation situation in the forests for the entire period of surveillance are consolidated into a database, which allows to forecast the dynamics for the contamination of forest ecosystems.

Steady (up to 2 per cent a year) decrease of the gamma ray irradiation dose rate is recorded, which is determined by radioactive decay, and migration of radionuclides deep into the soil.

The low rate of reducing the density of the contamination of soil, forest cover, gamma radiation dose rate, activity of the main components of forest plants provide the evidence as to the long-term character of the problems associated with radioactive contamination of forests as a result of the catastrophe at the Chernobyl NPP.

The intensity of the transfer of caesium-137 from soil to tree plantations changes depending on the conditions of growing – the type of forest, and forest site. Thus, uptake of radionuclides into pine trees for bilberry types of forest is maximal, and for codling and bracken types of forest it is minimal.

Content of caesium-137 in the trees of the main layer and their parts (timber, bark, branches with needles), as well as young growth trees and shrub species has been decreasing steadily.

Maximum accumulation of caesium-137 among the plants of the living ground cover has been established for mosses and ferns (Fig. 14).

Contamination of wild mushrooms with caesium-137 remains unvaryingly high. In the mushrooms which accumulate caesium-137 very intensely (milk mushroom, russule, goat's beard, yellow boletus, variegated boletus) transfer factor[1] amounts to 50x10-3 mI/kg. For the most valuable commercial species of mushrooms (chanterelle, porcino, rough boletus, orange-cup boletus) which belong to the medium accumulating group of mushrooms, in certain forest types the conversion factors approach the values, which secure content of caesium-137 in mushrooms within the permissible level.

[1] Transfer factor (TF) is the ratio of the specific activity of a radionuclide in a plant sample (Bq/kg) to the soil contamination density (kBq/sq.m)

Currently the area of the forest resources lying within the radioactively contaminated territory is 1.84 million hectares, or 19.6 per cent of the total area of forest resources of the republic. The major part of radioactively contaminated forests is under the supervision of the Ministry of Forestry of the Republic of Belarus (85 per cent) and the Department on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP (12 per cent). The forests of Gomel Oblast account for 1.2 million hectares or 63 per cent of the area of contaminated forests, and Mogilev Oblast – 0.5 million hectares (24 per cent).

The area of the forest resources in radioactively contaminated territories belonging to the organizations subordinate to the Ministry of Forestry is 1.57 million hectares (19.5 per cent of the total area). Annually the area of contaminated forests decreases (on average by 2.6 per cent), which fact is established based on the findings of the full-scale radiation survey of compartments over the area of 240-260 thousand hectares 915 per cent of the total contaminated territory of the forest resources).

The data of the radiation monitoring are submitted to the republican governing bodies, local executive and administrative authorities, legal entities, and are taken into account during the preparation of draft state programmes on the conservation of nature and environment protection, programmes on the mitigation of the consequences of the catastrophe at the Chernobyl NPP, programmes on securing radiation safety of the population, territorial comprehensive patterns of the conservation of natural resources and protection of the environment, surface and underground waters, as well as for informing the population about the radiation situation.

Utilization of the radiation monitoring data allows to secure activities on safe living on the contaminated territories.

3.5. Protective Measures in Agricultural Production

The large-scale contamination of the agricultural lands with long-lived radionuclides, determining the need to maintain the agricultural production in the situation of the radioactive contamination over a long period of time, is one of the most severe consequences of the Chernobyl disaster. The lands involved in the intensive agrarian production were contaminated.

The oblast chemicalization survey and design stations perform the radiation analysis of the environment every four years. Soil samples are taken from each quad (with the average quad size of 9 hectares).

As of January 1, 2011, 1009.9 thousand hectares of the agricultural lands contaminated with caesium-137 with contamination density of 37 – 1,480 kBq/sq.m (1-40 Ci/sq.km) are in use for agricultural production. Moreover, 348.2 thousand hectares of these soils are also contaminated with strontium-90 with contamination density of more than 5.6 kBq/sq.m or 0.15 Ci/sq.km.

The largest areas of agricultural lands contaminated with caesium-137 are concentrated in the Gomel Oblast (56.9%) and the Mogilev Oblast (26.6%). In the Brest, Minsk and Grodno Oblasts, the percentage of such lands in the total cultivated lands area makes respectively 7.7, 5.5 and 3.2 per cent.

Radioactive contamination in the agricultural products is mainly due to the root uptake of radionuclides by the plants and further consumption by livestock. At the same density of soil contamination with caesium-137 and strontium-90, the root uptake of the latter by the plants is on the average, due to its higher mobility, 10 times higher than that of caesium-137.

The accumulation of radionuclides in crops depends on the contamination density and type, the granulometric composition and agro-chemical properties of the soil, the biological characteristics of the plants.

The radionuclide transfer factors (TF), indicating the root uptake by the crops, vary with time, depending on the degree of fixation of caesium-137 and strontium-90 by the soil absorbing complex. Thus, from 2000 to 2010 the transfer factors for caesium-137 had decreased by 5–20% (by 5% in peaty soils and up to 20% in sod-podzolic soils).

The transfer factors for strontium-90 are lowering significantly slower than those for caesium-137. Within the next 10 years they are not expected to change significantly, which is taken into account in prognoses.

The transfer of radionuclides from forage to animal produce depends on the following:

- complete nutrition;
- well-balanced diets as regards the main mineral elements;
- the age of animals;
- the physiological condition;
- the productivity.

The contamination prognosis for animal produce is based on the data about the diet components contamination (i.e. the contamination of certain types of forage - hay, haylage, silage, etc.). In comparison with strontium-90, caesium-137 passes from forage to milk and meat more rapidly.

Since in most cases (50-70%) the radiation dose is formed due to the radionuclide intake from food products, the problem of reducing the radiation

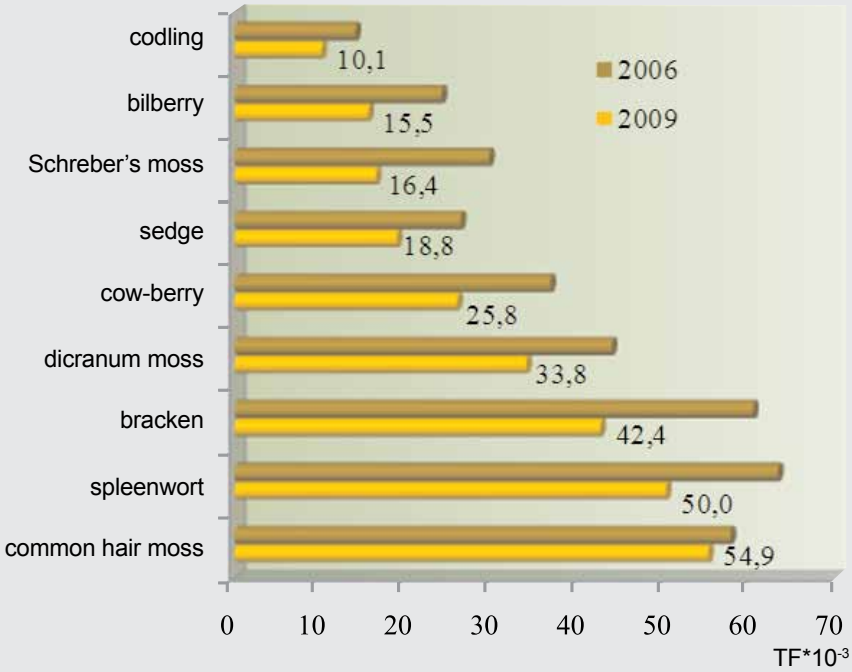


Fig. 14 . Caesium-137 transfer factors: soil to live ground cover plants

exposure for the population is addressed primarily through a set of agricultural protection measures.

Since the Chernobyl catastrophe and till the present day the agrarian production on the national lands contaminated with radionuclides has been maintained according to the scientific recommendations.

The national agrarian institutions have developed a set of agrochemical, soil-reclamation, and technological protection measures to repeatedly reduce the intake of radionuclides in agricultural products. Every 5 years the "Recommendations on agricultural production management in the situation of radioactive contamination of lands in the Republic of Belarus" are reviewed and updated.

The protective measures applied during the post-accident period can be divided into two stages: the first stage – from 1986 to 1992, and the second stage – from 1992 to the present days.

During the first stage, the lands with a high contamination density, where it is impossible to receive products with an acceptable radionuclide content, were removed from land use. Lupine, field pea, alfalfa, clover, vetch and other legumes, characterized by high accumulation of strontium-90, were excluded from the crop rotation; liming of acid soils was held widely; higher doses of phosphates and potash fertilizers were applied. In most of the wetlands the sod was drained and ploughed in and the hayfields and pastures were grassed and regrassed.

During the second stage the use of agrochemicals and agro-technical measures continued. The Recommendations were developed as regards the agricultural production management in the situation of radioactive contamination of lands in the Republic of Belarus, as well as the Republican Permitted Levels for caesium and strontium in food products and drinking water (RPL-99), the Republican Permitted Levels for caesium-137 and strontium-90 in agricultural raw materials and forages, and a number of recommendations and proposals for the production of crops with the minimum accumulation of radionuclides.

The data of the periodic agrochemical and radiological soil surveys and the permanent radiation quality control over the crop production serve as the guidelines for the implementation of protective measures.

The order of application of the protective and rehabilitative measures in the animal husbandry sector after the Chernobyl disaster can be subdivided into three stages.

the 1st stage – 1986–1989 – was the period of restrictive countermeasures to prevent the effects of the radiation damage in the animals and the radionuclide intake in the animal produce;

the 2nd stage – 1989-2000 – was the period of active and widespread use of melioration, zootechnical and veterinary measures to reduce the intake of caesium-137 and strontium-90 by the animal produce;

the 3rd stage - since 2000 – has been the rehabilitation period, characterized by the extensive use of the most efficient and cost-effective protective measures, the widespread use of the organizational countermeasures and the implementation of the development and rehabilitation programs for the most contaminated farms.

The system of protective measures applied in the agrarian production is shown in the diagram (Fig. 15).

Land use optimization

Investments in agricultural sector can be effective only on soils with high and medium fertility. Therefore the optimization of the land use is carried out stage by stage and based on the cadastral valuation of the fields and land plots with regard to their fertility, technological properties and location. The unproductive plots of arable land with a low assessment score (less than 20) are converted into grasslands. These lands are grassed and used for fodder production. The least fertile sandy and marshy soils with a density of caesium-137 exceeding 555 kBq/sq.m and a density of strontium-90 over 37 kBq/sq.m are reforested. The economic effect of removing of one hectare of unproductive soils from arable lands is estimated to be equivalent to USD 50 per year.

Cropping mix optimization

The selection of crops and varieties with the minimal accumulation of radionuclides is the most affordable means to reduce the root uptake of radionuclides by the crops.

The forecast as regards the likely contamination of the crop production enables planning in advance of a cropping mix suitable for cultivation on the contaminated lands, rotating the crops on the fields and individual sites with account to the different purposes of the products (food product, forage, raw material for further industrial processing, etc.).

An important protective and economic measure is to change the current structure of the areas under crops towards a larger proportion of high-protein legumes: clover, alfalfa, pea, lupine, etc. Within the first years after the catastrophe, legumes were removed from the crop rotation as crops, which accumulate higher concentrations of caesium and strontium radionuclides. The protein shortage problem is partially solved through the expansion of the rape crop area, the crop which has virtually no restrictions in respect of the density of radionuclide soil contamination. The cropping mix for the crop rotation is reasonably enriched with the high-yielding crops - rape, sunflower, wheat, corn, flax, etc., depending on the soil properties, the type of the radionuclide contamination, the resource potential.

Soil fertility improvement

A deficit-free balance of humus, phosphorus and potassium ensures good quality product with an acceptable radionuclides content and the proper return on investment in the agricultural production sector. The use of fertilizers at an application rate of 200-250 kg per one hectare of the area under crop is one of the prerequisites of self-sustaining crops production.

Along with the traditional protective measures – liming, applying higher doses of phosphatic and potash fertilizers – the full doses of new nitrogenous and complex fertilizers are applied. The use of the slow-acting forms of carbamide, ammonium sulphate and compound fertilizers, specially balanced for certain crops, can improve the payback through a yield increase by 20-40 per cent. For example, humated carbamide enhances the payback of 1 ton of nitrogen per 5 tons of forage units, with a net gain of USD 250. The new form of carbamide does not create a short-term surplus of mineral nitrogen compounds in the soil and does not cause the additional accumulation of radionuclides in the agricultural crop yield. Therefore, the loss of nitrogen is reduced by one-third and radionuclides and nitrates concentration in the product is lower by 10-30 per cent as compared to standard mineral fertilizers. The use of minimal doses of microfertilizers in the form of foliar fertilizing will ensure an improvement in the quality and quantity of the food and fodder crops yield. The complex use of plant protection products increases the yield of winter and spring crops by 6-8 kg/ha and raises the return on fertilizers by 20-35 per cent.

Re-specialization

Where a scientifically grounded set of special protective measures fails to achieve the sustainable production with a high radiological quality, the agricultural organizations have implemented re-specialization (reorientation) programs.

In the animal breeding sector the re-specialization aims to redirect the dairy production towards beef raising, or towards the reconstruction of the existing livestock buildings for loose housing of the cattle in the loafing areas.

The calculations show that, when using 500 tons of feed units of bulky feed produced at an average density of soil contamination with strontium-90 of 20 kBq/sq.m and with caesium-137 of 1,000 kBq/sq.m, approximately 2.9 MBq of radioactive strontium and approximately 67.6 MBq of radiocaesium would pass to the milk. The consumption of such dairy products by the population may result in a collective internal radiation dose equal to 1.1 Sv. When using the same feed for beef production, the collective dose will make only 0.04 Sv, or about 3 per cent of the dose received through the consumption of the milk contaminated with radionuclides. Thus, from the radiological point of view, cattle raising and fattening for meat production is much more preferable than dairy cattle breeding.

In case of consumption of bread and bakery made of 500 tons of contaminated grains with the activity of caesium-137 equal to 40 MBq and that of strontium-90 equal to 22 MBq, the collective public

exposure dose may be equal to 0.87 Sv. But if use this grain for fattening cattle, pigs and broilers, the internal dose received through the consumption of their meat will make respectively 0.02, 0.03 and 0.03 Sv. In other words, the population exposure dose can be reduced by 20-30 times.

The re-specialization in the crop production sector is based on the acreage structure improvement through growing crops with the minimal accumulation of radionuclides, on the development of seed farming as regards crops and perennial herbs, and on the increased forage production to meet the full demand.

In 2010 the execution of the presidential orders was completed related the development and implementation of the programs on re-specialization of the farms in order to ensure the clean production. The re-specialization programs were implemented in 57 farms, or in 19 per cent of all agricultural organizations possessing contaminated lands in Gomel and Mogilev Oblasts. Within the period from 2002 to 2010, BYR 142 billion were allocated for the implementation of these programs, including the farms of the Gomel Oblast – BYR 109 billion, and in Mogilev Oblast – BYR 33 billion.

Creating Cultivated Grasslands and Hayfields

An important protective measure is the creation of improved pastures and hayfields at a rate of 1 ha per cow in the public and private sectors with the mandatory renewal of the sod every 4-5 years and the annual fertilization of the grass. The special agricultural works are provided for in order to ensure the quality of the grass on the greenlands.

Radical improvement and surface improvement of greenlands

This measure is the most efficient in the feed production; it reduces the contamination of the grass by 2-6 times. During the first 10 years after the catastrophe, the radical improvement of the low productivity grasslands was carried out everywhere, in all farms. Today, on the area of 500 hectares with the contamination density less than 185 kBq/sq.m (out of the total 660 thousand hectares contaminated exclusively with caesium-137) one can receive clean forage which meets the standards, provided the greenlands fertility level is maintained. The remaining 160 thousand hectares are mainly unproductive greenlands needing a radical or a surface improvement of the hayfields and pastures, which guarantees the production of standard clean milk if use them for pasturing and feeding the dairy cattle.

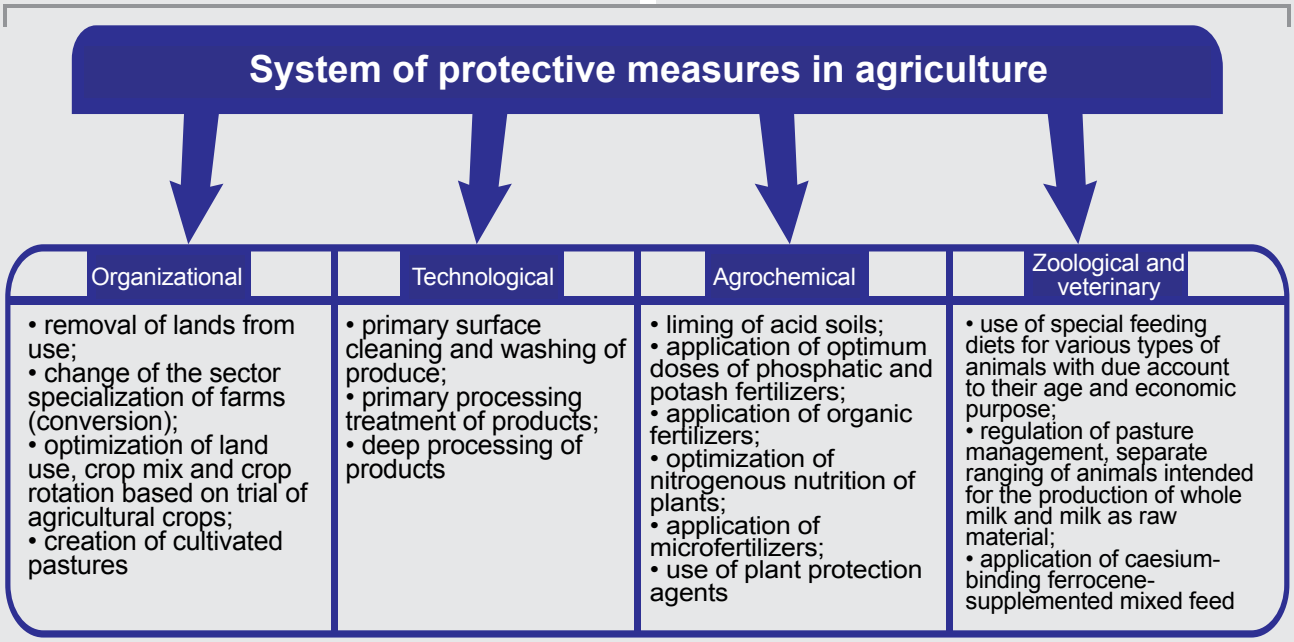


Fig. 15. System of protective measures in agriculture

Currently, the improvement of the pastures used for private cattle grazing is carried out as a protective measure with a priority for those settlements, where content of caesium-137 in milk exceeded the acceptable levels in the previous years.

By dressing grasslands with well-balanced fertilizers the productivity and duration of their use can be doubled, and the cost of the green fodder production can be reduced by one third.

Applying caesium binding agents

The content of radiocaesium passing to the animal products (meat, milk) decreases twice or more times, when caesium binding drugs are added to the rations of animals; these agents bind radionuclides selectively in the gastrointestinal

tract. For this purpose, the production and delivery of the boluses and the special ferrocene-supplemented mixed feed was organized.

In recent years, the ferrocene-supplemented mixed feed has been provided for the private dairy cattle in those settlements where there are no sufficient areas of improved pastures and hayfields. Altogether, during the period from 2001 to 2009, ferrocene drugs were provided for 88.2 thousand head of private dairy cattle in the villages with the insufficient area of improved pastures and hayfields.

Quantifying of the protective measures effectiveness is based on the two criteria. First, the data are compared on the content of radionuclides in the main types of raw products (milk, meat and grain) supplied by the large farms and smallholders across the affected regions and oblasts.

If the content of radionuclides in the products, revealed through the radiation monitoring, stabilizes at a level below the requirements of the sanitary standards (RPL-99) or continues to decline, the ongoing protective measures are considered effective. If the average content of radionuclides in the agricultural raw products, supplied for further processing, increases within 2 years or more, the protective measures are subject to correction (Table 11).

The results of the radiological control of milk produced in the smallholdings, carried out by the sanitary-epidemiological service of the Ministry of Health and by the dairy enterprises, are also used to assess the effectiveness of the protective measures.

Secondly, an important criterion in respect of the effectiveness of the agro-chemical protective measures is the dynamics of the proportion of soils with the optimum agrochemical parameters or of the improved grasslands and pastures. The evaluation according to this criterion is held once every four years by comparing the results of the two rounds of the agrochemical inspection of the farms and territories.

The application of the countermeasures during the first years after the catastrophe at the Chernobyl NPP (1987-1992) proved to be highly efficient. There was a significant decrease in the uptake of caesium-137 by the agricultural crops, which reduced the collective internal exposure dose through the food products consumption. The effectiveness of the protective measures in the crop sector during the next post-catastrophe period (1992-2005) decreased on average by 20-50 per cent. For the post-catastrophe period the intake of caesium-137 in agricultural products has lowered by 10-12 times. The intake of strontium-90 in foods since 1986 has been reduced by 3 times, mainly due to the protective measures applied. The data on the effectiveness of some protective measures are given in Table 12.

Whereas in 1986-1987 the production of grain and potatoes, unfit for the use for food purposes due to the high content of caesium-137, amounted to 340 thousand tons and to 89.5 thousand tons respectively, now virtually all the grain meets the hygienic regulations as to the content of caesium-137 (Fig. 16), and the potatoes and vegetables meet the

Table 11. Measures of efficiency of the application of agrochemical protective measures

Indicator	Variant, scenario	Conclusion on the efficiency of countermeasures	Data source
Production of products in the district, oblast with excess content of radionuclides (for 2-5 years with RPL being the same)	Reduced amount of products (or no products detected) with excess radionuclide content	Countermeasures are efficient	Sanitary and epidemiological service, veterinary service, laboratories of the Ministry of Agriculture and Food and processing plants
	Increased production of products with excess content of radionuclides	Countermeasures are not efficient	
Reduced content of radionuclides in crops and animal products	Radionuclide concentration in the products decreases or remains at the same level	Countermeasures are efficient	Sanitary and epidemiological service, veterinary service, laboratories of the Ministry of Agriculture and Food and processing plants
	Radionuclide concentration in the products increases	Countermeasures are not efficient	
Fertility improvement of the soils contaminated with radionuclides (within the period of four and over years)	Maintaining soil fertility indexes (pH, content of mobile forms of potash and phosphorus), increased share of soils with optimum agrochemical indexes	Countermeasures are efficient	Oblast chemicalization survey and design stations, data from two and more tours of agrochemical inspection of soils
	Reduction of soil fertility indexes (pH, content of mobile forms of potash and phosphorus)	Countermeasures are not efficient	

regulations both as to the content of caesium-137 and strontium-90.

In 1986-1987, in the public sector the production of milk with a higher than the permissible content of caesium-137 amounted to 524.6 thousand tons. In 2008, in the most severely contaminated Gomel Oblast, only about 90 tons of milk with the content of caesium-137 from 100 to 370 Bq/l was produced and supplied for further processing. The levels of caesium-137 in the milk produced by the farms of the Mogilev Oblast and in the Brest Oblast did not exceed 37 Bq/l and 65 Bq/l respectively (with the permissible level of 100 Bq/l).

The measures taken have significantly improved the quality of the food produced in the private farms and smallholdings.

The number of the settlements, where at least one sample of milk is recorded with content of caesium-137 exceeding 100 Bq/l, has decreased by 2.7 times over the last three years. In 2010, there remained only 25 such settlements (Fig. 17).

The fattening of animals at the final stage with the feed with low content of radionuclides has virtually eliminated the return of the livestock from the meat processing plants due to the live dosimetry results. In 2008, only one head of cattle was returned. In 2009, all dairy products, beef and pork met regulatory requirements as to the content of radionuclides.

The implementation of re-specialization program ensured a steady decline in the radionuclides content in the products. Whereas in 2003-2005 the meat processing plants returned 83 head of cattle, supplied by the problem households, in 2009 and in 2010 no livestock was returned. All milk produced in 2010 was in line with the republican permissible levels of caesium-137 for whole milk (100 Bq/l). Meat and potatoes produced also complied with the permissible levels of caesium-137 and strontium-90.

The protective measures enabled the farms to prevent a significant reduction in the fertility of the contaminated lands, to neutralize the acidity on the main part of their lands and to increase the concentration of mobile phosphates on a part of the contaminated lands. A half of the arable land meets the optimum level of potassium.

Annually the national budget allocates USD 50-60 million, or USD 51-55 per 1 hectare of contaminated agricultural lands for the protective measures. The dynamics of the funding over the past 10 years is shown in Fig. 18.

In 1996-2010, on average about 70 per cent of the total funding for the protective measures in the agricultural production were allocated for the implementation of the protective measures in the agricultural sector. The largest portion of funding (59%) was spent on protective measures in the Gomel Oblast.

Table 12. Efficiency of some protective measures

Working method	Efficiency
Combination of the primary and additional cultivation jobs, subsoil tillage (chisel, disk) and minimum cultivation, taking account of the soil type, moistening pattern, application of high-capacity equipment	Reduction of radionuclide accumulation in crops up to 1.3 times
Soil liming	Reduction of radionuclide accumulation in crops by 1.5-3 times
Application of organic fertilizers	Reduction of radionuclide accumulation in crops up to 1.3 times
Application of new forms of slow-acting nitrogen fertilizers	Reduction of radionuclide accumulation up to 1.4 times, nitrates in potatoes, vegetables and feed crops
Application of phosphorus fertilizers	Reduction of Cs-137 accumulation in crops up to 1.5 times, Sr-90 – by 1.2-3.5 times
Application of potash fertilizers	Reduction of Cs-137 accumulation in crops up to 2 times, Sr-90 – up to 1.5 times
Selection of species and varieties of crops with minimum accumulation	Reduction of radionuclide accumulation in crops depending on the plant species up to 30 times, depending on the variety – up to 7 times
Radical improvement of hayfields and pastures	Reduction of radionuclide accumulation in grass stand by 2.5–6 times
Surface improvement of hayfields and pastures	Reduction of radionuclide accumulation in grass stand by 1.5 – 2.9 times
Application of caesium-binding ferrocene-supplemented mixed feed for cattle	Reduction of Cs-137 accumulation in milk and meat by 2-3 times
Special feeding diets for various types of animals with due account to their age and other factors	Reduction of Cs-137 accumulation in milk and meat by 1.5 – 2.5 times

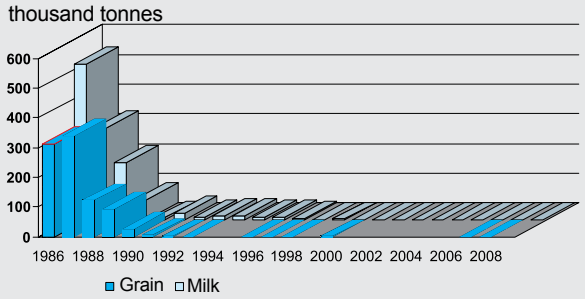


Fig. 16. Dynamics of the grain and milk production in the public sector of the Republic of Belarus with caesium-137 content in excess of permissible levels

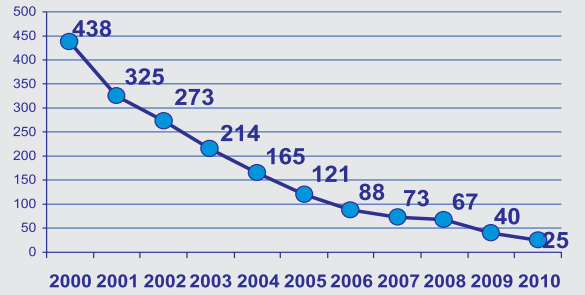


Fig. 17. Number of settlements where caesium-137 content in milk from smallholdings exceeds RPL-99, nationwide

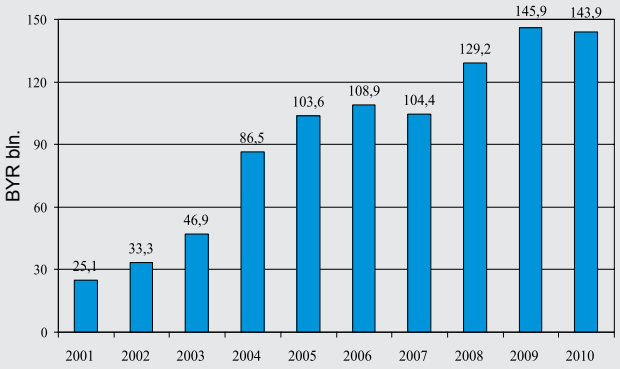


Fig. 18. Funding protective measures in agriculture

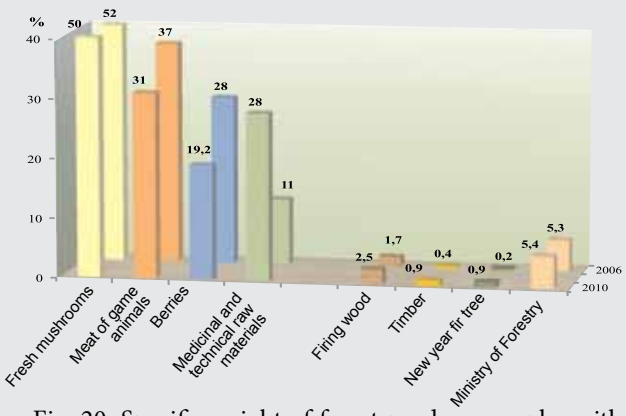


Fig. 20. Specific weight of forest produce samples with caesium-137 content in excess of permissible levels in 2006 and 2010

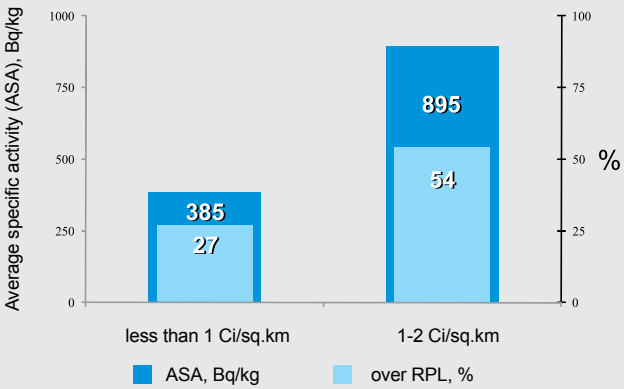


Fig. 21. Contamination of mushrooms of medium accumulation group with caesium-137 in 2010 in the context of different forest contamination density

The Instruction on the procedure for planning the need for material and technical resources and the funding for the implementation of the protective measures in the agricultural production sector in the territories with radioactive contamination, approved by Resolution of the Ministry for Emergency Situations No. 86 dated August 6, 2008 (National Register of Legal Acts of the Republic

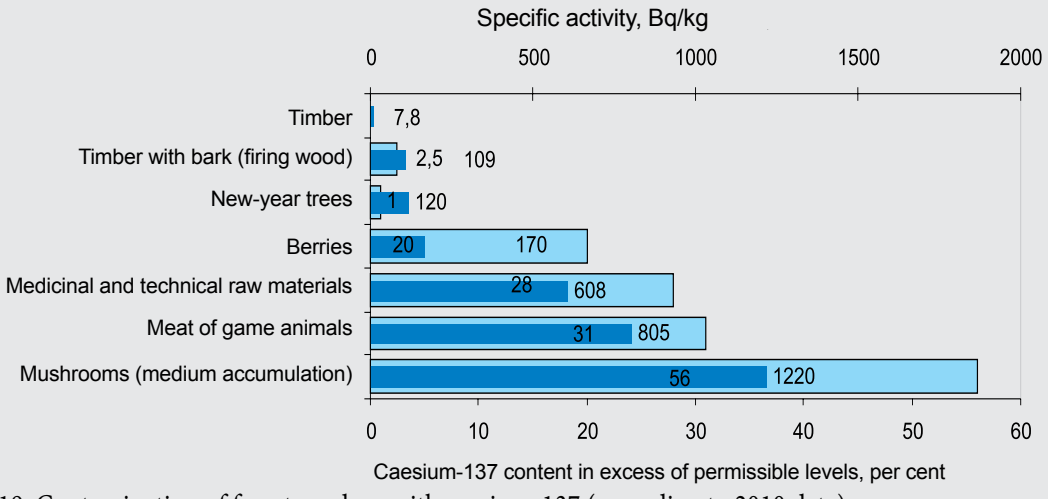


Fig. 19. Contamination of forest produce with caesium-137 (according to 2010 data)

of Belarus, 2008, No. 265, 8/19702), provides for liming of acid soils, supplying of phosphate and potash fertilizers, creating cultivated meadowlands, supplying of mixed fodder with a caesium binding supplement, etc. The scope of the main protective measures is shown in Table 13.

The agro-chemical protective measures combined with the modernization of the technical and technological infrastructure of the farms are the main strategic core of the system of radiation protection and rehabilitation of the rural settlements located in the contaminated areas. The agricultural production sector is also an important resource for employment of the population in the affected areas.

For sustainable economic development of agricultural production in the contaminated areas farms need to further take the protective measures in the crop and livestock production sectors, employ qualified specialists and use the modern agricultural equipment and best practices.

The clean agricultural production in compliance with the standards can only be achieved on the contaminated lands through the planned transformation of the lands, the optimal cropping mixture and the proper use of the final product in compliance with the forecast of the crops contamination, with regard to the soil characteristics and the results of the radiation monitoring.

The need is obvious to focus on the implementation of the protective measures on the lands with a high density of contamination with caesium-137 and strontium-90, 185 – 1480 kBq/sq.m and 11 – 111 kBq/sq.m respectively, in the regions with the problem and low cultivated soils.

As for the lands with a lower contamination density, it is recommended to focus funding on the soils with extremely adverse properties and an increased uptake of radionuclides by the crops.

The priority remains for the economically sound and socially acceptable protective measures, targeted to improve the soils fertility and self-sustained agricultural production.

3.6 Measures in Forestry

Forests are of immense importance as to their environmental, social and economical significance, and the suspension of forestry activity and forest exploitation on the contaminated territories is not practical. Radioactive contamination violated the well-established regime of forestry activity and demanded adopting new approaches to performing works within areas of radioactive contamination.

The system of protective measures for the sustainable forest management in radioactively contaminated areas has been introduced and is operative, this system includes: organization and technical, technological, restrictive, information countermeasures.

Major protective measures include: forest recreation and forestation, protection of forests from fires, radiation control and monitoring, dissemination of information. Information countermeasures include scientific research, training and further training of the forestry specialists, permanent informing of the forest workers and the population on the radiation situation in the forest resources.

Table 13 Scope of protective measures in agriculture

Year	Liming of acid soils, thousand hectares	Creation of hayfields and pastures, thousand hectares	Application of phosphorus and potash fertilizers, thousand tons of active material		Application of caesium binding mixed feed, thousand tons
			P_2O_5	K_2O	
2001	35,6	10,4	24,5	84,1	1,7
2002	52,1	7,9	17,9	58,6	1,1
2003	48,9	8,1	13,6	64,3	1,2
2004	48,7	13,8	27,3	92,5	1,3
2005	44,0	15,6	30,3	109,4	1,4
2006	40,6	13,4	26,7	87,8	1,5
2007	29,1	5,1	24,3	83,9	0,7
2008	31,1	5,6	24,1	86,2	0,4
2009	29,5	5,1	24,6	83,9	0,6
2010	31,5	3,7	24,3	82,3	0,7
Total	391,1	88,7	237,6	833,0	10,6

To effectively implement protective activities there have been requirements designed for forestry in radioactively contaminated areas, radiation control, monitoring, which are reflected in the regulatory and technical regulatory legal acts (Table 14).

Implementation of a comprehensive set of protective measures, observing the regulations for economic activity in the radioactively contaminated forests allowed to secure the sufficient level of radiation protection for the forest workers – the average annual external radiation dose does not exceed 1 mSv.

Following the Chernobyl catastrophe former farming lands were transferred to the forest funds, as it was not possible to produce clean products (according to standard) on these lands. All such lands were examined as to the content of caesium-137 in the soil, compartments were formed, and plans for forestation were shaped up. Annually artificial crops are created to secure regeneration, improving the species composition and the quality of forests, as well as biological and landscape diversity.

Forest fires on radioactively contaminated territories apart from direct damage - destruction and damage to timber, violation of the forest environment, expenditure on fire extinguishing and cleanup after the fires – cause additional radioactive contamination of the surrounding territories. During fires concentration of radionuclides in the surface air increases due to lifting of forest flammable materials with warm streams of air, which considerably deteriorates the radiation situation and the conditions for extinguishing fire. Protective measures are first of all aimed at prevention of forest fires, their timely detection and quick extinguishment. For instance, the number of incidents of forest fires in the most contaminated forestries has been brought to a minimum. For example, in 2010, which was characterized by high classes of fire risk, the area of all sites devastated by fire in the Vetka specialized forestry (45 per cent of the territory within resettlement areas) did not exceed 5 hectares.

The system of radiation control has been established and is operative in the forests; this system includes two subsystems: radiation control and radiation monitoring. Organization departments of the radiation control service – accredited laboratories and posts – operate with state of the art radiometric equipment and technologies for the prompt processing of the results of radioactive control, including GIS technologies, and with due regard to the regulatory and technical regulatory legal acts – rules, technical codes and existing practice.

Annual radiation survey of the forest fund lands, forest use sites (cut-over lands), forestry facilities and working places, radiation control of forestry produce allow to secure compliance to the current standards and rules.

The results of the radiation control of forestry produce – timber and wooden articles, food resources, medicinal herbs – are necessary for taking decisions on forest felling, supply of firewood, chipped wood for fuel, beaded timber and sawn goods outside the republic, as well as mushrooms, berries, birch syrup. All sold products come with documents supporting their radiation safety - correspondence to the permissible radionuclide content level.

As a rule, timber does not exceed the established permissible levels (RPL/Forestry-2001) in case

Table 14 Regulation of forestry and other activities in radioactively contaminated zones
There are four zones distinguished in zoning of forest resources: zone I is the zone with caesium-137 contamination density of 1 to 5 Ci/sq.km, zone II – 5-15 Ci/sq.km, zone III – 15-40 Ci/sq.km, zone IV - 40 Ci/sq.km and over. Subzones IA – from 1 to 2 Ci/sq.km and IB – from 2 to 5 Ci/sq.km are distinguished inside zone I.
("+" – permitted "–" – forbidden)

Forestry activities	Zone (subzone)				
	IA	IБ	II	III	IV
Cultural work					
Seed harvesting	+	+	+	-	-
Growing of seedlings in nurseries	+	+	+	-	-
Promotion of natural regeneration	+	+	+	+*	-
Creation of artificial crops, attendance, technical stocktaking	+	+	+	+	+*
Conservation and protection of forests					
Forest fire protection	+	+	+	+	+
Forest protection from forest offence	+	+	+	+	+
Protection of forests from pests and diseases	+	+	+	+	+
Forest felling					
Final felling	+	+	+	+*	-
Improvement thinning	+	+	+	+*	-

of harvesting on the territories with the density of soil contamination with caesium-137 less than 15 Ci/sq.km. In case of higher density of contamination the violation of RPL in timber of various categories of technical feasibility makes from 15 per cent in industrial wood and up to 60 per cent in firewood.

Most contaminated forest produce is still wild mushrooms and berries, medicinal herbs. High content of caesium-137 in mushrooms and berries would restrict berrying and gathering mushrooms in the years to come (Fig. 19).

The share of forest produce with radionuclide content in excess of the permissible level has not changed within the last five years (Fig. 20). This is explained by the fact that the reduction of the contamination of forest produce is determined mainly by radioactive decay of caesium-137. Employment of efficient technological protective measures to reduce its intake through the root system of plants in forest ecosystems is limited.

In wild mushrooms levels of radionuclide content as a rule exceed permissible levels when density of soil contamination with caesium-137 exceeds 2 Ci/sq.km. In certain conditions of growing – with considerable reserves of radionuclides in the forest cover and the upper mineral layer of the soil such excess has been established also with density less than 1 Ci/sq.km, including also for the mushrooms characterized by medium accumulation of radionuclides (Fig. 21).

Depending on the species of animals for whom the hunt is going on and their nutritive base radionuclide contamination levels differ by several times, being still very high (Fig. 22).

Current radiation control ensures observation of radiation safety standards, that is non-exceedance of the annual limit of 1 mSv for the workers and supplies of forest produce with radionuclide level below the permissible level (РДУ/ЛХ-2001, РДУ-99).

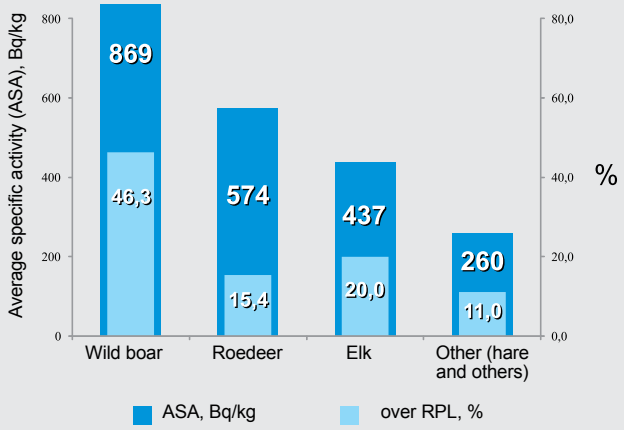


Fig. 22. Contamination of meat of game animals from forest areas with contamination density 1-6 Ci/sq.km with caesium-137

Forestry specialists and workers, population are constantly informed on the results of radiation control and monitoring.

Informing about the rules of forest exploitation in radioactively contaminated forests, possibilities of gathering and harvesting of forest gifts as well as the enlargement of the network of stations and establishment of radiation control posts at forest divisions during mass harvesting are performed constantly by forestry authorities.

Warning signs are installed in forest areas, stands and posters are mounted at forestry administration offices, at exits from roads, recreation sites etc. Instruction booklets "You are going to the woods…" for forestry workers and population have been developed and published traditionally during the last 15 years. Booklets for the population on forest use on the territory of a specific forestry contains both data on the rules of forest exploitation in radioactively contaminated forests, maps, and useful tips on possible spots for gathering mushrooms and berries, methods of reducing radionuclide content in gathered mushrooms, mushroom cultivation and many more.

Forms of information work have been constantly improved both for forestry specialists and population. Information on the website of State Institution of Radiation Control and Radiation Safety "Bellesrad" [17] is posted quite fully with permanent updating of the results of radiation survey in the forests, control of forest produce, and monitoring. Analytical materials on the radiation situation in forests, peculiarities of radioactive contamination, dynamics of the change of situation during the post-accident period are also posted here.

Availability and diversity of information continuously improves knowledge on the effects of the Chernobyl catastrophe and activities on mitigating them on the area of the forest funds both of the forestry workers and the population, allows to apply proposed standards and rules of conduct when visiting radioactively contaminated forests and using forest produce.

3.7 Radiation Control System

According to the Law of the Republic of Belarus "On Social Protection of People Affected by the Catastrophe at the Chernobyl NPP, Other Radiation Accidents" production and marketing of any types of produce where radionuclide content exceeds republican permissible levels established by technical regulations adopted by the Council of Ministers of the Republic of Belarus, and international standards. The products where radionuclide content exceeds permissible republican levels and international standards are subject to removal and disposal or underground disposal.

In order to reduce the risk of population morbidity and reducing irradiation exposure doses on radioactively contaminated territories according to the regulations of the Law of the Republic of Belarus "On the Legal Status of the Territories Which Suffered Radioactive Contamination Resulting from the Catastrophe at the Chernobyl NPP" periodic control of the radioactive contamination of soil, water, air, food, raw materials, living accommodation and manufacturing facilities.

By far an efficient system of radiation control of food, food staple and agricultural raw materials, foodstuffs and other forestry produce produced on radioactively contaminated territories in the Republic of Belarus.

Control of Chernobyl radioactive contamination is performed according to the territory and industry principle by radiation control units established by republican governing bodies, organizations, other legal entities and natural persons, including NGOs, in which one of the activities according to the Articles of Association is providing aid to the population affected by the Chernobyl catastrophe.

The republic wide system includes departmental systems.

Institutions of the Ministry of Health of the Republic of Belarus control of radioactive contamination of food produced in smallholdings as well as public sector as part of state sanitary supervision.

The Ministry of Agriculture and Foodstuffs implements:

— control of radioactive contamination of agricultural raw materials and products produced in agricultural organizations, as well as agricultural raw materials and products procured from farm households and natural persons for subsequent processing and sale;

— control of radioactive contamination of the territories of farmlands, land belonging to farm households and garden associations;

— control of radioactive contamination of water from their own bore wells used by processing enterprises, and water used for cattle.

Control of radioactive contamination at markets is performed by laboratories of veterinary and sanitary expertise.

The Ministry of Forestry monitors radioactive contamination of forests, forest produce harvested on the radioactively contaminated territories and products of its processing.

The Ministry of Natural Resources and Environmental Protection of the Republic of Belarus performs control of the radioactive contamination of the territories of settlements, and facilities situated in radioactively contaminated areas.

The Ministry of Housing Maintenance and Utilities monitors radioactive contamination of potable water, housing and utilities infrastructure, waste waters and their sediments at the sewage disposal plants, municipal waste on the radioactively contaminated territories.

The Belarusian Republican Union of Consumer Society (Belcoopsoyuz) secures monitoring of the radioactive contamination of the produce purchased and processed by consumer cooperatives.

The State Committee for Standardization of the Republic of Belarus performs metrological supervision of radioactive measurements of units under control.

In total there are about 850 radiation control units operating in the republic, over 2000 items of radiometric and spectrometric equipment are used, over 11 million samples are analyzed annually as per content of caesium-137 and about 18 thousand samples of strontium-90.

Radiation control units are departments, laboratories, stations accredited within the Accreditation System of the Republic of Belarus and parts of organizations which have licenses for the right to perform activity associated with control of radioactive contamination or which underwent the procedure for the assessment and verification of quality of measurements.

In the Republic of Belarus a number of radiation control units (laboratories, research centres, etc.) have the possibility of realizing high-accuracy methods of absolute measurements, perform trials of any category of complexity, including reference studies, using modern methods and tools of instrumentation analysis and various methods of radiochemical studies, have at their disposal a set of special state (national) references for the reproduction of radionuclide activity units and references of dosimetry values, they are equipped with model alpha, beta and gamma spectrometer facilities. These are laboratories of the State Committee for Standardization, organizations of the National Academy of Sciences of Belarus, etc.

Testing laboratories of the republican and oblasts veterinary and agrochemical services, oblast centres for hygiene and epidemiology perform measurements of ionizing radiations of caesium-137 and strontium-90 both with instrumental quick tests using spectrometers and radiometers, and with laboratory analysis methods, including radiochemical methods for the detection of strontium-90.

Laboratories of a number of processing plants along with instrument measurements of caesium-137 content have the possibility for measuring strontium-90 content in the raw materials and ready products with instrumental quick tests using beta spectrometers. Most units for the control of radioactive contamination (laboratories of the veterinary and sanitary expertise of markets, processing plants, etc.) perform caesium-137 measurements only with instrumental quick test methods using radiometric equipment.

Radiation control stations can measure gamma ray exposure dose rate with dosimeters and gamma-radiometers, collection and primary preparation of samples of the units under control.

The procedure for performing radiation control is supported with the necessary regulatory legal environment.

The largest network is the radiation control system of the Ministry of Agriculture and Food, which includes 517 laboratories and radiation control stations.

According to the established regulations all agricultural produce on the contaminated territory, including animal fodder and their diets, undergo control.

Raw materials and ready products at processing plants produced on radioactively contaminated territories undergo a three-step radiation control: initial check, inspection in the process of processing raw materials, control of ready produce.

The cattle coming to meat packing plants from farms situated on contaminated territories undergo live radiation control. Animals with content of caesium-137 in muscular tissue above the established standard are returned to the producer for treatment using specially designed diets to reduce radionuclide content in meat.

Thanks to the availability of the well-established control system there have been no instances registered when enterprises of the Ministry of Agriculture and Food would supply food or raw materials with radionuclide content in excess of the standard.

Equipping of the radiation control system with modern apparatuses and equipment, as a rule, domestic is performed within the framework of State Chernobyl Programmes. These are supplied to the radiation control units of state-financed organisations situated on radioactively contaminated territories, as well as to the laboratories of veterinary and sanitary expertise at markets on the whole territory of the country, which enables steady upgrading of the instrumentation pool of the radiation control system of the Republic of Belarus.

In 2007-2008 as part of an assignment under a Programme of Joint Activity on Overcoming the Consequences of the Chernobyl Catastrophe for 2006-2010 a radiation monitoring system was established for detecting strontium-90 in the bones of cattle aiming to enhance control of exported goods produced by processing plants of the republic. The "Veterinary and Sanitary Regulations for Control of Caesium-137 and Strontium-90 Content in Export Food and Agricultural raw Materials Liable to State Sanitary Supervision" have been elaborated. Twenty-four meat packing plants exporting their goods and veterinary laboratories have been equipped with the necessary measuring instrumentation, specialists have been trained. A number of laboratories at milk processing plants of Gomel Oblast have been equipped to establish a monitoring system for measuring strontium-90 content in milk and dairy products exported to the Russian Federation.

Apart from State Programmes, procurement of dosimetry, radiometric and spectrometry equipment for the radiation control network and training centres for radiologists is implemented within the framework of Union Programmes.

Only adequately trained specialists, who have been trained in radioactive contamination control according to the established procedure and who undergo retraining at sectoral refresher courses at least once in five years are allowed to control radioactive contamination.

The respective training centres operate in the republic:

- The Institute of Advanced Training and Continuing Education of the Agro-Industry, which has been at the Belarusian State Agrarian Technical University since 1990. About 500 specialists are trained here every year;The Institute of Advanced Training and Continuing Education of the Gomel F.Skaryna State University – about 200 specialists are trained here annually;
- Regional Training and Information Centre for Radiation Safety at the International State Sakharov Environmental University – about 100 people undergo training every year.

Training of specialists at the Gomel State University and International State Sakharov Environmental University is financed with State Chernobyl Programmes. As part of Union Programme in 2009-2010 radiation control system training centres were supplied with equipment for educational activities, radiometers and dosimeters. Unified curricula and study programmes for advanced training courses for radiation control specialists in the Republic of Belarus have been developed, agreed and evaluated. A study guide on the basics of radiation control has been developed and published.

3.8 Maintaining Exclusion Zones Polessie State Radiation and Environmental Reserve

The evacuation (exclusion) zone is a territory with the area of 1.7 thousand sq.km, from which all people who had resided here (24.7 thousand people) were evacuated during 1986. Since May 1986 the lands of the evacuation (exclusion) zone have been withdrawn from production. The resettlement zone covers the territory of 4.5 thousand sq.km in 15 districts of Gomel and Mogilev oblasts of the republic. The main approaches to maintaining these zones were formulated in the Concept of Maintaining Exclusion and Resettlement Zones (1994).

Administration of Exclusion and Resettlement

Zones is a special authority established by the Resolution of the Government No. 343 dated June 8, 1992 to manage exclusion and resettlement zones, organize and supervise their protection and ensure the order of maintenance in accordance with the law; representatives of his authority operate in 13 contaminated districts of Gomel and Mogilev oblasts.

According to the Law "On the Legal Status of the Territories Which Suffered Radioactive Contamination Resulting from the Catastrophe at the Chernobyl NPP" [2] only economic activities related to securing radiation safety, preventing carry-over of radioactive substances, implementation of nature conservation measures and research are allowed in the evacuation (exclusion) zone.

This zone is protected from unauthorized penetration of people, land transport and other vehicles.

The following is prohibited in the evacuation (exclusion) zone:

residing of the population, unauthorized stay of people;

unauthorized entry of all types of vehicles and other equipment, as well as timber-rafting;

transportation without special permission of construction materials and constructions, machines and equipment, household articles, timber, soil, peat, clay, sand, other mineral resources, plant fodder, medicinal herbs, mushrooms, berries and other products of additional forest exploitation (except for samples for research).

Staying in the evacuation (exclusion) zone is only permitted upon a special permit.

The activity related to the operation of radioactively contaminated territories is regulated by the Department on Mitigating the Consequences of the Chernobyl Catastrophe at the Ministry of Emergency Situations of the Republic of Belarus. Its competencies include:

preparing decisions on referring territories to the zones of radioactive contamination, establishing boundaries of radioactively hazardous lands on site;

introducing propositions on returning exclusion lands into economic turnover;

observing the legal regulation of radioactively contaminated territories (the resettlement procedure, admission of people, entry of vehicles, removal of property, etc.);

development and implementation of new approaches to reducing the level of radioactive contamination of the territory and its influence on the population and the environment, prevention of radionuclide spreading out to other areas;

establishing and supervision of the operation of special authorities on radioactively hazardous lands;

establishment and leadership of a special evacuation (exclusion) zone authority;

coordination of the preparation of technical regulatory legal acts and regulations aimed at the reduction of the irradiation collective dose of the population;

elaboration of the programmes of overcoming the effects of the catastrophe, distribution of material and technical resources and finance allocated for these purposes, establishing, coordination and funding of scientific and technical programmes covering various aspects of Chernobyl related research;

coordination of activities on minimizing the consequences of the catastrophe at the Chernobyl NPP;

organizing the system of underground disposal of radioactive waste, products, materials and other substances contaminated with radionuclides, and ensuring their safe operation;

- informing the population of the republic on the radiation situation, publication of maps and the list of settlements and facilities situated on the territory of radioactive contamination, coordination of raining and awareness raising activities with the population.

While the exclusion zone is the most radioactively contaminated compact territory adjacent to the Chernobyl NPP (a part of Bragin, Khoiniki and Narovlya districts of Gomel oblast), the resettlement zone is dispersed over the territory of 4.5 thousand sq.km in 15 districts of two oblasts of the republic, which creates certain difficulties in maintaining it.

In contrast to the exclusion zone, strictly limited economic activity is carried out on the territory of the resettlement zone associated with maintaining roads, electricity supply lines and other facilities of infrastructure significance in order.

Economic activity in the primary resettlement zone is carried out subject to observing sanitary regulations and radiation safety standards with due account to the techniques and methods aimed at securing production of goods with radionuclide content within permissible republican levels.

The following activities are prohibited in the primary resettlement zone without special permit:

removal of timber, soil, peat, clay, sand, other mineral resources, except samples for research;

all types of forest exploitation, including harvesting of wood, fodder, mushrooms, wild fruit, berries, medicinal herbs and technical raw materials, hunting, fishing, all types of water use, except extinguishing fires;

driving and grazing of household animals;

movement of all types of transport beyond roads and water-ways in general use, as well as timber-rafting;

entry to the territory of the people whose activity is not directly associated with performing works on this territory;

performance of any works involving soil disturbance if this could cause carry-over of radionuclides.

Staying on the territory of primary resettlement is allowed only upon special permit.

Economic activity, functioning of all types of transport, constructions, engineering utilities and services in the zones of subsequent resettlement should be performed subject to radiation safety standards, as well as instructions and regulations excluding spread of radionuclides over to other territories.

The following activities are prohibited on the territory of subsequent resettlement:

harvesting mushrooms, wild fruit, berries medicinal herbs and technical raw materials, hunting, fishing without special permit;

production and harvesting of products containing radionuclides in excess of the republican permissible levels;

any activity deteriorating radiation or environmental situation.

Sale of food raw materials and foodstuffs produced in the zone of subsequent resettlement is only permitted after radiometric control and providing that the republican permissible levels of radionuclide content are observed.

Stay of people on the territory of the zone of subsequent resettlement is only permitted upon special permit.

Former farming lands of the subsequent resettlement zone are characterized by a very non-homogenous soil covering and fertility level between 16 and 60 points. Contamination of soils with caesium-137 reaches 5400 kBq/sq.km, and strontium – 222 kBq/sq.km. Content of plutonium isotopes is comparatively low here and it is predominantly concentrated on the territory adjacent the exclusion zone.

According to the density of radionuclide contamination one could distinguish 3 groups of lands. The first group comprises about 67 thousand hectares of farming lands with caesium-137 contamination density less than 555 kBq/sq.m and strontium-90 – less than 74 kBq/sq.m. A part of such lands with domination of loamy soils and clay sands may be included into agricultural use at that stage of rehabilitation.

The second group with the area about 50 thousand hectares with soil contamination density with caesium-137 is 555-1,480 kBq/sq.m and strontium-90 – 74-11 kBq/sq.m can also be used in agricultural production in the long run, but will involve more costs on land reclamation and agrochemical measures. The lands of this group can be partially reclaimed at the first stage of rehabilitation for growing grain crops, rape and feed crops for the production of meat and milk raw materials. The inclusion of the lands into the agricultural turnover is only possible at a later stage of rehabilitation. The rehabilitation of resettled territories will demand state subsidies, as the cost price of agricultural produce on recultivated lands will be much higher.

It is not practical to plan agricultural use of sands and sand soils with bonitet score below 30, which require forest reclamation protection from outwash and blowing erosion, and lands of the third group with contamination density above 1,480 kBq/sq.m with caesium-137 and 111 kBq/sq.m with strontium-90.

Low-fertility lands of the resettlement zone unfit for agricultural use are subject to afforestation.

One of the major problems in maintaining the exclusion and resettlement zones is fighting forest fires. The following activities are carried out for this

end: arrangement of mineralized fire-breaks along compartment lines; ploughing around resettled villages along the perimeters of the buildings; maintaining anti-fire reservoirs; maintaining in good order of roads leading to most fire hazardous areas of the zone; waterlogging of a part of peat lands; air and land-based patrolling.

There is work done on designating afield the boundaries of lands removed from agricultural use and referred to the category of radioactively hazardous through installation of nameplates and warning signs. Their renovation is performed annually.

Safeguarding and protective measures are carried out in exclusion and resettlement zones to prevent unauthorized penetration of people, unsupervised removal of materials and ensuring proper sanitary and anti-fire condition. Safeguarding and protective measures are secured through systematic patrolling and operation of checkpoints.

Within the evacuation (exclusion) zones, zones of primary and subsequent resettlement, from where people were resettled, a stringent nature conservation regime, protection of territories, historic and cultural values are ensured. Improvement of cemeteries, renovation of monuments, graves of soldiers who died during the Great Patriotic War.

All types of activity in the evacuation (exclusion) zone and zone of primary resettlement are performed subject to restriction of the number of people involved in order to reduce the collective exposure dose.

These activities are financed from the funds allocated for overcoming the consequences of the catastrophe at the Chernobyl NPP.

In order to prevent unauthorized penetration of people to the territory of the Polessie reserve and transportation of cargoes, the personnel of District Department of Internal Affairs of Bragin, Khoiniki and Narovlya districts perform checkpoint operations, 6 checkpoints operate with twenty-four hour duty and there is patrolling of the zone with cars.

Specialized enterprises Radon (Mogilev oblast) and Polessie (Gomel oblast) have been established to perform measures aiming to improve the sanitary condition and reducing radiation hazard of the territories of primary and subsequent resettlement zones, from where people had been resettled.

About 13.5 thousand households and capital buildings have been buried on the resettled territories.

Most contaminated as a result of the catastrophe at the Chernobyl NPP were the territories of Bragin, Khoiniki and Narovlya districts in close vicinity to the Chernobyl NPP Here lie about one third of the total amount of radioactive caesium, over 70 per cent of strontium and 97 per cent of plutonium, which fell out onto the territory of Belarus. The density of contamination of the territory with caesium-137 is 37,000 kBq/sq.m (1,000 Ci/sq.km), strontium-90 – up to 1,500 kBq/sq.m (40 Ci/sq.km), plutonium-238, -239, -240 – up to 90 kBq/sq.m (2.5 Ci/sq.km). Levels of contamination with iodine-131 amounted to 1,000 Ci/sq.km and over, gamma-ray dose rates were from 5 to 100 mR/h.

Maximum level of caesium-137 contamination as a result of the accident (59,200 kBq/sq.m) was recorded in the former settlement of Kryuki of Bragin district, strontium-90 (1,800 kBq/sq.m) – in Khoiniki district, where maximum levels of contamination with alpha-radiating isotopes of plutonium-238, -239, -240 amounted up to 111 kBq/sq.m.

Contamination with long-living transuranium radionuclides made it impossible to return these territories into economic use in the foreseeable future (half life of plutonium-238 is 87.74 years, plutonium-239 – 24,110 years, plutonium-240 – 6,537 years, plutonium-241 – 14.4 years, americium-241 – 432.2 years).

Accordingly the Polessie State Ecological Reserve was established on the territory of the evacuation zone most severely contaminated as a result of the Chernobyl catastrophe under Resolution of the Central Committee of the Communist Party of Belarus No. 59-5 dated February 24, 1988. Its area was 1313 sq.km. By Resolution of the Council of Ministers of the Republic of Belarus No. 122 dated February 10 1989 it was renamed Polessie State Radiation and Environment Reserve (PSRER), and from that time on it has been subordinated to the republican authority on the problems of the consequences of the catastrophe at the Chernobyl NPP (currently this is the Department for Mitigation of Consequences of the Catastrophe at the Chernobyl NPP of the Ministry for Emergency Situations of the Republic of Belarus).

In 1993 another 849 sq.m of the contaminated lands of Bragin, Khoiniki, Narovlya, Kalinkovichi and Mozyr districts were included in to the PSRER, and its area amounted to 2,162 sq.km.

The reserve is divided into 3 areas, which lie within the boundaries of Bragin, Khoiniki and Narovlya districts. It is made up of 16 forestries. The administrative centre is situated in the town of Khoiniki; the research and experimental base are situated in the former settlement of Babchin. A research station "Masany" established in 1996 is located on the borderline with Ukraine, 12 km from the Chernobyl NPP.

The number of the employees of the reserve is 750 people.

Polessie State Radiation and Environment Reserve is the largest nature conservation organisation of Belarus and it deals with the following:

Ensuring a complex of activities to prevent the

carry-over of radionuclides to the adjacent territories;

Radiation and environmental monitoring of soil, air, flora and fauna;

Systematic scientific research to assess the influence of radioactive contamination of flora and fauna, natural resources inventory;

Protection of forest resources from fires, implementation of forest protective measures against forest pests and diseases;

Implementation of measures to maintain the optimal hydrological regime;

Securing checkpoint regime and implementation of protective and safeguarding measures to prevent unauthorized access of people, vehicles and removal of materials;

Combating poaching, interception of illegal minor forest exploitation and logging;

Securing natural development of the diversity of nature, implementation of measures to increase the population of rare species of plants and animals;

Protection and accounting of animals equivalent to hunting and commercial species, and listed in the Red Book of the Republic of Belarus;

Implementation of measures to prevent hydrophobia in wild animals and epizootics.

Forests cover 50.7 per cent of the territory of the reserve. Pines account for 44.3 per cent of forest covered area, birches – 33.3 per cent, sticky alder forest – 13.5 per cent, oak forests – 7.0 per cent.

The main water artery of the reserve - the river Pripyat – crosses it from northwest to southeast and its length within the PSRER is over 80 km. Considerable areas were exposed to secondary bogging. Currently marshland takes 8.4 per cent of the total area.

PSRER plays an essential part in the conservation of the biodiversity of the Polessie region, the republic and Eastern Europe due to the absence of people, economic activity and hunting. The lack of anthropogenous impact onto the ecosystem lead to the change of environmental conditions in biocenosis and enabled seral processes. Former farming lands, reclamation systems, roads are running wild, there is secondary bogging of the territory, and shrub invasion of meadows on the territory of the PSRER. The dynamics of the transformation of main types of farmlands within the period from 1988 to 2008 is given in the Atlas of Current and Expected Aspects of the Consequences of the Chernobyl Catastrophe on the Affected Territories of Russia and Belarus [18]. All these predetermine both abundance of usual animal species and forming and formation of sustainable proliferative populations of rare species of animals and plants, and secure their conservation.

The flora of the reserve includes 1,016 species. Here grow 884 species of tracheophytes, which makes about 50 per cent of the current flora of Belarus, including 39 protected species, out of which orchis, wild aster, sedge, naias, water hickory, Deptford pink, hoary groundsel, helleborine, yellow lady's slipper, sundew intermedia are very rare, and only occur sporadically on the territory of Belarus. Such rare species as floating moss and Siberian flag-leaf are quite numerous.

Forty-six species of land mammals or 76.7 per cent of the number of species of this group in Belarus are registered on the territory of the PSRER. Out of them six species – bear, badger, lynx, common dormouse, dormouse, and European bison are listed in the Red Book of the Republic of Belarus.

The reintroduction of bisons is complete. In 1996 16 European bisons (Bison bonasus) were brought here from the Belavezhskaya Pushcha National Park. Their number in 2010 increased up to 75 specimens. Due to the protective regime the largest local population of badgers exists and continues to grow (100-120 animals) on the territory of PSRER. The population of lynx has set on the level of 25-30 animals, about 4 bears live here permanently. The Przevalsky's horse – a new species for the theriofauna of Belarus protected internationally – has been registered here since 2007, and in 2010 there were 10 specimens.

Traditionally high is the number of animals belonging to hunted species. There are over 2,000 wild boars, 1,500 elks, 1,500 beavers, 2,000 blackcocks.

There are 213 species of birds registered on this territory, which represents 69.4 per cent of the bird fauna of Belarus, out of them 58 species are listed

in the Red Book of the Republic of Belarus. Some species appeared here after the catastrophe at the Chernobyl NPP.

The population of ern is numerous on the territory of PSRER, unlike all the rest of the territory of Belarus. About 10-15 couples nest here, and the overall number of the birds of this species amounts to 100 birds. The number of greater spotted eagle is estimated as 2-5 nesting couples. In winter and early spring old and young golden eagles are to be seen. There are many egrets (Egretta alba) – 30–50 nesting couples, bitterns – over 50 couples, black stork (Ciconia nigra) – 20–30 couples, lesser spotted eagle (Aquila pomarina) – over 20 couples, little crake (Porzana parva) – over 100 couples, common crane (Grus grus) – 30–50 couples, over 50 couples of little tern (Sterna albifrons) and whiskered tern (Chlidonias hybridus), European bee eater (Merops apiaster) and и common European kingfisher (Alcedo atthis). Other rare species are also numerous.

Out of 19 species of amphibians and reptiles inhabiting the territory of Belarus 17 have been observed in the PSRER. Here lies the nucleus of the nominative subspecies of the fresh-water turtle with about 70 thousand specimens, several habitats of smooth snakes and crested newt have been identified.

Thus, PSRER can be rightfully called the storeroom of the biological diversity not only of the Republic of Belarus but also Europe. Out of land vertebrates listed in the Red Book of the Republic of Belarus and inhabiting the territory of PSRER 15.4 per cent are listed in the Red List of the International Union for the Protection of Nature, all are protected according to the Berne Convention, 58.9 per cent are protected under the Bonn Convention of 1979.

High density of radioactive fallout on the soil determines the territory of the reserve as a potential source of secondary radioactive contamination.

These factors are the reason for the increased interest of researchers to the study and systematization of data on the peculiarities of the contamination of this region, parameters of horizontal and vertical migration of radionuclides, to the study of the engagement of radionuclides in the "soil-plants-animals" trophic chains.

The accumulation of radionuclides by wild animals that permanently live on the territory of the reserve is of scientific and practical interest. Average specific activity of caesium-137 in the tissues of land vertebrae in PSRER in 2006-2010 remained high: amphibians – 1.2–2.1 kBq/kg, reptiles – 3.8–4.4 kBq/kg, non-migrating birds – 11 kBq/kg; migrating birds – 1.3–2.5 kBq/kg; mammals belonging to hunted species in the republic, – 3.8–50.3 kBq/kg. Maximum levels in amphibians and reptiles amount to 13.3–27.4 kBq/kg, migrating nesting birds – to 11.9 kBq/kg, non-migrating birds – up to 174 kBq/kg, mammals (depending on the species) – from 21.9 to 1,417.5 kBq/kg. In comparison to the period 2001-2005 there has been no reduction of caesium-137 level in animals' tissues.

Maximum levels of the content of radiocaesium were found in mushrooms - up to 1,500 kBq/kg.

With the course of time the content of americium-241 in soil has increased, this is a daughter product of plutonium-241 decay. Being an alpha-emitter americium-241 is more dangerous than plutonim-241 (a beta-emitter). Within the quarter of a century following the catastrophe its activity in soil has increased twofold, and the density of contamination with this radionuclide in the exclusion zone achieves 96 kBq/sq.km (2.6 Ci/sq.km). This is the only radionuclide, the concentration of which in the environment will increase approximately until 2060.

In 2007-2008 the comprehensive radiation survey of the reserve was performed. The content of caesium-137, strontium-90, americium-241, plutonium-238, -239, -240 in the samples was measured. Maps of radioactive contamination of the territory of the reserve with the above mentioned radionuclides were created based on the acquired data as of January 1, 2009, as well as a forecast map of americium-241 contamination as of January 1, 2056 [17].

The territory of the PSRER became a unique testing ground for the study of the effects of radioactive contamination of natural and former agricultural ecosystems.

The scientific part of the PSRER is concentrated in the former settlement of Babchin. It is composed of three research departments: radiation and environmental monitoring, ecology of plant complexes and fauna, and the laboratory of radiochemistry and spectrometry.

The laboratory meets the criteria of the Accreditation system of the Republic of Belarus and has been certified to meet the requirements STB ISO/IEC 17025. In 2005-2007 within the framework of the IAEA technical cooperation project the laboratory was equipped with state-of-the-art equipment, such as a low background alpha/beta counter, Canberra gamma-spectrometers with hyper-pure germanium detectors, beryllium and carbon fibre windows, a Canberra alpha spectrometer, etc. Today the laboratory is capable of determining the whole range of radionuclides of Chernobyl origin.

In 1998 in pursuance of the instructions of the President of the Republic of Belarus an experimental horse-breeding farm was established in the reserve, which in 2006 was given the status of a pedigree farm for breeding the Russian Heavy Draft breed. The livestock of horses in 2010 amounted to 277.

Milling of the timber harvested during environmental harvesting is performed with

due regard to the limitations on the radioactive contamination level, an experimental bee garden is operating.

To protect the territory from unauthorized penetration there are 11 checkpoints at the PSRER with day-and-night duty. Along the perimeter of the reserve and roads there are nameplates and barriers are installed.

The employees of the reserve permanently working on the protected area are referred to the category of "personnel» according to the radiation safety standard. Working in the conditions of permanent effects of the radiation factor requires observing a special regime, including:

restriction of the time of staying in the zone;

use of personal protective gear;

necessity of the decontamination of transport;

monitoring radiation situation on site, and contamination of vehicles;

individual dosimetry control of external and internal radiation;

health monitoring of the personnel.

To fight forest fires 155 km of 40 m wide fire-breaks, 200 km of 12 m wide fire-breaks, 950 km of mineralized fire-breaks along roads, around former settlements, cemeteries, 97 artificial fire reservoirs were created. Thirty-seven observation towers were erected for timely detection of fire hazards.

3.9 Creating Conditions for the Recovery and Development of the Affected Regions: Construction, Infrastructure Development, Provision of Gas Supply

During the period of implementation of the fourth State Programme on overcoming the consequences of the Chernobyl catastrophe for 2006-2010 the expenditures

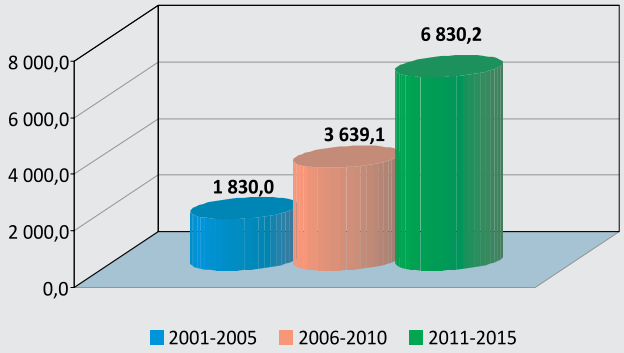


Fig. 23. Funding of State Programmes on the Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP.

from the republican budget exceeded BYR 3.6 billion (Fig. 23).

Up to two per cent of the expenditures of the budget of the Republic of Belarus are allocated for dealing with Chernobyl related problems annually.

The main priorities in capital development is residential construction, provision of gas supply, provision of contaminated districts with clean potable water as well as completion of construction of a number of educational, health care and communal facilities.

During the five-year period 434 construction projects have been completed or reconstructed. Among them are the hospital building of Gomel Oblast Oncologic Dispensary, central district hospital in the town of Vetka, radiological building of the Mogilev Oblast Oncologic Dispensary and others. Iron removal stations and artesian wells were also constructed in Brest, Gomel and Mogilev oblasts were constructed.

1194 apartments for privileged categories of citizens 963.5 thousand sq.km) were put into service (Fig. 24).

107.1 km of the public water supply network were put into operation, over 600 km of gas supply pipeline laid, 9,867 detached houses were supplied with

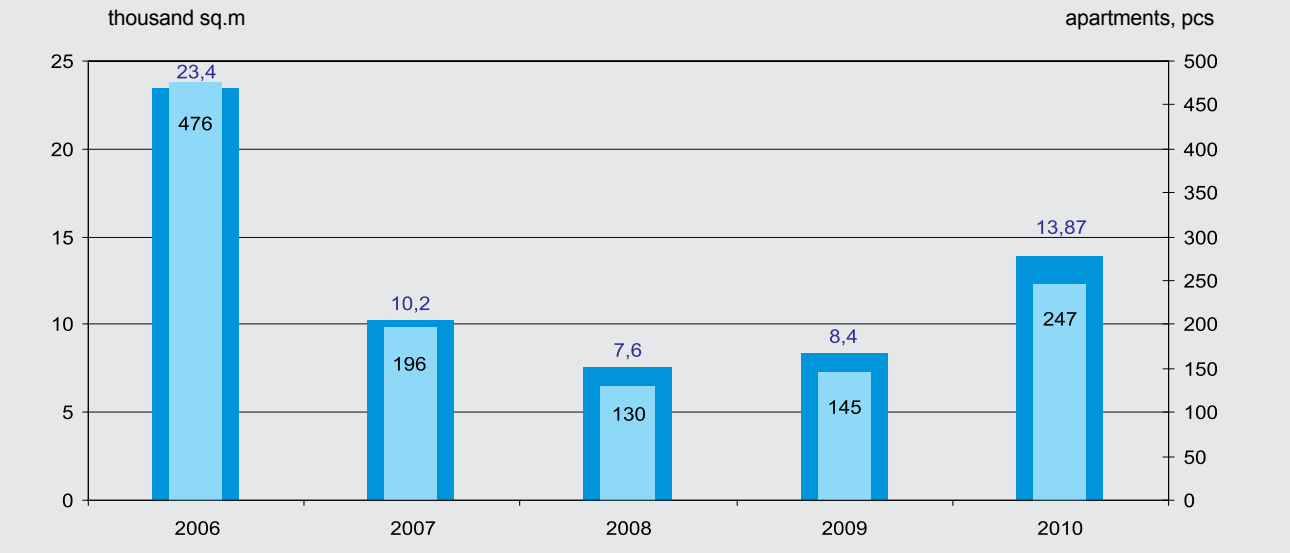


Fig. 24. Commissioning of housing

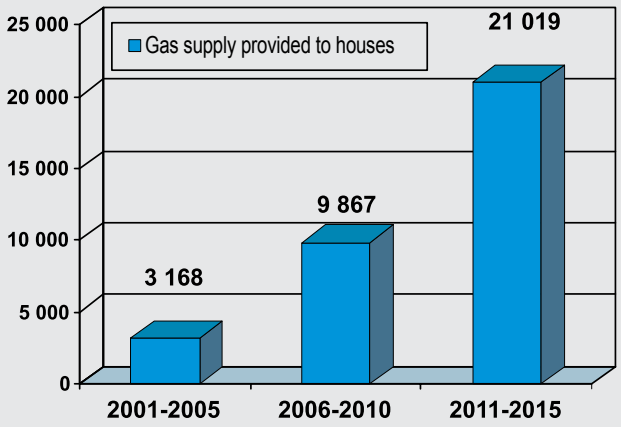


Fig. 25. Providing gas supply for housing facilities

gas (Fig. 25). Out of these 4,060 detached houses were provided with gas supply and 289.6 km of gas supply network were laid with the additional funds allocated to the oblasts' budgets in accordance with the instruction of the Head of state. As a result, there has been more than a threefold increase in the volumes of gas supply provision as compared to the previous five-year-period.

In 2010 there were 148 construction projects implemented, out of them there were 55 projects in house construction, 16 in municipal construction, 11 in the provision of gas supply, 8 in recreation, 8 in education, 12 in healthcare, 6 in agriculture, and another 3 projects in other areas of construction.

Preservation and promotion of the health of the population residing on radioactively contaminated territories is one of the priorities of the state. During 2001-2010 out-patient clinics designed for 598 visits a shift and hospitals for 613 beds were modernized or constructed.

The President and the Government of the Republic of Belarus are constantly looking for ways to deal with the problem of protecting children. Thus, the construction of CRRCs, their modernization and equipping were performed within the framework of the Presidential Programme "The Children of Belarus" (subprogramme "Children of Chernobyl"). Just within the last five-year period 15 projects have been put into operation: An addition of a primary school unit for 280 pupils to the Bragin secondary school, a secondary school for 650 pupils in Lelchitsy, an addition to the training and pedagogical complex in the village of Antonov of Narovlya district, children's rehabilitation and recuperation centres "Praleska" (Zhlobin district), "Sidelniki" (Mozyr district), "Ptich" (Petrikov district of Gomel oblast), and many others.

Since 2006 the Government of the Republic of Belarus along with the World Bank has implemented a project on the rehabilitation of districts affected by the catastrophe at the Chernobyl NPP (in line with the Loan Agreement between the Republic of Belarus and the International Bank for Reconstruction and Development) for the overall amount of USD 50 million. Activities to enhance the energy efficiency at 250 social facilities of the contaminated districts of Mogilev, Gomel and Brest oblasts, and also provision of gas supply for detached houses in the radionuclide contaminated districts (about 20 settlements) are implemented within the framework of the project.

The first stage of the international project "Rehabilitation of Districts Affected by the Catastrophe at the Chernobyl NPP" involving loan funds of the World Bank for the total amount of USD 47.1 million has been completed, out of these funds USD 20.2 million were attracted in 2010 (Table. 15).

During the period of implementation of the project works on the reconstruction and modernization of 19 boiler rooms were implemented. In Brest, Gomel and Mogilev oblasts 240 social infrastructure facilities were equipped with energy saving lighting fixtures, thermal rehabilitation of buildings at 106 social infrastructure facilities was carried out; 3,045 houses were provided with gas supply, 160.6 km of gas supply networks were laid.

In 2010 pilot projects on targeted rehabilitation of settlements and agricultural and processing plants situated on the affected territories were implemented within the framework of the Union Programme. Major of them were:

development of the production of marketable horse meat in the context of an agricultural farm situated on the radioactively contaminated territory - at the farm in Slavgorod district of Mogilev oblast, production of clean (according to standard) and competitive horse meat has been organized;

Table 15. Information on the execution of contracts under the World Bank project in 2007–2010

Year of implementation	Number of contracts concluded	Number of contracts executed	Expenditures in national currency under executed contracts (BYR bln.)
2007	14	7	5,3
2008	12	7	16,0
2009	31	26	49,5
2010	25	39	87,3
Total:	82	79	158,1

Oblast dental care centre, city of Gomel

Mogilev oblast oncologic dispensary (radiology building opened 2010)

High school in Lelchitsy settlement of Gomel Oblast (commissioned 2010)

Maternity hospital of the oblast clinical hospital, city of Gomel

adoption of new manufacturing methods for the production of dairy products at the private unitary enterprise "Polessie Cheeses" (town Khoiniki) from the dairy products of Khoiniki and Bragin districts – a new manufacturing process for the production of goods meeting the radiological safety requirements using the local raw materials base has been adopted;

organization of the production of new types of physiologically functional juice products from the local fruit, berries and vegetables – production of new types physiologically functional juice products from the local raw materials has been set up at Bykhov Canning and Vegetable Drying Plant Open Joint Stock Company (town of Bykhov of Mogilev oblast);

organization of the production of food with enhanced nutritional value and preventive properties for the population of radioactively contaminated territories – a pilot site for the production of dietary supplements under the "Dopinat" trademark ("Dopinat-selenium" and "Dopinat-iodine") has been put into operation, the procedure for baking new types of baking products and flour confectionery goods with improved mineral ingredients at the Khoiniki bread-baking plant has been tested;

organization of the production of food with antioxidant properties from dried vegetables and potatoes – the production of instant food from dried vegetables and potatoes at the Slavgorod Vegetable Drying Plant (Mogilev Oblast);

elaboration and implementation in the context of a basic farm of a standard project for the creation of the optimal fodder base for cattle breeding at the farms situated on the radioactively contaminated territories – by the example of KSUP Malozhinsky of Bragin District of Gomel Oblast the standard project on the creation of optimal fodder base for cattle breeding was elaborated;

establishment of the efficient zoned garden in order to provide the population of contaminated districts of Brest Oblast with clean fruit and berries – the zoned garden was laid out on the area of 50 hectares at the farming enterprise Olesha KMI of the village of Berezhnoye of Stolin District of Brest Oblast.

Kindergarten in the Belousha village of Stolin District of Brest Oblast (commissioned 2010 году)

Health care and recuperation facility at the Kolos CRRC

Pilot projects for the targeted rehabilitation of agricultural organizations and settlements served the prototype for the special innovation projects of the State Programme on Overcoming the Consequences of the Chernobyl Catastrophe for 2011-2015 and up to the period of 2020. Special projects were aimed at the socio-economic development of the affected regions with due account of the specific problems caused by the consequences of the catastrophe at the Chernobyl NPP. In the course of the implementation of special projects it is envisaged to:

restore and further develop the socio-economic potential of the territories contaminated with radionuclides resulting from the catastrophe at the Chernobyl NPP;

adopt modern methods for the production and processing of goods produced on radioactively contaminated territories, development of the stock of the meat and dairy cattle breeding and seed farming;

modernize and reequip the production sites in the regions affected by the catastrophe;

create new production units for processing natural material resources available in the affected regions;

Development of the infrastructure necessary for ensuring attractive living conditions of the population residing on radioactively contaminated territories.

It is planned that during the decade 76 various special projects would be implemented in the affected districts. Among them: organisation of the production of ceramic bricks in Rogachev district, establishment of the production of peat fuel pellets in Lelchitsy district, the construction of the dairy farm in the Pinsk District, creation of mushroom growing greenhouses in Dobrush district, reconstruction and technical reequipment of Uvarovichi flax processing plant, establishing a plant for the production of valuable species of fish in the Cherikov area. It is also planned to develop the breed stock of the meat and dairy cattle breeding and seed farming, develop the infrastructure of the affected districts and other areas of work.

Special projects aim to discover and develop the socio-economic potential of Chernobyl territories. New production units will be established and the existing productions will be modernized to implement these projects, most up-to-date technologies have been adopted. It is essential that such projects would be implemented in each of the 21 most affected districts.

Special projects will be financed from the republican budget and would involve other sources of financing (own funds of organizations, allocations from the local budget, borrowed money, including foreign investments, funds of other state and sector-specific programmes).

3.10 Radioecological Education, Training of Specialists, Informing the Population and the Public

Training of specialists on radioecology, radiation safety and radiation medicine, informing and awareness raising of the population of the affected districts on these issues are extremely important for the Republic of Belarus. The systematic work on the organization of radioecological education started in 1989, when by the resolution of the Ministry of Education and Science separate courses on radiation safety were introduces for all categories of students, trained at all levels (secondary school, post-secondary education establishments and higher institutions). In 1996 the Concept of Radiological education in the Republic of Belarus was elaborated, which was approved by the national Committee on radiation Protection and the Ministry of Education.

Educational establishments International State Sakharov Environmental University and Belarusian State Agricultural Academy – the oldest agrarian higher academic institution of the country and Europe – ensure training of high-quality specialists in radioecology, radiobiology, radiation safety.

Sakharov's University has trained over 800 radioecologists and radiobiologists as well as essentially broadened the scope of training of the specialists, which now embraces the majority of specialties of the ecological profile. Considering that there were enough specialists in radioecology in the economy as well as the decision of the governing bodies of the country on the development of nuclear power engineering, "Radioecology" specialty was closed in 2008, and instead the training of engineers in "Nuclear and Radiation Safety" started, and training in "Radiation Control and Monitoring" is performed as part of this specialty now.

Since 2006 the University switched onto the training of masters on "Nuclear and Radiation Safety". The content of training on this specialty encompasses all aspects of the activity of specialists on radiation protection and safe use of sources of ionizing radiation in all branches of the economy, prevention of radiation incidents, accidents and catastrophes, activity on overcoming and mitigating their effects.

Sakharov University starting from 2001 has provided continuous education within the IAEA Regional Courses on radiation protection and safety of the sources of ionizing radiation (duration of training in 2005-2006 was 23 weeks). Young specialists (up to 35 years) from CIS countries, Baltic States and eastern Europe who use Russian as a working language undergo training at these courses. By 2011 141 persons completed this course.

Training of radioecologists for the agriculture has been carried out since 1996 at the Agroecology Faculty of the Belarusian State Agrarian Academy (town of Gorki of Mogilev Oblast). The graduates of this faculty master up-to-date techniques of cultivating agricultural crops and obtaining cattle breeding products on radioactively contaminated territories in order to reduce the intake of radionuclides by humans and animals.

The Ministry of education has organized the process of continuous radioecological education of children and youth of the Republic of Belarus aiming to foster the culture of safe living in the context of radioactive contamination. Profound training in radioecology is envisaged for the children and youth in educational establishments as part of additional academic programmes, which are implemented through various forms of learning and extra-curricular activities. Radioecological education of schoolchildren is arranged in primary, secondary and upper classes of the comprehensive school in learning "Man and the World" subject, and optional classes in "Life Safety Fundamentals". The work is performed in the form of oral issue-related sessions during general education classes, profound study of subjects at optional courses, out-of-class and out-of-school activities, also involving specialists from organizations dealing with the consequences of the Chernobyl catastrophe.

To ensure radioecological education a number of educational materials have been elaborated in the Republic of Belarus, and the most considerable of them is the guide for teachers of secondary schools "Basics of Radioecology and Safe Living" issued upon the commission of the Department for Mitigation of the Consequences of the Catastrophe at the Chernobyl NPP of the Ministry of Emergency Situations of the Republic of Belarus in 2008.

At each of the stages of overcoming the consequences of the Chernobyl catastrophe Chernobyl oriented information work has had its peculiarities.

By 2000 task oriented informing of the population was not a top priority post-Chernobyl issue for the state governing bodies, state organisations and institutions involved in overcoming the consequences of the Chernobyl catastrophe, as urgent emergency measures were on the agenda: evacuation, mass decontamination, resettlement of people from hazardous places for residence, establishment of radiation control systems, medical and social protection, elaboration and adoption of countermeasures in agriculture and forestry. The state was to a much extent relying on the professional qualities of journalists, who informed the population about the effects of the Chernobyl catastrophe and the activities to mitigate them.

At the same time the State Establishment Sociology Institute of the National Academy of Sciences of Belarus regularly performed monitoring of the attitude of the population to Chernobyl issues on the whole and the extent of their satisfaction with the quantity and quality of the information on Chernobyl issues available to the people through sociological surveys. Considering the results of the public opinion survey since 1996 an attempt to enhance the efficiency of information support of the activities on the rehabilitation of the population of contaminated districts and relocatees was undertaken. It is worth noting that by that moment 84 per cent of people were rather guided by gossip around Chernobyl than official information. It became evident that profound systematic work was needed to change the situation fundamentally.

In 2003 the basis for the new stage of information work with the population of the affected districts, authorities and specialists was created in 2003 in the Republic of Belarus – it was the "Concept for Information Sharing on the Problems of the Chernobyl Catastrophe". Its further implementation involved over 20 organizations based on annual plans, which are adopted by the Department for Mitigation of Consequences of the Catastrophe at the Chernobyl NPP of the Ministry of Emergency Situations of the Republic of Belarus.

Another step towards the development of information work on Chernobyl topics was the establishment of the Russian Belarusian Information Centre on the Problems of the Consequences of the Catastrophe at the Chernobyl NPP (RBIC). In 2003 the Russian Branch of the RBIC started to operate at the Nuclear Safety Institute (IBRAE) of the Russian Academy of Sciences (city of Moscow), in September 2007 the Belarusian Branch of the Centre (BBRBIC) as an affiliated branch of the RRUE Institute of Radiology of the Ministry for Emergency Situations of the Republic of Belarus.

The programme of joint activity on overcoming the consequences of the Chernobyl catastrophe within the Union state for 2006-2010 was the first among Chernobyl programmes where a large section "Implementation of the general information policy on the problems of overcoming the consequences of the Chernobyl catastrophe" appeared, which included testing new approaches to Chernobyl-related information activity. During the implementation of this programme local

information focal points and Chernobyl-related centres were established in the affected districts, Chernobyl information resources, including electronic were elaborated; thematic information, awareness raising, training campaigns and activities were tested in practice; strategic and conceptual basics of this activity, and elements of its methodological support were developed.

As a result the following were established as a basis for information activities in the districts:

21 information focal points at district executive committees of the most severely affected districts (software and hardware system with a thematic information resource and a separate electronic mail address), their operation and interaction with BBRBIC is ensured by responsible specialists appointed by the chairmen of district executive committees.

8 information focal points of the Administration of Exclusion and Resettlement Zones (AERZ), whose employees raise public awareness on the rules for visiting and staying in these zones;

19 information and methodological centres "Radiation Safety and Basics of Safe Living" at educational institutions.

The choice of these as a place for information centres is due to the fact that children and young people are the most susceptible target group as regards adopting skills of safe living on radioactively contaminated territories, and later they act as guides for transmitting these skills to other categories of population.

Information interaction between the above mentioned focal points and centres with the BBRBIC has been organized. Practical testing of their interaction has been launched on a regular basis with other district-level organisations (district level), between centres (inter-district level), and with oblast and republican level organisations. The development of this interaction is a promising area of work, and a prerequisite for the transition over to the systematic operation of local information centres.

During the elaboration of Chernobyl information resources the focus was placed on electronic forms, which have become more available at the district level considering the advance in information and communication technologies. The most essential step in this direction became the establishment of an electronic information resource on Chernobyl topics, which contains diverse information of interest for the wide public: starting from the specialists of the system of radiological control, education, healthcare, culture, mass media up to the ordinary inhabitants of the affected territories, which could use this information for enhancing the level of the general radiological literacy. At the moment the information resources have been installed at the Gomel, Mogilev and Brest Oblast executive committees of the most severely affected districts (in total 21), information and methodological centres «Radiation Safety and Fundamentals of Safe Living" (in total 19), information focal points of the Administration of the Exclusion and Resettlement Zones (in total 8).

The elaboration of the information resource and its supply to the affected districts as part of the software and hardware system on a PC is one stage in the creation of the modern system of sharing experience and rehabilitation of the affected territories.

The information on Chernobyl topics is focused in two joint solutions of the Russian and Belarusian specialists - the Integrated Information Data Bank on the major aspects of consequences of the Chernobyl catastrophe on the affected territories of Russia and Belarus – the fundamental integrated scientific and reference publication with cartographical and reference and analytical and reference information on radioactive contamination of various landscapes, zoning of contaminated territories; exposure doses of the participants of cleanup works and the population; radiation and hygienic, demographic, socio-economic situation on contaminated territories; health effects; target programmes for the overcoming the consequences of the Chernobyl catastrophe and social protection of people.

A significant activity in the target information activity on Chernobyl topics of Internet users was the elaboration and launch of the Belarusian section of the RBIC website [19], which is oriented at a wide audience of the interested people and it contains most up-to-date information on the consequences of the catastrophe at the Chernobyl NPP and overcoming them, including the package of materials for the population "It is Important to Know", section "Chernobyl Science", e-library. There is an intention to transform later on the RBIC's website into a portal which will bring together internet resources of the affected districts on Chernobyl.

Since 2009 issuing of a monthly electronic journal "Reviving Our Native Land" has been organized, and its printed version is distributed to the legislative bodies and authorities of the Republic of Belarus and the Union State, oblast executive committees of the most affected oblasts, district executive committees and local organisations of 21 most affected districts. Since 2010 special editions of the journal oriented at foreign audiences have been issued to complement regular editions. Exhibition expositions "Reviving Our Native Land Together" for demonstration at the Union State, and "Chernobyl and Belarus": Past, Present, Future" – for demonstration in the European Union countries.

In 2006 the system of thematic events for different population groups and specialists was tested and it is now implemented through:

training workshops for the target groups of experts (healthcare professionals, pedagogues, specialists of information and advocacy groups, journalists and others);

- information and awareness raising campaigns (annual internet campaigns dedicated to the anniversaries of Chernobyl catastrophe, press tours of journalists to the Chernobyl affected districts to highlight the actual living conditions on affected territories, rehabilitation and development of these territories);

workshops and consultations with various groups of district level experts to study the peculiarities of the information strategy in working with the population at the current post-Chernobyl stage and its improvement.

The said activities allowed to form the prerequisites for the transition to the systematic work based on the support from the local information structures and resources of the affected districts, and define the strategy for the information activity on Chernobyl for the period after 2011.

The transformation of state priorities in the area of overcoming the consequences of the Chernobyl catastrophe (oriented to the recovery and development of the affected territories) and approaches to it had a considerable effect on the information work in this area, which is reflected in the State Programme on overcoming the consequences of the Chernobyl catastrophe for 2011-2015 and for the period up to 2020. To secure the implementation of the state information politics on Chernobyl at a unified concept basis instead of the formerly used "Concept for Information Sharing on the Problems of the Chernobyl Catastrophe" the Comprehensive System of Information Support on Overcoming the Consequences of the Chernobyl Catastrophe was elaborated and has been implemented since 2011. Its goal is systematic provision of republican and local state bodies of the Republic of Belarus with the information on the implementation of state policy on overcoming the consequences of the Chernobyl catastrophe, promotion of the forming of an active living position of the population aimed at the revival and development of Chernobyl affected territories, fostering radiological culture, forming a positive attitude to the affected districts on the part of the population of the Republic of Belarus and the world community.

4. LONG-TERM PROBLEMS OF THE MITIGATION OF THE CONSEQUENCES OF THE CHERNOBYL CATASTROPHE: SOLUTIONS AND STRATEGIES

4.1 Forecast as to contamination of territories with long-lived radionuclides

Article 4 of the Law "On the legal regime for the territories contaminated by the Chernobyl disaster" defines radioactive contamination zones as territories where the soil contamination density with cesium-137 is 37 kBq/sq.m (1 Ci/sq.km) and more; strontium-90 – 5.5 kBq/sq.m (0.15 Ci/sq.km) or more; plutonium-238, -239, -240 – 0.37 kBq/sq.m (0.01 Ci/sq.km) and more. The adopted zoning is used while planning and conducting the activities to minimize the effects of the catastrophe at the Chernobyl NPP and to ensure the radiation safety of the population.

The general trend in the radiation environment is a gradual reduction in the density of the contamination.

The main factors contributing to the reduction of the contamination levels include the natural decay of the radionuclides, the migration of the radionuclides in the soil and their fixation. The natural decay is the major factor that reduces the level of the contamination.

The total area of the contamination with radioactive caesium is gradually shrinking. According to the National Centre for Radiation Control and Environmental Monitoring, in 1986 23% of the national territory was contaminated with cesium-137 at a density exceeding 1 Ci/sq.km, while in 2001 this area made only 21%. In 2046, this area will make approximately 10% (i.e., it will have decreased by 2.4 times if compared with the initial contamination area in 1986).

The area of contamination with cesium-137 at a density of 15 Ci/sq.km and higher will shrink quicker and by 2016 it will have become by 3 times and by 2046 by about 10 times smaller than in it was 1986.

The dynamics of the radioactive contamination in the territory of Belarus until 2056 by oblasts is shown in [18].

It is the reduction of the contaminated areas that determines the need to periodically review the List of the towns, villages and other objects located in the contaminated zones.

By 2050, a significant reduction is expected in the number of the settlements (Table 16), falling within the zones of radioactive contamination.

4.2 Long-term land use strategy for territories with high levels of contamination

As for the areas with high levels of radioactive contamination, the land use here will focus on improvement of the management system for the territories from which the population was evacuated and resettled, the development of long-term strategies for operating of these areas, including the pass control to prevent unauthorized intrusion and activity; improvement of the management for the evacuation zone; improvement of the fire safety in the evacuation zone; the improvement and development of the scientific testing facility in the close-in zone of the Chernobyl NPP on the basis of the Polessie Radiation

Table 16 Forecast of the change of the number of settlements of the Republic of Belarus located ithin radioactive contamination zones

Year	Density of radioactive contamination, kBq/sq.m (Ci/sq.km)					
	Caesium-137			Strontium-90		
	555–1480 (15–40)	185–555 (5–15)	37–185 (1–5)	over 74 (over 2.0)	18,5–74 (0,5–2,0)	5,55–18,5 (0,15–0,5)
2006	25	552	2484	-	125	863
2010	22	506	1915	-	116	554
2015	13	361	1817	-	96	526
2020	8	294	1748	-	66	462
2025	6	228	1664	-	51	414
2030	2	174	1593	-	36	351
2040	-	95	1312	-	15	259
2050	-	57	1161	-	5	212
2090	-	1	428	-	-	36

and Environmental Reserve.

Due to the improvement of the radiological situation resulting from the lower levels of cesium-137 and strontium-90, the rehabilitation of some areas with limited public access is planned, including the return of agricultural lands in use, the removal of pass control in some sections of the controlled zones.

The zone borders with the pass control have been optimized in the Vetka, Khoiniki, Buda-Koshelevo districts of the Gomel Oblast and in the Klimovichi district of the Mogilev Oblast.

The territories subjected to the pass control are located in 8 districts of the Gomel Oblast (Bragin, Buda-Koshelevo, Vetka, Dobrush, Korma, Narovlya, Khoiniki, Chechersk) and 5 districts of the Mogilev Oblast (Klimovichi, Kostiukovichi, Krasnopolye, Slavgorod, Cherikov). The total area of the territory under pass control makes 5.5 thousand sq.km.

The State Program for 2011-2015 provides for the fire security management in the exclusion zones and compulsory evacuation zones through the annual arrangement of more than 240 hectares of fireproofing mineral strips along the public roads, around the evacuated settlements, the cemeteries and in the areas contiguous to the peat fields and woodlands.

There are 267 cemeteries in the exclusion and resettlement zones, which need maintenance works since the access of the population is restricted. The State program provides for a 5-year maintenance cycle for these cemeteries. Besides it includes the cost of maintenance of 92 World War II monuments and grave sites.

To inform the population about the special regime, the warning radiation alert signs are renewed and installed at the exits from the public roads passing through the territories under the pass control, as well as along the boundaries of the exclusion and compulsory evacuation zones.

Due to the continued work on the pass control cancellation, the maps of the correspondent districts of the Gomel and Mogilev Oblasts will be updated and published.

The territory of the Polessie State Radiation Ecological Reserve, which falls within the near Chernobyl NPP zone, has high levels of radioactive contamination. The mosaic and heterogeneous nature of the contamination does not allow selecting any areas suitable for returning them into the economic land use. The radionuclide contamination affected all the components of the environment: the lands, the forests, the rivers, the lakes, the animals, the plant systems, the air basin. There are no "clean" objects here – the difference lies only in the levels of pollution.

The specificity of the near zone is the contamination with transuranic elements, which is practically not observed in the farther remote areas. The contamination of the compulsory evacuation zone is also complicated by the presence of the fuel particles, the smallest particles of the nuclear fuel used at the destroyed 4th NPP unit, which were thrown to the environment by the explosion and fire and almost entirely fell within the 30-kilometer zone. These particles of uranium oxides almost do not dissolve in the natural environment and have a very high specific activity. In this regard, over the next centuries, the territory adjacent to the NPP will remain a source of danger to humans. Therefore, the exclusion and compulsory evacuation zone serves to protect the public from the additional radiation load and the potential risks of various diseases.

After people left this area, the anthropogenic pressure on the natural systems was lifted, and on the flora and fauna too. The shift of the development processes towards their natural destination has become noticeable. The groundwater level has raised, the territory is being swamped in some areas and slowly reafforestated in the natural way, the former farmlands are overgrown with wild grasses. The natural reserve territory is subject to a much more strict pass control than the territory of any other national environmental institution. The number of operated vehicles is minimized. The accessible food supply, the absence of the disturbance and discomfort factors have led to a sharp increase in the biodiversity of the wildlife. Consequently, another purpose of this zone must be viewed through the lens of a wild nature reserve. This approach is consistent with many international environmental treaties, signed by the Republic of Belarus.

The local flora and fauna, while under the constant observance, can provide significant scientific results as regards the prolonged effects of radiation on biota; the links between the doses and the effects can be reliably revealed and the conceptual radiobiology and medicine approaches can be defined. This approach uses plants and animals as biological indicators of the processes which a human can also undergo when living in this environment.

This determines another purpose of this zone as a scientific testing facility. The interest of the scientists in this area remains high. Many European countries with a developed nuclear power sector, with the similar climatic conditions closely follow the scientific publications of the Belarusian scientists in this field. The mankind should derive the maximum benefit and select everything rational from the bitter experience of this catastrophic event. The man should have experience in protection against potentially possible nuclear accidents in the future.

4.3 Environmental Radiation Monitoring

Radiation monitoring is a system of long-term regular observations to assess the radiological situation and make the forecast of its changes in the future. The monitoring data can be used for

the development planning of the national economy sectors at the territories affected by the radioactive contamination; for the assessment of the possible effects of the radiation factor on the human health; for the development of the regional environmental management strategies.

The environmental radiation monitoring in Belarus is a part of the National monitoring system. The radiation monitoring targets are the atmospheric air, the soil, the surface water and the groundwater.

Under the State Program for 2011-2015 and until 2020, in order to maintain the comparability of the results and taking into account their importance for life activities, the dynamics of the following environmental aspects will be monitored:

- the dose rate of gamma radiation (55 observation stations);
- the content of radioactive isotopes in the atmospheric air (the control over the atmospheric fallouts – 27 stations, the aerosols in the air – 7 stations);
- the content of radionuclides in the surface waters and the bottom sediments of the rivers and drainage systems;
- the dynamics of the radioactive contamination and the migration of radionuclides within the soil profile of the agricultural (15 permanent observation stations) and long-fallow lands (19 natural landscape grounds for geochemical testing);
- the dynamics of the radioactive contamination of the forest soils and vegetation (88 permanent observation stations).

The monitoring of the natural radiation background and the radioactive contamination of the atmospheric air, soil, surface water and groundwater is held at the radiation monitoring stations.

The radiation monitoring stations include the observation stations and posts, monitoring sections on the surface water bodies, monitoring wells and hydrogeological posts located in the areas with the natural or disturbed groundwater regime. The number and the location of the radiation monitoring stations, the list of the parameters and the frequency of the observations, the technology of the works carried out to organize and maintain the radiation monitoring provide sufficient information for an objective assessment of the radiological situation and the radioactive contamination of the environment.

The radiation monitoring data, subject to the long-term storage, shall be, in due order, included in the national data fund for information on the environment and harmful environmental effects.

The public bodies, legal and natural persons shall have the right to make requests to the information and analytical centre of the National Environmental Monitoring System of the Republic of Belarus and to receive free information obtained through the radiation monitoring, except for the information, access to which is limited by the legislation of the Republic of Belarus.

The data obtained as a result of the radiation monitoring, are provided for the national governing bodies, local executive and administrative bodies, legal entities and should be considered when drafting the state programs for the conservation of natural resources and environmental protection, the programs in the field of the radiation safety of the population, the programs to overcome the effects of the catastrophe at the Chernobyl NPP, the territorial complex schemes for the rational use of the natural resources and environment; when providing information on the radioactive contamination of air, soil, surface water and groundwater and informing the population about the radiation environment, and for other purposes.

In case of a threat of or an emergency related to the radioactive environmental contamination, the radiation monitoring information, in the manner prescribed by the Council of Ministers of the Republic of Belarus, shall be passed to the Ministry of Emergency Situations, brought to the national government bodies, to other public organizations subordinate to the Government of the Republic of Belarus, to the local executive and administrative authorities and to the public in order to take urgent measures to prevent the emergencies, minimize or eliminate their effects.

This system will be maintained in the foreseeable future.

4.4 Health Surveillance of the Affected Population: Periodic Medical Examinations, Development of Specialized Registries

About 1.1 million people reside on radioactively contaminated territories. A quarter of a century after the Chernobyl disaster the main concern for the people is their health status. The experience of the mitigation of catastrophe effects provides the evidence that the reduction of the negative radiation impact on the population depends to a large extent on the organization and efficiency of the activity of healthcare institutions.

The assessment of the current situation and forecasting the long-term effect of radiation exposure on the people of the Union State resulting from the Chernobyl catastrophe are of a high social and economic significance. The main information source on which modern knowledge about radiation risks and forms of dose-dependency is based is the population which survived the atomic bombing in Japan. But there is a well-justified doubt as to whether the obtained data may be applicable to the assessment of the situation in Belarus and Russia

after the Chernobyl catastrophe: different physical parameters of irradiation sources, other social and economic environment, ethnic and geographical peculiarities.

There are still discussions among academia on radiation risks as regards inducing cancers at low exposure doses. The ambiguous and very often even contradicting results in the native and international publications reflect different attitudes in the scientific community to the assessment of the biological effects of low dose radiation.

It is necessary to continue works on the creation and maintaining of the operation of medical and dosimetric as well as radioecological data banks of the Chernobyl registry; radiation and epidemiological studies to evaluate dose-dependency and forecasting health effects for the people exposed to radiation, as the registry is the most essential tool and information basis for shaping up a targeted approach to providing specialized medical care for the affected population.

The Unified Chernobyl Registry of Russia and Belarus will be further filled with data and enlarged. It was primarily established to ensure joint monitoring of the health status of the affected population, cleanup workers, and obtaining reliable data on the health and biological effects of the Chernobyl catastrophe.

The establishment of the Unified Registry is of great scientific and practical value, as the integration of data of the two registries of Russia and Belarus based on the standard principle of data arrangement, methods and criteria of comprehensive radiation, epidemiological and statistical analysis of the information guarantees a more precise assessment of Chernobyl health effects for the population of both countries, a higher representativeness and scientific credibility of predictive estimates of the said effects.

The following objectives are still topical:

reducing the risk of radiation induced and other diseases through introduction of preventive programmes aimed at increasing the resistance of the body to the influence of adverse factors;

early detection of radiation induced diseases among various categories of the affected population and cleanup workers;

increased effectiveness of therapy, prevention of disease recurrence and complications, reducing primary disablement and mortality;

reducing dose loading due to the use of modern low-dose diagnostic equipment.

In this context the adoption of state-of-the-art diagnostics and therapy technologies at the district level through the introduction of telemedicine and new therapeutic and diagnostic equipment and their efficient use at the local level comes to the foreground.

4.5 Social and Psychological Aspects of the Chernobyl Catastrophe

The insufficiency of information as well the complexity of the situation predetermined by the immensity of the catastrophe served as a reason for the emergence of sustainable stereotypes, the so-called Chernobyl clichés, which had and continue to have an adverse effect both on the social and psychological status of the people residing on contaminated territories and the forming of socio-cultural space of the Republic of Belarus on the whole. The existing stereotypes are the barrier to the further advance in the process of overcoming the consequences of the catastrophe and the development of the regions, as the participation of population in these processes at the current stage is a mandatory prerequisite.

The survey of the socio-psychological status of the population belonging to the category of "affected as a result of the catastrophe at the Chernobyl NPP" have been performed since 90-s [20, 21].

The socio-psychological effects of the catastrophe are manifested in the changed emotional status of the considerable part of the population, which leads to the exhaustion of the neuropsychic mechanisms, and disorders in the adaptive systems of the human body.

The following should be seen as primary causes of the observed psychogenetic disorders: insufficient knowledge of the effects of radiation; permanent anxiety about one's own health and well-being and those of the close relatives; especially children; a sharp change of the life stereotype (forced resettlement, violation of the established pattern of life, change of the place and subject matter of work); need for continuous observation of safety measures and undergoing preventive medical check-ups; narrowing the opportunities for professional self-actualization, especially in young people; discrepant information on the radiation situation and its effects. Without sufficient knowledge in radiation safety and attributing most diseases to even the lowest levels of irradiation the people give birth to the myths on the harm that living on radionuclide contaminated territory brings about, which in effect leads to dependency and non-productive lifestyle.

As a result, the population of the contaminated districts experience psychological stress, which is associated with the two factors acting in synergy: the presence of the actual radioactive contamination and the overall socio-economic tension.

The psychological consequences of the accident are to a great extent associated not only with the actual contamination of the environment but also with the actions of decision-makers, statements of mass media and the availability of different information flows. That is why the stress of the population residing on contaminated territories can be characterized as information induced. And adequate measures are needed to cope with it.

According to the findings of 2009-2010 there has been detected a positive dynamics both in the direction of the share and number of people in the risk group as to the degree of psycho-emotional tension brought about by the radiation factor, and the reduction of the share of people from among the people who need additional information on the problems of the consequences of living on territories affected by the catastrophe at the Chernobyl NPP. The share and the number of people falling within the risk group as per the degree of psycho-emotional tension have reduced from 40 per cent in 2009 to 17 per cent in 2010.

The analysis of sociological studies allows to draw a conclusion that the socio-psychological climate in the affected districts has significantly improved due to the rehabilitation measures taken in the recent years, including the recuperation of population, and providing social support, timely informing, and suchlike. Thus, the number of people who have managed to adapt to the living conditions has increased.

The number of people susceptible to the depressing feeling of the "victim psychology" has decreased sharply.

At the present time new approaches to informing and awareness raising of the population in the area of radiation safety and radioecology are implemented widely at the national level, which allows to overcome the socio-psychological stress, increase the life energy, form a healthy lifestyle of the population in the context of living in Chernobyl contaminated areas.

Therefore, in the State Programme on Overcoming the Consequences of the Catastrophe at the Chernobyl NPP for 2011-2015 and for the period up to 2020 information tasks have been enlarged and include:

reflecting the role of the state in addressing the comprehensive task of the rehabilitation and recovery of the affected territories at the local, national and international levels, representing the Republic of Belarus as an expert country with experience in the mitigation of the consequences of a nuclear disaster;

adequate reflection of the activity on contaminated territories, shaping up of a positive image of these areas;

more active involvement of the population, first of all young people in the process of the development of Chernobyl affected territories;

forming the radiological culture of the population, a safe lifestyle in the context of living on the contaminated territories, and adequate attitude to the current situation;

development, distribution and support to the operation of local information electronic resources, information structures, their integration into a network;

preservation and transmission of the memory on Chernobyl catastrophe and its consequences, including also in the context of the European culture.

4.6 Preservation and Transmission of the Memory on the Catastrophe

It is impossible to build the conscious future without the apprehension and analysis of the past. A quarter of a century is a notable landmark in the history of the country, this is huge work to overcome the effects, these are fates of millions of people. The inhabitants of 430 settlements were resettled and evacuated from radionuclide contaminated territories. Nowadays hundreds of people - when they come to their native place – cannot anymore find the traces of their own homes, as the buildings of many settlements and villages have been buried (eliminated in order to bring the resettled territories into the proper sanitary state). And they can only pass onto their children and grandchildren the memories about the places where their ancestors had lived. That is why any information which can preserve the memory on the resettled and buried villages is of utmost importance. The collected materials become a part of museum expositions.

The creation of a guide album to the contaminated territories of Belarus has been initiated within the framework of the State Programme on Overcoming the Consequences of the Catastrophe at the Chernobyl NPP for 2011-2015 and up to 2020. The edition would position 21 most severely affected districts not as an established stereotype of the «Chernobyl zone" but as the territories rich in cultural and natural assets, authentic traditions and people – bearers of these traditions. Today in some of these areas the share of the people of retirement age makes 70 per cent of the overall population. These people know and sing sacral and everyday songs, remember and retell local legends and stories, they are connoisseurs in crafts. The objective of the publication is to help preserve for the new generations the spiritual heritage of the "Chernobyl districts".

In Belarus there are people who were directly involved in extinguishing of the fire at the Chernobyl NPP and subduing the destroyed reactor. Every year, on the day of the tragedy, at the central square of the town of Bragin, which is located 45 km from the reactor, the requiem meeting is held near the monument to the evacuated villages and the bust of the fire-fighter Vasiliy Ignatenko, who, together with his team-mates, gave their lives to have barred the way to the fire and remained the victor in this unequal struggle. The grateful citizens from different parts of Belarus, the foreign guests come to pay the tribute to the memory of the hero.

In Minsk, in addition to the memorial meeting held on the street named after V. Ignatenko, another meeting is held near the memorial plaque installed on the facade of the house where another hero of Chernobyl had lived – the helicopter pilot Vasily Vodolazhsky, who was dropping the neutralizing mixture over the destroyed reactor and was teaching

the young pilots how to minimize the exposure during the work.

Unfortunately, not much is known today about the fate of the hundreds of people who carried out the priority evacuation activities, extinguished the fires, and later built a protective structure around the destroyed reactor – the sarcophagus. On occasion of the 25 years after the Chernobyl disaster, a book about the liquidators is being created in Belarus. It will help restore the memory about their life and feat. Not all of the liquidators will be able to describe the events of those days in this publication – some of them have died. But their names and deeds will be immortalized in the human memory.

Monuments and memorials were installed in many localities of Belarus in memory of the villages evacuated after the Chernobyl catastrophe. Thus, in Kalinkovichi a stone bird, a bittern, has frozen in the eternal mourning; another memorial installation stretches along the lake shore in the Cherikov District. Live voices will never sound in the houses on the "Buried Villages Avenue" in the Slavgorod District. The red carnations and the wreaths with the commemoration inscriptions on the ribbons will always remain at the foot of the monuments.

From year to year the memory of the Chernobyl disaster is wider reflected in the works of art and culture. In 2007, in Russia, at the international annual TV festival of the environmental films "Save and Preserve", the picture of the Belarusian journalists "The Pripyat Disco" was named the winner in the nomination "The Best Journalistic Documentary".

In 2010, in Bragin, the festival of children's documentary cinema was held, "The Crystal Stork Chick", which was attended by children from the regions of Belarus affected by the Chernobyl disaster. The plots of the films focused on the Chernobyl issue. "My generation and Chernobyl" was selected as the winning film. The most poignant impression is produced by the children's voiceover: «Chernobyl – it is when the houses are empty", "Chernobyl – it is a village where people do not live any more". And the phrase uttered with a sigh: "Chernobyl... Well, it is a kind of a disaster!" In Bragin the presentation of the commemoration book "In the face of... For the joy of… In memory of…". The publication presents poems by children and youth about the Chernobyl disaster and the lives of people afterwards.

In Minsk, in the Peoples' Friendship Park, the memorial signs "To the Victims of Chernobyl» and the "Hiroshima peace stone" were installed; the latter was the initiative of the Japanese public. On the wall in the Chernobyl church in honour of the icon of the Mother of God "The Seeking of the Lost", there is a memorial plaque, which was consecrated by His Eminence Philaret and which contains the text of the Testament to the descendants on behalf of the President of Belarus and Philaret, the Metropolitan of Minsk and Slutsk, the Patriarchal Exarch of All Belarus. This temple, built in the 1990-s at the expense of the Chernobyl non-governmental organizations and ordinary people, is not only a place for the memorial events, but also the centre for the documents about the people's heroism in overcoming the consequences of the Chernobyl disaster.

On the Prityts ky street a temple complex was built in memory of the victims of the Chernobyl disaster. It includes the Church in honour of the icon of the Mother of God "The Consolation of All Who Sorrow", the Church of St. Euphrosyne of Polotsk, the Chapel of St. Gabriel of Bialystok, the bell which leads to the compound, the icon-painting workshops, the Sunday school, the poorhouse, the refectory for the poor, the museum in memory of those who died in the Chernobyl disaster, the library, the church hotel and the memorial graveyard.

In June of 2010, in Minsk, Belarus, there was a significant event held in the Memorial Church of All Saints and in Memory of the Innocent Murder Victims in our Fatherland, that is in the heart of the memory of the fallen heroes of all wars. On that day a crypt was opened and in the wall niches of the crypt the remains of the unknown soldiers were buried. Here you will find not only the burials. The doors of the crypt are decorated with the six bas-reliefs "The Tears of Belarus" and each of them represents one of the places of glory and sorrow of the Belarusian people;

A monument to the resettled villages, Vasily Ignatenko's bust, settlement of Bragin

Chernobyl is among them as the living sorrow of the Belarusian, Ukrainian and Russian peoples.

Since 2007 the international seminars are regularly held on "The problems of the elimination of the Chernobyl disaster effects and the role of the Orthodox Church in the spiritual and moral education and psychological rehabilitation of the affected population".

The memory of the Chernobyl disaster has reached beyond the affected areas long ago. In 2007, as a part of the International "Cooperation for Rehabilitation (CORE)" Program, the festival "Tell me a story, Mr.

Cloud...” was held. Within one year children from Belarus, Russia, Ukraine, France, Germany, Austria, Spain, Cameroon, the Lebanon, the Philippines, along with the well-known cultural figures in their countries made up fairy tales, in which the main character was the cloud that had gushed from the Chernobyl NPP reactor in April 1986. The schoolchildren have never seen it. Maybe that is why their view at the Chernobyl events is particularly expressive. The children came up with 52 unique stories, and then made 10-minute films after these stories. Each team had their own view of the catastrophe and its consequences, but all the movies have an optimistic ending. The children look ahead with a smile. In each country, the children found the problems comparable with the Chernobyl accident: the war in the Lebanon, the AIDS problem in Africa, the global environmental problems of today... And through the prism of these national and international problems the children from the different countries were able to see and feel the tragedy of Chernobyl.

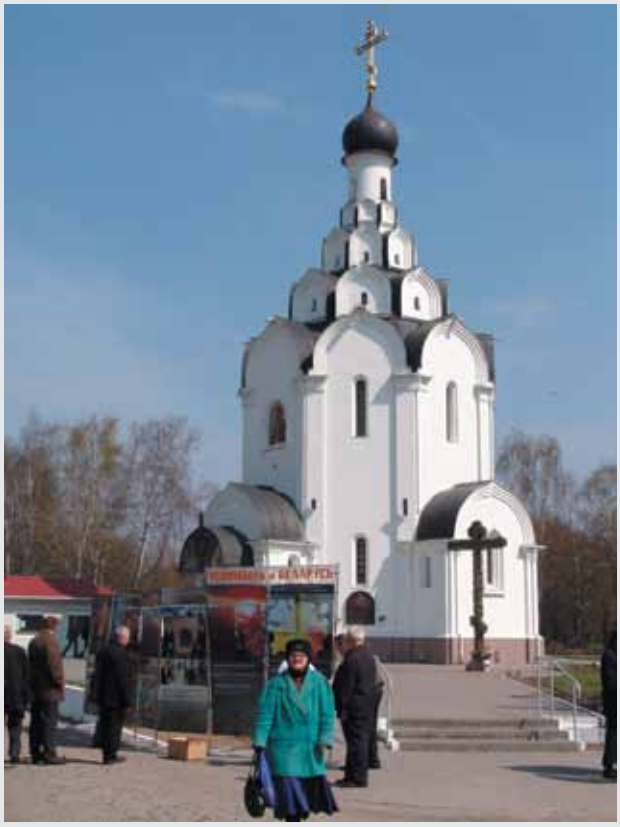
In 2010, the International Education Seminar “Chernobyl is the European Memory” gathered about three dozens of students from the European countries in the Belarusian capital, the city of Minsk. All of them were the national winners of the local history contests from Belarus, Belgium, Bulgaria, the Czech Republic, Germany, Estonia, Finland, the Netherlands, Denmark, Latvia, Poland, Romania, Russia, Serbia, Slovenia, Slovakia, Spain, Switzerland, and the Ukraine. The students are aware of the bitter lesson that was taught to the mankind by Chernobyl and realize that the preservation of the memory of this technogenic disaster is the necessary condition to correct the mistakes. The young people met the evacuated people and the liquidators and learned about the European projects to help the victims of Chernobyl. This seminar was a part of the project “25 years after Chernobyl”, organized by the Dortmund International Educational Centre and the Mercator Foundation in cooperation with the European association EUSTORY and the Johannes Rau International Centre for Education and Exchange (IBB) in Minsk.

Under this project 50 witnesses of the Chernobyl disaster from Belarus and Ukraine (the firemen, soldiers, doctors, engineers, etc.) will talk about their life and work to the people in 25 cities and towns of Germany. The meetings and interviews will take place from January to April, 2011. The missions will be supported by the exhibition of photos by Rudiger Lubricht “The Liquidators – the Forgotten Saviors of Europe”. The project will be closed by the event “Chernobyl as a pan-European Challenge”, which will be held in Berlin on 26 April, 2011, on the day of mourning and gratitude to the people who did a lot to eliminate the effects of the Chernobyl disaster.

In 2011 the Republic of Belarus launched the international exhibition “Chernobyl and Belarus:

Memorial stone “To the victims of Chernobyl”, city of Minsk

Memorial “Stone of Peace of Hiroshima”, city of Minsk



Chernobyl church in honour of the icon of the Mother of God "The Seeking of the Lost", city of Minsk

Past, Present and Future" intended for demonstration in the European Union countries: the Czech Republic, Austria, Belgium, Germany, the Netherlands and Switzerland. The event is devoted to the 25 years after the Chernobyl disaster.

During the exposition the presentation of the catalogue "The Sorrow Painted in a Brush" will be held, which includes the works created by the Belarusian artists. Their paintings reflect the beauty of the Belarusian nature, of the places affected by the Chernobyl disaster, the heroism of the liquidators, the challenging fates of the survivors in this tragedy. Children also paint Chernobyl. The young Belarusians have sent over a thousand works in the framework of the initiative "Chernobyl and Belarus: Past, Present and Future". Many of the young artists live in the affected areas, so their paintings are especially realistic. Chernobyl for them means not the statistics, but their everyday life. That is why it is particularly important that in every painting, even the saddest one, there are signs of joy and hope. The children are sure: after the pain of the past the joy of the future will surely come.

The exhibition "Belarus: 25 years after Chernobyl" will be held in April – May, 2011 at the National History Museum of Belarus and will become an important cultural event, which, with the help of the modern exhibition technologies, will demonstrate to the visitors the main results of the implementation of the public policies to overcome the consequences of the accident at the Chernobyl NPP and the cultural heritage of the affected areas.

The memory of the consequences of the accident at the Chernobyl NPP should be preserved forever as an invaluable lesson and a warning for the future generations.

To remember the Chernobyl tragedy is important not only for the countries that faced the bulk of the disaster impact.

4.7 The Strategy for the Development of the Affected Regions Objectives for the Period up to 2020

The implementation of the focused state policy in the mitigation of the consequences of the Chernobyl catastrophe made it possible to cope with a number of essential tasks. Social protection of the people affected by the catastrophe at the Chernobyl NPP, reducing the risk of adverse effects to the health of the cleanup workers and the affected population, and achieving positive results in the socio-economic rehabilitation of the contaminated territories have been secured.

At the same time, the immensity of the radioactive contamination and the complexity of the radiation protection of the population and rehabilitation of the affected territories demand that work aimed at both the mitigation of the consequences of the catastrophe at the Chernobyl NPP and the revival and sustainable socio-economic development of the affected population be continued.

In the long run the state policy on overcoming the consequences of the catastrophe at the Chernobyl NPP builds up on the transition from post-accident rehabilitation measures to the development of the social and economic potential of the affected regions, and creating a more attractive living environment for the people residing in these areas.

The following objectives are defined as most topical for 2011-2015 and for the period up to 2020:

ensuring the production of goods meeting the republican and international hygienic standards (transition to the standard for caesium-137 content in beef and mutton at 160 Bq/kg, in line with the standard adopted in the Russian Federation);

implementation of the complete set of protective measures in 473 settlements where the average annual effective radiation dose might exceed 1 mSv, and maintaining of a part of protective measures in 1929 settlements, where the average annual effective radiation dose amounts to 0.1 - 1 mSv, which will secure maintaining the radiation safety at the achieved level;

meeting the requirements as regards the social protection of people affected by the catastrophe at the Chernobyl NPP in accordance with the Law of the Republic of Belarus On Social Protection of

From the exhibition "Chernobyl and Belarus: Past, Present and Future"

People Affected by the Catastrophe at the Chernobyl NPP, Other Radiation Accidents;

continuous health surveillance of the people affected by the catastrophe at the Chernobyl NPP to reduce the risk of health effects for the present and future generations;

free meals for children, their recuperation and sanatorium-resort therapy;

implementation of the system of additional measures to protect forests from fires, minimize exposure doses of the forestry workers, ensure conservation of forest resources on radioactively contaminated territories;

further activity on return to commercial use of the lands previously withdrawn from agricultural production with due account of the requirements of radiation safety and cost-effectiveness;

allocation of funds for the construction of accommodation facilities of the state residential stock to be provided to people in line with the legislation currently in force as housing perk and accommodation for the privileged category of people, social infrastructure facilities, establishment of the necessary utilities infrastructure and new production units;

continuing scientific support to the activities within the State Programme;

further activities on maintaining the exclusion and resettlement zones, burying buildings in the said zones (220 settlements need to be buried in the resettlement zones);

ensuring radiation control and monitoring;

improving information work with the population residing in radionuclide contaminated territories, and enhanced methods of information sharing with the state bodies and the public on the implementation of the state policy in the sphere of overcoming the consequences of the catastrophe at the Chernobyl NPP.

It is planned to put new approaches towards the exploitation of radionuclide contaminated territories in terms of radiation security and cost-effectiveness into practice through the implementation of special projects aiming to revive and develop the affected territories, including building up industries, which would ensure the development and production of non-subsidy and profitable goods.

The criteria for the elaboration of special projects are as follows: contamination of products above the established republican permissible levels as per radionuclide content, the problem of sale of produce on the export and domestic market due to its contamination with radionuclides, average annual effective radiation dose of the population in excess of 1 mSv, lack of qualified specialists, etc. These projects shall be developed upon propositions of the local executive and administrative bodies, and public sector customers of the programme.

AFTERWORD

All information presented in the report - statistics, comparative analysis, forecasts, conclusions - serve to demonstrate both the immensity of the consequences of the Chernobyl catastrophe and the complexity of the situation that the Republic of Belarus faces in decision making, choosing specific action and achieving noticeable results in the mitigation of these effects. But the primary commendable choice of the young sovereign state was that the affected territories were not abandoned – either alienated, resettled or those where over a million people live now – while the acquired experience of living in conditions of radioactive contamination enables planning the strategy of their long-term development.

The peculiar character of the effects of the disaster are so that notwithstanding considerable positive outcomes there is much to be done to revive and develop the affected territories and ensure sustainable improvement of the living conditions of the people residing here. Among the top priorities in the further activity of the government are: the improvement and development of the system of target-specific healthcare and recuperation of people; improvement and development of the system of protective measures; implementation of projects aimed at the sustainable functioning of territories and settlements; creation of an efficient information space on radiation safety, radioecological literacy, and noospheric thinking with due regard to the realia of the civilization's technological development.

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