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1. Introduction

Many people still do not manage to perceive the real scale of the tragedy suffered by Belarus following the explosion of the Chernobyl Nuclear Power Plant (NPP) reactor in the neighboring Ukraine. The large scale of negative environmental, medical, social and economic phenomena which followed as an outcome of this radiation emergency demands more than just a narrow approach based on radiation security. Taking into account that the negative consequences of the explosion were much graver for such a small country as Belarus than for other affected countries, the consequences are better described as a *catastrophe* or a *national environmental emergency*. Almost a quarter of the country with one fifth of the population was affected to a substantial degree. The outcomes of the Chernobyl catastrophe both for the population, as well as for the economy of Belarus, can hardly be measured.

Many, especially those outside Belarus, think the Chernobyl tragedy is an event from the past. But the catastrophe continues to have a devastating effect on all areas of activity in our country. What is worse, one cannot be sure that the most tragic impacts on the health of people and the state of environment are gone – even now, 16 years after the tragedy.

Today, numerous deviations from normal health are recorded in people living on contaminated areas. These are defined both by radiation, as well as other factors, primarily the poor standard of living. Medical manifestations of the serious stress are widely noted among the population. By now, a sure relationship has been proved to exist between the radiation exposure and the unprecedented growth in the incidence of thyroid cancer among Belarusian children.

The Chernobyl-affected areas of Belarus are characterized by a distorted demographic structure. More than 135,000 people were resettled, at least 200,000 people were forced to become refugees fleeing from the contaminated areas in an unorganized manner. Youth, intelligencia, qualified professionals and managers continue to be the main groups of people leaving these areas. In some most affected districts the share of retired people reaches 70%, which is almost three times the average for the country.

Radioactive contamination of territories is the cause of serious problems in agriculture, especially in terms of the availability of food products of acceptable radiological quality. About 20% of all agricultural lands were significantly contaminated by radionuclides, this happening in the traditionally best agricultural areas! The Government is forced to maintain agriculture on most of such lands – otherwise it would be impossible to resolve the employment issue. This is accompanied by heavy outlays of resources for protective measures, ensuring that the content of radionuclides in the agricultural goods produced stays within the admissible limits.

Despite the fact that in the recent years the Government kept spending a significant portion of its budget for dealing with the consequences of the catastrophe,

the scale of the post-Chernobyl problems is much bigger than the capacity of the country to overcome them. Just like other young states, which emerged after the break-up of the Soviet Union, Belarus is undergoing transformation from a planned to a market economy. The consequences of the Chernobyl catastrophe coincided in time with the hardships linked to the demolition of the past and erection of a new system of state. When building a new structure of governance, the young Belarusian state has to overcome numerous social and economic problems, while at the same time doing its best to minimize the consequences of the Chernobyl NPP disaster.

On the background of a serious of emergencies and crises overwhelming the international community, Chernobyl is almost completely forgotten. We need to state, that the size of assistance from the international community is inadequate to the scale of problems, and this assistance is not always effective. The purpose of this report is to draw the attention of the world to post-Chernobyl problems of Belarus, and to remind of the fact that the victims of that catastrophe are still in need of assistance.

2. National legislative and normative base

When the Chernobyl Nuclear Power Plant (NPP) exploded, Belarus had neither legislative nor normative base to deal with radiation emergencies. In the first several years which followed the tragedy, the normative documents issued in Belarus were based on the analogous documents adopted in the former USSR.

2.1. The legislative base

In 1991 the Supreme Soviet of the Republic of Belarus adopted a *Law on Social Protection of Citizens Who Suffered from the Chernobyl Nuclear Power Plant Catastrophe*, and a *Law on the Legal Regime of Areas Impacted by the Radioactive Contamination from the Chernobyl Nuclear Power Plant Catastrophe*. The *Law on Social Protection of Citizens Who Suffered from the Chernobyl Nuclear Power Plant Catastrophe* defined protection of the rights and interests of citizens who participated in the liquidation of consequences of the disaster, the resettled, those who moved from the radioactively contaminated area to new places, those who continued to stay on contaminated areas, those who participated in liquidation of consequences or suffered from disasters at other nuclear plants of civil or military purpose, those who suffered from tests, trainings or other activities related to nuclear plants, including nuclear weapons.

The *Law of the Republic of Belarus on the Legal Regime of Areas Impacted by the Radioactive Contamination from the Chernobyl Nuclear Power Plant Catastrophe* defines the legal regime of those areas of the country which were subject to radioactive contamination from the Chernobyl NPP disaster. The objective of the law is to define ways to lower the radiation exposure of people and ecosystems, facilitate nature-rehabilitation and protective activities, rational use of natural, commercial and scientific potential of these areas. The law defines such terms as *national radiation ecological emergency*, radioactively contaminated territories, radioactively risky land, exclusion areas, lands with limited economic activities, etc. Article 4 of the Law divides the territory of Belarus into zones (Table 2.1) in accordance with the level of radioactive contamination of soil and the size of the average annual effective radiation dose.

Decisions on including a certain area into one zone or another is made by the Government once a corresponding ceiling is exceeded at least for one of the following parameters: the average annual radiation dose, density of contamination by Cs, Sr or Plutonium isotopes.

In 1998 the National Assembly adopted a *Law on Radiation Security of Population*. This law is meant to improve the system of radiation security in the country, and its transition to meet the international standards and guidelines. The limit for average annual effective radiation dose for Belarusian population was set at 1 mSv.

Table 2.1

Zones of the Republic of Belarus according to the radioactivity contamination level and irradiation doses of population

Zone	Effective dose, mSv per year	Contamination density, kBq per sq. m		
		Cs-137	Sr-90	Pu-238, -239, -240
Zone with periodic radiation control	<1	37–185	5,55–18,5	0,37–0,74
Zone with the right to resettle	1 – 5	185–555	18,5–74	0,74–1,85
Zone of the secondary resettlement	> 5	555–1480	74–111	1,85–3,7
Zone of the primary resettlement	> 5	> 1480	> 111	> 3,7
Evacuation (exclusion) zone	Area adjacent to the Chernobyl NPP from which people were evacuated in 1985			

2.2. The normative base

Presently the key national documents in the area of radiation safety and population protection are:

- Norms of Radiation Safety (NRS 2000)
- Key sanitary rules for ensuring radiation safety (Key sanitary rules 2002)
- Catalogue of yearly effective forecasted exposure doses for people in the Republic of Belarus 1998/2001
- National admissible levels for the radioactive Cesium and Strontium content in food products and potable water (National Admissible Levels 1999), (Table 2.2)
- National admissible levels for the radioactive Cesium and Strontium content in agricultural raw materials, (Table 2.3)
- National admissible levels for the radioactive Cesium and Strontium content in key types of fodder, (Table 2.4)
- National admissible levels for the Cesium-137 content in timber, timber goods and other non-food forestry products (Table 2.5)
- Rules for forestry at contaminated areas (Table 2.6)

Table 2.2

National admissible levels for the radioactive Cesium and Strontium content in food products and potable water (National Admissible Levels 1999)

#	Name of product	Bq per kg or liter
For Cs-137		
1.	Potable water	10
2.	Milk and fresh milk products	100
3.	Condensed and concentrated milk	200
4.	Curds and curd products	50
5.	Rennet and melted cheese	50
6.	Milk butter	100
7.	Meat and meat products, including: 7.1 Beef, mutton and their products 7.2 Pork, chicken and their products	500 180
8.	Potato	80
9.	Bread and bakery	40
10.	Flour, groats, sugar	60
11.	Plant fats	40
12.	Animal fats and margarine	100
13.	Vegetables and root crops	100
14.	Fruit	40
15.	Horticultural berries	70
16.	Canned vegetables, fruit and horticultural berries	74
17.	Wild-growing berries and canned products out of those	185
18.	Fresh mushrooms	370
19.	Dry mushrooms	2500
20.	Special ready-use baby food	37
For Sr-90		
21.	Potable water	0,37
22.	Milk and fresh milk products	3,7
23.	Bread and bakery	3,7
24.	Potato	3,7
25.	Special ready-use baby food	1,85

Table 2.3

National admissible levels for the radioactive Cesium and Strontium content in agricultural raw materials

Raw materials	Content, Bq per kg	
	Cs – 137	Sr –90
<i>Milk to be processed into:</i>		
Milk butter	370	18
Fresh milk products, curds and cheese	100	3,7
Dry and condensed milk	30	3,7
<i>Meat:</i>		
Beef, mutton, pork, chicken	500	<i>No norm established</i>
	180	<i>No norm established</i>
<i>Plants:</i>		
Vegetables	100	<i>No norm established</i>
Fruit	40	<i>No norm established</i>
Horticultural berries	70	<i>No norm established</i>
Grain	90	11
Grain for baby food	55	3,7
Other materials	370	<i>No norm established</i>

Table 2.4

National admissible levels for the radioactive Cesium and Strontium content in key types of fodder

Fodder type	Content, Bq per kg				
	Cs - 137			Sr – 90	
	Fresh milk	Milk for butter production	Meat, final feeding	Fresh milk	Milk for butter production
Hay	1300	1850	1300	260	1300
Straw	330	900	700	185	900
Hay-based material	500	900	500	100	500
Silage	240	600	240	50	250
Root crops	160	600	300	37	185
Grain for fodder, mash	180	600	480	100	500
Green matter	165	600	240	37	185
Pine, grass and bone flour	900	-	-	-	-
Wash grains, pulp, treacle, draft					
Fiber, milk products	600	-	-	-	-
Other types	900	-	-	-	-

Table 2.5

National admissible levels for the Cesium-137 content in timber, timber goods and other non-food forestry products

#	<i>Products/goods</i>	Specific radioactivity content, Bq per kg
1.	Roundwood timber products	
1.1	Roundwood for construction of walls in buildings	740
1.2	Other roundwood products	1480
2.	Process wood	1480
3.	Fuel wood	740
4.	Lumber, wooden goods and components	
4.1	Lumber, wooden goods and components for construction (internal isolation) of residential houses	740
4.2	Lumber, wooden goods and components, other	1850
5.	Other non-food forestry products	1850

Table 2.6

Rules for forestry at contaminated areas
(«+» – allowed «-» - not allowed)

Forestry operations/activities	Density of contamination by Cs-137, kBq per sq. m				
	37-74	74-185	185-555	555-1840	>1840
Establishment of tree-seed plantations and nurseries	+	+	-	-	-
Establishment of improved hay-making fields	+	+	-	-	-
Establishment of berry plantations	-	-	-	-	-
Anti-fire activities at forests and construction of reservoirs	+	+	+	+	+
Harvesting of seed	+	+	+	-	-
<i>Facilitation of natural reforestation processes</i>	+	+	+	+*	-
Protection of forests from fires, illegal activities, pests and diseases	+	+	+	+	+
Final harvest felling	+	+	+	+*	-
Intermediate felling	+	+	+	-	-
Selective felling	+	+	+	+*	-
Clear felling and other types of felling	+	+	+	+*	+*
Collection of berries	+	-	-	-	-
Collection of mushrooms					
With low and medium capacity to accumulate radionuclides	+	-	-	-	-
With strong capacity to accumulate radionuclides	-	-	-	-	-
Collection of medicinal plants	+	-	-	-	-
Pasturing of working and fattening cattle, procurement of hay for it	+	+	-	-	-
Pasturing of cows and procurement of hay for it	+	-	-	-	-
Apiculture	+	+	+	-	-
Procurement of birch juice	+	+	+	-	-
Fishing and hunting	+	+	+	-	-

* allowed according to special regulations (projects)

3. Radioecological consequences

After the explosion of the Chernobyl nuclear plant reactor, radioactive particles descended on a substantial area of Belarus. The first several weeks following the catastrophe extremely high levels of contamination by short-living isotopes, specifically Iodine-131, were recorded in all of Belarus. In some places the irradiation dose was as high as 0.5 mSv per hour (which is more than 1,000 higher than the natural radioactivity background). Contamination by Iodine-131 caused high irradiation doses of the thyroid gland in almost every person of the country (the so-called iodine attack), resulting in increased thyroid pathology, especially among children.

In the subsequent period, which is also true for the present time and the nearest future, the radioecological situation in the country was defined by the impact of long-living isotopes. These include Cs-137, Sr-90, as well as trans-Uranium elements such as Plutonium-238,239,240,241 and Americium-241.

Analysis of radioactive contamination of Europe by Cs-137 shows that about 35% of the Chernobyl-related deposit of this radionuclides is found in Belarus. 23% of the country is contaminated by Cs-137 to the level over 37 kBq per sq. m. For comparison, the same indicator for Ukraine is 5%, and for Russia – 0.6%. This is an indication of much graver and complex consequences of the Chernobyl NPP disaster for Belarus, as compared to Russia and Ukraine.

As a consequence of contamination, radionuclides are now present in almost all components of ecosystems and are engaged in geochemical and trophic migration cycles. This defines the multiplicity of ways through which Belarusian people may be exposed to internal and external irradiation, creates additional risk to people's health, prevents from normal use of natural resources.

3.1. Contamination with Iodine-131

In April-May 1986 the highest deposition density for Iodine-131 in the closest vicinity of the Chernobyl Nuclear Power Plant occurred in Bragin, Khoyniki, Narovlia districts of Gomel region: there the density of contamination of soil by this element was 37,000 kBq per sq. km and more. Some areas in the south-west and north of Gomel region, as well as particular districts of Mogiliov and Brest regions, were also contaminated to a significant extent.

One outcome of the contamination by short-living radionuclides in the first several days following the disaster was a significant increase in the gamma-irradiation dose observed in all of Belarus (Fig. 3.1).

Taking into account the substantial impact of the radioactive Iodine-131 deposition on the health of population, the pattern of distribution of this isotope in Belarus as of 10 May 1986 was reconstructed (Fig. 3.2).

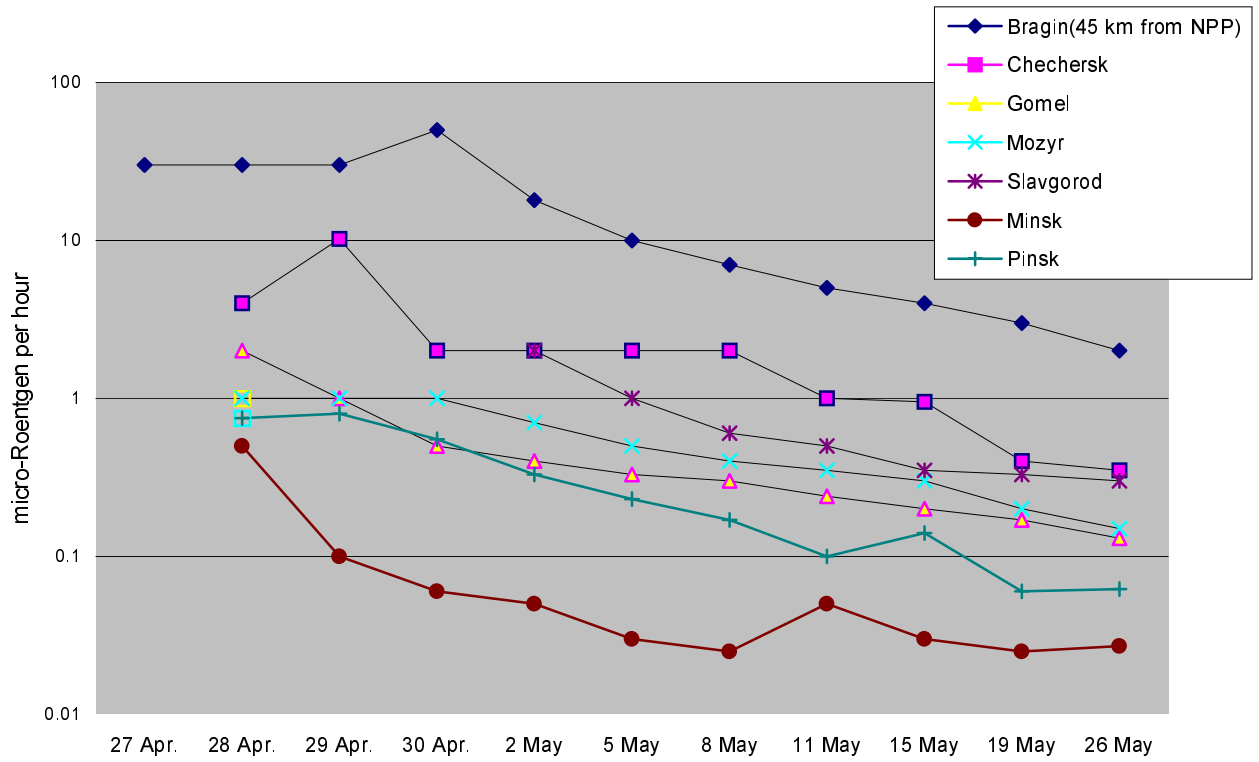


Fig. 3.1 The pattern of gamma-ray exposure on permanent monitoring sites of Hydro-Meteorological Service, 1986

Условные обозначения

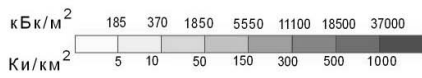


Fig. 3.2 Contamination of Belarus with Iodine 131

3.2. Contamination with Cs-137

The pre-disaster contamination of soil in Belarus with Cs-137 from globally migrating particles was 1.5 to 3.7 kBq per sq. m in isolated locations. After the Chernobyl disaster contamination with Cs-137 on 136,500 square km (66% of Belarus) exceeded 10 kBq per square meter. The area under Cs-137 contamination over 37 kBq per sq. km was 46.45 sq. km, which was 23% of the country's area (Fig. 3.3).

The maximal level of soil contamination with Cs-137 was about 60,000 kBq per sq. m, and was observed in selected dwellings both in the close and distant vicinity of the power plant.

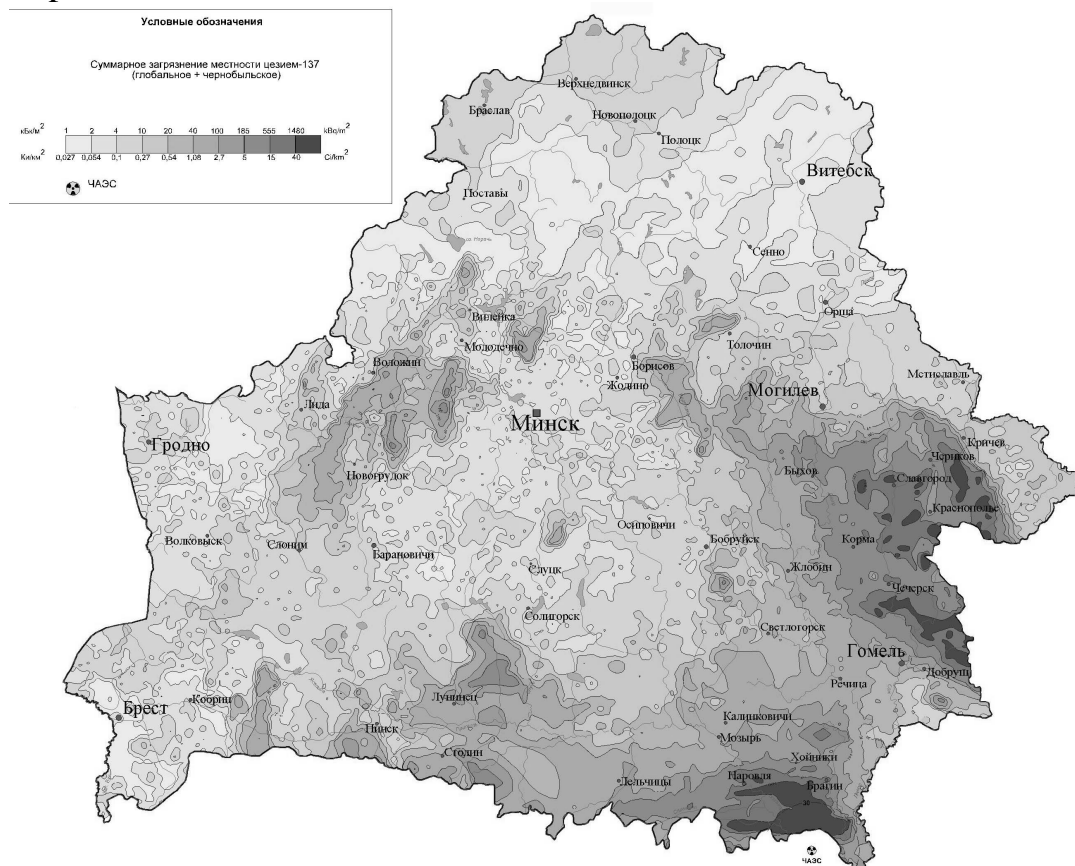


Fig. 3.3 Contamination of Belarus with Cs-137 (1986)

As of January 2001, about 43,510 sq.km (21% of the country) was contaminated with Cs-137 in excess of 37 kBq per sq. m (Fig. 3.4).

As a result of natural decay of radioactive Cs-137 the area under contamination is shrinking gradually. There are maps of projected Cs-137 contamination for 2016 and 2046, indicating that by 2016 the area under Cs-137 contamination in excess of 37 kBq per sq. m will be reduced 1.5 times compared to the initial situation (1986); and 2.4 times by 2046.

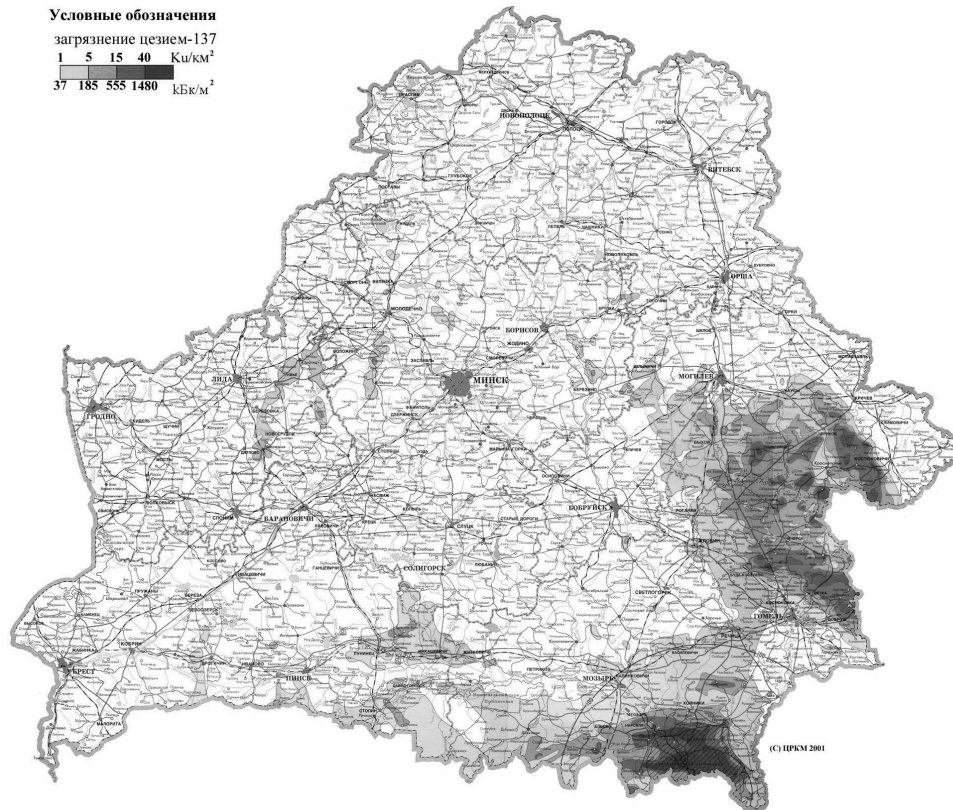


Рис. 3.4. Contamination of Belarus with Cs-137 (2001)

3.3. Contamination with Sr-90

Contamination of Belarus with Sr-90 is bound to specific locations (Fig. 3.5). Soils contaminated with Sr-90 over 5.5 kBq per sq. m cover 21,100 sq. km in Gomel and Mogilev regions, which is 10% of the country's territory. Maximal Sr-90 contamination was found to be 1,800 kBq per sq. m: this record was made within the 30-km zone around the power plant. The highest Sr-90 density for distant areas was recorded some 140-250 km away from the plant: 29-137 kBq per sq. m.

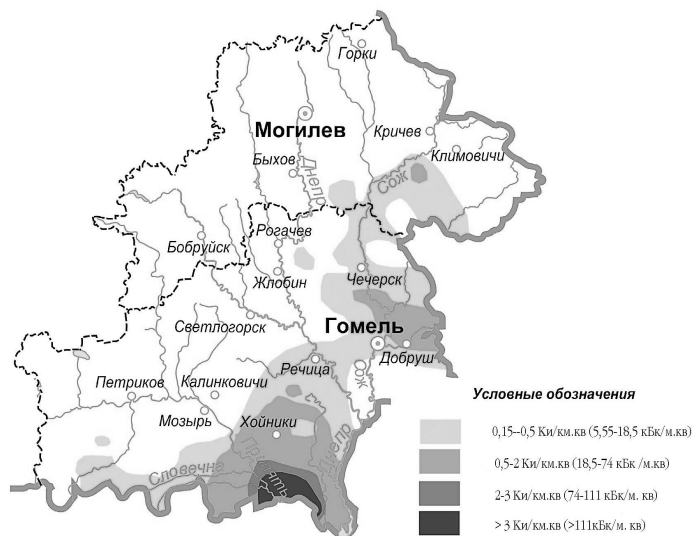


Fig. 3.5 Contamination of Belarus with Sr-90

3.4. Contamination with trans-Uranium elements

Contamination of soil with Plutonium isotopes-238,-239,-240 over 0.37 kBq per sq. km (Fig.3.6) accounts for about 4,000 sq. km, which is 2% of the country. These areas are mainly located in Gomel and Mogiliov regions. The highest density of these isotopes is found in the 30-km zone around the Chernobyl Nuclear Power Plant: over 111 kBq per sq. m.

Fig. 3.6 Contamination of Belarus with trans-Uranium elements

Trans-Uranium elements tend to reveal higher specific activity of Americium-241, which is attributable to natural decay of Plutonium-241. There are forecasts indicating that by 2058 the specific density of Americium will surpass the cumulative activity of all Plutonium isotopes by about 1.8 times.

3.5. Radioactive contamination of soil, water and air

Soil is the main source for migration of radionuclides into food chains. Presently, 70-90% stock of Cs-137, 40-60% stock of Sr-90 and up to 95% stock of trans-Uranium elements continue to be retained in the upper root layer of soil. The share of mobile Cs elements in soil, i.e. those readily available to plants is 10-15%, Sr 50-70%. The share of mobile Plutonium and Americium forms is 10-13%.

As active soil particles continue to decay, leaching of radionuclides out of them results, with their subsequent transformation into forms available to plants. This proves that the risk of radioactive contamination of vegetable products continues to exist, especially with Sr-90. The risk is equally true in respect of edible, feeding, and medicinal wild plants.

Radioactive contamination of soils results in direct damages to agriculture, especially when talking about the quality of goods produced. Non-agricultural ecosystems have suffered too.

Considering water resources, the largest contamination occurred in the catchments of the Dnieper, Sozh, Pripyat rivers. Water in rivers has good self-purification capacity, which is explained by constant outflow of particles and deposition

of radioactive elements to the bottom of the river or stream. Data from monitoring of waterbodies indicates, that the radiation situation in the basins of the Dnieper, Sozh, and Pripyat rivers, has stabilized: from 1986 through 2002 the yearly average Cs-137 concentrations in these river systems have reduced substantially (Fig. 3.7). No records were made of Cs-137 exceeding the established limit of 10 Bq per liter, or Sr-90 exceeding the established 0.37 Bq per liter of water in rivers. However the content of Cs-137 in the surface water is closely linked to the stock of radionuclides in catchment soils and in bottom deposits. In years with abnormal water regime the transfer or radioactive elements may rise substantially, including the cross-border exchange.

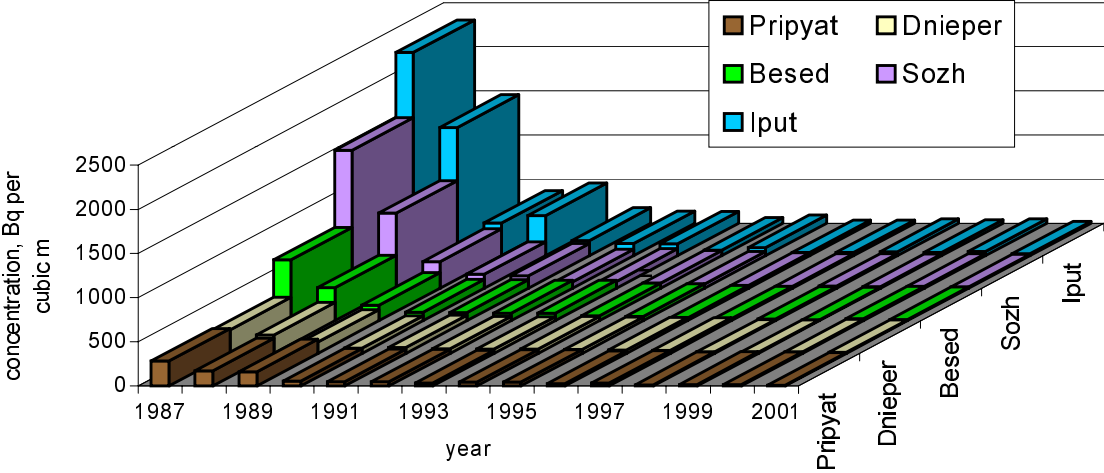
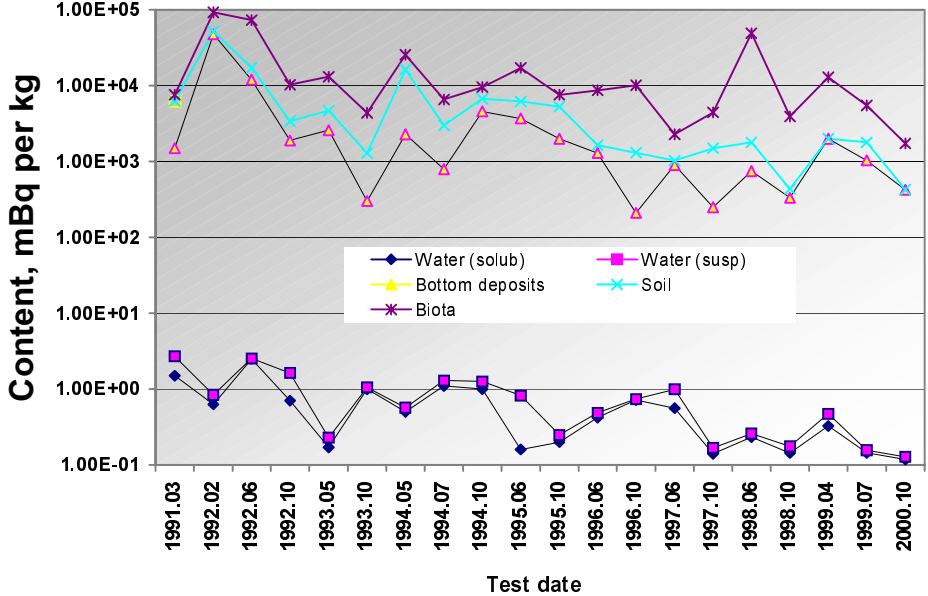


Fig. 3.7. Changes in the yearly average concentrations of Cs-137 in Belarusian rivers in 1987-2001

Bottom deposits and water biota are main contributors to the cumulative radioactivity of water systems (Fig. 3.8, 3.9). With time their contamination changes insignificantly.

In closed and slow-discharge lake-type water systems radionuclides will continue



to migrate from the neighboring areas to the pit of the water body. Lakes located on contaminated areas have especially high concentrations of water-soluble Cs-137 and Sr-90, as well as huge reserves of radionuclides in bottom deposits. Being attractive fishing and recreation grounds, lakes can have some role in the exposure of local people.

Fig. 3.8. Content of ^{137}Cs in water system components, the Braginka river (near Gden village)

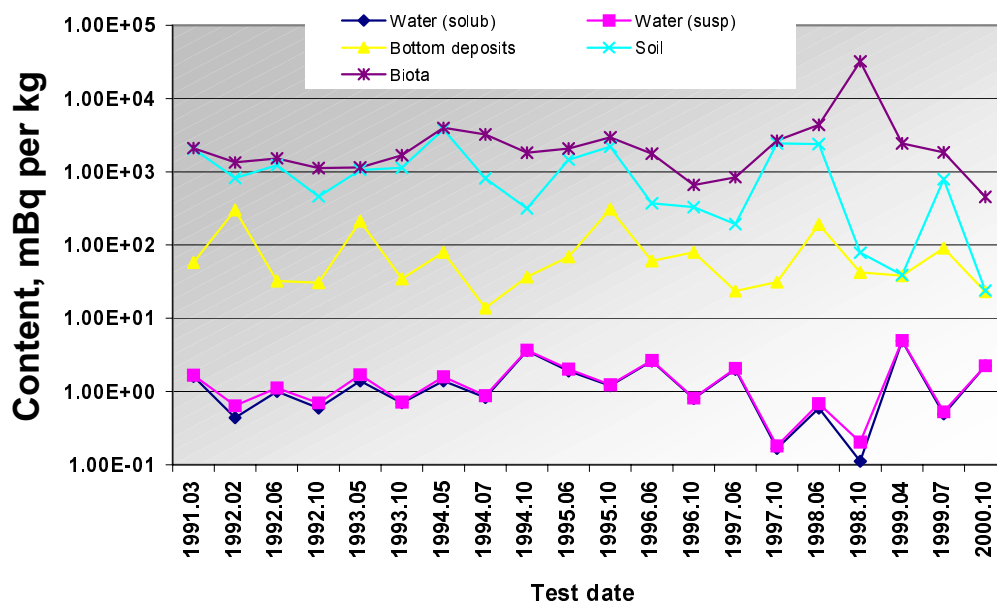


Fig. 3.9. Trend of ^{90}Sr content in water system components

Underground water is a key source of drinking and commercial water supply. Surveys of the underground water confirm that the presence of radionuclides in it water does not exceed national permissible levels. At the same time, it is worth mentioning that in contrast to the pre-disaster period, the records done for the groundwater in Belarus in the post-Chernobyl period indicate of a 1-2 point higher content of radionuclides (0.007 Bq per liter).

Radioactive contamination of air continues to remain a critical issue mainly for areas adjacent to the exclusion zone. The contamination is measured by the presence of radioactive dust in the surface level of atmosphere. Dust is produced in large quantities during agricultural and other activities. Active agricultural activities in the districts adjoining the exclusion zone cause substantial local increase of dust present in the air (over 1 mg per cubic meter) in spring. As a result, in the period of extensive agricultural field activities many areas with less contaminated soils occasionally experience local increases of Plutonium concentration in the air: up to 10 mBq per cubic meter. The concentration of Plutonium-239, 240 in the air in close vicinity of dust sources (agricultural machinery, vehicles) rises to 20 mBq per cubic meter. Extreme events, mainly forest and peat fires, further contribute to radioactive contamination of air: this became especially obvious in the dry year 2002.

3.6. Contamination of forests, flora and fauna

1.7 million ha of forests in Belarus (23% of all forested area of the country) were contaminated with radionuclides as a result of the Chernobyl Nuclear Power Plant disaster. Presently the over-ground stratum of forest trees contains 5-7% of all radionuclides. Forecasts show that contamination of forests with radionuclides will continue to increase. Over the next 10-15 years the surface phytomass will accumulate 10-15% of the overall Cs-137 deposited in forests. Out of all forest ecosystems, the living upper-soil cover has the highest concentration of ^{90}Sr and ^{137}Cs . As a result, mushrooms and berries (bilberry, cranberry, wild strawberry) turn out to be the most contaminated forest products. Radionuclide content in these products exceeds the maximal permissible levels even on areas with low soil contamination density (below 37 kBq per sq. m.).

Comparison of Sr and Cs accumulation capacity of natural meadow vegetation over the last several years reveals a trend of increased share of Sr among the accumulated isotopes.

Wetland ecosystems, especially bogs, have abnormally high accumulation of radionuclides by commercially valuable wild flora species.

Monitoring of wild plant populations shows that natural complexes in general are relatively well resistant to the impact of radioactivity. Most plants on contaminated areas did not suffer any significant impact. However, despite the lack of visible disruptions on the population and cenotic levels, the mutation load which is accumulating in the genomes may result in increased dominance of radioactivity-resistant species in phytocenoses. There is a number of other disruptions: decreased fertility of grain crops, alterations in processes such as photosynthesis and protein synthesis, etc.

Increased content of Cs-137 was noted in the muscle tissue in fauna species living on the contaminated areas (Fig. 3.10). One of the defining factors for accumulation of radionuclides in terrestrial fauna species are the habitat conditions. The highest presence of radioactive Cs among huntable birds was recorded among those species who inhabit dry open spaces, such as the Grey Partridge. The waterbirds which accumulate radionuclides most actively include garganey, mallards, and shovelers.

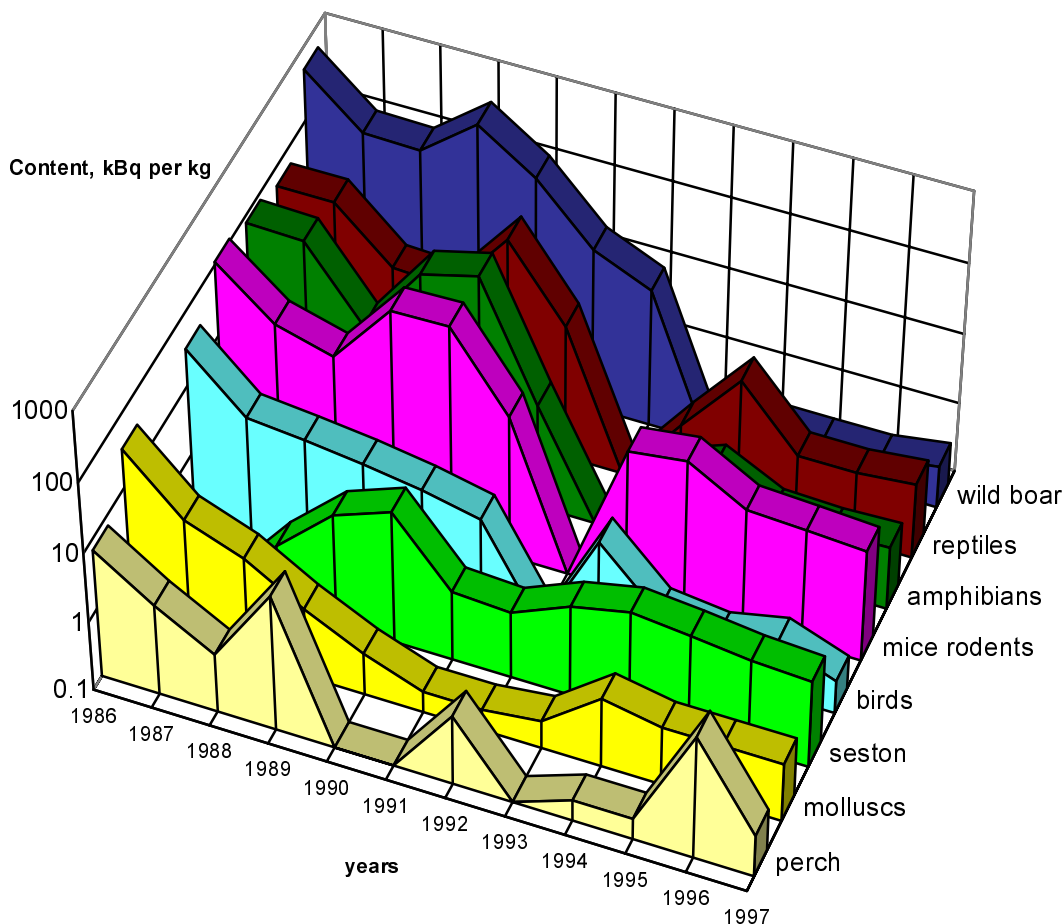


Fig.3.10. Trends for Cs-137 in various taxonomic and ecological groups

Presence of radionuclides in hoofed mammals inhabiting the most contaminated districts remains high: the dynamics of their fluctuations are defined mainly by climatic properties of the year, and also depend on the season. Thus, the tissue and organs of ungulates have increased content of radionuclides in summer and fall, which is attributable to abundant presence of Cs-137 in the vegetation they consume.

Predators (such as wolves and foxes), being the final links of the food chain, have the highest presence of radionuclides: up to 50 kBq per kg in wolves, and up to 47 kBq per kg in foxes, which is up to 12 times higher than for grass-eating animals.

Overall, no substantial reduction in the radionuclide content of wild animals can be expected in the future. Stabilization of radioactive contamination of fauna with yearly and seasonal fluctuations will remain the prevailing trend in the future, just like it has been over the last several years.

Study of insects in the contaminated areas identified a wide range of potential vectors. A substantial figure which their populations amount to cumulatively, is a sign of real risk of infection or invasion, providing good conditions for circulation of agents of Rabbitfever, Russian tick-borne encephalitis, and Californian fever, even when the year is generally unfavorable. In especially wet years, the abundance of insects increases. The studies performed so far make it possible to conclude that no improvement in the epizootic situation at contaminated districts should be expected.

4. Radiation doses received by the population of Belarus

One of the key sources of Chernobyl-resulting radiation exposure of Belarusian people was radioactive iodine (mainly Iodine-131) which affected primarily the thyroid gland. The key category of people thus affected are young people 17-30 years of age, who at the moment of the tragedy were children and adolescents. Table 4.1 depicts the distribution of doses borne by thyroid glands of people, based on direct examinations done in 1986. The findings of the examination showed that over 30% of children beyond 2 years of age received doses in excess of 1 Grey. The table indicates that doses were the highest among children and adolescents.

Table 4.1

Distribution of individual radiation doses among people, based on measurement of dose values in May-June 1986

Age group	Dose interval, Grey			Total number
	0-0,3	0,3-1	>1	
0-6 months	244 39.3%	175 28.2%	202 32.5%	621 100%
6 months – 2 years	1930 43.9%	1174 26.8%	1288 29.3%	4392 100%
2-7 years	6694 57.0%	3019 25.7%	2028 17.3%	11741 100%
7-12 years	6489 60.8%	2868 26.9%	1307 12.3%	10664 100%
12-17 years	5531 59.8%	2555 27.6%	1163 12.6%	9249 100%
>17 years	59945 72.8%	16513 20,1%	5840 7.1%	82298 100%

In the most severely contaminated rural areas, average doses received by thyroid glands in young children reached 3 Grey and more. The collective radiation dose for thyroid gland, received by Belarusian as a result of the Iodine attack was over 500,000 person-Grey (Table 4.2.).

Table 4.2

Distribution of collective radiation doses for thyroid gland, received by Belarusians

Region	Collective dose for thyroid gland, person-Grey			
	0-6 years old	7-17 years	Over 17	Total
Brest	35000	19200	46500	100700
Vitebsk	500	300	900	1700
Gomel	96600	53700	151000	301300
Grodno	16400	9000	24000	49400
Minsk	23000	12600	32700	68300
Mogiliov	9900	5400	16300	31600
Total for Belarus	181400	100200	271400	553000

The collective dose received by Belarusians from external and internal Chernobyl-linked radiation sources over 16 years which elapsed since the tragedy, is about 50,000 person-Sv, including the dose received by thyroid glands (Table 4.3).

Distribution of collective radiation dose in Belarus, by regions

Region	Collective radiation dose, person-Sv
Brest	6988
Vitebsk	278
Gomel	27721
Grodno	3066
Minsk	4671
Mogiliov	5866
Total for Belarus	48590

The contribution of Sr radionuclides into the cumulative radiation dose has since the time of the disaster been insignificant: 1-4% of the cumulative dose. Trans-Uranium elements are even less important: 0.1-1% of the cumulative dose. About half of the collective dose was received by Belarusians in the first year following the catastrophe; 80% was realized in the first 5 years. About 5% of the cumulative dose account for children born after the disaster.

People of Belarus continue to remain under the radioactive exposure, which nowadays is 90% defined by long-living Cs radionuclides. The exposure results in varying dose values received by people from external and internal sources, the dose size depending on the radio-ecological environment and level of land contamination with Cs-137. Over the post-disaster period the external dose scale has been progressively declining, which is attributed to the physical decay of the nuclides and infiltration of radioactive particles into deep soil (Fig. 4.1).

Fig. 4.1 The trend pattern of external doses received by the population after the Chernobyl disaster

Unlike the declining trend of the externally received doses, the situation with internal exposure is not as optimistic. Multi-year findings of the whole-body counting show that from second half of 1986 through 1990-1991 there was a clear reduction trend in the content of radioactive Cs in people's bodies. However, in the subsequent years the specific radioactivity values did not change significantly (Fig. 4.2).

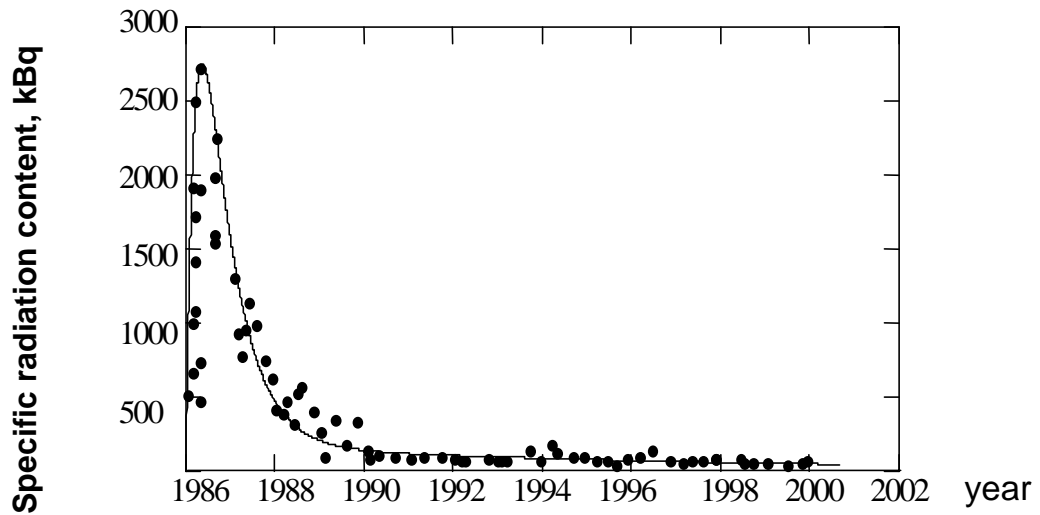


Fig. 4.2 The trend pattern of radioactive Cs content in the population living at contaminated areas

For some of the towns and villages in the Polesie area of Gomel region, a rise in the content of radioactive Cs in the body has been recorded, despite all protective measures (Fig. 4.3)

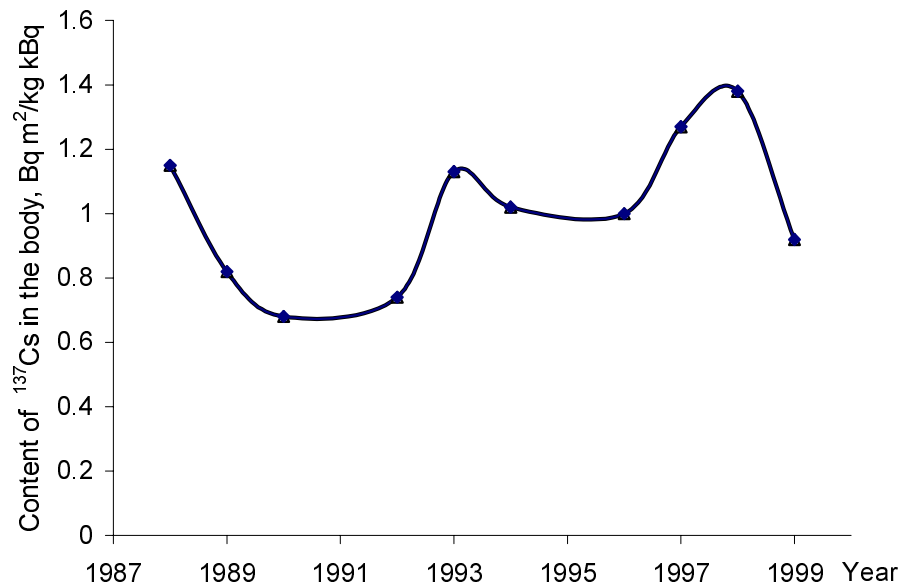


Fig. 4.3 Trend for content of radioactive Cs in the population of Narovlia district, Gomel region

The highest doses were received by liquidators of the disaster who were working within the 30-km zone of the Chernobyl NPP (Fig. 4.4). Comparable doses were received by the population evacuated from the 30-km zone (Table 4.4).

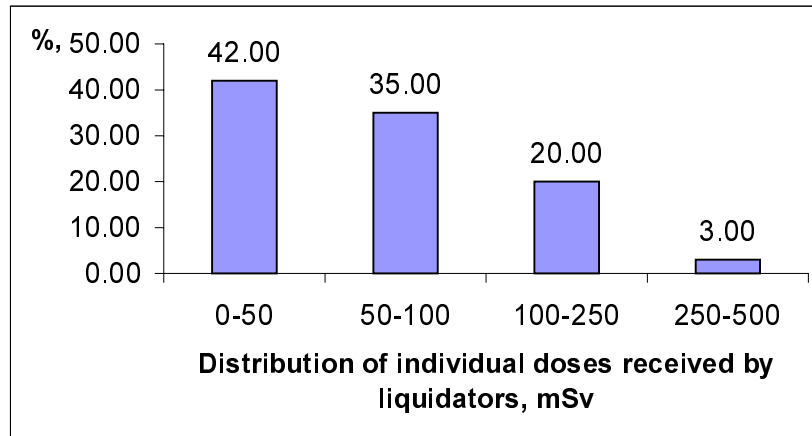


Fig.4.4 Distribution of individual doses, received by liquidators, mSv

Table 4.4

Average irradiation doses received by evacuated population

Evacuation stage	I-131 radiation dose absorbed by thyroid gland, Grey	Effective dose	
		Internal Cs-linked irradiation, mSv	External irradiation dose, mSv
2-7 May	1.33	2.1	31.2
3-10 June	1.04	1.6	15.9
August-September	0.66	0.9	20.3

6. Agricultural production at contaminated areas

Over 1.8 million ha of agricultural areas in Belarus were subject to radioactive contamination by Cs-137 over 37 kBq per sq. m (which is about 20% of the total agricultural area). These include 265,000 ha where the density of contamination with ^{137}Cs exceeds 1480 kBq per sq. m, ^{90}Sr - 111 kBq per sq. m, Plutonium – over 3.7 kBq per sq. m. These areas were excluded from agriculture.

Presently, agricultural activities in Belarus are carried out on 1,296,800 ha where Cs-137 contamination density exceeds 37 kBq per sq. m. It is especially difficult to carry out agriculture on areas with ^{137}Cs contamination density between 185-1480 kBq per sq. m (336,000 ha), and those which are at the same time contaminated with ^{90}Sr in the interval of 11-111 kBq per sq. m (189,000 ha). In the last decade, 16,000 ha of lands previously excluded from agriculture were returned back to economic use.

The existing system for radiation monitoring of soils areas enables regular (once in four years) adjustment of data on contamination of agricultural fields.

6.1. Production of foodstuffs at contaminated lands

The protective measures carried out so far, in combination with natural self-purification of lands, enabled a 10-12 times reduction in the inflow of Cs-137 to agricultural products (Fig.6.1)

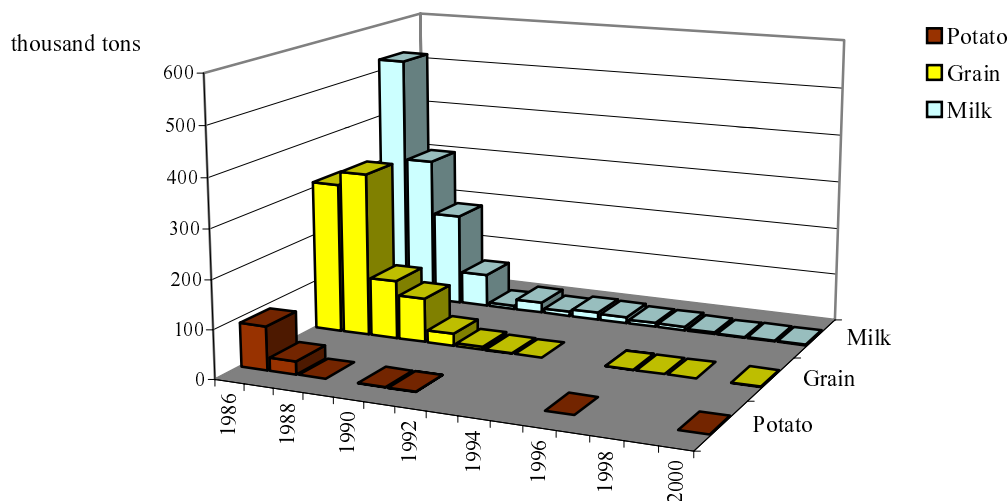
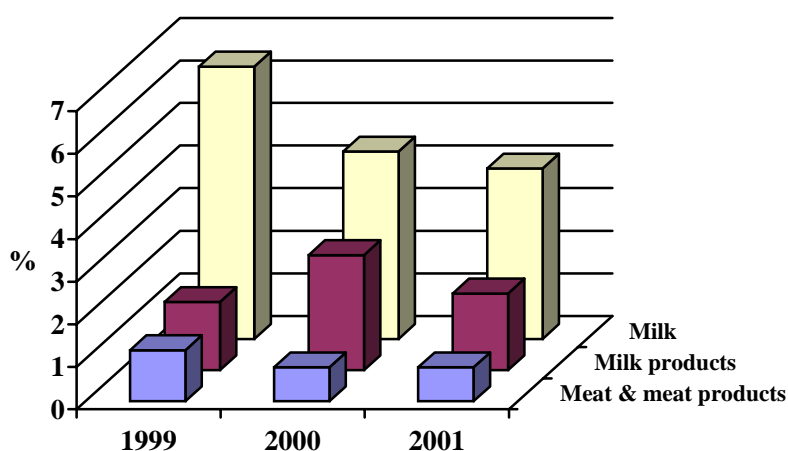


Fig 6.1. Trends for production of agricultural goods with excess content of ^{137}Cs in 1986-2001

In the last 5 years production of milk with excess content of Cs-137 in the public sector fell 5.5 times, and 1.7 times in the private. The return of cattle from meat-production plants reduced twice. However, a substantial share of fodder produced still contains Cs in excess of the established limits. Feed crops with excess radionuclides are most frequently produced on soils where Cs-137 contamination is over 555 kBq per square meter. The feed crops may also be contaminated on less polluted areas, if they are grown on low-fertility, waterlogged and peat soils.

The quality of goods produced in private households is of special concern, despite the slow decline in the contamination level of such foodstuffs in time (Fig. 6.2)

Fig. 6.2 Share (%) of tests of goods produced by private households where the norms for ^{137}Cs were exceeded



In 1997-2001 some of the dwellings in Belarus were recorded to produce milk with ^{137}Cs content over 100 Bq per liter (Table 6.1). The fact that the amount of such “unfavorable” dwellings is declining very slowly, is troubling. Overall, up to 10% of milk produced in private households still contains radionuclides in excess of the established limits.

Table 6.1

Number of dwellings in different regions of Belarus, where milk was found to have ^{137}Cs content in excess of the existing norms (based on tests of privately produced goods, by Sanitary and Epidemiological Service of Belarus)

Region	Over 111 Bq per liter		Over 100 Bq per liter		
	1997	1998	1999	2000	2001
Brest	97	90	73	54	49
Gomel	380	351	143	225	225
Grodno	7	2	4	4	1
Minsk	7	7	3	1	1
Mogiliov	89	66	56	43	50
Belarus, total	580	516	379	327	326

In the public sector, a small amount of milk with excess radionuclide content (1,447 tons in 2000 and 1,214 tons in 2001 overall in Belarus) is used for butter production, with the final product meeting the established norms. Private households use milk mainly for personal consumption, putting people’s health at risk, especially of young children. Production of contaminated beef by private households is another problem.

In the public sector, where there is a system of year-long monitoring of Cs-137 content in the animals, the return ratio of cattle did not exceed 0.1% of the overall amount of cattle entering processing for meat production.

During the post-disaster period various methods enabled only a 2-3 time reduction in the contribution of Sr-90 into the food chain: the mobility of this element in soil and its availability to plants never declined; on the opposite, in some cases it reveals an increasing trend. This is why short-term agrochemical protective measures can not always reduce the inflow of Sr-90 into agricultural production. In 2001 32,100 tons of grain, and 8,800 tons of potato produced had Sr-90 content in excess of the existing limits.

Practical experience has shown that normatively clean food products can be obtained from soils where density of contamination with radioactive Sr is below 11-19 kBq per sq. m, provided appropriate fertilizers are used effectively. Radical reduction of Sr-90 accumulation in plants on soils with higher contamination density is only possible under intense long-time cultivation of soil, which requires substantial financial and material resources.

Prerequisites for achieving Sr-90 clean food products in a short term perspective should be: step-by-stage transformation of land, differentiated placement of various crops, as well as targeted use of final products.

6.2. Economic issues linked to agricultural activities on contaminated areas

The economic crisis has further aggravated the consequences of the Chernobyl catastrophe in Belarus. The outcomes of this crisis became especially obvious on contaminated areas. Up through 1990 agricultural output was never going down the level of the pre-disaster year of 1985. Some slight decline in the production of grain crops in the most affected areas by 1990 was linked only to withdrawal of land: the efficiency of arable farming at this time had even increased (Table 6.2).

However, production of grain crops on contaminated areas has fallen 2-3 times over 1990-2000, while overall in Belarus the decline was only 20%. Declining productivity of land in the most contaminated area is also alarming: the pace of this decline for arable lands and grasslands is almost twice the national average. Milk and meat production in the affected areas has dropped even more dramatically. For example, production of meat in five of the affected districts has fallen about five times compared to the 1990 level (Table 6.3).

Declining productivity of agriculture has contributed to a sharp increase in the cost of agricultural production. The underlying cause of the situation is the outflow of young qualified specialists, as well as shrinking government's assistance to agriculture on affected areas. Overall in the past years only half of the needed amount of protective agricultural measures was applied. Unlike in the past, the economic situation most enterprises face today does not allow to obtain enough operational resources in the amounts needed to overcome the increasing trends of soil fertility loss.

Table 6.2

Production of vegetable goods in the public sector, % of 1985 level

	1990	1995	2000	2001
Grain production				

Belarus	122	90	77	80
Contaminated areas	84-99	48-69	29-62	29-52
Productivity of arable lands				
Belarus	122	85	74	77
Contaminated areas	103-122	58-86	40-83	42-78
Productivity of grasslands				
Belarus	108	88	71	79
Contaminated areas	97-120	59-75	36-63	50-64

Table 6.3

Production of meat and milk in the public sector, % of 1985

	1995	2000	2001
Milk			
Belarus	54	47	52
Contaminated areas	23-51	18-51	19-47
Meat			
Belarus	44	45	48
Contaminated areas	38-48	24-48	6-26

The lower pay-back ceiling for grain production in Belarus is about 17 centners per ha, potato – 90 centners per ha. On radioactively contaminated areas costs rise by 10-15%. This means that profitable agriculture here is only possible when the grain harvest is 20 centners per ha and more, while arable land productivity is 30 centners/ha, and grassland is 20 centners per ha and more. The 2001 data of the Ministry of Agriculture shows that out of 395 enterprises working on the most contaminated areas of Gomel region only 73 produced grain harvest over 20 centners per ha; 235 enterprises had potato output less than 100 centners per ha. Production of grain and potato was unprofitable at most enterprises on contaminated areas.

In the first years following the disaster leguminous crops were excluded from agriculture, being very active accumulators of radioactive Cs and Sr. Supply of cattle farms with protein-rich fodder in most districts is only 80-85% of the requirement. This results in about a 35% decline of cattle production, large overuse of fodder and unprofitable production of milk and meat. Presently, improved radiological situation and new knowledge make it possible for leguminous crops to be reintroduced on affected areas. Rape plantations is another way to resolve the protein deficit issue: this plant does not have limitations in terms of radioactive contamination of soil.

The economic situation in the country demands that agriculture on contaminated areas be equally profitable and self-reliable. Even when the presence of radionuclides in the produce is within the permissible levels, agricultural production at most enterprises remains uncompetitive and unprofitable. It is exactly this type of enterprises which suffered the biggest damages from the catastrophe and which lost most of the qualified staff. Depreciation of main assets and almost full lack of operational resources make it impossible to maintain even the present production level, not to mention any increased targets.

Agricultural production both in the short- and long-term perspective, will continue to have key importance for employment of population on affected areas. There is an evident need for targeted use of financial and material resources, as well as for attracting new investment.

6.3. Soil fertility and environmental issues

Soil fertility is a key factor defining migration of long-living radionuclides to agricultural crops and the food chain. Agrochemical properties of soil have a prevailing effect on the specifics of radionuclide accumulation in agricultural harvests. For example, a 1.0 to 3.5% shift in the humus content of soddy-podzolic sandy-loam soil results in a 1.5-2 time less radionuclides migrating from soil to perennial gramineous crops. When exchange-ready potassium compounds are optimal and neutral pH is achieved, the migration may further fall 2-3 times.

Recently, many contaminated areas have been recorded to contain soils with declining phosphorus and potassium content; soil acidulation becomes evident in some districts. Loss of humus on arable fields and declining soil fertility are especially obvious in the affected districts of Gomel region. The worsening of soil fertility properties increases the risk of more active migration of radionuclides to agricultural crops, which is further aggravated by the overall reduction of field productivity and declining economic output indicators at many enterprises.

The share of permanently or temporarily wet soils in the contaminated area is about 37% of the overall area of agricultural fields. In the last 30 years, about two thirds of wetlands were drained, but most of the drainage network now requires maintenance and repair. Re-wetting of the drained areas is another urgent issue. With the current lack of investment funds for reconstruction of the drainage network, large previously drained areas may be rewetted, whereby the migration of radionuclides to grass fodder, milk and meat is going to increase manifold. Proper maintenance of the drainage network on contaminated areas should be a priority and remain under the control of the Government.

Water and wind erosion result in secondary horizontal redistribution of radionuclides. Depending on the intensity of erosion, the presence of radionuclides in the arable upper soil on low-lying areas may increase by up to 75%.

6.4. Objectives to be achieved

Increase soil fertility. Wide-scale rehabilitation of soil fertility and optimization of soil properties is an irreplaceable prerequisite for profitable agriculture on areas contaminated with radionuclides. Of key priority is to ensure deficit-free (for poor soils, a positive) balance of humus, phosphorus, and potassium: without it, production of high quality goods with admissible levels of radionuclides, would be impossible.

Alongside with traditional protective countermeasures, such as liming, increased doses of phosphorus and potassium fertilizer, full doses of new nitrogen and complex fertilizer are needed.

One of the key priorities should be increasing the productivity of arable lands to 40 centners per ha, of grasslands to 20-30 centners per ha. The average annual production of milk per cow should be increased to 3.0-3.5 tons; the average daily buildup of the body weight of one individual of meat cattle should be increased to 600-700 grams, provided the costs of achieving this objective are rational and well justified.

Optimization of land use. In present conditions investment in farming may only be effective on soils with high and moderate fertility potential. This is why a complete multi-stage optimization of land-used should be realized, building on a new inventory of fields and land parcels classified by their fertility, technological properties and location. At the first stage, all low-production arable land with low value (less than 20 points) should be transformed into grasslands, acknowledging that under the current pricing environment arable farming would never be profitable on such areas. The least fertile sandy and waterlogged soils, with ^{137}Cs contamination density over 555 kBq per sq. km, and ^{90}Sr over 37 kBq per sq. km should be afforested. The economic effect from one hectare of low-production land being excluded from arable agriculture is assessed to amount to USD 50 per year.

Crop distribution. An important protective and economic tool to improve agriculture on contaminated areas is review of the traditional crop distribution pattern. The need for increased share of high-stalk crops is evident. A differentiated approach is needed to complete the existing crop structure with highly profitable crops, such as rape, sunflower, wheat, corn, peas, lupine, clover, and lucerne: this should be done with account of soil properties, type and distribution of contamination, resource potential, as well as other factors.

Cattle breeding pastures and hay-making fields. The availability of improved grasslands is presently only about one third of the requirement, which is explained by rapid degradation of grass-stands. In this respect, one of the key priorities should be establishment of high-quality pastures and improved hay-fields. These should be developed in such a way, so that at least one hectare is available per each cow both in public and private sector; sod should be recultivated once every 4-5 years; fertilizer supplements should be introduced to grass stands annually. Enough green forage should be made available first of all to private cow owners at 326 towns and villages, where milk was recorded to have excess presence of Cs-137: over 10 Bq per liter.

Reconstruction of the amelioration network. In the recent year, there has been almost no repair or maintenance of the existing amelioration schemes: about one third of the drained areas is excessively wet. Most of the schemes require operational service and cleaning of ditches. Overly wet areas with unfavorable water regime evidence increased migration of radionuclides from soil to perennial grasses. Reconstruction of drainage systems should be carried out on 62,900 ha; open drainage schemes on another 44,500 ha require repair. Unless these activities are carried out in the nearest years, part of the rewetted lands will have to be excluded from agriculture.

6.5. Conclusion

For Belarus in general, the budget for protective countermeasures that could enable profitable agriculture on 1.2 million ha of radioactively contaminated land, meeting the standards of the National Admissible Levels – 99, is estimated to amount to 77 million

dollars per year. In view of limited resources, the importance of self-reliable, energy-saving and environmentally acceptable countermeasures is huge.

Study and improvement of economic and technological parameters of highly-profitable industrial crops, such as rape, sunflower, sugar beet, is very important. Another urgent need is modernization and enlargement of the existing capacity to process oil plants for industrial purposes, as well as the capacity to process potato and grain crops into alcohol and starch. Resolving these issues would require improved international cooperation and attraction of new investment.

An example of successful international cooperation was the IAEA-assisted pilot project BYE/5/004 on planting and processing of rapeseed from contaminated areas. The objective of the project was production of competitive environmentally clean goods, outsourcing Cs-137 and Sr-90 radionuclides from the food chain by growing rape seed on contaminated areas, with their subsequent processing using modern industrial technologies. IAEA has invested over a million dollars into this project.

Areas under winter and spring rape in contaminated districts of Gomel and Mogiliov regions have grown more than 4 times over the last two years, and occupy now 22-25 thousand ha. The contaminated areas can potentially accommodate up to 40,000 ha of new rape plantations every year. With harvests of 15-20 centners of seed per ha, each enterprise would have up to \$30-50 profit per hectare, while at the same time preparing their land for wheat in an excellent way. The butter-production plant just built is ready to produce radionuclides-free butter. The expected profit is USD 40-50 per ton of butter.

7. Socio-economic consequences

The Chernobyl catastrophe affected all areas of people's life: economy, culture, science, etc. 2,640 sq. km of agricultural land was excluded from economy. Arable lands and gross agricultural production declined dramatically, cattle stock shrank correspondingly.

The use of forest, raw, mineral and other type of resources reduced significantly. 132 mineral deposits are located on the contaminated area, including 47% of commercial deposits of molding sand, 19% of mason and lime sand, as well as 91% of glass-making sand deposits of the country. The contaminated areas cover 20% of commercial chalk deposits, 13% of brick clay, 40% of refractory clay, 65% of building stone, and 16% of cement material deposits.

22 mineral resource deposits were excluded from use, the stock of which is estimated to amount to 5 million cubic meters of mason sand, sand-and-gravel materials and clays, 7.7 million tons of chalk and 13.5 million tons of peat. Geological exploration plans no longer encompass development of the Pripyat oil-and-gas district: its stock is estimated at 52.2 million tons of oil.

Forestry has suffered severely. About one quarter of the forest stock of the country, 17,300 sq. km were affected by radionuclides. The annual loss of timber currently exceeds 2 million cubic meters; by 2010 the annual losses are expected to rise to 3.5 million cubic meters. In Gomel and Mogiliov regions 51.6 and 36.4% of forests are contaminated correspondingly. Timber production is excluded completely from those areas where the density of contamination with Cs-137 exceeds 555 kBq per sq. m.

About 340 industrial enterprises are located on the contaminated areas, where the economic conditions continue to decline. Resettlement of people from the most affected areas resulted in cessation of activities at many industrial enterprises and institutions of social infrastructure. Others continue to suffer significant losses following reduction in output, inability to pay-back the costs and investment made into the buildings, constructions, equipment, amelioration schemes. Losses of fuel and raw materials are equally large.

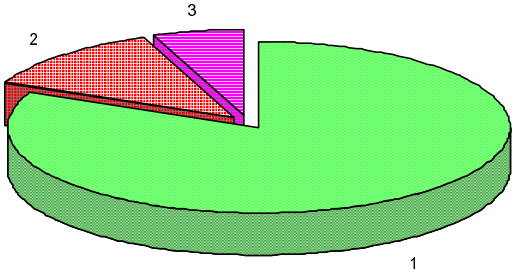
The economic crisis has put the contaminated areas into especially difficult socio-economic conditions. Crisis symptoms are especially evident here: overall industrial decline, outflow of people, underdeveloped consumer sector, low quality of service in the social and domestic sector, as well as health care.

Under these conditions it is almost impossible to achieve either rapid resurrection of the affected areas, or restoration of local economic infrastructure. Only a long-term rehabilitation of such areas is possible, and this should envisage a multi-stage re-introduction of the lost economic potential while at the same time insuring the security for people living on such areas, and enabling development of those industries which are best suited for operation under radioactive contamination, without affecting the health of people.

The damage, incurred by Belarus as a result of the Chernobyl catastrophe, when projected over a 30-year recovery period is estimated to amount to USD 235 billion, which is equal to 32 national 1985-year budgets of the country. The estimate includes

the losses linked to health decline, industrial and social sphere, agriculture, construction industry, transportation and communications, communal utilities sector; pollution of mineral, land, water, forest and other resources, as well as additional costs borne in relation to liquidation and minimization of the consequences of the disaster, and finally those linked to establishment of safe living conditions on affected areas. The composition of the economic damage incurred by Belarus as a result of the Chernobyl NPP catastrophe, classified by types of losses and economic sectors, is depicted at Fig. 7.1 and Table 7.1

The largest share in the overall composition of damage over 1986-2015 (81.6%) is the expenditure linked to maintenance of production and the cost of protective countermeasures: this is almost USD 191.7 billion. Direct and indirect losses account for about USD 30 billion (12.6%). Foregone income is estimated to amount to USD 13.7 billion (5.8%). Direct losses include the cost of national wealth excluded from use: fixed and operational industrial assets, social infrastructure, houses, natural resources.



- 1 – Additional expenditure related to maintenance of production and protective countermeasures, USD 191.7 billion
- 2 – Direct and indirect losses, USD 29.6 billion
- 3 – Foregone income, USD 13.7 billion

Fig. 7.1. Composition of the damage incurred by Belarus as a result of the Chernobyl NPP disaster, up to 2015

The indirect losses include: losses defined by the changes in the economic and social environment (living conditions, household situation, health of people), by factors which resulted in disrupted or stopped industrial production, reduced labor efficiency, increased cost and complexity of servicing various institutions of public, cooperative, or private ownership, as well as losses resulting from migration of population from contaminated areas.

Calculation of the forgone income included: reduced industrial output, reduced production of goods and services at contaminated areas, the cost of goods which were discarded having a very high presence of radionuclides, incremental costs related to compensation of under-delivery of goods and products, costs of recovering the quality of goods, costs from terminated contracts, annulled projects, frozen loans, payment of fines, fees, etc.

Additional expenditure for Chernobyl issues included funding of measures to overcome the consequences of the disaster and secure normal operational environment for various industries on the contaminated areas, including establishment of safe living

conditions. These include payments to compensate for the damage incurred as a result of the disaster; the amount of additional resources attracted to compensate for losses and foregone income, expenses for deactivation and organization of control over the radiation situation.

Table 7.1

Sectoral composition of the socio-economic damage incurred by Belarus from the Chernobyl NPP disaster, billions of USD

Sectors of economy	Years				
	1986-1990	1991-1995	1996-2000	2001-2015	1986-2015
Health care	4,05	16,77	18,13	54,32	93,27
Agriculture	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
Raw materials and water resources	2,00	0,12	0,15	0,40	2,67
Transportation and communications	0,93	1,20	0,36	0,90	3,39
Social sphere	2,84	5,45	2,96	6,45	17,70
Deactivation 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

The assessment of the damage incurred by Belarus is not final because the cause-effect relationships reflecting the impact of radioactive contamination on various areas of life, are quite complex. Science still lacks full and final information about the medical and biological, social and environmental consequences of the Chernobyl disaster.

One of the key sources for funding of the National Program is the emergency tax, introduced in 1992. Before 1994 it was 18% of the salary fund of each Belarus-based enterprise, excluding those involved in agriculture. But the tax only covered slightly over half of the budget expenditure allocated for the recovery from the disaster. The remaining 30-35% were funded directly from the national budget. In 1994 the Government had to lower the emergency tax rate first to 12, and in 1998 to 4%.

Despite all the efforts of the Government, the budget allocations for dealing with the Chernobyl disaster consequences are insufficient. All attempts to mobilize resources directly from enterprises, local budgets, extra-budgetary sources, as well as foreign investment, were unsuccessful. As the national economic crisis becomes more and more serious, and the reforms get lower, these potential sources of funding protective and recovery measures become ever less realistic.

One of the underlying reasons for that is the chronically low economic efficiency of most of the enterprises located in the radioactively contaminated area. As a result, many of them do not have financial resources needed even for the most urgent economic operations, such as upgrade of fixed and operational assets: needless to say, they have nothing left for funding of protective or recovery measures. The same reason

explains why funds of the local budgets are also limited. Moreover, budgets of those districts and regions which suffered from the Chernobyl catastrophe are normally subsidized by the national budget. Very often they lack resources even for the vitally important health care, education, salaries of people involved in the public sector.

The huge deficit of funding for minimization of consequences and recovery from the disaster affects the scale and pace of protective and rehabilitative countermeasures. Thus, over the period of 1991-1995 budgetary and other allocations for the minimization of the outcomes and recovery from Chernobyl disaster, were less than 15 percent of the overall Chernobyl-linked socio-economic damage for this specific five-year period. The situation never improved in the subsequent five years (1996-2000).

8. National Programs to Overcome the Consequences of the Chernobyl Catastrophe

Practical work to overcome the consequences of the Chernobyl disaster is carried out in the framework of special national programs, funded from the budget. The first national program of this kind (1990-1992) was implemented when Belarus was still part of the USSR: it was a so-called “union-republican” program. In 1993-1995 and 1996-2000 two national Belarusian programs were implemented. Presently the *National Program on Mitigation of Consequences of the Chernobyl NPP Catastrophe for 2001-2005 and until 2010* is under implementation. This is an indication that Chernobyl issues will remain high on the national agenda far into the future.

The State Committee of the Republic of Belarus on Problems of the Consequences of the Catastrophe at the Chernobyl NPP was put in charge of implementation of the said national programs. Today it is called the Committee on the Problems of the Consequences of the Catastrophe at the Chernobyl NPP under the Council of Ministers (Comchernobyl).

8.1. Key outcomes of the national programs, 1990-2000

Every year the budget of Belarus was bearing a substantial load of expenditure for mitigation of the Chernobyl NPP consequences: 1991 – 16.8% of the budget, 1992 – 12.6%, 1993 – 9.6%, 1994 – 6.9%, 1995 – 7.3%, 1996 – 10.9%, 1997 – 9.9%, 1998 – 8.9%, 1999 – 8.7%, 2000 – 6.6%. However, these allocations have been insufficient to effectively resolve all issues in the foreseeable future. While the total damage to Belarus linked to the disaster is estimated to amount to 32 annual national budgets, over the past 10 years the country has managed to allocated only about 1.5 budgets for this purpose.

Despite this, the synergetic efforts of the state authorities, legislators, scientists and experts did result in resolving some of the burning issues:

- Resettlement of about 140,000 people from the most contaminated areas is almost complete, as is their adaptation to new settlements.
- Normative and legal base was developed to deal with almost all aspects of disaster mitigation
- Protective countermeasures in agriculture enable good control over agricultural production. A system of radiation control and monitoring was established and is functioning reliably.
- Districts contaminated with radionuclides are subject to complex measures to increase the quality of health care. Over a million of people annually undergo a detailed medical examination.
- A social protection system for all categories of affected population is in place.

8.2. National Program for 2001-2005 and until 2010

Adoption of the *National Program to Mitigate Consequences of the Chernobyl NPP Catastrophe for 2001-2005 and until 2010* was preceded by elaboration of its

concept. Both the concept and the draft Program were subject of meticulous discussions and coordination with stakeholders representing all national agencies involved in the process.

The key goal of the National Program is to reduce health damage, mitigate social and psychological consequences of the Chernobyl NPP disaster, as well as undertake socio-economic, radiation and ecological rehabilitation of the contaminated territories, returning them back to normal operations.

The Program has the following objectives:

- development and improvement, on the basis of scientific and practical recommendations, of medical dispensary system to cater for the affected population
- implementation of protective countermeasures at the most contaminated districts of Gomel, Mogiliov, and Brest regions
- ensuring full social protection of population groups who were affected by the Chernobyl NPP disaster
- mitigation of social and psychological impacts of the disaster
- obtaining full and objective information on radioactive contamination of environment and levels of radioactive impact on population, in order to enable well-grounded decisions and adjustment of decisions made before
- enabling production of clean agricultural products, with radionuclide content within the admissible limits established by the Ministry of Health of Belarus, in order to reduce the radiation exposure of population
- increasing the quality of outer facilities (infrastructure) at the contaminated towns and villages, ensuring proper sanitary and communal environment for the population
- scientific research to provide proper background for planning and implementation of practical measures
- international cooperation on mitigation of the consequences of the disaster.

One of the key provisions of the National Program is the section on scientific backup as a tool in planning and implementation of decisions. Without coordination and targeted approach it is impossible to resolve urgent issues successfully. Being an inalienable element of the National Program the scientific component is a key to its block-type composition (Fig. 8.1). The logic of Program's composition is driven by its main goal: reducing the damage to people's health, mitigating negative social and psychological consequences of the disaster. One of the most important areas of scientific research is analysis of the health of the affected population, dose loads, impact on ecosystems. These areas ensure feedback, which is important for efficient governance targeted at concrete objectives.

National budget remains the key funding sources for the program. Some of the funding sources were in the past transferred to the local level, and these will also be used to fund activities of the Program, such as: contracting people for specific jobs at contaminated areas, dispensary care of people affected by the Chernobyl NPP disaster, distribution of free medicines, other activities.

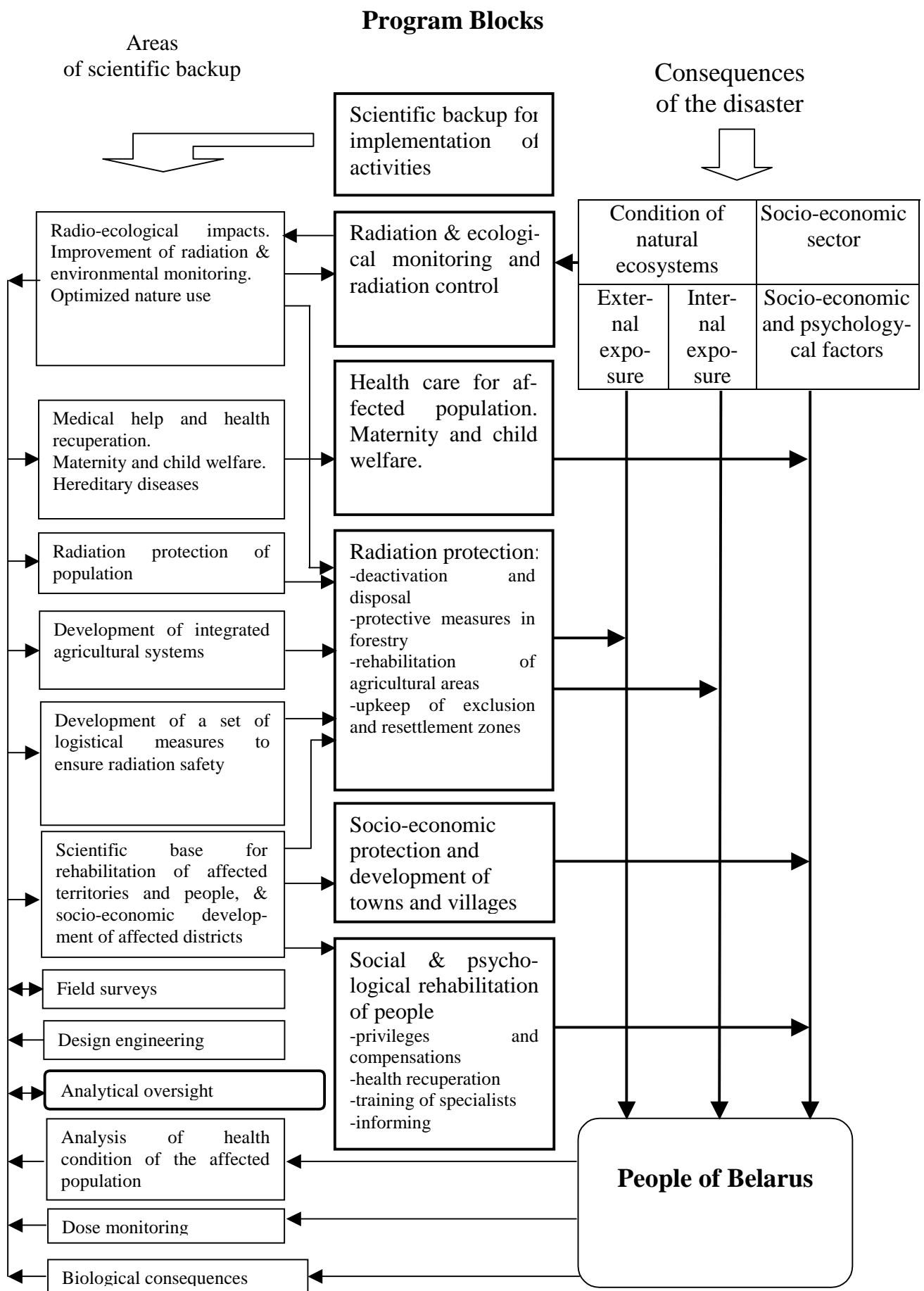


Fig. 8.1 Composition of the National Program and its scientific backup

9. Conclusions

1. In Belarus the Chernobyl catastrophe caused many serious long-term problems, affecting vital interests of millions of people and having an effect on the health condition, life style, welfare, working environment. Implementation of national programs to overcome the consequences of the catastrophe shows that the resources allocated from the state budget are insufficient to resolve these issues in the nearest future.
2. Apart from serious environmental damage, the Chernobyl catastrophe resulted in unprecedented irradiation of Belarusian population, which required development and implementation of a set of protective measures to limit the external and internal exposure. In some of the affected areas the radiation situation remains difficult; the objective of producing agricultural goods meeting the established sanitary norms has only partially been achieved. There are districts, in which the average annual effective dose of irradiation by Chernobyl-deposited radionuclides exceeds 1 mSv: according to the national legislation this is an indication of a need for additional protective measures.
3. Most population has, over the course of the years elapsed since the disaster, already received up to 80% of their life-long irradiation dose. However, those born after 1990 will continue receiving irradiation doses over the course of their lives both from external, as well as internal sources, the latter being the outcome of consumption of contaminated foodstuffs.
4. Doses of irradiation received by the population define the decline in the health condition of people at affected areas. Incidence of radiation-caused thyroid cancer among those irradiated by Iodine-131 when a child or an adolescent, continues to rise dramatically. Increased incidence of the disease has been recorded among the liquidators and adult population as well. It is forecasted that over the course of 50 years since the disaster, about 15,000 thyroid cancers are going to be registered among Belarusian people.
5. Many other stochastic outcomes of irradiation exposure have as of now not manifested in people which is to be attributed to a longer latent period and the chronic character of small dose exposure. For some of the most severely irradiated groups of affected population there is reliable data on trends towards increased frequency of oncologic solid diseases. Forecasts made so far indicate of a possibility that the probability of developing such a diseases by an effected person may increase by several percent over his or her life. In order to better identify the role of radioactivity in possible rise of the probability of oncological diseases a detailed, well planned and long-term radiation and epidemiological study is required.
6. The health effects of the Chernobyl catastrophe are not limited only to purely radiological consequences. The health of the population is impacted by the low living standard and generally unfavorable environmental situation. The catastrophe

has contributed to establishment among many people of an inadequate perception of radiation risk, resulting in psychological discomfort. A combined impact of radiation as well as non-radiation factors linked to the Chernobyl catastrophe results in worse health condition of all categories of affected people, which is manifested in increased incidence of non-oncologic diseases (endocrine system diseases, cardio-vascular diseases, psychoneurologic disorders, etc.).

7. Negative demographic trends are being observed on radioactively contaminated areas. Decreased birth-rate, increased mortality, dropping number of able-bodied population are current trends. As a consequence a spiral effect is observed: the mentioned factors in combination with continued outflow of intelligencia, professionals and managers, further contribute to aggravation of day-to-day problems, worsening health of people in affected areas and destabilization of the overall situation.
8. A special concern in the society is the condition of children health, which is marked by growth in diseases, decline in the number of practically healthy children, increased amount of immune system disorders.
9. The system of free-of-charge obligatory medical examination, treatment, health recuperation and rehabilitation of the suffered population, which has existed over the first several years following the tragedy, can not be fully implemented in the present-day economic conditions. Without adequate attention of the world community, this will in the nearest future result in further worsening of the health of people and increased mortality among the affected population.
10. The Chernobyl catastrophe brought about a number of serious problems in agriculture and forestry: the two sectors in which most of the population in the affected regions have traditionally been employed. Implementation of scientifically grounded agricultural and forestry techniques enabled production of clean crops at contaminated areas, but not all issues have been resolved. In order to ensure safe economic activities on the affected areas operational investments are required that would help maintain high soil fertility, continued protective measures, increase the competitiveness of products and the profitability of enterprises.
11. The most important problem in overcoming the consequences of the Chernobyl catastrophe is an integrated radiation and socio-economic recovery of contaminated areas. Realizing the main objective of rehabilitation, i.e. achieving a real economic recovery and sustainable development of the affected areas, requires improvement of national approaches and international assistance to build up and improve social infrastructure of the affected areas and places of residence of resettled population. Another very important objective is establishment of favorable conditions for national and international investment.
12. One of the barriers to rehabilitation is the psychological state of people and the low level of their awareness. A system for informing and educating people on radiation indicators, effectiveness of countermeasures and other aspects is required in order to facilitate better understanding by affected people of scientific and medical recommendations for safe livelihoods. It is important to make sure that the

Chernobyl victim syndrome is overcome – something which is one of the key barriers to engagement of population in active social and economic activities.

13. The complexity and diversity of Chernobyl-born problems dictate that scientific studies in corresponding areas be maintained at high level. The following key areas of research are especially relevant for Belarus:
 - radiation epidemiology
 - impact of psychological and social factors on the health of affected population
 - radiological impact of small doses on biological subjects and ecosystems
 - elaboration of optimal and systemic countermeasures in agriculture and forestry
 - elaboration and improvement of technology for deactivation of socially important objects and disposal of deactivation wastes
 - elaboration of a rehabilitation package for the affected areas.
14. With no single international strategy for scientific research into the Chernobyl-related issues, and under lack of funding for national scientific programs, it is expedient to broaden international coordination and cooperation in the area of research.
15. In general the perception of issues, related to Chernobyl catastrophe, both at the national, as well as global level, is disproportionate to the real scale of the issue and its importance. Despite the 16 years which elapsed since the Chernobyl disaster, it can be stated, that there are no generally accepted methodological approaches to assessment of the consequences of large radiation disasters and development of full-scale integrated packages of activities to overcome such disasters. This is a substantial gap in the system of disaster response.