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THE STATE AND PROSPECTS FOR VITAL ACTIVITIES IN THE RADIOCONTAMINATED AREAS OF ZHYTOMYR POLISSYA

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Abstract. The paper deals with the after-effects of the radioactive contamination of Zhytomyr province. In 1986, Ukrainian government decided to divide the area into 4 zones: the restricted access zone, the zone of obligatory resettlement, the zone of the guaranteed voluntary resettlement and the zone of the strict radiological control. The paper also analyses the ecological and socio-economic situation in the region 20 years after the Tchernobyl disaster. Not all citizens agreed to be displaced and many of them come back. Nowadays, about 4.5 thousand people live in the province. The long-term trends in the development of the economy and improvement of vital activities conditions in Zhytomyr Polissya have been determined.

Key words: Tchernobyl, radioactive contamination, agriculture, irradiation

PROBLEM FORMULATION

More than two decades have passed since the accident at the Tchernobyl nuclear power plant which brought about one of the largest ecological disaster in the human history. The radionuclides released from the reactor's unit 4 into the atmosphere covered vast territories of Ukraine, Byelorussia, Russia and reached many European countries. The Tchernobyl accident has radically changed the environment for a large segment of the population, essentially affected the development of many branches of the economy, resulted in the demographic situation change and disrupted the lifestyle of millions of people which had been formed for decades.

Ukraine became the epicenter of the disaster. About 42 000 sq. km of its territory was radiocontaminated. Zhytomyr province proved to be one of the most affected ones, with 15.3 thousand sq. km or 50.9% of its territory being contaminated lands. Over 700 human

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settlements comprising one third of towns, 37% of urban type localities and 47.1% of villages are situated in the contaminated area.

Before the accident the above areas of Zhytomyr Polissya played an important part in the province's economy. They accounted for 21.5% of the region's industrial production, specifically 40.7% of lumber, 46.1% of chemical equipment, 57.7% of china and glazed pottery, 60.8% of farm machines and 93.0% of broken stone. Their share in agricultural production was as follows: grain 23.8%, potatoes 50.2%, fiber flax 58.6%, hops 68.0%, meat 33.8%, milk 36.6%.

The radioactive contamination caused a severe ecological damage to the Polissya environment, resulted in the destruction of many biocenoses, restricted agricultural production, all this having long-term undesirable ecological and socio-psychological effects.

RESEARCH AIM AND METHODS

The aim has been to analyse the ecological and socio-economic state in the radiocontaminated areas of Zhytomyr Polissya and outline prospects for their development.

The methods of the research envisaged have been: taking advantage of regulatory acts, statistical reports and monographs; a study and assessment of the situation directly in the enterprises in the province; sampling of substances and their laboratory analysis; measurements taken in the objects under study.

RESEARCH RESULTS

The legislative determination of the legal regime in the radiocontaminated area and measures for its assurance are specified in the law of Ukraine "On the legal regime of the territory contaminated as a result of the Tchernobyl accident" [On the legal... 1991]. It regulates the issues related to the territory division into zones depending on the rate of exceeding the natural pre-accident radionuclide level in the environment, landscape, geochemical characteristics of soils as well as their usage and protection regimes, living and working conditions of the population, economic and other activities. The boundaries of specific zones were formed by governmental resolutions in 1991-1995, the radiocontaminated areas of Zhytomyr province were divided into 4 zones:

I. The 30 km restricted access zone (30 km average radius zone). The population was resettled from it in 1986.

II. The zone of obligatory resettlement (with contamination density of $^{137}Cs > 15$ Ci·km^{-2}, > 555 kBq·m^{-2}; $^{90}Sr > 3$ Ci·km^{-2}, > 111 kBq·m^{-2})[1].

III. The zone of the guaranteed voluntary resettlement (the contamination density is $^{137}Cs > 5 \div 15$ Ci·km^{-2}, $185 \div 555$ kBq·m^{-2}; $^{90}Sr > 0.15 \div 3$ Ci·km^{-2}, $5.55 \div 111$ kBq·m^{-2}).

[1]Bq stands for Becquerel, unit of radionuclide decay rate (per second), Ci stands for Curie equal to 37 GBq, i.e. $3.7 \cdot 10^{10}$ Bq.

IV. The zone of the strict radiological control (the contaminated density is $^{137}Cs > 1 \div 5$ $Ci \cdot km^{-2}$, $37 \div 185$ $kBq \cdot m^{-2}$; $^{90}Sr > 0.02 \div 0.15$ $Ci \cdot km^{-2}$, $0.74 \div 5.55$ $kBq \cdot m^{-2}$).

The restricted access zone covers 7 settlements (4 in Narodychy district and 3 in Ovruch district). In 2005, the population of zones II, III, and IV amounted to 352 500, which is by 45000 person less than in 1986. The resettlement of the zone II has not been complete. Some of inhabitants returned to their places shortly after the resettlement, others are still coming back. The zone comprises 63 settlements, of which 36 are located in the Ovruch district, 4 in the Lugyny district, 2 in the Olevsk district, 1 in the Korosten district, and 1 in the Malyn district. The average numbers of the population in zone II in 2005 are presented in table 1.

Table 1. The population numbers in the obligatory resettlement zone, person
Tabela 1. Liczba ludności w strefie przymusowego wysiedlenia, osoby

Age groups	Total in the zone	In districts					
		Korosten	Lugyny	Malyn	Narodychi	Ovruch	other
Total population of which:	4388	71	190	16	3740	210	161
Children under 14	835	5	36	-	745	24	5
Teenagers (15–17)	115	2	5	-	102	1	5
Old-aged persons	1375	90	90	10	1075	109	1

Source: author's calculation.
Źródło: opracowanie własne.

As the table 1 shows most people live in the Narodychi, Ovruch and Lugyny districts, 3740 (2508 in the town of Narodychi itself), 210 and 190 persons respectively. Some of them receive neither external food supply nor medical service. These people's future will depend on the extent to which socio-psychological, medical, ecological and economic aspects of their vital activities will be taken into account in the strategy of the revival and development of the radio-contaminated areas.

It is a widely known fact that resettling inevitably causes social and psychological tension which would be more harmful for human health than radiological after-effects. According to many researchers the resettlement 5 to 15 years after the accident is a mistake. This policy must be thoroughly elaborated, for "the mechanical" resettlement of people, especially nowadays, is not effective. First, ecologically clean areas may not be considered fully safe. Annually, the province enterprises pollute the environment with thousands tons of toxic and chemical wastes, which are very hazardous to human health. Second, migrants do not make themselves at home in new places: they are deprived of their native homes, usual flora and fauna, their customs and habits differ from local ones. In addition, the state is not always able to render them an adequate financial support.

Taking into consideration the fact that the radioactive contamination was not distributed evenly but in a spotty way, it might be reasonable to resettle people at their will to neighboring villages, some 3–4 km away from their native places, if the contamination levels in new villages are permissible. This will help to evade the above-mentioned problems. There exists another peculiarity of this zone, i.e. settlements inhabited by 1, 2 or 3,

sometimes by 10 families. They are mainly people of advanced age. The best way out for them is their resettlement to zone's nearest and more populated localities (Narodychi, for example), with more families inhabiting, with developed social infrastructure and available housing. But in order to fulfill the above certain alterations to the present legislation should be made. The legal status of some settlements should be changed from zone II to zone III.

To our mind [Malynovsky et al. 2005] the rural population would agree on the above provided the social benefits and guarantees mandatory for the population of zone II are preserved in the reclassified areas. Relevant changes in the legislation should also allow to allocate funds for the improvement of the people's life standard in Narodychi, Bazar, Siltsi etc, which belong to zone II and these financial subsidies for the above purpose are not permitted there. Undoubtedly all these changes ought to be processed with an active participation of the public, local and central authorities and with an involvement of corresponding research institutions.

The examination of houses and barns in the most contaminated resettled villages has shown that β-radiation levels do not exceed permissible values (see table 2).

Table 2. The values of β-flow in the buildings of some settlements
Tabela 2. Wielkość promieniowania β w budynkach w niektórych wsiach

Settlement	Inner porch particles·cm^{-2}·min^{-1}	Kitchen particles·cm^{-2}·min^{-1}	Living-room particles·cm^{-2}·min^{-1}	Store rooms particles·cm^{-2}·min^{-1}	Barn particles·cm^{-2}·min^{-1}
Poliske	4–20	3–7	3–6	4–8	15–35
V. Klishchi	3–11	3–11	3–8	4–7	8–17
Shyshelivka	4–7	10–5	10–5	12–5	16–10
M. Minky	5–10	9–8	9–5	13–7	28–17
Sosnivka	3–6	3–4	4	6–3	8–3
Stovpychne	3	3	4	4	3
Sydory	3–4	3	3–5	5–6	8–6
Malenivka	5	6	6	4	8
Vystupovychi	3–5	3–7	3–5	3–8	4–7

Source: author's calculation.
Źródło: opracowanie własne.

The difference between γ-radiation of the buildings and β-radiation flow from them are minor and are within the limits of measuring apparatus errors. The greatest difference between γ- and β-radiation has been observed in thin wooden barns for keeping livestock and storing hay and is caused by fluctuations in γ-radiation rather than by radionuclide content in barn walls. Besides, it has been established that in particular construction materials (brick, plaster, floor and wall boards, farmyard fences) the ^{137}Cs specific activity ranges from 10 to 30 $Bq \cdot kg^{-1}$. Hence, one can conclude that burial of abandoned structures is not urgent today as the above objects have much lower surface contamination than the norms stipulated for β- and γ-radiation sources. Thus, they cannot be referred to as radioactive wastes, for the surface flow of β-particles does not exceed the value of 150 particles·min^{-1}·cm^{-2} ($5 \cdot 10^4$ $Bq \cdot m^{-2}$).

The life quality of people in the radio-contaminated areas is largely determined by the level of internal and external radioactive exposure. In 20 years since the Tchernobyl accident it has markedly decreased as a result of:

- natural processes (radionuclide decay, their fixation and reallocation in environmental objects);
- counter-measures aimed at lowering irradiation doses.

However, the irradiation is still high. We have conducted studies with the aim of determining the amount of the annual equivalent dose received by the population of Polissya. The results of the investigations have shown that it was at the level of 1–5 mSv[2] per year; 75 % of the dose is due to the consumption of food products and water, i.e. due to internal radioactive exposure. Table 3 presents the data on the annual dose calculation for the people living in the northern districts of Zhytomyr province on the basis of the consumer basket and the determed special radioactivity of food products.

As it is seen in the table 3, the dose of internal irradiation exceeds the permissible level (1 mSv·year^{-1}) and makes 2.12 mSv·year^{-1}, with 2/3 due to ^{137}Cs and 1/3 to ^{90}Sr. Mushrooms and forest berries account for 82.8 % of ^{137}Cs burden and dairy products for 10.7%. The intake of ^{90}Sr with dairy products is 50%, with potatoes 20.6% and with bread

Table 3. Radioactivity of consumer goods basket and doses of ^{137}Cs and ^{90}Sr internal irradiation for residents of Zhytomyr province northern districts

Tabela 3. Radioaktywność koszyka konsumpcji żywności i dawki wewnętrznego napromieniowania izotopami 137Cs i 90Sr mieszkańców północnych powiatów obwodu żytomierskiego

Foodstuffs	Daily consumption, kg	Radionuclide concentration, Bq·kg^{-1}		Daily intake, Bq		Annual irradiation dose, mSv·year^{-1}	
		137Cs	90Sr	137Cs	90Sr	137Cs	90Sr
Bread	0.41	15.9	9.4	6.5	3.85	0.033	0.110
Milk and dairy products	1.0	29.3	12.6	29.3	12.60	0.150	0.359
Meat	0.2	19.6	–	3.9	–	0.020	–
Fish	0.05	23.6	–	1.2	–	0.06	–
Eggs	0.14	2.1	–	0.3	–	0.002	–
Potatoes	0.5	9.3	10.4	4.6	5.20	0.024	0.148
Root vegetables	0.05	16.0	14.0	0.8	0.70	0.004	0.20
Leaf vegetables	0.05	13.8	10.6	0.7	0.53	0.004	0.015
Fruit	0.4	3.9	–	1.6	–	0.008	–
Forest berries	0.011	2391.6	60.5	26.3	0.67	0.134	0.019
Mushrooms	0.01	19774	165.5	197.7	1.66	1.010	0.047
Total	2.821			272.9	25.21	1.4	0.718
Annual dose of irradiation, mSv·year^{-1}						1.4	0.72

Source: author's calculation.
Źródło: opracowanie własne.

[2]mSv stands for micro Sieverts, Sievert is a unit of received equivalent of the dose of radiation, equal to Joule per squared second.

15.3%. The total contribution of mushrooms and forest berries to the annual dose of internal exposure makes 57%, so the exclusion of these products from the diet can decrease the dose to the level less than 1 $mSv \cdot year^{-1}$.

The control over the radionuclide contamination level of agricultural produce, foodstuffs, water, forest products is of great importance, as more than 90% of ^{137}Cs and ^{90}Sr deposit is contained in the upper 20-cm layer and in rangelands in 5-cm layer of the ground.

The farmlands of the region are located on meadow-boggy, peat-boggy and light soils which are characterized by a high coefficient of radionuclide transfer to plants, which results in agricultural produce contamination. It is with crops that the radionuclides are removed from the soil and that is why the internal exposure, which in turn is created due to foodstuffs and animal feeds, should mainly be lowered through carrying out complex countermeasures in farming. The use of feed additives such as sorbents and "clean" feeds should be given a priority.

CONCLUSIONS

Taking into account a large contribution of dairy products to the internal exposure dose (about 24%), surface and basic cultivation of natural forage lands which produce the most contaminated feeds, especially when used as pastures, is of great importance. This measure results in a sharp increase in livestock productivity, thus reducing radiation in milk and meat. It should be noted that fundamental improvement of meadows and pastures requires sowing large amounts of cereal type grass and leguminous seeds; the production of which is being low-cost and profitable and in steady demand in foreign markets.

The soils in Zhytomyr province northern districts are characterized by a high acidity level, so the most efficient measure for reducing radionuclide accumulation in crops harvested is liming the soil, which gives an increase in grass yields and allows to grow the leguminous plants. The province's total of farmlands which urgently require liming amounts to 156.5 thousand hectares and 609 thousand tonnes of $CaCO_3$ is needed in order to conduct the above measure. Bilokorovychi lime deposits located in the Polissya zone of the province contain about 50 million tonnes, which fully meets the requirements in lime. Taking into account liming effects lasting for 5 years the annual area limed would become 31 thousand hectares, its total cost being 18 million Ukrainian crowns.

In crop production preference should be given to such traditional branches as:

- flax growing, since flax (fibre and seeds) does not exceed the permissible level of radionuclide accumulation when proper agri-technical measures are taken;
- potato growing, as potato is considered "the second bread"; the branch no.1 priority must be the solution of the problems related to the rotation and renewal of varieties with the governmental support, particularly on individual farms where the bulk of the crop has been grown in the last years; the above said requires a well-organized system of seed production;
- hop growing with its generous financial support from the state, which covers nearly all technological operations in hop production with the exception of harvesting;

Ukrainian hop produce is increasingly becoming competitive both on the domestic and foreign markets.

In order to optimally utilize lands of zone III the following rehabilitation directions can be suggested:

- artificial afforestation (on territories which are not suitable for other economic activities);
- introduction of small-size fruit growing;
- establishment of nurseries for forest plants.

The production of beef and water-fowl meat, goose in particular, should make up quite a substantial part of animal husbandry because of relatively low cost of pasture keeping. Horse breeding should be given a further development: both draft horses to be used in farming and warm blood breeds for sale.

In the last 20 years since the Tchernobyl accident the radiological situation in the Zhytomyr province radio-contaminated areas has markedly improved. But there still exists a great number of problems which urge the state and local authorities, as well as enterprise management bodies, to work out purpose-oriented programmes and organizational measures. Two significant aspects related to the after-effects of the Tchernobyl disaster should be singled out. These are radiological and socio-economic. The present-day governmental policy should be aimed at protecting the population from radiation as well as compensating moral, social and economic losses caused by the accident itself and its after-effects. The revival of production, activation of some organisational and biological measures as to minimize the Tchernobyl after-effects, considerable social protection will enable people to live a fuller life and work in radio-contaminated areas of Zhytomyr province.

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STAN I PERSPEKTYWY DZIAŁAŃ REWITALIZACYJNYCH W SKAŻONYM RADIOAKTYWNIE REGIONIE CZARNOBYLU

Streszczenie. W wyniku katastrofy w Czarnobylu w 1986 roku prawo ukraińskie wprowadziło wokół miejsca wybuchu 4 strefy, z których pierwsza jest strefą ograniczonego dostępu, druga strefą przymusowego wysiedlenia, trzecia strefą dobrowolnego przesiedlenia i czwarta strefą ścisłej kontroli radiologicznej. Nie wszyscy mieszkańcy dali się jednak wysiedlić ze strefy drugiej, a wielu tam powraca. Obecnie żyje w niej około 4,5 tysiąca ludzi. Autor proponuje zmienić status części tej strefy na status strefy trzeciej, ale z zachowaniem przywilejów obowiązujących w strefie drugiej i zwiększeniem rządowej pomocy dla tych okolic. Wewnętrzne napromieniowanie mieszkańców tej strefy pochodzi głównie z konsumpcji grzybów i jagód; gdyby wyeliminować te składniki żywności, wewnętrzne dawki napromieniowania zeszłyby poniżej dopuszczalnej granicy. Wysuwa się także propozycje kierunków rozwoju produkcji rolniczej w strefach skażonych.

Słowa kluczowe: Czarnobyl, skażenie radioaktywne, rolnictwo, napromieniowanie

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