Health Effects of Chernobyl and Fukushima: 30 and 5 years down the line

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CONTENTS

GENERAL ABBREVIATIONS, UNIT ABBREVIATIONS, AND TERMINOLOGY

AMS – Academy of Medical Sciences.

ACS DB DEMOSMONITOR - Automated control system of data bases of monitoring of medical and demographic consequences of Chernobyl catastrophe.

ARS - Acute Radiation Syndrome.

ATR - Attributive risk.

BSSR - Belorussian Soviet Socialistic Republic.

Bq (kBq) - Becquerel ($Bq \cdot 10^3$), radioactivity unit, in the SI system.

CER - Clinical and Epidemiological Register.

CFS - Chronic Fatigue Syndrome.

CLL - Chronic lymphoid leukaemia.

CI - Confidence Interval.

$Ci \cdot km^{-2}$ - level of radioactive contamination of the territory, outdatednon-system unit (1 $Ci \cdot km^{-2} = 37\ kBq \cdot m^{-2}$)

CNS - Central Nervous System.

DCS - Diseases of the Circulatory System.

DS – Department of Statistics of Ukraine.

CMU - Cabinet of Ministers of Ukraine.

EAR - Excess Absolute Risk.

ERR - Excessive Relative Risk.

ED – Effective Dose.

FGI - French-German Initiative for Chernobyl.

Gy - Grey, absorbed dose unit, in the SI system.

GR - Growth Rate.

IAEA - International Atomic Energy Agency.

ICD - International Classification of Diseases.

IChP-1991 - International Chernobyl Project.

ICRP – International Commission on Radiological Protection.

IPHECA - International Program on Health Effects of the Chernobyl Accident.

IQ - Intelligence Quotient.

JSDF - Japan Self-Defense Force.

$kBq \cdot m^{-2}$ - level of radioactive contamination of the territory, in the SI system.

ME - Ministry of Ukraine of Emergencies and Affairs of Population Protection from the Consequences of Chernobyl Catastrophe.

MH - Ministry for Health.

MIAU - Ministry of Internal Affairs of Ukraine.

NAMSU - National Academy of Medical Sciences of Ukraine.

NASU - National Academy of Sciences of Ukraine.

NCRPU - National Commission on Radiation Protection of Population of Ukraine.

NPP - Nuclear Power Plant.

NRER - National Radiation and Epidemiological Registry.

OR - Odds Ratio.

PTSD – Post-traumatic Stress Disorder.

RADRUE - Realistic Analytical Dose Reconstruction and Uncertainty Analysis.

RCR – Radioactively Contaminated Rayon.

RCT – Radioactively Contaminated Territories.

Rem - roentgen equivalent in man, the biological equivalent of Roentgen, outdatednon-system unit for effective expose dose, 1 rem=0.01 Sv.

RF - Russian Federation.

RR - Relative Risk.

RSFSR – Russian Soviet Federation Socialistic Republic.

RSSU_97 - Radiation Safety Standard of Ukraine_97.

NRCRM - State Institution «National Research Centre for Radiation Medicine of NAMS of Ukraine».

SIR – Standardized Incidence Ratio.

SRU - The State register of Ukraine of the persons survived after the Chernobyl catastrophe», State Registry of Ukraine.

Sv (mSv) - Sievert (milliSievert) - effective dose unit, in the SI system.

TEPCO - Tokyo Electric Power Company.

UACOS – Ukrainian-American Chernobyl Ocular Study.

UNSCEAR – United Nations Scientific Committee on the Effects of Atomic Radiation.

USSR - The Union of Soviet Socialistic Republics.

UkrSSR - The Ukrainian Soviet Socialistic Republic.

WHO - World Health Organization.

Clean-up workers (liquidators, recovery operation workers, Chernobyl emergency workers) - citizens of the USSR including the UkrSSR who has participated in any activities connected with damage control and mitigation of the catastrophe and its consequences in the exclusion zone regardless of number of working days in 1986-1987, and at least 30 calendar days in 1988-1990. Citizens temporarily sent on mission to work in the exclusion zone, including servicemen, employees of state, public and other enterprises, establishments and organizations irrespective from their departmental relation, and also those who worked at least 14 days in 1986 at functioning points of population sanitary treatment and decontamination of technical devices or at their building are also attributed to the clean-up workers

Radioactive contamination - presence of radioactive substances in or on a material or the human body or elsewhere being undesirable or potentially harmful. Units of measurements are: $Bq \cdot l^{-1}$, $Bq \cdot kg^{-1}$, $Bq \cdot m^{-2}$, $Ci \cdot l^{-1}$, $Ci \cdot kg^{-1}$, $Ci \cdot km^{-2}$.

Radiation effect - effects, for which a causative role of radiation exposure is proven; there are deterministic and stochastic effects.

Radioactively contaminated territories (RCT) – territories in Ukraine (Law of Ukraine, 1991a) with a stable contamination of environment by radioactive substances above a pre-accidental level, that with due regard for the natural-climatic and complex ecological characteristics of specific territories could result to irradiation of population to above 1.0 mSv (0.1 rem) per year, and which requires measures of radiation protection of population. Territories subjected to radioactively contamination, are divided in zones:

1) *exclusion zone* is a territory, which has been radioactively contaminated after the Chernobyl catastrophe, and from which the population has been evacuated in 1986.

2) *zone of obligatory (compulsory) resettlement* is a territory exposed to intensive long half-life radionuclide contamination with density of soil deposition at a threshold values of 15.0 $Ci \cdot km^{-2}$ (555 $kBq \cdot m^{-2}$) and above for isotopes of caesium, or 3.0 $Ci \cdot km^{-2}$ (111 $kBq \cdot m^{-2}$) and more for strontium, or 0.1 $Ci \cdot km^{-2}$ (3.7 $kBq \cdot m^{-2}$) and over for plutonium. As a result the average by-settlement radiation dose of an equivalent human irradiation dose in a view of factors of radionuclides migration to the plants and other factors can exceed 5.0 mSv (0.5 rem) per one year is above the dose levels, been received in the pre-accident period;

3) *zone of guaranteed voluntary resettlement* is a territory with soil contamination density by isotopes of caesium from 5.0 up to 15.0 $Ci \cdot km^{-2}$ (185 up to 555 $kBq \cdot m^{-2}$), or strontium from 0.15 up to 3.0 $Ci \cdot km^{-2}$ (5.55 up to 111 $kBq \cdot m^{-2}$), or plutonium from 0,01 up to 0.1 $Ci \cdot km^{-2}$ (0.37 up to 3.7 $kBq \cdot m^{-2}$), where the average settlement of an equivalent human irradiation dose in a view of factors

of radionuclide migration to the plants and other factors can exceed 1.0 mSv (0.1 rem) per one year above the doses, been received in the pre-accident period;

4) *zone of strict radio-ecological control* is a territory with soil contamination density by isotopes of caesium from 1.0 up to 5.0 $Ci \cdot km^{-2}$ (37 up to 187 $kBq \cdot m^{-2}$), or strontium from 0.02 up to 0.15 $Ci \cdot km^{-2}$ (0.74 up to 1.85 $kBq \cdot m^{-2}$), or plutonium from 0.005 up to 0.01 $Ci \cdot km^{-2}$ (0.185 up to 0.37 $kBq \cdot m^{-2}$) provided that the average settlement of an equivalent human irradiation dose in a view of factors of radionuclide migration to the plants and other factors exceeds 0.5 mSv (0.05 rem) per one year above the doses, been received in the pre-accident period.

Resettlement - because of possible exceeding of a life dose over 350 mSv in the inhabitants of the RCT the Government of the USSR in 1990 has accepted the decision to resettle from these districts in UkrSR, BSSR and RSFSR more than 200.000 people. About 50.000 persons had to be resettled to the clean districts in UkrSSR. The resettlement had to be carried out in 1991-1992. Further, in Ukraine the resettlement proceeded from zones of obligatory (compulsory) resettlement, guaranteed voluntary resettlement and strict radio-ecological control.

Chernobyl catastrophe survivors. The following population groups in Ukraine are recognised as the Chernobyl catastrophe survivors:

1) evacuees from the exclusion zone (including persons who at the moment of evacuation were at a fetal life period, later they have been born and become the adult persons nowadays) and person who had moved from zones of obligatory (compulsory) resettlement and guaranteed voluntarily resettlement;

2) individuals been permanently resident within the territories of obligatory (compulsory) and guaranteed voluntarily resettlement zones at the moment of the catastrophe, or having resided at least for two years on the territory of obligatory (compulsory) resettlement zone as of January 1, 1993, or at least for three years within the territories of guaranteed voluntarily resettlement zone, and individuals relocated or migrated themselves from those territories;

3) individuals been permanently resident or working in zones of obligatory (compulsory) and guaranteed voluntarily resettlement under condition that they have lived or worked there in the zone of obligatory (compulsory) resettlement for at least two years as of 1, January, 1993, and in the zone of guaranteed voluntarily resettlement – for at least three years;

4) individuals been permanently resident or working within territories of strict radio-ecological control zone under the condition that they have lived or worked there for at least four years as of January 1, 1993;

5) individuals having worked temporary since the moment of the catastrophe till July 1, 1986 for at least 14 calendars days or at least 3 months during 1986-1987 on the territory of obligatory (compulsory) resettlement zone under the condition that they were sent to that zone by an order of ministries, establishments, executive committees of oblast Councils of Peoples' Deputies;

6) children with thyroid irradiation doses exceeding the threshold levels established by the MH of Ukraine.

Notes

1. Units of measurement used in the report are those presented in submitted documents. Recalculation in the International system units is stated in brackets behind them.
2. Territory of and Ukraine and of Belarus consists of several provinces (called "oblasts"), in turn each "oblast" consists of several districts (such district is called "rayon" or region).
3. The name for the city of Kiev in Ukrainian is "Kyiv", and for the city of Chernobyl is "Chornobyl". The spellings "Kiev" and "Chernobyl" are used in this report being known and recognised internationally.

3 REHABILITATION

3.1 Ukraine

In recent years the governing authorities of oblasts, which suffered from the Chernobyl catastrophe, have continued to implement the measures to mitigate its consequences. Main attention was focused on radiological, social, and economic rehabilitation of the contaminated territories. The purpose was to return them to a normal life, to provide people with work and create the opportunities for the towns, cities, settlements and citizens to realize their economic potential.

Realisation of the measures mentioned above was conducted in Ukraine according to the «State Program on liquidation of consequences of the Chernobyl catastrophe for 2006-2010» (Program 1 Ukr, 2006). This program was mainly focused on the completing of the process of economic recovery of the inhabited territories outside the exclusion zone and other settlements and locations heavily populated with evacuated people in order to realize further social, medical and psychological rehabilitation and radiation protection. The scheduled measures also included the financing from the state budget, development of legal background for the solution of rehabilitation issues, as well as the increase of the radio-ecological knowledge level and informing/education of population and staff that conduct measures on liquidation of consequences of the catastrophe. The framework of the program also included elaboration of the state program of rehabilitation of contaminated territories.

Unfortunately this program was not fully realized (Recommendations, 2012). It was stated by the Parliament of Ukraine that the Cabinet of Ministers of Ukraine had introduced no projects on the following:

- creation of legal mechanisms to stimulate the steady development of contaminated territories;
- intensification of industrial activity and increase of their investment attractiveness;
- solution of the problem of complex social and economic development of the territories and places of compact residence of evacuated of people;
- launch of agricultural production on these territories;
- providing survivors with housing.

Supplying the radiologically safe agricultural products, restoration and development of traditional branches of agriculture on contaminated territories has not been provided. No work has been done on the budget program "Radiological protection of the population and ecological improvement of sanitary conditions of the territory exposed to the radioactive contamination". Since 2008 no works have been financed on soil lime treatment, and since 2009 – on radiological examination of lands, evaluation of efficiency of counter measures, special programmes in stock-raising, purchasing the equipment for radiological control, its repair and maintenance, fire-prevention measures in forests, dosimetric monitoring. Nowadays the liquidation of the consequences of the catastrophe has been conducted outside the state program framework. The CMU has submitted no draft for the review by the Parliament of the State program of liquidation of the consequences of Chernobyl catastrophe for 2013-2016, and later for 2014-2018. Deadline of the final submission of the project was repeatedly postponed and the last date was in May, 2013. However, there is no Program up to now.

There is no long-term strategy for liquidation of the consequences of the Chernobyl catastrophe in Ukraine yet. Some issues of the further measures on liquidation of the consequences of the catastrophe are outlined in Recommendations (2015). In particular, it was recommended that the

CMU should submit for consideration to the Parliament the draft of the State program for overcoming the consequences of the Chernobyl catastrophe for 2016-2026. The following measures are envisaged for consideration there:

- improvement of health care and sanitary conditions of people survived after the Chernobyl catastrophe as well as providing them with medicines;
- complex social and economic development of the territories, which were exposed to radioactive contamination and places of compact residence of evacuated people;
- providing the catastrophe survivors with housing;
- monitoring the radiological consequences of catastrophe, manufacturing of radiologically safe agricultural products;
- radiation protection of population and ecological improvement of sanitary conditions of territories exposed to the radioactive contamination;
- informing the citizens on the issues of radiation conditions at the territories;
- providing of scientific research works and information systems.

It was also suggested that some amendments should be introduced to the laws in connection with the liquidation of the zone of the intensive radio-ecological control with respect to the requirements of the State hygienic norms "Radiation Safety Standard of Ukraine_97" (RSSU_97) and the results of dosimetric passportization of populated areas. Unfortunately, up to November 1, 2015 no decision has been adopted on the official level of Ukraine on these issues for the 30-th anniversary of the Chernobyl catastrophe.

Taking into account all the stated above it is to be supposed that the liquidation of the Chernobyl catastrophe consequences in Ukraine will take the indefinitely great while.

(N. Omelianets)

3.2 Belarus

The existing health programmes in Belarus, Russia and Ukraine are different for the convalescents of acute radiation sickness, clean-up workers, population of contaminated territories, and the entire population.

To realise these goals the Council of Ministers has adopted two government programs in Belarus. On 11.01.2006 the Council of Ministers of the Republic of Belarus approved the State program for 2006-2010 (Program 1 Bel, 2006). It was aimed at the socio-economic and environmental rehabilitation of radio-contaminated territories, creation of conditions for economic activities without restrictions by the radiation factor and further reducing of the health risks.

The medical part of the Program was aimed at a special healthcare supervision (clinical examination) of about 1,300,000 people affected by the disaster including about 260,000 children. This population is under the control for malignant tumours of the thyroid gland, nodular and multinodular goitre, malignant tumours of respiratory tract organs, breast, and digestive system. The function of the State Register was provided within Program framework by filling it with data on health state of the survived population.

The implemented sub-program "Children of Chernobyl" within the Presidential program "Children of Belarus" covered the health resort treatment and rehabilitation of the survived population.

On December 31, 2010 the Council of Ministers of the Republic of Belarus issued a Resolution #1922 approving a new State Program for 2011-2015 and for the period up to 2020 (Program 2 Bel,

2011). Its objectives are to reduce further the risk of adverse health effects in the Chernobyl catastrophe survivors, facilitate the transition from rehabilitation of territories to their sustainable economic and social development with the obligatory provision of radiation safety requirements.

By the end of 2014 there were 1,600,000 people, including 261,500 children and adolescents (0-18 years old) under a special healthcare supervision (outpatient check-up) in healthcare institutions of Belarus. During the year 2014 the 1,500,000 people were examined, including 261,500 children and adolescents. The costs for the health check-ups of population amounted to 647,8 billion Roubles of the National Bank of Belarus (about 43,200,000 US Dollars at the exchange rate in 2014). The number of citizens involved in the local programs of health rehabilitation is about 89,500 including 81,500 children (Bashilov *et al.*, 2015). The State Registry branches are launched in 207 healthcare institutions of Minsk city and regions with a total number of 278,800 registered people (Program 2 Bel, 2011).

According to the Resolution of the Council of Ministers of the Union State of December 13, 2013, N^{o} 21, the Program of joint activities to overcome the consequences of the Chernobyl disaster for the period until 2016 was approved within the framework of the Union State of Russia and Belarus activities (Program 3 Bel, 2016).

The objective of the Program is to improve the overall policy of life safety of citizens of Belarus and Russia who were exposed to radiation as a result of the Chernobyl catastrophe as well as the quality of life of the people living within contaminated territories; and to ensure a cooperation between Russia and Belarus in case of emergency response at the contaminated territories. For this purpose keeping with the Unified Chernobyl Register of Belarus and Russia the joint study group was formed from citizens of Russia and Belarus with high radiation risk of various radiation-induced diseases. The uniform standards for diagnosis and treatment were developed.

Despite a large scope of work conducted in Belarus, the consequences of the Chernobyl catastrophe are not yet eliminated. As of January 1, 2010 the area of farmland contaminated with ^{137}Cs was 1,021,200 hectares of which 350,600 hectares also contaminated with ^{90}Sr. From 2000 to 2010 the area of such land has decreased by 21% (from 1,297,000 to 1,021,200 hectares). The total area of contaminated territories of Ukraine, Belarus and Russia is 145,000 km^2. The 1,400,000 people including 222,800 children and adolescents affected by the Chernobyl catastrophe are under a special healthcare supervision in the country. Health check-ups covers the 100% of children and 98-99% of adults (Program 2 Bel, 2011).

(S. Igumnov)

3.3 Russian Federation

The regions of the RF most affected by the Chernobyl catastrophe are Bryansk, Kaluga, Orel and Tula. As of January 1, 2011 (Rus. nat. report, 2011) in the areas of radioactive contamination were 5,414 settlements, inhabited by about 1,600,000 people, also in the areas of radioactive contamination of the Bryansk, Kaluga, Orel and Tula regions - about 1,200,000 people. In just 25 years among the liquidators (this is a little more than 190 thousand people) died from all causes of about 40 thousand people. The most common cause of death was chronic ischemic heart disease (1,763 cases), and in the group of solid cancers the greatest contribution was made by malignant tumors of the bronchi and lungs (485 cases). Herewith overall mortality of the liquidators, according to the data of the National Report (Rus. nat. report, 2015) does not exceed the corresponding values or the male population of Russia.

According to the results of monitoring it can be concluded that nowadays in areas contaminated by the Chernobyl catastrophe, the radiation situation has been stabilized (Bruk *et al.*, 2014). By 2014, the population dose due to the Chernobyl catastrophe has been significantly reduced. In 13 of the 14 regions of the RF affected by the Chernobyl catastrophe there are no localities where the average dose of the critical groups of population exceeded 1.0 mSv·year^{-1}. Only in 299 settlements of the Bryansk region the average annual radiation dose to the critical group of the population still exceed 1.0 mSv·year^{-1}. Wherein the maximum value of the average annual dose of critical groups of inhabitants is 5.9 mSv·year^{-1}, and for all the inhabitants of settlements as a whole - 3.1 mSv·year^{-1}. However, the maximum radiation dose, which locals could receive in the absence of radiation protection and self-restriction in consumption of local foods (SGED90), is 8.0 mSv·year^{-1}.

With RF Government Decree of October 8, 2015 N^0 1074 (Decree, 1074) was approved a new version of the list of settlements subjected to radioactive contamination as a result of the Chernobyl catastrophe. From contaminated areas were excluded 558 settlements, and 383 settlements were converted to a lower level of contamination in connection with a change in the radiation situation. The list of benefits for the citizens living in the contaminated areas has not been changed.

During the period 1992-2010 by the Government of the RF have been adopted and implemented four federal (state) targeted programs for overcoming the consequences of the Chernobyl accident (1993, 1996, 1997 and 2001, respectively), four programs for the protection of the child population (1990, 1993, 1997 and 2000.), and two programs for providing housing for the liquidators of the Chernobyl accident (1995 and 2002). Furthermore, in 1998–2010 was carried out the complex of measures within the framework of the three Russian-Belarusian programs of joint activities to overcome the consequences of the Chernobyl catastrophe within the Union State (1998, 2002 and 2006). About 80% of the total quantity of work has been carried out in the framework of targeted programs, which have been implemented in 1992–1995 (Rus. nat. report 2015). Since 2002 all activities on overcoming the consequences of the Chernobyl accident have been carried out in the framework of the federal target program "Overcoming the consequences of radiation accidents for the period up to 2010". In general, within the framework of programs of overcoming the consequences of the Chernobyl accident succeeded to perform a significant amount of work: in the 1992-2010 were put into operation more than 1,300,000 m^2 of total area of residential buildings, schools for more than 19,000 pupils, hospitals with 3,827 beds, outpatient clinics for more than 10,000 visits per shift, gas and water supply networks with a total length of more than 4,000 km, roads with total length of over 820 km, and others.

Up for now, had two targeted programs:
- Government of the RF of February 12, 2011 N^0 186-p has adopted the federal target program “Overcoming the consequences of radiation accidents for the period up to 2015” (Fed. Program-2011);
- The Council of Ministers of the Union State on May 24, 2013 N^0 2 has adopted a joint program of “The program of joint activities to overcome the consequences of the Chernobyl disaster within the Union State for 2016” (Union Program-2013).

The objectives of the programs are differed in some ways. The Federal program has focused mainly on social and economic development of the affected regions, while the Union program aimed at harmonizing legislation in the field of security of residents of the affected regions, cooperation between Russia and Belarus to the emergency response, development and effective use of advanced technology medical care and rehabilitation.

The results of the Programs implementation are widely published (Rus. nat. report, 2011; Bel. nat. report, 2011; Analytical report, 2013; Chlistun, 2014). Certain joint actions of Ukraine and Russia were carried out to eliminate the health effects of the Chernobyl catastrophe (Serdiuk *et al.*, 2011).

Establishment of the National Radiation and Epidemiological Registry (NRER) - was a progressive step in the elimination of the Chernobyl catastrophe consequences in the RF. Its objective is to use the results of medical observation of the registered citizens to provide them with the addressed health care and to make prognosis regarding medical radiological consequences, including the long–term ones. The Medical Radiological Research Center of A.F. Tsyb provides the unified federal database register with the scientific-methodological basis and organizational-technological support. NRER functions since 1986. The Russian State Medical Dosimetric Register has become its basis. It was part of the Soviet Union Distributing Register, established by the USSR MH in 1986, soon after the Chernobyl disaster.

NRER provides supervision to all the subjects living in Russia exposed to ionizing radiation as a result of radiation accidents. It includes 12 categories of those exposed to ionizing radiation resulting from the Chernobyl catastrophe. Among them the following categories exist: Category 1 (CHAES-1): acute radiation sickness, category 2 (CHAES-2): handicapped, category 3 (CHAES-3): clean-up workers 86-87, category 4 (CHAES-4): clean-up workers 88-90, Category 5 (CHAES-5): employed (alienation zone), category 6 (CHAES-6): evacuees, category 7 (CHAES-7): living (zone with the right of resettlement), category 8 (CHAES-8): living (resettlement zone), category 9 (CHAES-9): employed (resettlement zone), category 10 (CHAES-10): those who left, category 11 (CHAES-11): military, Category 12 (CHAES-12): descendants.

At present the United Federal Register database contains information from 9,563,495 forms. The total number of registered in the NRER subjects is 204,197. Of those currently 530,245 people are under the observation.

The particular feature of the NRER is that it is common for Belarus and the RF. Unlike in Ukraine, its data are the basis for majority of international "Chernobyl" Programs. Unfortunately, the data of the NRER in the RF are not fully comparable with Ukrainian ones in SRU due to certain differences in observation categories.

The results of the NRER observation and generalization are regularly published in the Bulletin of the National Radiation and Epidemiological Registry (Radiation & Risk. Bulletin). The latter has been published since 1992 with the periodicity of 4 issues per year. Its publications summarize the major radiological and medical consequences of the Chernobyl catastrophe.

Establishment and maintenance of the International Chernobyl Project Portal (ICRIN) is one of the important achievements of Russia.

(S. Igumnov, N. Omelianets)

3.4 Future of the radioactively contaminated territories

Data stated above show that the Chernobyl catastrophe and its aftermath caused considerable environmental and public health impact. Countermeasures managed by the authorities of affected states expectedly still have not enough result on the Chernobyl catastrophe consequences, i.e. the effects were reduced to some extent.

Even 30 years after the catastrophe the passport radiation dose exceeded 1 mSv·year^{-1} in 541 settlements out of the 2,302 ones where the dosimetric passportization was provide in Ukraine.

Doses in the range of 1-5 mSv·year^{-1} were assessed in 26 settlements. According to the Law of Ukraine as of 1.01.2015 the zone of strict radio-ecological control ('zone 4') was excluded from the list of radioactively contaminated ones. As a result more than 1,287 settlements with population of about 1,600,000 people including more than 300,000 children were qualified as not contaminated ones. However, the government has not approved the list. At the same time, the country has in fact stopped to conduct the radiation protection of population and rehabilitation of RCT with settlements, and monitoring of radioactive contamination levels. Given the fact that natural rehabilitation processes are not sufficient (Kaschparov *et al*., 2011) and the radionuclides of caesium, strontium, transuranium elements and their fission products will be maintained in contaminated soils for hundreds of years one may expect a very long period until the pre-accident conditions will appear. Actually the contaminated territories have become a radiation geochemical province of anthropogenic origin. Moreover, for all subsequent years its inhabitants and their descendants will be the subjects of post-accident extra exposure to ionising radiation. With humanistic, scientific, and applied points of view the living conditions and health of these people should be the key issue within state activities. Returning of these territories to the pre-accident radiation levels should be an objective here. Scientists should have the opportunity to investigate the effects of such unique phenomena as radiation geochemical province of anthropogenic origin on nature and public health.

To solve these problems professor D. Bazyka and professor I. Ovsiannets (2014) have made suggestions on possible concept of elimination of consequences of the Chernobyl catastrophe in Ukraine in the current century. Authors suggest considering zones of radiation hazard, contaminated lands, and radiobiological province among the RCT in Ukraine. Zones of radiation hazard include the territory of the exclusion zone and part of the zone of obligatory (compulsory) resettlement from where the population have been already resettled. Contaminated lands correspond to the part of zone of obligatory (compulsory) resettlement from where the population was not yet resettled and the zone of guaranteed voluntary resettlement where the irradiation doses are greater than 0.5 mSv·year^{-1}. The radiobiological province comprises the territory of zone of guaranteed voluntary resettlement and of a strict radio-ecological control in which the radiation dose will not exceed 0.5 mSv·year^{-1}. In the zone of radiation hazard it is proposed to implement the measures envisaged by the Concept of the exclusion zone of the Chernobyl NPP in Ukraine (Concept, 2012) and the Law of Ukraine on the removal of the Chernobyl NPP from operation and Shelter Object conversion into an ecologically safe system (Law of Ukraine, 2009). As we have mentioned above both experts and practitioners for many years cannot come to a consensus concerning the return of evacuees and possibility of the "Chernobyl tourism" (Radiation safety rules, 2013). There has been a debate on the establishment of the Chernobyl exclusion zone biosphere reserve i.e. a reserved area (Baryakhtar *et al*., 2015). The Parliament of Ukraine requested the CMU to accelerate the preparation of proposals for the establishment of the reserve (Recommendations, 2015).

In the zone of radiation contaminated land the liquidation of consequences of catastrophe it is recommended to be continue subject to the provisions stipulated by the requirements of the current Chernobyl legislation. In the zone of radiobiological province it is proposed to abolish any measures of limitation of additional exposure of population, and to create the conditions for secure economic activity, residence and employment of population without restrictions due to the radiation factor if the dose from additional exposure does not exceed 0.5 mSv·year^{-1}, and finally to continue the monitoring of radioactive contamination. Radiation protection of population should be based on the requirements of the Radiation Safety Standard of Ukraine_97 (RSSU_97). Residents of this zone should continue to have the status of the Chernobyl catastrophe survivors and corresponding healthcare supervision. Preferences can be set only to the persons with diseases for which a causal link can be identified with the impact of ionising radiation or other harmful factors. Descendants of irradiated people are of a particular concern. In the absence of funding in the healthcare system after

2008 no information was summarised on the health of children born to persons who were children at the time of the accident. In this regard, the ability to track the stochastic effects of radiation, teratogenic and genetic disorders is lost.

These propositions are put forward for the further scientific justification of objectives and measures to eliminate the consequences of the catastrophe in remote period, and of the State program for overcoming the consequences of the Chernobyl catastrophe for 2016-2026.

(N. Om[illegible])