RISKS ASSESSMENT OF IMPACT OF RADIOACTIVE RELEASES ON THE ENVIRONMENT AND HUMAN FROM LARGE RADIATION ACCIDENTS - A BASIS FOR PLANNING AND MANAGEMENT OF RESOURCES FOR PREVENTING AND DIMINISHING THE RISKS

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Experience of overcoming the consequences of large radiation accidents either at nuclear installations or in the case of disintegration of highly active isotopic sources, testifies that resources (human, financial, intellectual, material, etc.) necessary for solving such tasks frequently arrives at enormous amount. The distraction of considerable resources on liquidation of accidents in a separately taken country can put concrete region or the whole country on the verge of social-economic crisis and necessity of bringing in of large volumes of assistance from outside, including international. Examining the practice of management (distribution, use) of resources, selected for overcoming of consequences of large accidents with the significant radioactive release into the environment one can see influence of several human factors on this major process. It is necessary to mark out that these factors can lead to considerable either underestimation or overestimation of resources required as compared to really required. Several following factors can be highlighted:

- political (desire of politicians to direct resources which not always are adequate to situation);
- decision-making by executive power in default of correct grounds or necessary information, and similarly at absence of specific experience and knowledge;
- enhanced influence on a decision making process concerning the resource selection of separate public groups (scientists, specialists, nongovernmental organizations and social groups, lobbyist and corporate informal groups) in absence of grounded methods and criteria.

On example of works on overcoming of consequences of the Chornobyl catastrophe some approaches to objective comprehension of planning process of finite (and often not sufficient) resource which. Approach is based on calculation of index of radiological risks (IRR) of certain event (process), which is stipulated by presence of radiation-dangerous objects and radioactive contaminated territories in the Chornobyl Exclusion Zone. The IRR is designed as a product (IRR = P*CD) of the probability (P) of event realization by the collective dose (CD) to the public and the personnel, involved into mitigation of consequences of an accident. For the aims of planning it is important to divide risks as present and future ones, as well as risks from repeated events.

Table 1. Radioactivity stocks distributed in natural and technogenic objects at the Chornobyl exclusion zone (for 2001)

Object	Activity, PBq			
	Total	^{137}Cs	^{90}Sr	TRU
Territory of the exclusion zone	8.13	5.5	2.5	0.13
Cooling pond of the Chornobyl NPP	0.22	0.19	0.03	0.002
Near surface radwaste disposal points	5.49	3.6	1.8	0.09
Near surface points for temporary localization of radwaste	2.14	1.4	0.7	0.04
TOTAL	16	10.7	5	0.26
Object "Shelter“ (damaged nuclear fuel)	370	240	130	5
Spent nuclear fuel of the Chornobyl NPP (reactor blocks Nos. 1,2 and 3, and SNFDF–1)	Spent fuel assembly – 21284, spent additional absorber – 1753			

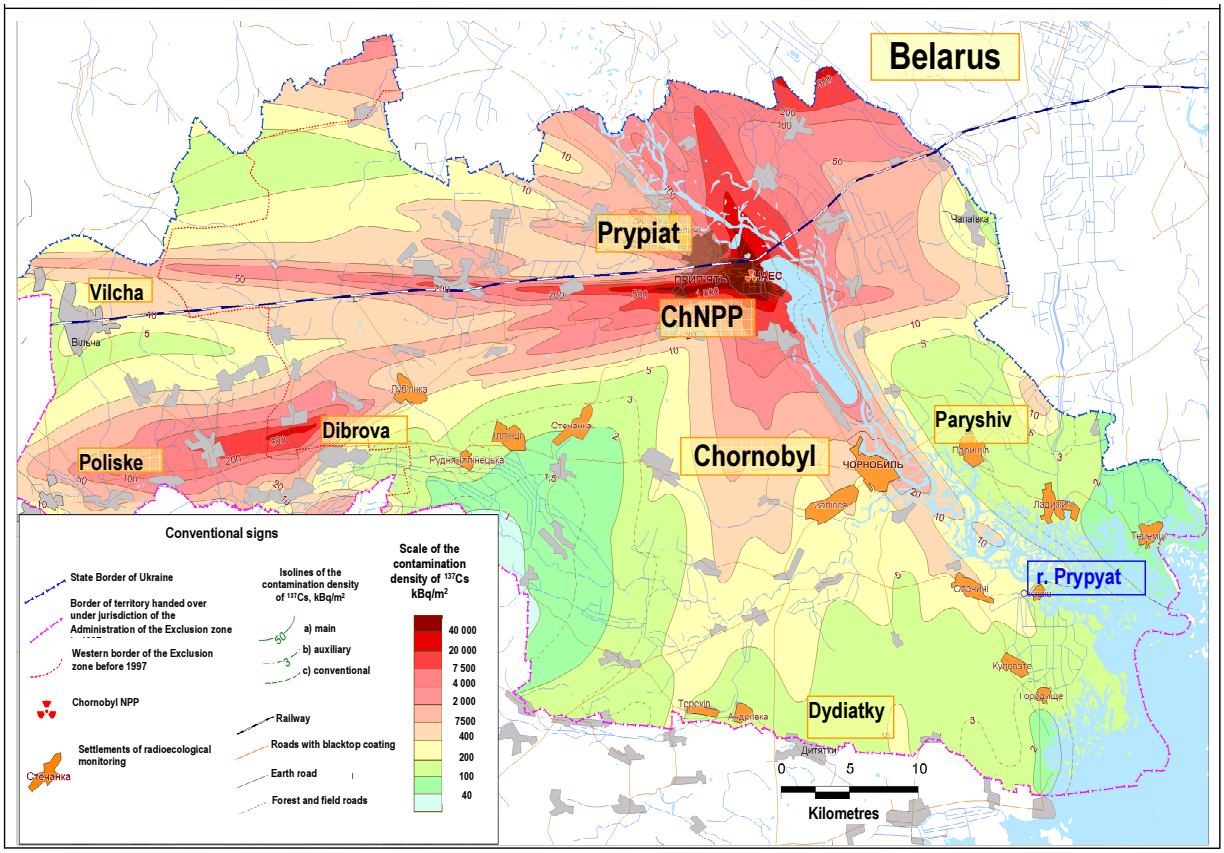

Figure 1. Surface soil ^{137}Cs contamination of the Exclusion zone (2003)

Table 2. Radionuclide effluents (emission) from different sources of the exclusion zone

Effluents and emission	Radioactivity, TBq·year^{-1}			Probability realization
	Total	^{137}Cs	^{90}Sr	
Out the Exclusion Zone				
Effluents by river Prypyat out the exclusion zone in 1995-2004 (range of variation)	1.9-13.3	0.5-3.1	1.4-10.2	Continual
Effluents by river Prypyat out the exclusion zone in 2004	2.9	0.7	2.2	
Drainage from the cooling pond by filtration water	1.1	0.1	1.0	Continual
Wind re-suspension	0.7	0.5	0.2	Periodically
Biogenic migration	0.07	0.055	0.015	Continual
Technogenic migration	0.016	0.012	0.004	Continual
Object Shelter (discharges into the environment)				
Organised discharges	0.0065			Continual
Unorganized discharges through fissures	0.0004	0.0003		Continual
Chornobyl NPP (effluents and emission into the environment)				
Gas-aerosol emission	0.0003	0.0003	0.00002	Continual
Discharges into the cooling pond by effluents	0.030	0.023	0.007	Continual

Table 3. Calculation of radionuclide effluents and emission at the exclusion zone in emergency cases

Effluents and emission	Total radioactivity, TBq·year^{-1}	Realisation probability per year
Out the Exclusion Zone		
Effluents out the Exclusion Zone due to wash-out from flood land at freshet of 25% probability (without protective constructions)	18.5	0.25
Effluents out the Exclusion Zone due to wash-out from flood land at freshet of 25% probability (with protective constructions)	11	0.25
Aerosol emission during forest fires	1.1-1.5	0.2
Aerosol emission during tornado passing	0.11-6.3	0.05
Unauthorised consumption of foodstuff at the Exclusion Zone	0.002	0.01
Object Shelter (discharges into the environment)		
Aerosol emission during collapse of the Object Shelter construction	155	$10^{-2} – 10^{-4}$

Processes of formation of doses to the personnel and the public are not equivalent; therefore neither individual nor collective dose on itself can not describe completely the radiation risk from particular objects at CEZ. For this purpose a concept of "integral index of radiation risk" (IIRR) is introduced. IIRR takes into account the collective dose constraint (CDC) from certain factor or object and also probability of CDC realization (P): IIRR = CDC·P. Thus a comparative estimation of radiation risks from main factors (objects) at the Chornobyl exclusion zone is drawn up below:

Table 4. Comparative assessment of radiological risks of main factors (sources) at the exclusion zone

Source of exposure	IDC, $mSv \cdot y^{-1}$	CDC, $man \cdot Sv \cdot y^{-1}$	P	IIRR	Remark
Water effluents by river Prypyat	2	250	0.25	63	Flood. Very conservative estimation, ≈30% is transboundary transfer from Belarus
Exposure of the personnel at regular working conditions	1.8	25	1.0	25	Current exposure, the internal exposure is not taken into account. After the active phase of works at the Object "Shelter" and the Chornobyl NPP begins the noticeable increase is expected
Accident at the object Shelter	2000	200	0.01	2	Very conservative estimation
Automobile transport	1.4	1.2	1.0	1.2	Re-suspension, atmospheric emission out the CEZ
Unauthorized consumption of foodstuff of local origin	25	100	0.01	1.0	It is a subject of regular monitoring
Wind re-suspension	0.2	3	0.2	0.6	Fire, hurricane

- Individual dose constraint (IDC)
- Collective dose constraint (CDC)
- Probability of CDC realization (P), $year^{-1}$
- Integral index of radiation risk (IIRR = CDC·P)

CONCLUSIONS AND APPLICATION ON A MACROLEVEL FOR A MANAGEMENT RESOURCES

1. The highest IRR value is associated with the radionuclide streams which are carried by surface water. Thus, taking into account location of the Chornobyl Exclusion Zone in a riverhead Dnipro, risks are considerable for a greater part of the Ukrainian public. This situation requires reserving the considerable resources, making prognosis of short-term events (floods). Resource demand will gradually go down after decades.
2. Risks related to current impact of the destroyed 4th block of Chornobyl NPP or a credible incident there makes necessary to direct considerable resources towards maintenance of the

attained safety level of the accidental block (not increasing of current risks) and towards emergency preparedness (preventions or minimization of future risks), as well as accumulations of considerable resources, including international, for transfer of the accidental nuclear reactor block into an ecologically safe system (removal of future considerable risks).

3. Meaningful IRR values for radionuclide emission via air in the case of large fires on highly radioactive territories specify on the necessity of distribution of sufficient resources for prevention of fires, diminishing of fire risks on the territory of the Chornobyl Exclusion Zone (diminishing of risks) and maintenance of fire-prevention readiness during many decades (reserving and rapid bringing in of specific resources in a case of fires).
4. Unauthorized consumption of foodstuff products from (or in) the Chornobyl Exclusion Zone is characterized by a high value of the IRR and demands relatively short resources (monitoring systems, informing, specific resource - legislative pursuit and other). Risks will remain a lot of decades.