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THE PROBLEMS OF HYGIENIC CLASSIFICATION OF RADIOACTIVE WASTE UNDER RESTORATION OF CONTAMINATED AREAS

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Abstract

Experience on restoration of contaminated areas in the past ten years reveals a specific problem in the general problem of solid radioactive waste management as a result of decontamination of the settlements. That specific problem concerns conventionally radioactive waste (CRW), which might be to some extent dangerous for human being.In the documents of IAEA and ICRP the approaches aimed at exemption or exclusion insignificant amount of radioactive wastes from regulatory control are actively being developed. In turn, Russia does not have so far either methodic or regulatory documents on management of very low level radioactive waste.Two approaches are considered in the paper under development of derived levels for CRW in case of restoration of contaminated areas. The first one is based on restriction of individual risk at level about 10^{-6} per year (negligible level). The second one accounts for global man-made background and uses acceptable factor of excess of that background as a criterion.Under the first approach (restriction of individual risk) the lowest boundary of CRW is estimated to be equal to 3 Bq kg^{-1} for ^{239}Pu; 30 Bq kg^{-1} for ^{90}Sr; and 300 Bq kg^{-1} for ^{137}Cs, respectively. Those levels of specific activity approximately correspond to the areas contaminated by the above mentioned radionuclides 0.3 kBq m^{-2}, 3 kBq m^{-2}, and 30 kBq m^{-2}, respectively.Under the second approach if one accepts factor of 3 of excess of global man-made background, than the levels of specific activity will be 0.05 kBq m^{-2} for ^{239}Pu; 2.5 kBq m^{-2} for ^{90}Sr, and 7.2 kBq m^{-2} for ^{137}Cs. Comparison of the levels obtained according to the second approach shows that they will be several times lower than that according to the first approach.

In 1997 at the session of the ICRP it was stressed that the main efforts should be aimed at development of the approaches regarding protection of the public in situations of prolonged radiation exposure. In Academician L. A. Ilyin's opinion, that type of exposure encompasses different situations, but the creation of strategy to provide radiation protection for the territories with radioactive man-made residues resulting from the radiation accidents and the past nuclear activities is the most important for Russia.

Also the problem of rehabilitation of the areas released and their further use can be arisen as a result of ceasing of exploitation of radiation-dangerous facilities or of possible shortening of size of sanitary-defense zone of a given facility under compliance with the requirements OSPORB-99 [2]. In that connection, the consistent system of criteria and hygienic standards in order to provide socially acceptable guarantees for radiation protection needs to be developed.

Social justification for the restoration criteria can schematically be considered for some important scenarios of population activities on the contaminated areas:

(1)Providing commercial agricultural industry;

(2)Construction of dwellings in areas considered;

(3)Management of radioactive residues resulting from decontamination and improvement of a settlement.

The restoration criteria under providing commercial agricultural industry by the population. In that case the compliance with standards on permissible levels of specific activity of radionuclides in foods and in raw food materials produced in contaminated areas should be considered to be the main socially acceptable hygienic criterion of normality [3]. We would like to stress that those standards are spread expanded to commodities. Those standards have been established on the basis of the intervention exemption levels for foodstuffs of 1 mSv a^{-1}, that corresponds to the recent ICRP recommendations [4]. Table 1 presents the reference limit values of surface and specific activity of ^{90}Sr and ^{137}Cs in soil of agricultural land, for which agricultural production with radionuclide content corresponding to the limit levels can be obtained without applying remedial actions.

TABLE 1. THE REFERENCE LIMIT VALUES OF SURFACE AND SPECIFIC ACTIVITY OF ^{90}Sr AND ^{137}Cs IN SOIL OF AGRICULTURAL LAND CORRESPONDING TO PERMISSIBLE LEVELS OF RADIONUCLIDES IN FOODS AND RAW FOOD MATERIALS (ROUNDED)

Food	Radio-nuclide	Transfer coefficient, 10^{-3} m^2 kg^{-1} [5-8]		Limit values of surface activity, kBq m^{-2}		Limit values of specific activity, kBq kg^{-1} *)	
		Soddy-podzolic sand	Chernozem powerful	Soddy-podzolic sand	Chernozem powerful	Soddy-podzolic sand	Chernozem powerful
Grain	^{90}Sr ^{137}Cs	3.0 0.3	0.2 0.02	50 300	700 4000	0.11 0.7	1.5 9.0
Potatoes	^{90}Sr ^{137}Cs	0.5 0.1	0.04 0.01	120 3200	1500 3200	0.3 7.0	3.0 70.0
Milk	^{90}Sr ^{137}Cs	1.0 0.2	0.08 0.03	25 250	300 1700	0.12 1.2	1.5 8.0

*) Under production of grain and potatoes the depth of arable layer is accepted to be equal to 25 cm, for natural pastures-10 cm.

From Table 1 it follows that the direction of dairy animals is critical in the problem of returning to normality according to the agricultural scenario. Specific activity of radionuclides in soil (surface activity) in areas, which can be accepted for unrestrained land use is as follows:

— for ^{90}Sr about 120 Bq kg^{-1} (25 kBq m^{-2}) under soddy-podzolic sand soil and about 1500 Bq kg^{-1} (300 kBq m^{-2}) under chernozem;

— for ^{137}Cs about 1200 Bq kg^{-1} (250 kBq m^{-2}) under soddy-podzolic sand soil and about 8000 Bq kg^{-1} (1700 kBq m^{-2}) under chernozem;

The restoration criteria under construction of dwellings in areas considered. In this case the two following situations should be considered:

- construction of dwellings in areas contaminated as a result of radiation accidents;
- construction of dwellings in areas released near normal working facilities.

In the first situation it is unlikely to be socially justified to address more strong requirements to construction sites comparing with the available radiation conditions in the living part of the settlement considered. From the other side it is not reasonable to construct buildings in the more contaminated areas because it is necessary to avoid creating the situation when the residents of new houses are a critical group of the population. For example, for the territories contaminated by the releases of the Chernobyl accident the intervention exemption level of 1 mSv a^{-1} was accepted for effective dose in a settlement resulting from all the exposure routes from the accidental fallout. It would be reasonable in those settlements where such level is reached to exclude exceeding that level in case of construction of new dwellings.

In the second situation, not exceeding the effective dose of 10 μSv a^{-1} from the past man-made radioactive residues would definitely be acceptable variant to use land released from the jurisdiction of radiation-dangerous object. The upper limit of dose, which can be perceived as social acceptable is likely to be of 100 μSv a^{-1}. Because the ICRP recommends the intervention exemption level of 1 mSv a^{-1} under trade of building materials [4], possible 10% add to it due to the past normal use of radiation source does not seem to be extraordinary.

Management of radioactive residues resulting from decontamination and improvement of a settlement. In the general problem of restoration of the territories the specific problem how to manage of large amount of very low level radioactive residues is inevitably arisen. The experience of restoration of contaminated areas in Russia after the Chernobyl accident shows that by the present time a significant amount of residues as a result of decontamination has been accumulated and that process goes on. According to available classification those residues can not be considered as radioactive residues. In the problem of management of those residues there is a specific problem because they can be dangerous to some extant for a human being. In the context of this report those residues are called conventionally radioactive waste (CRW).

CRW can be raw material, material, soil, residues of decontamination, and commodities with specific activity for:

- beta-emitting radionuclides less than 100 kBq kg^{-1};
- alfa-emitting radionuclides (excluding transuranium radionuclides) less than 10 kBq kg^{-1};
- transuranium radionuclides less than 10 kBq kg^{-1}.

Distinguished from radioactive residues, CRW can be restricted use on the basis of hygienic conclusion of the bodies of state sanitary-epidemiology inspection. Radiation-hygiene peculiarities of management of CRW comparing with management of radioactive residues can be formulates as follows:

- It is necessary to take into account that CRW, as a rule, are created in large areas as a result of intervention. They distinguish from radioactive residues, which, as a rule, are created under the normal practice within the framework of industrial site of the source used.
- In case of impossibility or inexpediency to use CRW, they are moved to special sites for temporary storage or to the places for burying of social (non-radioactive) residues. Those materials should not have take off radioactive contamination. Order, conditions, and ways to bury such residues are set by local authorities in case of

availability of the conclusion prepared by the bodies of state sanitary-epidemiology inspection.

- The places where CRW are kept can be used in distant future (accounting for radioactive decay).
- CRW can be managed, recycled, or utilized without any technical or technological requirements applied to radioactive residues. No defense requires to the workers (who provide decontamination) from ionizing radiation. It means management of CRW is allowed for personnel and for population.

Because members of the population are allowed to manage CRW it is reasonable to settle the low level of CRW on the basis of the condition that exposure dose for them during the period of management of CRW will be negligible, i.e. about 10 μSv a^{-1}.

The calculations show that in case of typical scenario of management of decontamination residues in a settlement (accumulation, loading, transportation, burying) the derived low levels of specific activity of the radionuclides in soil are as follows: 3 Bq kg^{-1} for ^{239}Pu; 30 Bq kg^{-1} for ^{90}Sr; and 300 Bq kg^{-1} for ^{137}Cs. Those levels of specific activity approximately correspond to the areas contaminated by the above mentioned radionuclides 0.3 kBq m^{-2}, 3 kBq m^{-2}, and 30 kBq m^{-2}, respectively (see Table 2).

TABLE 2. REFERENCE LOW LEVELS OF SPECIFIC AND SURFACE ACTIVITY OF CRW

Radionuclide	The main exposure pathway	Specific activity in surface layer of soil, Bq kg^{-1}	Average soil contamination, kBq m^{-2}
^{239}Pu	Inhalation	3	0.3
^{90}Sr	Distant and contact exposure to skin	30	3.0
^{137}Cs	External	300	30.0

It is necessary to stress that differentiated hygienic approach, based on analysis of risk, doses, exposure routes is difficult for public perception. The simplest perception of radiation prosperity is directly connected with the value of exceeding factor of the average global contamination of environment by man-made radionuclides. Factor of three likely to be perceptible as a normal accounting for local fluctuations of global man-made radiation background. In that case the low level of CRW will be as follows: 0.05 kBq m^{-2} for ^{239}Pu; 2.5 kBq m^{-2} for ^{90}Sr, and 7.2 kBq m^{-2} for ^{137}Cs. Taking into account the estimates by UNSCEAR [9] those levels result to annual effective dose in 1999 about 10 μSv a^{-1}, i.e. about 200 times lower than that from natural background dose. It is obvious that such radical approach to interpretation of normality of radiological situation is enough absurd.

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DISCUSSION AFTER THE PRESENTATION OF M.N. SAVKIN

A.M. MATUSHENKO (Russian Federation): To what extent do the upper limits for the concentrations of radionuclides in foodstuffs mentioned by you agree with the Codex Alimentarius upper limits applicable in international trade?

M.N. SAVKIN (Russian Federation): The Codex Alimentarius upper limits-and also the European Union's upper limits-were set in the light of the Chernobyl accident. In our work, we have used ICRP's exemption approach, which is based on the 1 mSv/year dose criterion.

In point of fact, the proposed strict upper limits for the concentration of caesium-137 in the soil are not observed at only 17 farms in the Bryansk region. They do not hamper agricultural activity in Russia.

V.I. ZEMLIANUKHIN (Russian Federation): You referred to concentrations of caesium, strontium and plutonium radionuclides in "conventionally" (very slightly) radioactive waste. Can one use those concentrations as clean-up criteria?

M.N. SAVKIN (Russian Federation): They are a lower limit for decision-making below which the soil may be considered to be uncontaminated. The upper level corresponds to a radionuclide concentration of about 10% of the concentration in low-level waste.