Retrospective Determination of Doses from Local Fallout of Nuclear Explosions

O.N. Prokof'ev, O.A. Smirnov
Institute of Radiation Hygiene, Sankt – Petersburg, Russia

INTRODUCTION

The problem of retrospective determination of doses from local fallout of nuclear explosions conducted more 40 years ago remains vital today. The cause of this is necessity to estimate doses there, where such estimations yet were not obtained, and to raise a reliability of doses estimations obtained earlier. The most difficulties at retrospective determination of doses take place in such a regions, where at once after nuclear explosions the parameters of radiation situation were not measured. Now in such a regions the deposit of long – lived radionuclides (^{90}Sr, ^{137}Cs, ^{239}Pu) on the upper layer of soil is the most reliable source of information about local fallout, took place in the past. This source of information for the retrospective determination of doses of external irradiation has been used by Beck and Krey (1). On the basis of Hicks results (2) they have received the coefficient for conversion of a ^{137}Cs deposit value on the ground from local fallout to the dose of external irradiation. It was assumed that the value of this coefficient depends only on the fallout time t_f. However, it is necessary to take into account that a value of this coefficient in reality depends yet on yield and on altitude of explosion.

Hicks (2) has assumed that a mass chains of radionuclides produced by explosion may be subdivided into two groups refractory and volatile. However, along the radionuclides of mass chains there are the elements of the intermediate group (Rb, Mo, Ag, Cd, Sn, Sb, Te, Cs, Sm, Eu), for which or their oxides the points of boiling are near to temperature of melting of SiO_2 (3, 4). Therefore, the mass chains 92 - 94, 99, 142, 143, 153 and 156 cannot be considered as completely refractory and the mass chains 90, 101, 103 – 139 cannot be considered as completely volatile. The assumptions, which had been made at determination of coefficient for conversion of a ^{137}Cs deposit value on the ground to the dose of external irradiation, limit a possibility of its application especially for a distances of more than 500 km from ground zero. However, the large contingents of population, for which till now doses had not been estimated, reside namely at such a distances.

The objective of this paper is to improve the method of retrospective determination of doses of external irradiation from local fallout of nuclear explosions on the basis of ^{137}Cs deposit value on the ground and to enlarge territories, where a retrospective determination of doses will be possible.

MATERIALS AND METHODS

The most short – lived radionuclides, which are produced by explosion with high yields, completely decay before that, as the radioactive particles fall out on the ground, and, therefore, such a radionuclides do not take part in irradiation of population. At a radioactive decay the most short – lived radionuclides after explosion usually transfer in radionuclides with more long half – lives. Only the radionuclides with half – lives not less than 10 minutes may take part in irradiation of the population. Such a radionuclides do not completely decay before that, as particles bearing radionuclides fall out on the ground, and, therefore, such a radionuclides are a dose – forming radionuclides (DFR). The distribution of atoms of that or other DFR of mass chain between a volume of melt and a surface of particles mainly depends on a behavior in fireball of atoms of most short – lived radionuclides – precursors, which present this mass chain during activation of particles.

In accordance to a particle activation model in a fireball the radionuclides are considered as elements forming chemical compositions (3). In dependence on a boiling point of the most stable chemical composition, which is formed with element under high temperature, the elements are subdivided into 3 groups: refractory, intermediate and volatile. The radionuclides from group of refractory elements completely (100%) enter into volume of melt of particles. The radionuclides from group of volatile elements (Br, I and the noble gases) do not condensed on particles neither up to, nor after a moment t_s of particles solidification. The part of atoms of radionuclide from group of intermediate elements is condensed on a surface of liquid particles and is distributed in volume of melt. The rest of atoms is condensed on a surface of particles at once after a moment t_s. This atoms remain on a surface of particles. For group of the intermediate elements the fractions of total number of atoms, which penetrate into volume of melt, were accepted the same as represented in work (4).

The quantities of atoms per one fission for each radionuclide i of mass chain j at a moment t_s $(N_i^{(j)}(t_s))$ were calculated on the basis of independent fission yields and of parameters of mass chains. The specific quantities of atoms of each DFR k of mass chain j per one fission in volume $v_k^{(j)}$ and on surface $s_k^{(j)}$ of particles were calculated as follows

$$v_k^{(j)} = \sum_{i=1}^{k} f_i^{(j)} * N_i^{(j)}(t_s), \quad (1)$$

$$s_k^{(j)} = \sum_{i=1}^{k} (1 - f_i^{(j)}) * N_i^{(j)}(t_s), \quad (2)$$

where $f_i^{(j)}$ is fraction of total quantity of atoms of radionuclide i of mass chain j in volume of melt. Summation in eqns (1) and (2) is fulfilled over all shot – lived radionuclides precursors, each of which at radioactive decay transfer in DFR k of mass chain j, and is finished in DFR k. The calculations of $v_k^{(j)}$ and $s_k^{(j)}$ were carried out for all DFR-s of mass chains from 83 up to 156 for $t_s=7s$ and $t_s=20s$ after detonation, which correspond to 20 kt and 200 kt yields, respectively (3).

The experimental (5 - 8) and theoretical (9) investigations have shown, that for particles of fallout both surface and volumetric concentrations of atoms of radionuclide do not depend on a size of particle. Then the quantity of atoms of radionuclide k of mass chain j per unit area of the ground from local fallout brought to a moment of a detonation can be determined by

$$p_k^{(j)}(0) = F * (v_k^{(j)} * \frac{V_s}{V} + s_k^{(j)} * \frac{S_s}{S}), \quad (3)$$

where F is a total quantity of fission occured at explosion; V and S are a volume of melt and a surface of all particles in an initial cloud of explosion at the time of completion of their activation; V_s and S_s are a volume of melt and a surface of all particles fell out on unit area of the ground in point considered.

The alteration of sizes of particles, which fall out at different distances from ground zero, is the main reason of fractionation (modification of radionuclides composition in fallout). The dimensionless deviation parameter in the form of

$$x = (\frac{V_s}{S_s}) / (\frac{V}{S}). \quad (4)$$

had been suggested in 1978 (10) as the value, which quantitatively determines a degree of fractionation. Parameter x determines a value of deviation of the ratio of volume of melt to a surface for all particles in a sample of fallout from such a ratio for all particles in an initial cloud of explosion, i.e. parameter x measures value of the reason of fractionation. If $x=1$, then mixture of radionuclides in fallout is unfractionated. If $x>1$ $(x<1)$, then in fallout there are predominantly DFR-s of those mass chains, which during activation of particles in a fireball were represented by radionuclides from group of the refractory elements (of intermediate and volatile elements). With help of deviation parameter eqn (3) can be rewritten as follows

$$p_k^{(j)}(0, x) / (s_k^{(j)} + x * v_k^{(j)}) = F * S_s / S. \quad (5)$$

The left part of eqn (5) is equal to the value, which does not depend neither on number of radionuclide nor on number of mass chain. It enables the quantity of atoms of radionuclide k of mass chain j per unit area of the ground from local fallout brought to time of explosion to calculate on the basis of quantity of atoms of another radionuclide per unit area of the ground from local fallout, for example, of ^{137}Cs (or ^{90}Sr), as follows

$$p_k^{(j)}(0, x) = r_k^{(j)}(x) * p_{Cs}(0, x), \quad (6)$$

where

$$r_k^{(j)}(x) = (x * v_k^{(j)} + s_k^{(j)}) / (x * v_{Cs} + s_{Cs}). \quad (7)$$

The function, which describes a change of activity of DFR with time, can be obtained by superposition of several components. The DFR considered can be first, second or third in a sequence of DFR-s of mass – chain. The number of a DFR in this sequence determines a structure of the function, which describes a change of activity of this DFR with time. Almost each mass chain of fission products can be decomposed in several components so, that one component will describe a change with time of activity of DFR considered on basis of not more than 3 successively genetically connected radionuclides without branchings. The quantity of components, which appear as a result of decomposition of the concrete mass chain, depends on the quantity of DFR-s in this mass chain and on a structure of genetical connection between these radionuclides. The quantity of such components always is not less, and in most cases is more than the quantity of DFR-s in mass chain considered.

The change with time of activity of DFR k of a mass chain j from one component, which have two

radionuclides – precursors, is described by

$$a_k^{(j)}(t,x) = F_k^{(j)}(t,x) * p_{Cs}(0,x), \text{ disintegration / (h m}^2\text{)}, \qquad (8)$$

where

$$F_k^{(j)}(t,x) = L_k^{(j)} * exp(-L_k^{(j)} * t) * r_k^{(j)}(x) + k_{k-1}^{(j)} * L_k^{(j)} * L_{k-1}^{(j)} * \left[\frac{exp(-L_k^{(j)} * t)}{L_{k-1}^{(j)} - L_k^{(j)}} + \frac{exp(-L_{k-1}^{(j)} * t)}{L_k^{(j)} - L_{k-1}^{(j)}} \right] * r_{k-1}^{(j)}(x) +$$

$$k_{k-1}^{(j)} * k_{k-2}^{(j)} * L_k^{(j)} * L_{k-1}^{(j)} * L_{k-2}^{(j)} * \left[\frac{exp(-L_k^{(j)} * t)}{(L_{k-1}^{(j)} - L_k^{(j)}) * (L_{k-2}^{(j)} - L_k^{(j)})} + \frac{exp(-L_{k-1}^{(j)} * t)}{(L_k^{(j)} - L_{k-1}^{(j)}) * (L_{k-2}^{(j)} - L_{k-1}^{(j)})} + \frac{exp(L_{k-2}^{(j)} * t)}{(L_k^{(j)} - L_{k-2}^{(j)}) * (L_{k-1}^{(j)} - L_{k-2}^{(j)})} \right] * r_{k-2}^{(j)}(x), \qquad (9)$$

where t is the time after explosion, h; $L_{k-2}^{(j)}$; $L_{k-1}^{(j)}$; $L_k^{(j)}$ are decay constants of radionuclides, which are successively genetically connected in mass chain j, h^{-1}; $k_{k-2}^{(j)}$, $k_{k-1}^{(j)}$ are branching factors in mass chain j at transformation of radionuclide *k-2* into radionuclide *k-1* and of radionuclide *k-1* into radionuclide k, respectively. If in a considered component the radionuclide k has only one precursor, then in eqn (9) it is necessary to accept $r_{k-2}^{(j)}(x)=0$, and if it has not the precursors, then it is necessary to accept $r_{k-2}^{(j)}(x)= r_{k-1}^{(j)}=0$. If the surface activity of ^{137}Cs on the ground at a moment $t=0$ is 1 kBq m^{-2}, then the change with time of the surface activity of DFR k of mass chain j on the ground is described as follows

$$A_k^{(j)}(t,x) = 3.79 * 10^5 * F_k^{(j)}(t,x), \text{ kBq m}^{-2}. \qquad (10)$$

For the unprotected man the effective dose rate (EDR) from one component of DFR k of mass chain j at 1 m above the ground is determined by $EDR_k^{(j)}(t,x)=A_k^{(j)}(t,x)*d_k$, where d_k is a coefficient for convertion of a surface activity of DFR k on the ground to EDR, nSv m^2 h^{-1} kBq^{-1}. The values of d_k have been calculated on the basis of results of work (11).

RESULTS

The total $EDR(t, x)$ has been obtained by means of summation of $EDR^{(j)}{}_k(t, x)$ over all components of all DFR-s. In the calculation of total effective dose ED(t_f, x) at first an integration of $EDR_k^{(j)}(t_f, x)$ from each component over time between the limits (fallout time) t_f and infinity was made and then summation over all components of all DFR-s was performed. Since the values presented in Tables 1 and 2 have been obtained for surface activity of ^{137}Cs on the ground equal to 1 kBq m^{-2}, they are specific $EDR(t, x)(SEDR(t, x))$ and specific $ED(t_f, x)(SED(t_f, x))$. The moment t_f in Table 2 must be chosen equal to moment of peak γ-exposure rate t_p. If γ-exposure rate reading is absent it is possible to accept t_f equal to the fallout arrival time t_a. This leads to some overestimation of SED value determined from Table 2. The value of possible overestimation one can obtain by means of determination of SED for supplementary moment $t_f=(t_a * t_e)^{1/2}$, where t_e is end of fallout time. The value of SED received by such a way will be somewhat less, than actual one. This more accurate determination may be neccesary only for a comparatively early fallout time t_f (not more than 5h after explosion), because for more later fallout time the SED weakly depend on t_f. The values of SED give a possibility to determine values of ED on the basis of the surface activity of ^{137}Cs from local fallout on the ground. The values of SEDR give a possibility to determine surface activity of ^{137}Cs from local fallout on the ground on the basis of γ-exposure rate measurements made at once after explosion.

The method of calculation of parameter x was presented in work (4). The upper diameter D_u (low diameter D_l) of particles, which fell out on the ground in point considered, is determined on the basis of arrival time t_a (end time t_e) of fallout in this point and of altitude of the cloud top (bottom). The moment t_a (t_e) determines a most short (long) time interval, which is required for fall of particles in this point. The particle, for which by other things being equal it is required most short (long) time interval for fall from maximal (minimal) altitude, has a maximal (minimal) size. The moments t_a and t_e may be determined from γ-exposure rate reading and in case of its absent may be calculated by known formulas (12, 13).

Table 1.The SEDR as a function of time after explosion and of deviation parameter

Time after explosion(1), h	Values of SEDR (mSv m^2 h^{-1} kBq^{-1}) for x						
	0.6	1.0	1.5	3..0	5.0.	7.0	10.0
1	4.23	5.22	6.45	10.15	15.07	19.98	27.34
2	1.82	2.24	2.77	4.36	6.47	8.58	11.74
3	1.06	1.29	1.59	2.49	3.69	4.88	6.67
4	0.70	0.86	1.05	1.63	2.40	3.18	4.34
5	0.51	0.62	0.76	1.17	1.71	2.26	3.08
6	0.40	0.48	0.59	0.90	1.31	1.72	2.34
7	0.33	0.40	0.48	0.73	1.06	1.39	1.88
8	0.29	0.34	0.41	0.62	0.89	1.17	1.58
10	0.23	0.27	0.32	0.48	0.69	0.90	1.21
12	0.19	0.23	0.27	0.40	0.57	0.74	1.00
14	0.16	0.19	0.23	0.34	0.49	0.63	0.85
16	0.14	0.16	0.20	0.29	0.42	0.55	0.75
20	0.10	0.13	0.15	0.23	0.33	0.44	0.60
24	0.08	0.10	0.12	0.19	0.27	0.36	0.49
30	0.06	0.07	0.09	0.14	0.21	0.28	0.38

1) It is accepted, that time after explosion is more than or equal to fallout time.

Table 2. The SED as a function of fallout time and of deviation parameter

Fallout time, h	Values of SED (cSv m^2 kBq^{-1}) for x						
	0.6	1.0	1.5	3..0	5.0.	7.0	10.0
1	1.49	1.82	2.22	3.43	5.01	6.58	8.90
2	1.22	1.48	1.80	2.77	4.04	5.30	7.16
3	1.08	1.31	1.60	2.44	3.56	4.67	6.30
4	1.00	1.21	1.47	2.24	3.27	4.28	5.78
5	0.94	1.13	1.38	2.11	3.07	4.02	5.42
6	0.89	1.08	1.31	2.01	2.92	3.83	5.16
7	0.86	1.04	1.26	1.93	2.81	3.68	4.96
8	0.82	1.00	1.21	1.86	2.71	3.55	4.79
10	0.77	0.94	1.14	1.75	2.56	3.35	4.52
12	0.73	0.89	1.08	1.67	2.43	3.19	4.31
14	0.70	0.85	1.03	1.59	2.33	3.06	4.13
16	0.67	0.81	0.99	1.53	2.24	2.94	3.98
20	0.62	0.75	0.92	1.43	2.09	2.75	3.72
24	0.58	0.71	0.87	1.35	1.97	2.59	3.51
30	0.54	0.66	0.81	1.25	1.83	2.41	3.25

DISCUSSION

The verification of results may be carried out with help of data of event Harry. For this explosion a normalized altitude is $\overline{H} = 2.9$ m $t^{-1/3}$ (t is ton), and a maximal diameter of particle entirely melted is D_p=24.2 μm. For Nevada soils it was recommended to accept D_m=130 μm (D_m is a median particle diameter of log – normal mass particle size distribution in initial cloud of explosion) and h=0.602 (h is a standard deviation of decimal logarithm of particle diameter) (12). The altitudes of top (8.1 km) and of bottom (4.2 km) cloud were taken from Fig. 2 of work (14) for 32 kt yield of explosion. The input data and results of calculation are presented in Table 3. For conversion of ED to external exposure a coefficient 2.71 cSv kg mC^{-1} (0.7 cSv R^{-1}) has been used (15).
According to measurement of exposure rate in S – George after event Harry (16) at the moment 5.65h after explosion the exposure rate was 0.0578 mC kg^{-1} h^{-1} (0.224 R/h) or the EDR was 0.157 cSv h^{-1}. If x=1.85 and t_f=5.65 h, then by means of linear interpolation of data from Table 1 one can receive SEDR (5.65h; 1.85)= 0.0726 (cSv m^2 h^{-1} kBq^{-1}). Then the surface activity of ^{137}Cs on the ground in S – George from event Harry is

Table 3. The estimations of doses of external irradiation from event Harry

Location	T_a, hour	Surface concentration of ^{137}Cs(4, kBq m^{-2}	D_u, μm	D_l, μm	X	SED cSv m^2 kBq^{-1}	Dose of external irradiation, mC kg^{-1}(R)	
							This work	Work (1)
Santa – George	4.7(1	2.02	83	42	1.85	1.58	1.16(4.5)	0.95(3.7)
Enterprise	4.7(2	0.94	83	42	1.85	1.58	0.54(2.1)	0.44(1.7)
Kanab	6.5(3	0.4	72	35	1.70	1.37	0.26(1.0)	0.18(0.7)

1) From work (16). 2) It was accepted as for Santa – George. 3) It was calculated by assumption, that t_a for Kanab increased in comparison with t_a for Santa – George direct proportional to distance from ground zero. 4) Data of work (1) corrected for decay to 1953.

0.157 (cSv h^{-1})/0.0726 (cSv m^2 h^{-1} kBq^{-1})=2.16 kBq m^{-2}. This result little differs (6%) from the value obtained by means of measurement (1). The good accordance of our estimations with results received earlier corroborates a validity of approach suggested.

The values of SEDR and SED, presented in Tables 1 and 2, belong to version of fission of ^{239}Pu by neutrons of the detonation spectrum and t_s=7s. In order to estimate a possible alteration of SEDR and SED values because of the displacement of t_s and of a change of material fueled device the calculations of SEDR and SED were carried out yet for three versions of fission: 1) of ^{239}Pu by neutrons of the detonation spectrum and t_s=20s, 2) of ^{238}U by neutrons with energy 14 MeV and t_s=7s, 3) of ^{238}U by neutrons with energy 14 MeV and t_s=20s. The comparison of results (Tables 4 and 5) shows, that an imprecisions of input information in relation of the material fueled device and of the moment t_s have significantly less influence on the SEDR and SED values, than a possible imprecisions of the deviation parameter x and of a moment t_f. The influence on the dose estimations of a possible difference between mass particle size distribution used in calculation and actual one can be seen on the basis of data of event Harry. If to accept D_m=100 μm and h=0.76, as it was recommended earlier (17), then at keeping back all other input parameters for this explosion without change the deviation parameter for S – George will be 3.8. Then according to Table 2 the value of SED (4.7h; 3.8)=2.47 cSv m^2 kBq^{-1}. This leads to in 1.6 times larger estimation of ED for S – George in comparison with value

Table 4. The comparison of SEDR values for different versions

Time after explosion(1,h	Version	Values of SEDR ((mSv m^2) (h $kBq)^{-1}$) for x				
		0.6	1.0	3.0	7.0	10.0
1	^{239}Pu, t_s=7s	4.23	5.22	10.15	19.98	27.34
	^{239}Pu, t_s=20s	4.25	5.20	9.95	19.43	26.53
	^{238}U, t_s=7s	4.17	5.20	10.34	20.59	28.26
	^{238}U, t_s=20s	4.78	5.82	11.04	21.45	29.24
30	^{239}Pu, t_s=7s	0.056	0.070	0.139	0.277	0.380
	^{239}Pu, t_s=20s	0.056	0.070	0.138	0.274	0.376
	^{238}U, t_s=7s	0.049	0.060	0.114	0.222	0.303
	^{238}U, t_s=20s	0.048	0.059	0.114	0.222	0.303

1) It is accepted, that time after explosion is more than or equal to fallout time

Table 5. The comparison of SED values for different versions

Fallout time, h	Version	Values of SED ((cSv m^2) ($kBq)^{-1}$) for x				
		0.6	1.0	3.0	7.0	10.0
1	^{239}Pu, t_s=7s	1.49	1.82	3.43	6.58	8.90
	^{239}Pu, t_s=20s	1.47	1.80	3.45	6.70	9.07
	^{238}U, t_s=7s	1.43	1.73	3.24	6.19	8.36
	^{238}U, t_s=20s	1.44	1.76	3.34	6.43	8.70
30	^{239}Pu, t_s=7s	0.54	0.66	1.25	2.41	3.25
	^{239}Pu, t_s=20s	0.54	0.66	1.27	2.48	3.37
	^{238}U, t_s=7s	0.50	0.60	1.10	2.08	2.81
	^{238}U, t_s=20s	0.49	0.60	1.12	2.14	2.90

given in Table 3. It is interesting to note, that the V_s/S_s ratio at considered replacement of values D_m and h practically did not change, but the value of V/S ratio decreased in 2 times. The value of V_s/S_s ratio mainly depends on estimation of a moment t_a and for event Harry at D_m=130 μm and h=0.602 decrease from 8.3 μm to 7.1 μm at increase of moment t_a from 3.7 to 6.5 h. Thus a difference of a mass particle size distribution in initial cloud of explosion used in calculation from actual one especially strongly influences on the estimation of parameter x.

The range of particles sizes in fallout used in calculation can be displaced relative actual one because of an error in determination of a cloud top and cloud bottom altitudes and because of error in estimation of moment t_a for location considered. The error in estimation of a bottom cloud altitude more strongly influences on estimation of the value of the deviation parameter, but even in this case at 1 km error for ground explosion of 20 kt yield the displacement of value of deviation parameter does not exceed 4%. The error because of the displacement of moment t_a is more significant. At a displacement of t_a estimation by 25% the relative error in estimation of deviation parameter will be approximately 10%, that leads to error in estimation of SED at level of 5%, if x near 7. The standard deviation of instrumental determination of surface activity of ^{137}Cs on the ground by means of analysis of soil samples is approximately 8% (1).

The relative error ε in estimation of surface activity of ^{137}Cs on the ground from local fallout can be calculated by

$$\varepsilon = (\Delta P + \Delta P_g)/(P - P_g) = (\frac{\Delta P}{P} + \frac{P_g}{P} * \frac{\Delta P_g}{P_g})/(1 - \frac{P_g}{P}), \qquad (11)$$

where ΔP and ΔP_g are the absolute errors in estimation of a total surface activity of ^{137}Cs on the ground, and of its global component, respectively; P and P_g are a total surface activity of ^{137}Cs on the ground and its global component, respectively. The relative error ε grows with increase of contribution of global fallout to surface activity of ^{137}Cs on the ground (Table 6). It has been accepted, that $\Delta P/P = \Delta P_g/P_g = 0.2$. Since the value of ED with other things being equal is directly proportional to local component of surface activity of ^{137}Cs on the ground, so the estimation of relative error ε determines also the relative error in estimation of ED.

The retrospective estimation of doses of external irradiation for population often may have interest even in such a case, when the estimation is carried out with uncertainty at the level near 100%. This level of uncertainty gives a possibility to estimate a low value of ED, for which the application of a method suggested may be useful. For the average surface activity of ^{137}Cs on the ground from global fallout equal to 1.5 kBq m^{-2}, which existed in a middle of 90 years for $50^0 - 60^0$ N latitude band, with

Table 6. The dependence of relative error ε on fraction of global component

P_g/P	0.1	0.3	0.5	0.7	0.8	0.9
ε	0.24	0.37	0.60	1.13	1.80	3.80

the relative error 113% (see Table 6) one can estimate ED in such a case, when the total surface activity of ^{137}Cs is 2.14 kBq m^{-2}, and the contribution to surface activity of ^{137}Cs from local fallout is 0.64 kBq m^{-2}. If this contribution was determined in 1998, so it corresponds to the surface activity of ^{137}Cs from local fallout equal to 1.82 kBq m^{-2} in 1953 (1953 is accepted as year of explosion, which caused local fallout). In case, when the parameter deviation x=1, the fallout arrival time t_a=30 hour, and the surface activity of ^{137}Cs on the ground from local fallout equal to 1.82 kBq m^{-2}, the value of ED will be 1.2 cSv. Under the same input data with the relative error 60% it is possible to estimate ED at the level of 2.8 cSv. This estimations approximately show a low values of ED, which may be determined under given conditions by method suggested.

CONCLUSIONS

The difference of mass particle size distribution in initial cloud of explosion used in calculation from actual one, the imprecision in determination of fallout arrival time and the uncertainty of estimation of global fallout contribution to surface activity of ^{137}Cs on the ground give the main contribution to total error of ED estimation from external irradiation on the basis of value of ^{137}Cs deposit on the ground. The uncertainties of input information concerning both solidification time of particles in fireball and material fueled device have significantly less influence on the value of ED estimation error. This gives a possibility to believe, that on the basis of the value of ^{137}Cs deposit on the ground the ED of external irradiation (it is possible from local fallout of several explosions) may be estimated with a relative error not more than 100% even in such a cases, when the partial contributions to ^{137}Cs deposit on the ground from a concrete explosions are precisely unknown.

The method suggested has the most interest for regions, where there is only one source of information about the local fallout, which took place in the past. Such a source is the ^{137}Cs and ^{90}Sr deposit on the ground. As a rule a similar regions locate sufficiently far from a test sites approximately from several hundreds km to 1000 km and more. Namely in such a regions the estimations of doses for population from tests of nuclear weapons have not been obtained till now. However, for estimation of unfavourable consequences from irradiation such a regions have a significant interest, as they comprise the large contingents of population.

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Nuclear fallout is the residual radioactive material propelled into the upper atmosphere following a nuclear blast, so called because it "falls out" of the sky after the explosion and the shock wave has passed. It commonly refers to the radioactive dust and ash created when a nuclear weapon explodes. The amount and spread of fallout is a product of the size of the weapon and the altitude at which it is detonated. Fallout may get entrained with the products of a pyrocumulus cloud and fall as black rain Radioactive fallout from nuclear explosions has affected the population around the world to some extent. After the Chernobyl nuclear power plant accident in 1986, the inhabitants of Sweden suffered from 137Cs exposure, after five years, cancer growth was observed [35], in Belarus [29, 61], Russia [29, 39] and Ukraine [28], the incidence of thyroid cancer increased sharply in children. Based on these data, a screening of the incidence of thyroid cancer in Fukushima was carried out, which also showed a high growth of this nosology [48, 50].Â 34. Evseeva T.I., Geras'kin S.A., MaJstrenko T.A., Belykh E.S. Assessment of soil degradation in regions of nuclear power explosions at Semipalatinsk Nuclear Test Site // Radiats Biol Radioecol. 2011. Mar-Apr; 51(2): 264-72. The problem of discovery and identification of the global and local nuclear fallouts in reconstruction of the radiation situation especially in the mountain landscape conditions is discussed in the article.Â Long-term studies of the consequences of the radiation impact of nuclear tests at the Semipalatinsk test site on the territory and population of the Altai Republic revealed facts of local contamination of the soil cover 137Cs. The problem of identification and identification of global and local fallouts is discussed in the reconstruction of the radiation situation, especially in mountainous terrain. Key words Consequences of the radiation impact, nuclear tests, Semipalatinsk test site, population, territory republic Altai, local fallouts, reconstruction of the radiation situation. References. Retrospective Dose Assessment for the Population Living in Areas of Local Fallout from the Semipalatinsk Nuclear Test Site Part I: External Exposure. Konstantin GORDEEV. 1.Â to which the exposure rate P(t) at any time t (starting from the end-of-fallout time, t0+âˆ†t) can be assessed on the basis of available historical measurement of exposure rate P(tm) performed at time tm as follows: P(t) = P(tm) Ã— (t/tm)â€“n. (3).Â populations living in areas of local fallout from atmospheric nuclear explosions. Methodical directions MU 2.6.1.1001-00. Official publication. The experimentally determined dose was considered to consist of two contributions: dose from natural radiation background accumulated during a tooth enamel lifetime and dose obtained as a result of nuclear tests (excess dose). The last contribution is subject of the interest for present dose reconstruction. At first, the intensity of the RIS was converted into a dose absorbed by enamel Den (expressed in mGy) calibrated using calibration by a 60Co Î³-source. Second, excess dose in enamel was determined by subtraction of contribution of the natural background radiation during the enamel existence