Chernobyl Accident: Assessment of the Collective Thyroid Dose for the Belarusian Population

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This paper presents two methodologies of assessment of the collective thyroid dose from ^{131}I and the results of those assessments for the Belarusian population living in different areas and in the Republic as a whole.

FIRST METHODOLOGY OF ASSESSMENT OF THE COLLECTIVE THYROID DOSE

The first methodology was developed at the Institute of Biophysics in Moscow, Russia. In this methodology, two approaches were used to estimate the collective thyroid dose from ^{131}I received by the Belarusian population, depending on the area considered. The first approach was based on the results of individual thyroid dose estimates obtained for residents whose thyroid ^{131}I activity was measured within a few weeks after the Chernobyl accident (1). That approach was applied for those territories where a sufficient number of the residents had been measured. The second approach (so called "semiempirical" method) was derived from the relationship obtained between the mean adult thyroid dose and the deposition density of ^{131}I or ^{137}Cs in villages (2). That approach was applied for the rest of the Belarusian territories where thyroid burdens of the population had not been measured.

In the first case, the estimate of the collective thyroid dose, D_{cx}, for area x was obtained on the basis of (a) the "measured" individual doses, D_{ijx}, in the settlements j located in area x, and (b) the population in each age group according to the following equation:

$$D_{xc} = \sum_{j=1}^{n_x} \left(N_{jx} \times \frac{1}{n_{jx}} \sum_{i=1}^{n_{jx}} D_{ijx} \right), \text{ Gy} \qquad (1)$$

where n_{jx} is the number of measured individual doses D_{ijx} in settlement jx;
n_x is the number of settlements located in area x;
N_{jx} is the number of residents in settlement jx.

In the second case the estimate of the collective dose is calculated according to equation (2):

$$D_{xc} = \sum_{j=1}^{n_x} \left(N_{jx} \times D_{jx} \right), \text{ Gy} \qquad (2)$$

where D_{jx} is the average thyroid dose for settlement j located in area x, Gy.

The values of D_{jx} in equation (2) for the rural adult population who consumed fresh cow's milk and lived in areas x with combined deposition ("dry" plus "wet") as well as lived in the areas where aerosols of large size deposited (within the "central spot") are calculated according to the following equations:

$$D_{jx} = [3.3 \times q_x(I) + 1.3 \times q_{jx}(I)] \times 10^{-8}, \text{ Gy} \qquad (3)$$

and

$$D_{jx} = [3.3 \times R_x \times q_x(Cs) + 1.3 \times R_{jx} \times q_{jx}(Cs)] \times 10^{-8}, \text{ Gy} \qquad (4)$$

where $q_x(I)$ and $q_{jx}(I)$ are average ^{131}I ground deposition density in area x and in settlement jx, respectively, Bq m^{-2};
$q_x(Cs)$ and $q_{jx}(Cs)$ are average ^{137}Cs ground deposition density in area x and in settlement jx, respectively, Bq m^{-2};
R_x, R_{jx} are ratios of the ^{131}I to ^{137}Cs ground deposition densities in area x and in settlement jx, dimensionless.

However, an analytical investigation (3) and the analysis of available "experimental" data on the D_{jx}/q_{jx}

ratio showed that use of formula (3) provides reliable estimates of average thyroid doses only for the areas with similar percentages of ^{131}I activity deposited according to dry and wet processes.

In order to provide better estimates of thyroid doses for the areas with different percentages for wet and dry deposition as well as for the areas with solely dry deposition (denoted with the subscript "d") equations (3) and (4) were rewritten in another manner:

$$D_{jx} = [12.4 \times q_{xd}(I) + 1.3 \times q_{jx}(I)] \times 10^{-8}, \quad Gy \qquad (5)$$

and

$$D_{jx} = [12.4 \times R_{xd} \times q_{xd}(Cs) + 1.3 \times R_{jx} \times q_{jx}(Cs)] \times 10^{-8}, \quad Gy \qquad (6)$$

The numerical value of the coefficient in the first terms of equations (5) and (6) was changed according to a proportional change in the value of parameter "q" due to replacement of "q_x" with "q_{xd}" for sample area (x_s), which had been used to estimate the numerical values of the coefficients in equations (3) and (4). In general, that value may vary upon the amount of fallout activity intercepted by grass by "wet" deposition in addition to the amount of fallout activity intercepted by grass by "dry" deposition. If such additional amount of activity is equal to zero then the value of the coefficient for combined deposition will be approximately equal to its value for solely dry deposition. If, for example, such additional amount of activity is equal to the amount of deposited activity by dry deposition, then the numerical value of the considered coefficient for the combined fallout should exceed by a factor of up to 2 the value that is attributed to solely dry deposition.

The results of analysis of available data for various contaminated areas did not show such distinction. The numerical value 12.4×10^{-8} in equations (5) and (6) was used to estimate D_{jx} for the settlements located in areas with solely dry deposition.

The delineation of areas x with similar percentages of dry and wet deposition is carried out with orientation on dry deposition from the same radioactive cloud. Under such delineation it is assumed that the values of q_{xd} within the delineated area x do not vary more than three times. This corresponds to 50% of the uncertainty associated with the determination of the ground deposition density in settlement jx.

For the areas with solely dry deposition, there is no similar restriction. They can be very large and do not depend upon the level of radionuclide deposition from the same cloud.

It follows from the above that, in general, the borders of the delineated areas x do not coincide with the borders of administrative units (Raion and Oblast). In principle, the area x may include one settlement or many settlements.

Equations (6) and (7) are valid in the case of approximately similar life-style of the residents and pasture grass conditions in comparison to the reference area x, which covers part of Bragin and Khoiniki Raions of Gomel Oblast. Peculiarities of any area (for example, yield of grass, its quality, the date that pasture use began, evacuation and relocation of the residents etc.) are accounted for by the insertion of correction coefficients (as multipliers) into the equations used to calculate D_{jx} (3).

The estimates of D_j for the areas with solely dry deposition are calculated according to equations:

$$D_j \cong 1.2 \times 10^{-7} \times q_j(I), \quad Gy \qquad (7)$$

or

$$D_j \cong 1.2 \times 10^{-7} \times R_j \times q_j(Cs), \quad Gy \qquad (8)$$

Equations (1), (2), (6), and (8) have been used in this paper to estimate the collective thyroid dose from ^{131}I for the Belarusian population living in different areas and in the Republic as a whole.

ESTIMATES OF COLLECTIVE THYROID DOSE (FIRST METHODOLOGY)

Table 1 gives the results of assessment of the collective thyroid dose calculated on the basis of "measured" individual thyroid doses (first approach) for the more contaminated territories in Gomel and Mogilev Oblasts.

In order to make such an assessment, in a manner similar to what was done in our previous evaluation in 1996 (2), the results of the second iteration of estimation of average thyroid doses for the settlements and areas where ^{131}I thyroidal content was measured (4) were used.

.Table 1. The estimates of average and collective thyroid doses, calculated on the basis of direct thyroid measurements carried out in the highly contaminated areas of Gomel and Mogilev Oblasts of Belarus

Area	Average (D_{jx}) and collective (N_{jx}×D_{jx}, D_{xc}) thyroid dose estimates													
	(0-6) y				(7-17) y				adults				total	
	n_{jx}, persons	N_{jx}, persons	D_{jx}, Gy	N_{jx}×D_{jx}, 10^3 person Gy	n_{jx}, persons	N_{jx}, persons	D_{jx}, Gy	N_{jx}×D_{jx}, 10^3 person Gy	n_{jx}, persons	N_{jx}, persons	D_{jx}, Gy	N_{jx}×D_{jx}, 10^3 person Gy	N_c, Persons	D_{xc}, 10^3 person Gy
Gomel Oblast														
Khoiniki town	393	1620	0.46	0.75	565	2580	0.33	0.85	734	12000	0.17	2.04	16200	3.64
Evacuated villages (before 5 May 1986) in Khoiniki raion	158	353	4.7	1.66	364	498	2.3	1.15	1581	2449	1.6	3.92	3300	6.73
Villages not evacuated before 5 May 1986 in Khoiniki raion	1367	2842	1.57	4.46	2412	3717	0.66	2.45	10560	18941	0.47	8.90	25500	15.81
Bragin town	207	550	0.80	0.44	289	850	0.46	0.39	299	4100	0.25	1.03	5500	1.86
Komarin town	137	250	0.51	0.13	324	400	0.27	0.11	1095	1850	0.17	0.31	2500	0.55
Evacuated villages (before 5 May 1986) in Bragin raion	276	659	2.10	1.38	410	930	1.10	1.02	2452	4571	0.8	3.66	6160	6.06
Villages not evacuated before 5 May 1986 in Bragin raion	1149	2692	1.56	4.20	2356	3679	0.70	2.58	15084	18269	0.4	7.31	24640	14.09
Narovlya town	468	1110	0.4	0.44	725	1790	0.22	0.39	3175	8200	0.13	1.07	11100	1.90
Evacuated villages (before 5 May 1986) in Narovlya raion	33	170	1.55	0.26	61	240	0.63	0.15	700	1180	0.45	0.53	1590	0.94
Villages not evacuated before 5 May 1986 in Narovlya raion	338	1673	1.34	2.24	487	2138	0.71	1.52	2499	11099	0.36	4.00	14910	7.76
Vetka town	375	960	0.64	0.61	293	1540	0.21	0.32	807	7100	0.16	1.14	9600	2.07
Villages in Vetka raion	276	3202	1.60	5.12	375	4334	0.91	3.94	581	21764	0.34	7.40	29300	16.46
Buda-Koshelev town	67	1300	0.39	0.51	104	2000	0.19	0.38	354	9700	0.1	0.97	13000	1.86
Villages in Buda-Kosh. raion	47	4210	0.38	1.60	24	5777	0.23	1.33	286	28513	0.11	3.13	38500	6.06
Korma town	22	630	0.13	0.082	28	970	0.041	0.040	138	4700	0.04	0.19	6300	0.31
Villages in Korma raion	60	2216	0.23	0.51	288	3047	0.18	0.55	177	15037	0.06	0.90	20300	1.96
Total in rural settlements in Gomel Oblast	5373	24437		24.39	9105	34490		17.17	40522	169473		46.50	228400	88.06

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mogilev Oblast														
Slavgorod town	124	750	0.081	0.060	223	1240	0.031	0.038	898	5600	0.033	0.18	7590	0.28
Villages in Slavgorod raion	212	1698	0.22	0.37	521	2144	0.12	0.26	933	12568	0.095	1.20	16410	1.83
Krasnopolye town		640	0.31	0.20		960	0.14	0.13		4800	0.095	0.46	6400	0.79
Villages in Krasnopolye raion	205	1614	0.62	1.00	596	2156	0.35	0.75	2003	11930	0.19	2.3	15700	4.05
Chericov town		770	0.27	0.21		1230	0.10	0.12	12	5700	0.065	0.37	7700	0.70
Villages in Chericov raion	417	1515	0.54	0.82	531	1928	0.18	0.35	2160	11258	0.13	1.46	14700	2.63
Klimovichi town		1630	0.18	0.29		2570	0.065	0.17	15	12100	0.044	0.53	16300	0.99
Villages in Klimovichi raion	136	2226	0.36 x 0.5 =0.18*	0.40	163	2760	0.14 x 0.5 =0.07*	0.19	780	16515	0.088 x 0.5 =0.044*	0.73	21500	1.32
Kostukovichi town	21	1080	0.27	0.29	9	1720	0.080	0.14	69	8000	0.053	0.42	10800	0.85
Villages in Kostukovichi raion	491	2408	0.45 x 0.66 =0.30**	0.72	491	3102	0.25 x 0.66 =0.17**	0.51	2670	17889	0.21 x 0.66 =0.15**	2.48	23400	3.71
Total in Mogilev Oblast	1606	14331		4.36	2535	19810		2.66	9540	106359		10.13	140500	17.15
Cities in the Republic of Belarus														
Minsk	3755	182698	0.08	14.62	2605	259703	0.029	7.53	11539	1067499	0.018	19.21	1509900	41.36
Gomel	228	59012	0.46	27.15	298	83884	0.16	13.42	1382	344804	0.078	26.89	487700	67.46
Mogilev	329	43439	0.08	3.48	300	61748	0.03	1.85	742	253813	0.02	5.08	359000	10.41
Mozyr	117	12100	0.21	2.54	127	17200	0.13	2.24	346	70700	0.097	6.86	100000	11.64
Total in cities	4429	297249		44.76	3330	422535		25.04	14009	1736816		58.04	2456600	130.9
Grand total	**11408**	**336017**		**76.5**	**14970**	**476835**		**44.9**	**64071**	**2012648**		**114.7**	**2825500**	**236**

* - About half of the territory of Klimovichi raion was much less contaminated then the other part of that raion;

** - About one third of the territory of Kostukovichi raion was much less contaminated then the other part of that raion;

It is worth noting that, in the 1996 evaluation (2), in order to estimate average thyroid doses for the settlements only the representative results received for the settlements were used. The total number of “measured” doses presented in Table 1 (N≈90,000) is less then the total number of “measured” doses available in the databank for the Belarusian population (N≈130,000). For example, Table 1 does not contain the “measured” doses available for the residents in Rechitsa and Loev raions of Gomel Oblast, because only those residents were measured whose ^{131}I thyroidal content exceeded some definite level (which varied several times during May 1986). Average doses calculated for the settlements on the basis of available “measured” doses located in these raions do not reflect true average thyroid doses for them. Besides, the “measured” doses available for the Minsk inhabitants, who left Minsk for the more contaminated areas, were not taken into account.

Table 2 gives the results of assessment of collective thyroid dose for the Republic as a whole. Table 2 presents summary results from Table 1 as well as estimates of collective thyroid dose obtained by the second approach (semiempirical model) for the areas where the number of residents with “measured” doses is small or equal to zero. The estimates of collective and average thyroid doses, calculated according to equations (1), (2), (5), (6), (7), and (8) presented in Tables 1 and 2 would have been higher, if fallout had occurred after the beginning of the pasture season, as was not the case for large territories of Belarus (first of all, where dry fallout occurred).

Table 2. The results of assessment of the collective thyroid dose D_c from ^{131}I for the Belarusian population

NN	Area	Assessment of the collective dose for the age-groups							
		0-6 y		7-17 y		Adults		Total	
		N, 10^3 persons	D_c, 10^3 person Gy	N, 10^3 persons	D_c, 10^3 person Gy	N, 10^3 persons	D_c, 10^3 person Gy	N, 10^3 per-sons	D_c, 10^3 person Gy
1	Minsk city	183	14.6	260	7.5	1067	19.2	1510	41.3
2	Minsk Oblast	172	2.4	243	1.7	1148	5.4	1562	9.5
3	**Total in Minsk Oblast**	354	17.0	50.2	9.2	2215	24.6	3072	50.8
4	Gomel city	59	27.2	83.9	13.4	345	26.9	488	67.5
5	Evacuated villages (before 5 May 1986) in Bragin, Khoiniki, and Narovlya raions	1.2	3.3	1.7	2.3	8.2	8.1	11.0	13.7
6	Villages not evacuated before 5 May 1986 in Bragin, Khoiniki, and Narovlya raions	10.7	12.7	15.2	8.3	74.4	24.7	100	45.7
7	The other areas of Gomel Oblast with sufficient number of the “measured” doses	24.6	11.0	34.9	8.8	158	19.6	217	39.4
8	The remainder areas of Gomel Oblast where the thyroid measurements were not conducted	93.5	61.0	132	31.3	639	108.3	864	200.6
9	**Total in Gomel Oblast**	189	115.2	268	64.1	1224	187.6	1680	366.9
10	Mogilev city	43.4	3.5	61.7	1.9	254	5.1	359	10.5
11	Five raions of Mogilev Oblast: Slavgorod, Kli-movichi, Krasnopolye, Kostukovichi, Chericov	14.3	4.3	19.8	2.7	106	10.2	140	17.2
12	The remainder raions of Mogilev Oblast	85.3	7.1	119	3.6	591	13.8	796	24.5
13	**Total in Mogilev Oblast**	143	14.9	201	8.2	952	29.1	1295	52.2
14	**Total in Brest Oblast**	171	16.9	244	8.9	993	25.7	1409	51.5
15	**Total in Vitebsk Oblast**	151	0.9	211	0.6	1034	2.1	1397	3.6
16	**Total in Grodno Oblast**	128	2.9	181	1.5	841	4.9	1149	9.3
17	**Total in Republic**	1131	167.8	1607	92.5	7259	274.0	10002	534

In order to estimate the average thyroid doses in the different areas, the fact that pasture use began at different times in different areas was taken into account by multiplying the results obtained by the semiempirical model (equations (6) and (8)) by a correction coefficient, k. The following values of k were used:

- Gomel Oblast excluding Korma and Chechersk raions: k = 1.0
- Korma and Chechersk raions of Gomel Oblast: k = 0.5

- Mogilev Oblast: k = 0.3
- Brest Oblast excluding Baranovichi raion: k = 1.0
- Baranovichi raion of Brest Oblast: k = 0.5
- Vitebsk Oblast: k = 0.25
- Grodno Oblast excluding Volkovich and Slonim raions: k = 0.5
- Volkovich and Slonim raions of Grodno Oblast: k = 0.33
- Minsk Oblast excluding Kopylsk, Nesvizh, Slutsk, and Soligorsk raions: k = 0.5
- Kopylsk, Nesvizh, Slutsk, and Soligorsk raions of Minsk Oblast: k = 0.33

In addition, it was postulated that the thyroid doses received by persons in the capital of an Oblast was two times lower than those received by the rural population of the Oblast.

The values of the ratio $\overline{R}$ =q(I)/q(Cs) in equations (6) and (8) for various areas were determined on the basis of experimental data. In the absence of such data, the value of the ratio $\overline{R}$ was assumed to be equal to that obtained in a neighbouring area with a similar type of contamination. The values of the ratio $\overline{R}$ were generally found to decrease as the values of q(Cs) increased. They were up to 40 in Vitebsk Oblast where fallout from the Chernobyl accident was low. The minimum values of the ratio $\overline{R}$ were equal to 3 in the most contaminated places of Chericov raion in Gomel Oblast, located in the “northeastern spot”.

It was assumed that the quality of the grass was the same on the date when pasture use began for all areas considered. It was also assumed that substantial migration of the population did not occur in areas where measurements were not conducted.

The comparison of the results of assessment of the collective thyroid dose for the total population of Belarus presented in Table 2 with those estimated in 1996 (2) shows that the new estimate (approximately 530,000 person-Gy) does not differ much from the previous estimate (about 510,000 person Gy). However, because of a more detailed analysis and of the use of improved data on ^{137}Cs ground deposition density, as well as on the population distribution in Belarus, substantial changes were made in the estimates of collective thyroid dose for the populations of some areas.

SECOND METHODOLOGY OF ASSESSMENT OF THE COLLECTIVE THYROID DOSE

The second methodology was developed in Minsk at the Research and Clinical Institute of Radiation Medicine and Endocrinology and at the Institute of Power Engineering Problems. The methodology is based on the use of a radioecological model adapted to the conditions of Belarus (5).

The following pathways were considered in the model:

- consumption of locally produced milk contaminated as the result of grass and soil intake by cows; and
- consumption of leafy vegetables.

The intake function of ^{131}I was evaluated using the following assumptions:

- the radioactive contamination of the ground was caused by a single deposition;
- people did not change their dietary habits during the first few weeks after the accident; and
- no countermeasures (except evacuation) were applied.

Taking into account those assumptions, the time-dependent intake of ^{131}I for the *i*-th age group has been calculated as:

$$I_i(t) = TF_m \cdot \int_0^t (C_g(\tau) \cdot I_g \cdot \exp(-\lambda_{w+d} \cdot \Delta t_{pd}) + C_s(\tau) \cdot \frac{I_s}{H_s \cdot \rho_s}) \cdot \lambda_b \cdot \exp(-(\lambda_b + \lambda_r) \cdot (t-\tau)) d\tau \times$$
$$\times \exp(-\lambda_r \cdot (\Delta t_m + \Delta t_{pd})) \cdot P_m \cdot V_{i,m} + C_g(t) \cdot \exp(-(\lambda_{w+d} + \lambda_r) \cdot \Delta t_{ld}) \cdot \exp(-\lambda_r \cdot \Delta t_l) \cdot P_l \cdot V_{i,l}, \quad (9)$$

where TF_m – cow’s intake-to-milk transfer factor, d L^{-1};
$C_g(\tau), C_s(\tau)$ – ^{131}I concentration in vegetation (kBq·kg^{-1}) and in soil (kBq·m^{-2});
I_g, I_s – daily intake of grass and soil by cow, kg·d^{-1};
λ_{w+d} – removal rate of the radionuclide from grass due to weathering and growth dilution, d^{-1}.
Δt_{pd} – period from deposition till starting of pasture period, d;
Δt_{ld} – period from deposition till starting of leafy vegetable consumption, d;
H_s – depth of upper soil layer where deposited activity was distributed, m;
ρ_s – upper soil layer density, kg·m^{-3};
λ_b – biological rate of iodine elimination from cow’s milk, d^{-1};
λ_r – radioactive decay constant of radionuclide, d^{-1};
Δt_m, Δt_l – storage time period for milk and leafy vegetable, d;

P_m, P_l – processing factors for milk and leafy vegetable;
$V_{i,m}$, $V_{i,l}$ – daily intake of milk and leafy vegetable by members of *i*-th age group, kg·d^{-1}.

The variations with time after ground deposition of the activity concentration in grass, $C_g(t)$, and in soil, $C_s(t)$, are given by:

$$C_g(t) = GD_{131} \cdot \frac{f}{Y} \cdot \exp(-(\lambda_{w+d} + \lambda_r) \cdot t), \text{ and} \qquad (10)$$

$$C_s(t) = GD_{131} \cdot (1 - f) \cdot \exp(-\lambda_r \cdot t), \qquad (11)$$

where GD_{131} – ground deposition of ^{131}I, kBq·m^{-2};
f – initial interception fraction of ^{131}I by vegetation;
Y – yield of vegetation at the time of deposition, kg·m^{-2}.

The ^{131}I ground deposition GD_{131} in the settlement was estimated as:

$$GD_{131} = \sigma_{137} \cdot R_{I/Cs}, \qquad (12)$$

where σ_{137} – ^{137}Cs deposition density, kBq·m^{-2};
$R_{I/Cs}$ – ratio of ^{131}I and ^{137}Cs activities for ground deposition.

The relationship between the ^{131}I ground deposition density, obtained from results of measurements of ^{131}I activities in soil and grass, and the initial interception fraction has been assumed to be as follows:

$$f = 14{,}8 \cdot (GD_{131})^{-0{,}54}. \qquad (13)$$

The values of the model parameters used in the calculation of the collective thyroid dose are summarized in Table 3.

Table 3. Values of model parameters

Parameter	Units	Value
$R_{I/Cs}$	-	7–45*
Y	kg·m^{-2}	0.27
I_g	kg·d^{-1}	40
I_s	kg·d^{-1}	1
Δt_{pd}	d	0–8*
Δt_{ld}	d	14–22*
H_s	m	$5\cdot10^{-3}$
ρ_s	kg·m^{-3}	$1\cdot10^{3}$
TF_m	d·L^{-1}	$2.3\cdot10^{-3}$
λ_b	d^{-1}	0.99
λ_{w+d}	d^{-1}	0.067
Δt_m	d	0–1*
Δt_l	d	0–1*
P_m	-	1.0
P_l	-	0.7
$V_{i,m}$	L·d^{-1}	0.4–0.7**
$V_{i,l}$	kg·d^{-1}	0,03
DF_i	Gy·kBq^{-1}	$3.7\cdot10^{-3}$–$4.4\cdot10^{-4}$**

* Different values were taken for different regions of the Republic;

** Values vary according to the age group.

The estimated collective thyroid doses obtained with this methodology for the population of each Oblast of Belarus and for the entire Republic are presented in Table 4.

Table 4. Collective thyroid doses from ^{131}I intake for the population of Belarus

Oblast	Thyroid collective dose, 10^3 person·Gy			
	0–6 y	7–17 y	20 y	Total
Brest	46.8	26.2	56.0	129
Vitebsk	0.9	0.5	1.4	2.8
Gomel	139	77.5	185.5	402
Grodno	6.6	3.7	8.9	19.2
Minsk	16.2	9.0	16.6	41.8
Mogilev	19.5	10.5	23.6	53.6
Republic	229	127.4	292	648

CONCLUSION

Collective thyroid doses resulting from ^{131}I intake caused by the Chernobyl accident have been estimated for the populations of Belarus, broken down by Oblast and by age group, using two different methodologies, developed independently in Minsk and in Moscow. The collective thyroid doses obtained by the two methodologies for the populations of the Gomel and Mogilev Oblasts, which were the most contaminated and in which most of the radiation measurements were made after the accident, are very similar, while the results obtained for less contaminated Oblasts vary by a factor of up to 4. This is probably due to the fact that the two methodologies make use of the available radiation measurements and that more assumptions are needed to estimate the collective thyroid doses in the less contaminated Oblasts than in Gomel and Mogilev Oblasts.

The collective thyroid doses resulting from ^{131}I intake for the entire population of Belarus are found to be 530,000 and 650,000 person Gy according to the methodologies developed in Moscow and in Minsk, respectively. About one third of the collective thyroid dose was received by children aged less than 7 at the time of the accident.

REFERENCES

1. Yu.I.Gavrilin; Khrouch, V.; Shinkarev, S.; Krysenko, N.; Skryabin, A.; Bouville A.; Anspaugh L. *Chernobyl accident: Reconstruction of thyroid dose for inhabitants of the Republic of Belarus.* Health Phys. 76(2):105-119; 1999.
2. Yu.I.Gavrilin.; Khrouch, V. T.; Shinkarev, S. M.; Drozdovitch, V.; Minenko, V.; Shemyakina, E.; Bouville, A.; Anspaugh, L. *Estimation of thyroid doses received by the population of Belarus as a result of the Chernobyl accident.* The radiological consequences of the Chernobyl accident. Proceedings of the first international conference, Minsk, Belarus, 18 to 22 March 1986 (Editors: A. Karaoglou, G. Desmet, G. N. Kelly and H. G. Menzel). European Commission report EUR 16544 EN. Luxembourg; 1996:1011-1020.
3. Yu.Gavrilin; V.Khrouch; S.Shinkarev. *Justification of the "semiempirical" model of thyroid dose formation*. (To be published in 2000). (in Russian).
4. V.T.Khrouch, Yu.I.Gavrilin, S.M.Shinkarev. *Correction of individual thyroid dose estimates (calculated earlier using the results of direct thyroid measurements) on the basis of the results of personal interviewing and using the semiempirical formula.* Moscow: Institute of Biophysics; Report No. 15-20/95; 1996 (in Russian).
5. V.V.Drozdovitch, G.M.Goulko, V.F.Minenko, H.G.Paretzke, G.Voigt, and Ya.I.Kenigsberg. *Thyroid dose reconstruction for the population of Belarus after the Chernobyl accident.* Radiat. Environ. Biophys. 36:17-23 (1997).