

CONSEQUENCES OF THE CHERNOBYL ACCIDENT IN LITHUANIA

A. MASTAUSKAS

Ministry of Health of the Republic of Lithuania, State Public Health Centre,
Vilnius, Lithuania

T. NEDVECKAITE, V. FILISTOVIC

Radiation Protection Department, Institute of Physics,
Vilnius, Lithuania



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1. INTRODUCTION

After the Chernobyl accident of 26 April, 1986, population dose assessment favours the view that the radiation risk of population effected by the early fallout would be different from that in regions contaminated later. Taking into account the short half-time of the most important radioactive iodine isotopes, thyroid disorders would be expected mainly to follow the early fallout distribution.

At the time of accident at Unite 4 of the Chernobyl NPP, surface winds were from the Southeast. The initial explosions and heat carried volatile radioactive materials to the 1,5 km height, from where they were transported over the Western part of Belarus, Southern and Western part of Lithuania toward Scandinavian countries [1]. Thus the volatile radioiodine and some other radionuclides were detected in Lithuania on the very first days after the accident. The main task of the work - to conduct short half-time radioiodine and long half-time radiocesium dose assessment of Lithuanian inhabitants as a result of the early Chernobyl accident fallout.

2. RADIOIODINE DOSE ESTIMATION

Iodine radionuclides may be transferred through various environmental media before being taken into the human body, e.g. air-grass-cattle-milk-man pathway [2].

The behaviour of iodine in the atmosphere is of prime consideration to the nuclear industry and is especially important in the case of nuclear accident [3]. The physicochemical compounds of airborne ^{131}I released during the Chernobyl accident, were investigated world-wide although separation of radioiodine into aerosol-associated, gaseous inorganic and organic as well as relative concentration of each form were reported only for a few locations [4]. It was more common to determine only aerosol-associated radioiodine [5] and the estimations for the remaining radioiodine depended on the interpretation of modellers.

After the Chernobyl accident the most unexpected outcome of the airborne radioiodine measurements was the detection of inorganic and organic gaseous ^{131}I in abundance. Knowledge of radioiodine compounds abundance, deduced from these measurements, supports the evidence for necessity of standardized methods for aerosol-associated, gaseous inorganic (mostly $^{131}\text{IONO}_2$, ^{131}IO , H^{131}I , HO^{131}I and night-time $^{131}\text{I}_2$) and gaseous organic (mostly $\text{CH}_3^{131}\text{I}$) measurements in the case of NPP accident [6]. These measurements are essential in the field of countermeasures available in the early phase of the NPP accidents, thyroid dose assessment as well as in NPP accident scenarios modelling.

The measurements of airborne radioiodine were performed in Lithuania during the period from 30 April to 10 May 1986. A special sampler was used to separate airborne radioiodine into three species: aerosol-associated (by means of Petrianov filters), inorganic gaseous radioiodine (by means of 2 beds of activated coconut charcoal) and organic gaseous radioiodine (by means of 2 beds of activated charcoal impregnated with triethylenediamine). All the samples were measured for radioactivity using Ge-Li high resolution spectrometry. The results of measurements are tabulated in Table I.

TABLE I. RADIOIODINE ACTIVITY CONCENTRATION IN ATMOSPHERIC AIR IN VILNIUS AFTER THE CHERNOBYL ACCIDENT (Bq m^{-3}) IN 1986

Samplin g	^{131}I			^{132}I		^{133}I	
	FPA-15 (aer.)	BAU-A (inorg.)	BAU-A + HTMA (org.)	FPA-15 (aer.)	BAU-A + HTMA (gas)	FPA-15 (aer.)	BAU-A + HTMA (gas)
04.30	13±1	12.5±2	30±4	18±5	10±3	0.8±0.2	2.4±0.6
05.01	2.0±0.2	1.0±0.2	2.5±0.4	1.3±0.4	0.5±0.2	-	-
05.05	0.37±0.04	0.14±0.03	0.53±0.10	-	-	-	-
05.06	0.31±0.04	0.12±0.03	0.55±0.11	-	-	-	-
05.07	0.29±0.04	0.04±0.01	0.25±0.06	-	-	-	-
05.08	10.0±0.1	5.9±0.8	15.2±0.2	-	-	-	-
05.10	0.42±0.06	0.08±0.02	0.70±0.04	-	-	-	-

Radioiodine activity in pasture grass (Fig. 1) varied over a broad range as well as in milk consumed by inhabitants of Lithuania (Fig. 2). Milk activity reached a peak on the 4th day after deposition and then decreased with an effective half-time ranging from $4,2\pm 0,6$ days in more contaminated area to $5,2\pm 0,9$ days in other areas of Lithuania (Fig. 3). The value of the grass-milk transition coefficient was as large as $0.18\pm 0.06 \text{ m}^2 \text{ L}^{-1}$.

Thyroid examination by special dosimetric teams for assessing individual absorbed doses was not available in Lithuania for reasons beyond the control of experimenters. Although, once the concentration of radioiodine in a given environment is known, the amount of inhaled and ingested radioiodine can be estimated based on a model of iodine metabolism in a human body. Referring to these data thyroid doses were calculated using the modified ICRP three-compartment cyclic model of iodine kinetics in the human body. This ICRP model was modified to include the effect of stable iodine intakes on radioiodine intakes explicitly [7]. The probabilistic dose assessment method was

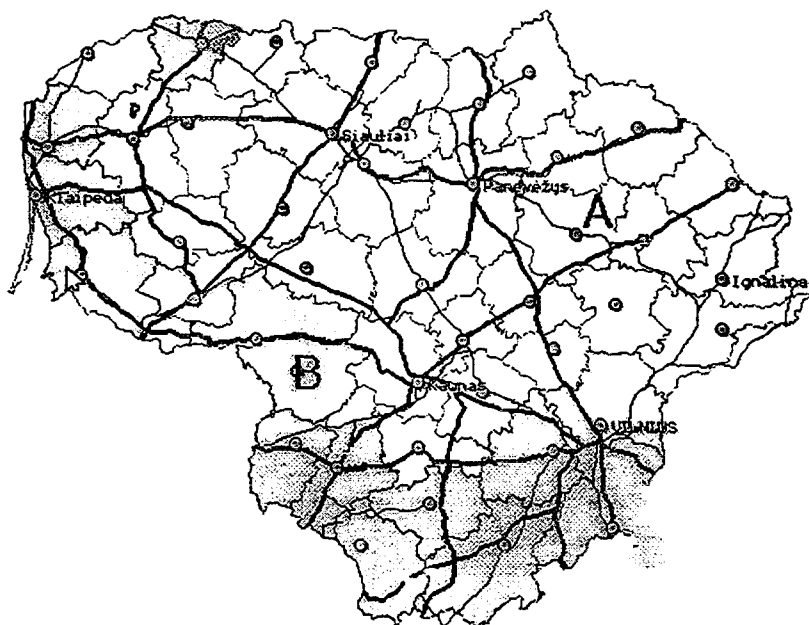


FIG. 1. The peculiarities of pasture grass contamination by ^{131}I in Lithuania after the Chernobyl accident: A - the predominant radionuclide ^{131}I up to 2 kBq kg^{-1} fresh weight, B - radiocesium and some other isotopes, ^{131}I activity concentration up to 50 kBq kg^{-1} fresh weight

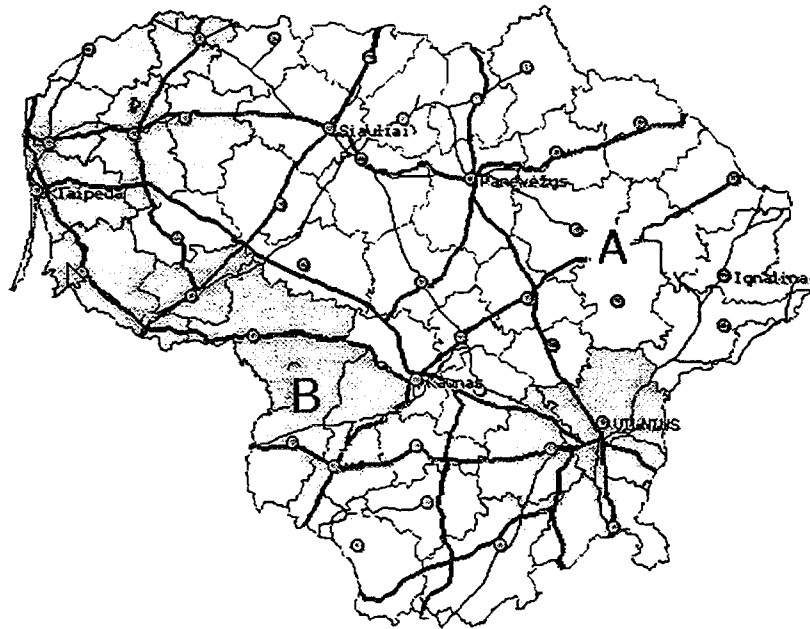


FIG. 2. The peculiarities of milk contamination by ^{131}I in Lithuania after the Chernobyl accident: A - less than tolerable ^{131}I intake level (370 Bq L^{-1} for infants), B - more than tolerable intake level (up to 10000 Bq L^{-1})

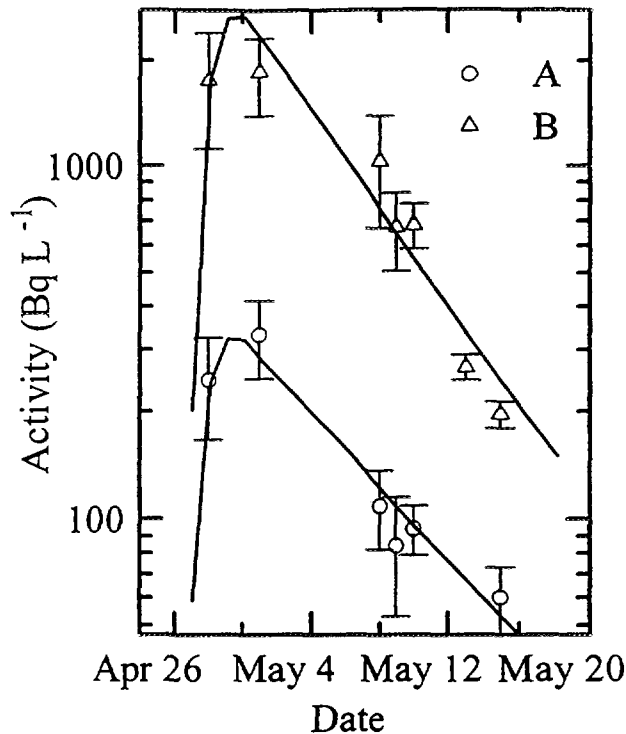


FIG. 3. Time dependent approximation of the observed ^{131}I activity concentration in milk in different areas of Lithuania (according to Fig. 2) after the Chernobyl accident

used in conjunction with more realistic estimates of doses. The consideration of regional iodine deficiency resulted in twofold increase of equivalent thyroid doses (Table II). It should be noted that the contribution of ^{132}I and ^{133}I inhaled on the very first days to the thyroid equivalent dose was insignificant - no greater than $0,12 \text{ mSv}$ for adults and $0,34 \text{ mSv}$ - for infants.

TABLE II. INFANT AND ADULT EQUIVALENT DOSES TO THYROID IN DIFFERENT AREAS OF LITHUANIA (ACCORDING TO FIG. 2) AFTER THE CHERNOBYL ACCIDENT

Age	Area	Equivalent doses to thyroid (mSv)						
		Without regard for iodine deficiency (determ.)	With regard to iodine deficiency					95th per- cent.
			Determ.	Mean	s.d.	Median	Mode	
Infant	A	10 ± 2	21	22	10	20	16	39
	B	73 ± 10	158	164	70	150	127	280
Adult	A	1.2 ± 0.2	2.7	2.8	1.0	2.6	2.3	4
	B	9.1 ± 0.9	20	21	7.5	20	17.7	28

Until recent time the epidemiology of thyroid diseases was not investigated in Lithuania. Apart from the consequences of the Chernobyl accident, the great source of potential radiation risk in Lithuania is the Ignalina NPP. Two of its functioning reactors are of the same type as in the Chernobyl NPP. This plant is listed among the most dangerous in Europe. That is why physicians and scientists of various fields units in solving the problem of thyroid diseases epidemiology in Lithuania. The joint project was initiated in 1992. This union was actively supported by Open Lithuanian Foundation and Lithuanian Health Ministry.

In addition the evaluation of influence of the Ignalina NPP on the number of thyroid disorders is under investigations. Interest in radiation risk around the Ignalina NPP has coincided with the building and licensing of this facility and undergoes a rise by virtue of the fact that during the period from 1984 to 1995 more than 300 GBq ¹³¹I were released to the atmosphere [8]. That is why the environmental iodine monitoring and epidemiological studies are under investigation in this region. The fact that epidemiological studies of population are so difficult to interpret has been unseating for many epidemiologist and health physicist [9-11].

3. RADIOCESIUM DOSE ESTIMATION

The evaluation of radiocesium and radiostrontium intake with food into the human body in Lithuania was started at the beginning of 1965 and is continued until the present time. There was no considerable increase of radiostrontium in foodchain in Lithuania after the Chernobyl accident. This work deals with food contamination, annual intake and dose equivalent from radiocesium after the Chernobyl accident.

Concerning the evaluation of radiocesium intake with food particular attention has been given to the data of the first 3-y study after the Chernobyl accident. Intake of radiocesium to the human body was evaluated on the basis of analysis of individual diets and foodstuffs. The main components of foodstuffs, namely milk, meat, bread and vegetables, were collected in some districts every month. Samples were mixed thoroughly, dried and ashed at a temperature 450 °C. The ash was homogenized, weighted and placed in a counting beaker. Radiocesium activity concentrations were determined by using high resolution Ge-Li spectrometry or otherwise by chemical separation. The average annual radiocesium content in the main components of foodstuffs is presented in Fig. 4. Taking into account the radiocesium content in foodstuffs and individual diets, annual whole-body dose equivalent for infant, children and adult population according [12] have been calculated. As illustrated in Fig. 5, infant, children and adult dose equivalent from ¹³⁴Cs and ¹³⁷Cs in the Northern part of Lithuania was little more as compared with background, and in the Western part - no more than 50% higher than that after the nuclear weapon tests.

4. CONCLUSIONS

In Lithuania early fallout of the Chernobyl accident determined equivalent thyroid doses as high as 160 mSv for infants and 20 mSv for adults in comparison with radiocesium doses of two

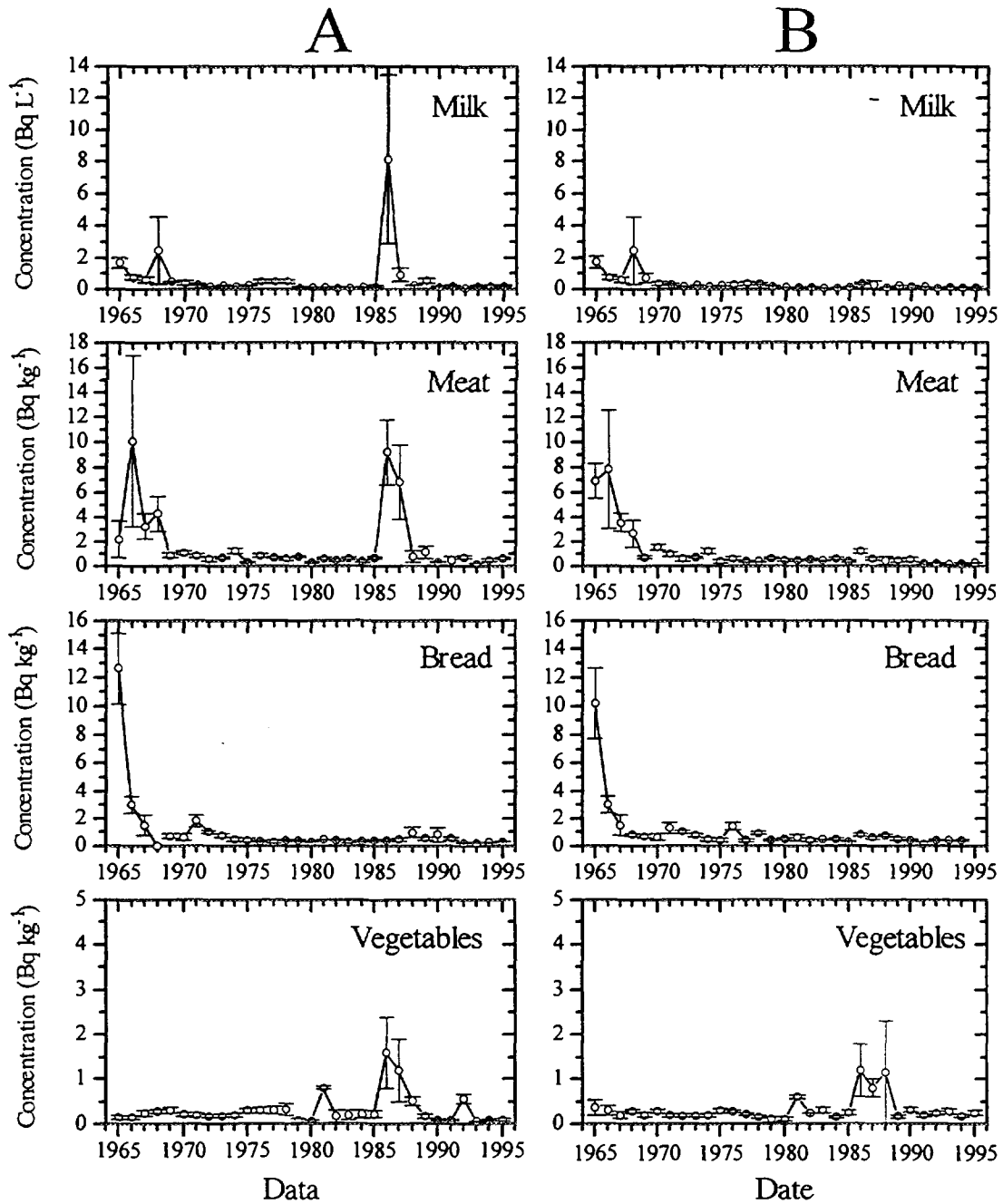


FIG. 4. Radiocesium activity concentration of the main components of foodstuffs in Lithuania (according to Fig. 2) during the period 1965 to 1995

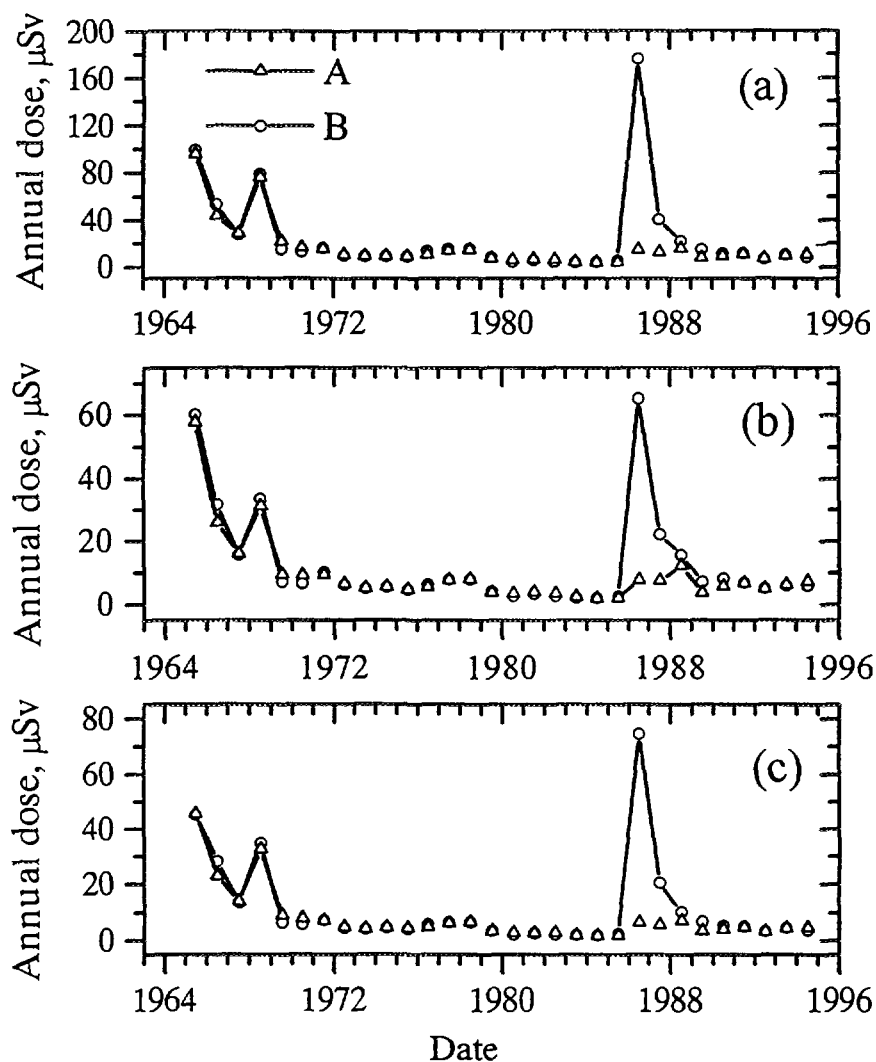


FIG. 5. Variations of whole-body radiocesium dose equivalent for infant (a), children (b) and adult (c) population in Lithuania (according to Fig. 2) during the period 1965 to 1995

orders of magnitude smaller. These data are inconsistent with that in regions contaminated latter [13]. The present stage of investigation is focused on epidemiological and clinical studies of the thyroid disorders with consideration for the influence of the Ignalina NPP as 300 GBq of ^{131}I have been released in the NPP region since 1984 to 1993. The extrapolation of low doses health effects are still tentative, but there is growing promise, that information about the consequences of the Chernobyl accident will bring us closer to balanced view of radiation risk.

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