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RADIOACTIVITY MEASUREMENTS OF WATER, MILK AND DAIRY PRODUCTS VEGETABLES AND GRASS FROM THE SURROUNDINGS OF CRACOW ON THE AFTERMATH OF CHERNOBYL REACTOR ACCIDENT

T. Cywicka-Jakiel, P. Grychowski, I. Hajdas, M. Jasińska, L. Kołakowski, L. Loskiewicz, Z. Mazgaj, J. Mikulski, E. Ochab

Institute of Nuclear Physics 31-342 Cracow, Radzikowskiego 152, Poland

ABSTRACT

The measurements of radioactive contamination of water and food products were carried out shortly after the Chernobyl nuclear reactor accident. Using the measured values, the committed effective dose equivalent for adult population of Cracow was estimated.

After the Chernobyl nuclear reactor accident on the 26-th April 1986 a number of laboratories in the Institute of Nuclear Physics carried out the radioactivity measurements of food products from surroundings of Cracow, using γ -ray spectrometers based on Ge(Li) and NaI(Tl) detectors. 1715 samples were measured. In order to shorten the measurement time, the samples were voluminous i.e. having the volume 1 or 1.2 dm³. This in turn obliged us to use standards to take the absorption of radiation inside the sample volume into account. In the case of milk and vegetables the difference in the absorption, due to small changes in specific density were not taken into account whereas for measuring cheese special standards of ¹³¹I and ¹³⁷Cs in gelatine were prepared. The standards for ¹³¹I and ¹³⁷Cs were obtained from commercial Na¹³¹I and ¹³⁷CsCl solutions. The activities of one litre standard solutions were calculated with the following errors:

¹³¹ I standard	A = 5.01 kBq	+3.5%
		-6.0%
¹³⁷ Cs standard	A = 1.834 kBq	+2.8%
		-3.5%

After the rainfall during the night of the 1-st of May 1986 radioactivity of drinking water from many intakes of Cracow waterworks was measured. The maximum values of ¹³¹I activity were measured in Vistula river on the 2-nd of May (531 Bq/dm³) - see Fig.1. In the first days of May also

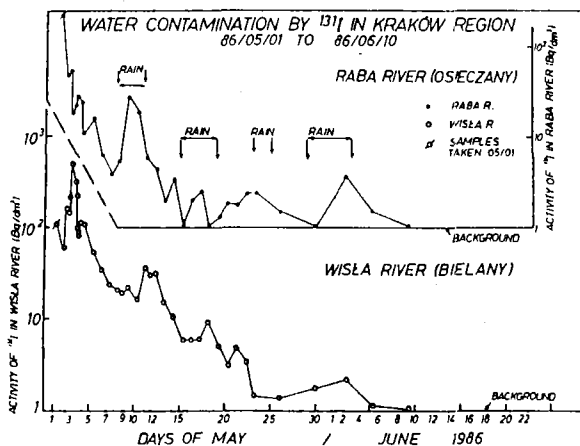


Fig.1 Activity of ^{131}I in Wisła and Raba rivers as measured from the 1st of May to the 18th of June 1986.

^{132}Te radioactivity was observed. After May the 5-th it was not measurable any longer. No contamination with ^{134}Cs , ^{137}Cs and ^{103}Ru were observed either. At the end of May the activity of ^{131}I in water fell down to 2 Bq/dm^3 .

Starting from the 1-st of May systematic measurements of milk and dairy products were carried out. The level of ^{131}I activity in milk coming from dairies supplying Cracow is shown in Fig.2.

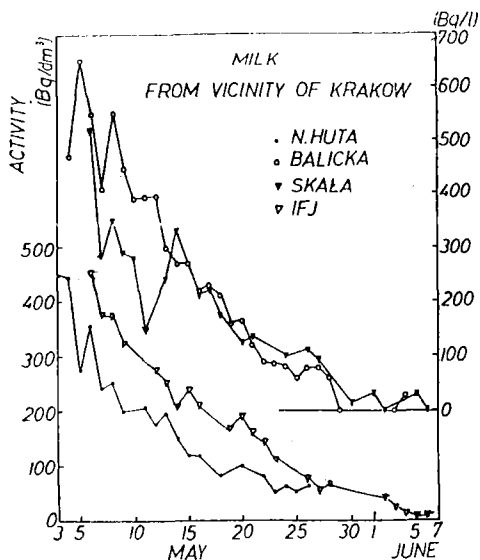


Fig.2 Activity changes of ^{131}I in milk from vicinity of Krakow. IFJ meant milk as served to Institute of Nuclear Physics (IFJ) personnel.

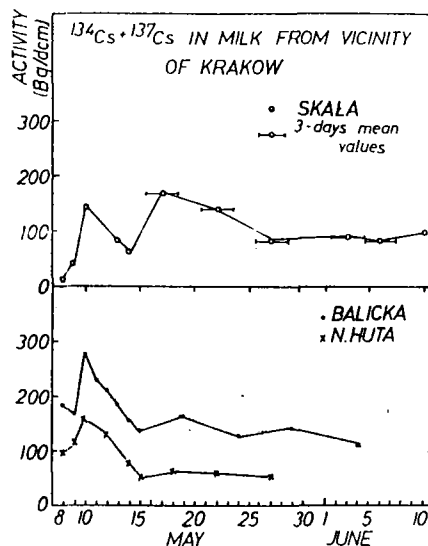
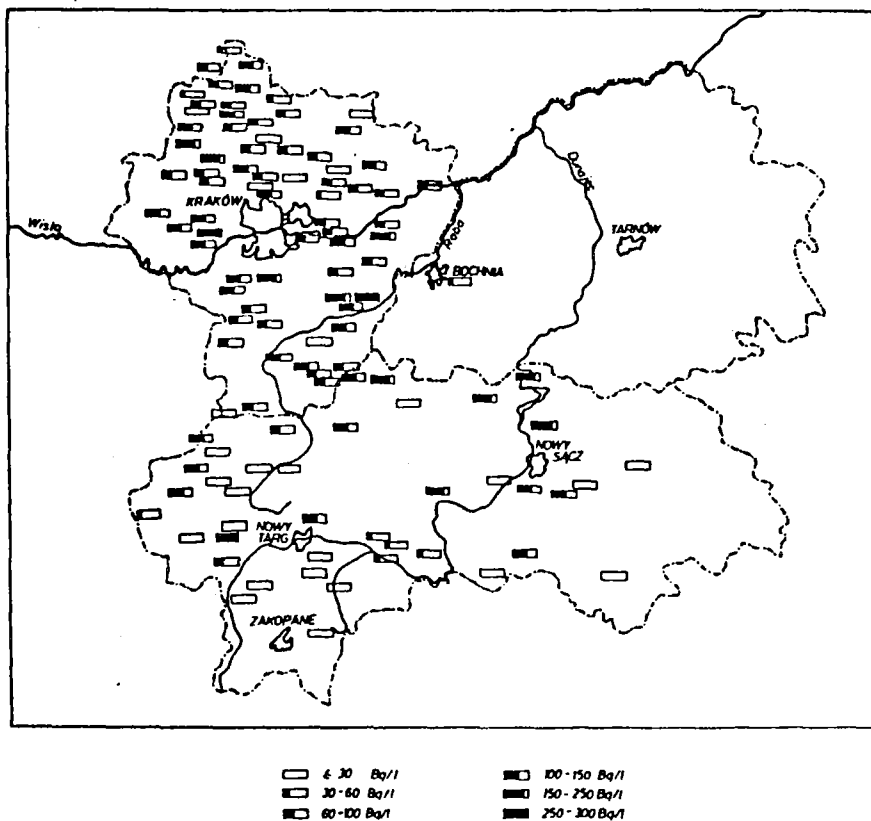


Fig.3 Activity of ^{134}Cs , ^{137}Cs in milk from vicinity of Krakow during the period the 8th of May to June the 10th 1986.

The high activity equal to 650 Bq/dm^3 was measured on the 5-th of May. By the 10-th of May the radioactive caesium contamination of dairy milk reached its maximum values. Two Cs isotopes - ^{137}Cs and ^{134}Cs were observed. The activity of ^{134}Cs was about 50% of ^{137}Cs activity. The sum of ^{134}Cs and ^{137}Cs activity in milk coming from three main dairies is shown in Fig.3.

Between the 29-th of May 11-th of June we have controlled the milk from 126 local milk collection centers from Cracow, Nowy Targ and Nowy Sącz counties. The map of caesium contamination of these milk samples is shown in Fig.4.



$^{137}\text{Cs} + ^{134}\text{Cs}$ CONCENTRATION IN MILK

Fig.4 Spatial variations of the $^{134}\text{Cs} + ^{137}\text{Cs}$ activity in cow milk from Kraków and Nowy Sącz regions. Measurements had been done from the 9th of May to the 11th of June 1986.

The milk-powder, for infants and early born babies, arriving from different factories at wholesale warehouses in Cracow was controlled from the end of May until late in June 1986. The contamination of 64 samples by ^{131}I as well as by $^{137+134}\text{Cs}$ was determined. At the measurement time 16 samples exceeded 1000 Bq/kg (max. 2350 Bq/kg) and 47 exceeded 370 Bq/kg. It should be noted, however, that one liter of milk used for consumption is obtained by mixing ca. 150 g of milk-powder with water.

The solid dairy products as e.g. cheese were also measured. The highest value of ^{131}I activity in cottage cheese produced in Cracow vicinity reached 810 Bq/kg and fell rapidly to value of about 150-200 Bq/kg by the 27-th of May. Cottage cheese from Nowy Targ and Nowy Sącz counties showed lower contamination value (not exceeding 500 Bq/kg) and tending to 150-200 Bq/kg by the 23-th of May. This is probably the result of use of the last year s hay in the cow diet. On the other hand the sheep s white cheese shows very high contamination values. At this time the sheep were graying freely on alps and meadows. The time development of the contamination values by ^{131}I and $^{137+134}\text{Cs}$ in sheep white cheese samples taken in the vicinity of Gorlice is shown in Fig.5. The initial activity was 13300 Bq/kg and diminished very fast with apparent $T_{1/2} = 4.5\text{d}$. This means the fast weathering of ^{131}I from the grass of pastures.

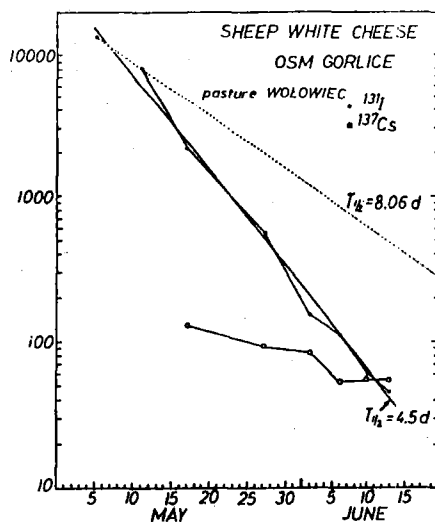


Fig.5 Activity of ^{131}I and ^{137}Cs in sheep white cheese from Gorlice dairy. Dotted line represents the exponential decay of initial ^{131}I activity with $T_{1/2} = 8.06$ days.

The measurement of vegetables started only by the 13-th of May. The highest contamination was found in foliaceous vegetables: lettuce, leaves of parsley, leek and chive - ranging from a few hundred up to 2-3 thousands of Bq/kg. The samples were obtained from Cracow and Nowy Sącz regions. Various radioactive isotopes mainly ^{132}Te , ^{132}I , ^{131}I were observed in the first few days. Later, by the end of May ^{106}Ru dominated. In June only caesium was measurable. The high concentration (max. 1659 Bq/kg) of ^{103}Ru came as a sort of surprise.

The concentration of radioisotopes in fruits, fruit products and grass were measured only in random chosen samples. The results are listed in Tab.1 and Tab.2.

TABLE 1. Radioactivity of $^{137+134}\text{Cs}$ in fruit and fruit products from vicinity of Krakow.

No	Sample No	Sample origin	Measurement date	$^{137+134}\text{Cs}$ Activity [Bq/kg]
	Red currant fruit			
1	485	Kraków	1986/7/4	147
2	491	Wadowice	1986/7/7	284
3	493	Kraków	1986/7/8	94
4	481	Kraków	1986/7/3	64
5	440	Łapanów	1986/6/20	128
6	465	Koziów	1986/6/27	228
	Black currant fruit			
1	486	Kraków	1986/7/4	124
2	490	Stanisław	1986/7/7	232
3	492	Kraków	1986/7/8	175
4	495	Gdów	1986/7/8	393
5	561	Stróże	1986/7/9	96
6	503	Łapanów	1986/7/11	239
	Black currant juice			
1	480	Kraków	1986/7/3	84
2	543	Jelenia Góra	1987/4/10	40
	Raspberry fruit			
1	486	Choczniá	1986/7/7	125
	Gooseberry fruit			
1	489	Lgota	1986/7/7	110
2	482	Kraków	1986/7/3	38
	Dog rose fruit			
1	487	Kraków	1986/7/7	106

The committed effective dose equivalent for adult population of Cracow was estimated using measured values of activity of air and food products.

TABLE 2. Radionuclide concentrations in grass samples

No	Locality	No meas.	Date of meas	Activity Bq/kg			
				¹³¹ I	¹⁰³ Ru	¹³⁷ Cs	¹³⁴ Cs
1	Liplas	902	10.05.86	809	958	908	490
2	Nowy Targ	1042	16.05.86	1157	808	216	
3	Nowy Targ	1056	16.05.86	795	766	372	
4	Nowy Targ	1135	20.05.86	180	278	131	
5	Kozłów	171	16.05.86	993	not calculated		
6	Kozłów	296	28.05.86	127	(503)		510
7	Kozłów	295	28.05.86	215	(431)		304
8	Kozłów	341	5.06.86	206			787
9	Kozłów	405	13.06.86	2±2			98
10	Kozłów		20.06.86	2±2			172
11	Rudawa	668	10.05.86	5187	(2472)		2618 together with ¹³² I
12	Rudawa	311	2.06.86	485	(2300)		1460
13	Rudawa-second grass	317	2.06.86	33	(88)		198
14	Lubomierz - vale	214	20.05.86	594	not calculated		
15	Lubomierz - mountain pass	215	20.05.86	2419	not calculated		

The model prepared by ICRP [1] for routine dosimetry assessments was used for estimation of inhalation and ingestion doses. The "DOSE-MARC" model factors [2] and activities data taken from [3] were used for estimation of the external irradiation dose equivalent. For the month of May 1986 it was 0.05 mSv (5 mrem) for inhalation dose and 0.165 mSv (16.5 mrem) for ingestion dose and 0.053 mSv (5.3 mrem) for external irradiation - see Fig.6.

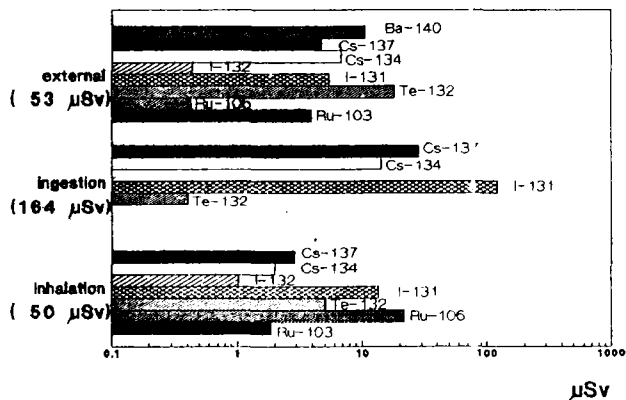


Fig. 6 Estimation of effective dose equivalent for adult of Cracow in May 1986

The more detailed report was published as an INP preprint [4].

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2. D. Charles, M.J. Crick, T.P. Fell, J.R. Greenhalgh "DOSE-MARC: the dosimetric Module in the Methodology for assessing the Radiological Consequences of Accidental Releases" NRPB-M74, (1982)
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