Pilot investigation of food products contamination by caesium-137 in selected areas of Ukraine affected by the Chernobyl catastrophe in 1986

Iryna Labunska, Greenpeace Research Laboratories, University of Exeter, Exeter, UK
Stan Vincent, Greenpeace International, Amsterdam, The Netherlands
Nikki Westwood, Greenpeace International, Amsterdam, The Netherlands
Paul Johnston, Greenpeace Research Laboratories, University of Exeter, Exeter, UK

April 2011

Introduction

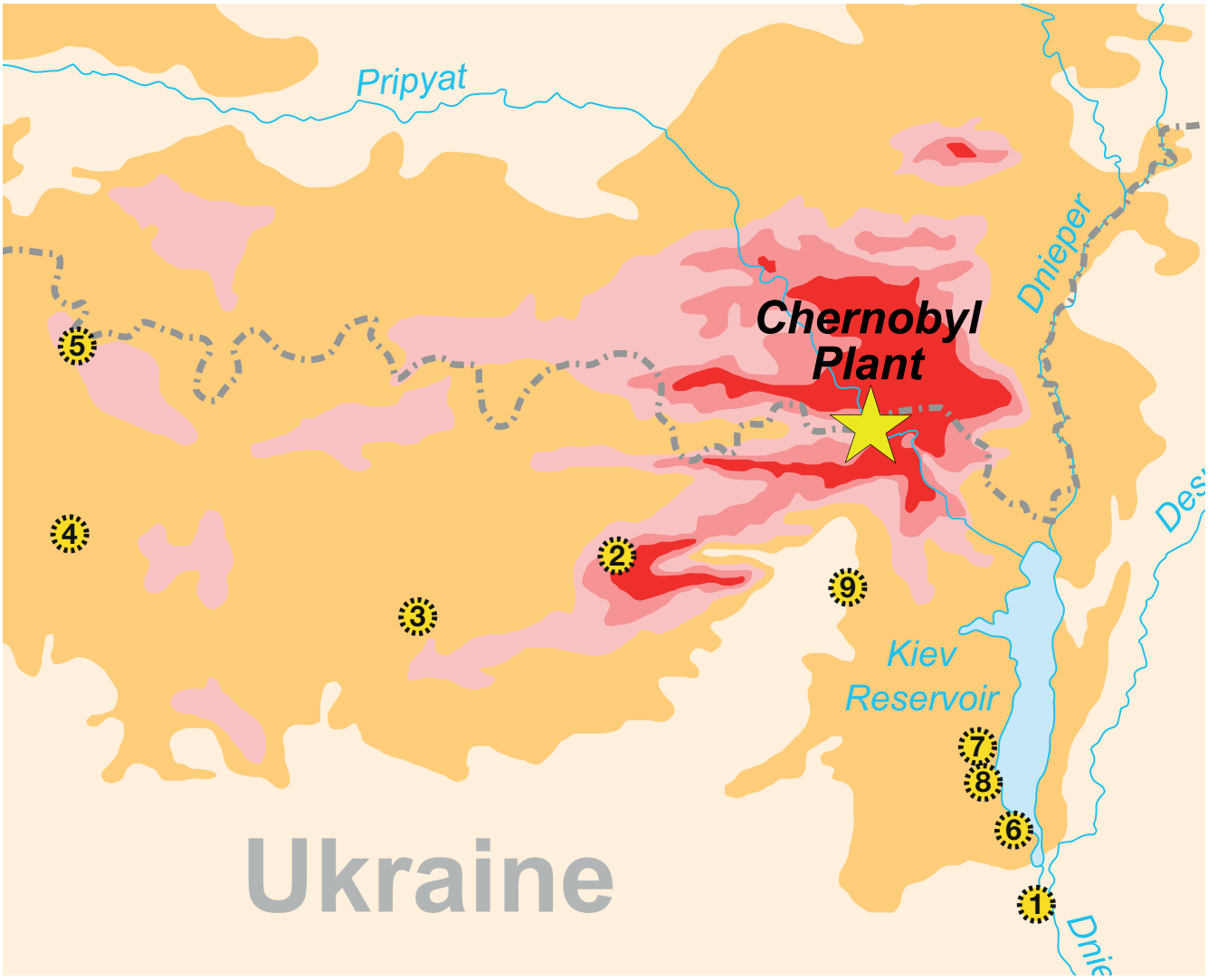
The radioactivity released as a result of the explosions of the No.4 Reactor at the Chernobyl NPP plant in 1986 caused a number of severe problems affecting many countries worldwide. One of the greatest concerns was the release, transport and subsequent deposition of caesium-137, a long-lived radionuclide (half life $T_{1/2}$ = 30.1 y), which is able to pass through the food chain and accumulate in milk, fish and other food products (Travnikova et al. 2004, Schwaiger et al. 2004, Forberg et al. 1994, Voors & Weers 1989). Over the years following the accident, the Ukrainian government undertook regular analyses of foodstuffs produced in contaminated areas and these data were published in the reports of the Ministry of Emergencies and Affairs of Population Protection from Consequences of Chernobyl Catastrophe (see: MESU 2008). For the last two years this monitoring has not been performed, and accordingly an important long-term data set is no longer being added to.

The current study was, therefore, designed and carried out by Greenpeace International as a small pilot investigation into the current situation with respect to radionuclide contamination of foodstuffs in the region. The study targeted selected areas of the Ukraine where such contamination has been found in past surveillance monitoring programs (Kashparov et al. 2009). In these studies, Rivnenska Oblast in Ukraine was found to have the highest levels of radiocaesium in milk and also showed the highest levels of caesium-137 in humans (Bondarenko 2010). The levels of soil contamination by caesium-137 in Rivnenska Oblast are not the highest found in Ukraine. Nevertheless, a unique peaty type of soil in the region, which is often waterlogged, is characterised by high caesium-137 soil-to-plant transfer coefficient, and this has led to a much higher accumulation of radiocaesium in plants and, consequently, in animals grazing on these plants (Prister et al. 1993).

The current study does not, and was not intended to, represent a comprehensive description of either the scope of the food contamination by radionuclides throughout Ukraine or in any particular region of Ukraine. Nonetheless, it provides some insight into ongoing problems with several categories of food products that are important components of the basic diet of the population in areas contaminated by radionuclides released from Chernobyl NPP in 1986.

Sampling programme

In March 2011, a Greenpeace research team visited several places in Rivnenska and Zhytomyrska Oblast, Ukraine, to collect samples of food products produced in those areas and which comprise a significant component of the local diet. Samples of food were also obtained from several locations in Kyivska Oblast for comparative purposes. The locations visited are shown on the map, which follows. A total of 114 samples of food products were either purchased from the public food markets or given by local farmers for analysis. The list of sampling locations, food product types and number of samples obtained from each location are presented in Table 1.



0 50 100 Kilometres

0 50 100 Miles

Confiscated/Closed Zone
Greater than 40 curies per square kilometre (Ci/km²) of caesium-137

Permanent Control Zone
15 to 40 Ci/km² of caesium-137

Periodic Control Zone
5 to 15 Ci/km² of caesium-137

Unnamed zone
1 to 15 Ci/km² of caesium-137

1. **Kiev**
2. **Narodichi (Rosohivske), Zhytomyrska Oblast**
3. **Lugyny (Rudnya Zherevetska), Zhytomyrska Oblast**
4. **Rokytne, Rivnens'ka, Oblast**
5. **Drozdyn, Rivnens'ka, Oblast**
6. **Novi Petrivtsi, Kiev Oblast**
7. **Dymer, Kiev Oblast**
8. **Novi Sokoly, Kiev Oblast**
9. **Demydiv, Kiev Oblast**

Food samples obtained from Kyivska Oblast were mainly purchased from the markets located in villages named in Table 1 and from Shevchenka Square market, located on the northern outskirts of Kiev. A member of the public donated a single dried mushroom sample from Novi Sokoly village, Kyivska Oblast. Local farmers donated all of the samples from Rivnenska Oblast and Zhytomyrska Oblast during Greenpeace research team visits.

	Milk and milk products	Mushrooms	Berries, fruits and berry jam	Potatoes	Beetroots	Carrots	Honey	Others
Kyivska Oblast								
Kyiv, Shevcheka Sq.	3	-	1	-	-	-	1	-
Demydiv	5	2	-	1	-	1	-	1b, 1e
Novo-Petrivtsi	1	-	-	-	-	-	-	1a
Dymer	3	2	3	-	-	-	2	1c, 1d
Novi Sokoly	-	1	-	-	-	-	-	-
Rivnenska Oblast								
Drozdyn	15	9	9	17	9	7	-	-
Rokytne	-	1	-	-	-	-	-	-
Zhytomyrska Oblast								
Rydnya Zherevetska	6	1	1	-	-	-	-	
Rosohivske	1	1	2	-	-	-	1	1f
Narodychi	-	1	1	-	-	-	-	-

Table 1. List of sampling locations, samples types and number of samples of each type collected from settlements in Kyivska, Rivnenska and Zhytomyrska Oblast, Ukraine, March 2011.
a - mincemeat, b - tomato puree, c - walnuts, d - onions, e - dried beans, f - dried thyme.

Methodology

A portable Berthold Becquerel monitor LB200 with a scintillation detector (containing a NaI crystal) was used to carry out analyses. This instrument is designed to measure the activity of gamma-emitters in foodstuffs, liquids and bulk materials. This was used to carry out preliminary measurements of activity of a large proportion of the collected samples. A subset of 70 samples, including milk and milk products, mushrooms, berries and honey, were analysed using the Becquerel monitor. Background measurements were taken using distilled water as an analyte before every sequence of the sample analyses to an accuracy better than 5%. Sample measurements were considered to be complete when a measurement accuracy of 3% was reached.

A second sub-set of 74 samples, which also included selected samples that had already been analysed in the field together with previously unprocessed samples, was sent for analysis to the Laboratory of Nuclear-Physics Methods of Analysis and Radiochemistry of the Ukrainian Institute of Agricultural Radiology, National University of Life and Environmental Sciences of Ukraine (UIAR). These samples were analysed for caesium-137 content using certified gamma-spectrometers SEG-001 “AKP-S”-63(Ukraine).

Results and discussion

1. Milk and milk products

Thirty-four milk and milk product samples were obtained in this current study. Results from a sub-set of 13 milk samples, which were analysed for caesium-137 content by the UIAR laboratory, showed a good correlation with the measurements conducted in the field using the portable Becquerel monitor LB200. The majority of the results for duplicate milk sample analyses were within the range of the statistical uncertainty of the measurement (see Table 2). The analysis for caesium-137 content conducted by the UIAR laboratory has confirmed that caesium-137 was the main nuclide responsible for radioactivity of milk samples analysed in this study.

Ratio values presented in results Tables 2-4 were calculated, where possible, using data on the caesium-137 content in the samples obtained using the gamma-spectrometers SEG-001 "AKP-S"-63 (UIAR) referenced to the Ukrainian Acceptable Levels for caesium-137 in food products (MHU 2006). Similarly, in cases where analysis was performed using the Becquerel Monitor LB200, the activity of the samples was also compared with the Ukrainian Acceptable Levels for caesium-137.

Kyivska Oblast

Caesium-137 levels in all 12 samples of milk and milk products (soft cheese, sour cream and hard cheese) obtained from Kiev and Kyivska Oblast were below the detection limits of both instruments used for measurements (<20Bq/l using LB200 monitor ; <3 and <14 for milk and sour cream respectively using the SEG-001 spectrometer).

Zhytomyrska Oblast

Of the seven samples of milk obtained from Zhytomyrska Oblast, none of them exceeded Ukrainian Adult Acceptable Levels for caesium-137 (AAL caesium-137) of 100Bq/l (MHU 2006). However, one sample from Rudnya Zherevetska showed activity of 60 Bq/l. If this milk were to be given to a child, it would exceed 1.5 times the Acceptable Levels for Children for caesium-137 (ChAL caesium-137), of 40Bq/l (MHU 2006).

Rivnenska Oblast

Fifteen samples of milk were obtained from Drozdyn, Rivnenska Oblast. Eight of them were below AAL caesium-137, while the remaining seven samples showed caesium-137 to be in the range of 142 – 665Bq/l exceeding the AAL caesium-137 by 1.4 to 6.5 times respectively (see Table 2). At the same time, 14 out of 15 milk samples (93%) from this village exceeded ChAL caesium-137 by factors ranging between 1.2 and 16.3 times.

Activity, Bq/l (GP)*	Uncertainty (97%), Bq/l (GP)*	Caesium-137, Bq/kg (UIAR)**	Uncertainty (95%), % (UIAR)**	Ratio to AAL caesium-137 (100 Bq/l)	Ratio to ChAL caesium-137 (40 Bq/l)
61	15	n/a	n/a	0.6	1.5
295	20	300	13	3.0	7.5
181	16	170	15	1.7	4.3
142	16	n/a	n/a	1.4	3.6
154	16	140	15	1.4	3.5
32	14	n/a	n/a	0.3	0.8
174	17	150	15	1.5	3.8
57	17	n/a	n/a	0.6	1.4
56	19	n/a	n/a	0.6	1.4
245	19	200	14	2.0	5
665	30	650	11	6.5	16.3
78	18	n/a	n/a	0.8	2.0
90	15	n/a	n/a	0.9	2.3
49	14	n/a	n/a	0.5	1.2
51	10	46	27	0.5	1.2

Table 2. Activity of radionuclides (in Bq/l) and caesium-137 content (in Bq/kg) in samples of raw milk obtained from local farmers in the village of Drozdyn, Rivnenska Oblast Ukraine, March 2011.
*n/a – not analysed; * - data analysis by Greenpeace Research Laboratories, Exeter, UK; ** - data analysis by Ukrainian Institute of Agricultural Radiology (UIAR), Kiev, Ukraine.*

It is important to note that the milk samples analysed were collected in early spring. At this time the cattle are mostly fed with hay. According to local farmers bringing milk in for analysis, some of this feed originates from other regions of Ukraine where levels of soil contamination by caesium-137 are much lower. Not all farmers, however, have the financial resources to buy clean hay, and they prepare hay stock for winter from local pastures. The highest level of caesium-137 (at 665Bq/l) in milk recorded from this village was obtained from a family that used only locally harvested hay. In the late spring and summer when all cattle are grazed on local pastures, the level of caesium-137 in milk increases. The average content of caesium-137 in milk from Drozdyn village has generally been high over the years following the explosion; the data for 2004, 2005, 2006, 2007 and 2008 for one particular grazing meadow Dubniki were 564±167, 645±220, 594±218, 706±145, and 733±179Bq/l respectively (Kashparov et al. 2009).

In fact, milk samples from this village have exceeded AAL caesium-137 for 10 consecutive years (1999-2009). Milk from cows grazing on other pastures around this village had lower levels of caesium-137, but still exceeded AAL caesium-137 and, consequently, ChAL caesium-137 also. The results of the research (Kashparov et al. 2009), which evaluated the radiological condition of 120 pastures in 37 villages in Rivnenska Oblast of Ukraine, have shown that:

- Milk samples obtained from cattle grazing on 87 pastures (73%) have always (48%) or partially (29%) exceeded AAL caesium-137 during 2004-2008;
- 65 pastures (54%) could be fully or partially remediated using an appropriate programme of agricultural measures.

2. Wild mushrooms and berries

Radioactive contamination may be spread to distant areas through various routes, including precipitation from radioactive clouds. Fallout levels, therefore, may differ dramatically in places geographically close. Many countries in which wild mushrooms are habitually consumed, including Ukraine, Belarus, Russia, Poland, Italy and Hungary, recorded increased levels of radiocaesium in mushrooms analysed after the Chernobyl catastrophe. The observed values were at least one order of magnitude higher than those reported before 1985 (Kalač 2001, Tsvetnova & Shcheglov 1994).

Eighteen samples of wild mushrooms were obtained in this study, including 6 preserved (marinated) and 12 dried samples, together with 15 samples of wild berries including fresh cranberries, dried blueberries, frozen blueberries, and blueberry jam. None of the nine fresh cranberry samples that were obtained from Drozdyn village showed caesium-137 levels above the detection limits of both of the techniques used for measurements in this study. The results for other samples are presented in Table 3.

Kyivska Oblast

Of the three samples of marinated mushrooms purchased in Kyivska Oblast, two samples (from Demydiv and Dymer markets) had activity below detection limits of the Bequerel monitor. These were not sent for further caesium-137 analysis. The second sample from Dymer, however, had a caesium-137 content 1.5 times the AL caesium-137 of 500Bq/kg (MHU 2006). Dried mushrooms obtained from Demydiv market were 4.4 times the AL caesium-137 and from Novi Sokoly 1.2 times the limit of 2500Bq/kg which has been set for wild dried mushrooms and berries (MHU 2006). The activity of the single sample of dried cranberries from Dymer market was below detection limits of the Becquerel monitor and it was not sent for further analysis.

	Sample type	Activity, Bq/kg (GP)*	Unc. (97%), Bq/kg (GP)*	Caesium-137 Bq/kg (UIAR)**	Unc. (95%), % (UIAR)**	Ratio to AL caesium-137 ***
Dymer	marinated mushrooms	<20	-	<12	-	-
	marinated mushrooms	818	41	760	10	1.5
	dried cranberries	<20	-	n/a	n/a	-
Demydiv	marinated mushrooms	<20	-	n/a	n/a	-
	dried mushrooms	9539	186	11000	10	4.4
Novi Sokoly	dried mushrooms	n/a	n/a	2900	10	1.2
R.Zherevetska	marinated mushrooms	271	68	210	13	0.42
	frozen blueberries	807	33	730	10	1.5
Rosohivske	dried blueberries	21814	900	12100	10	4.8
	dried mushrooms	25304	813	29700	10	11.9
	dried ashberries	n/a	n/a	51	30	0.02
Narodichi	dried mushrooms	n/a	n/a	288000	10	115.2
	blueberry jam	2377	60	2180	10	4.4
Drozdyn	marinated mushrooms	544	28	490	10	1.0
	dried mushrooms	4018	182	7300	10	2.9
	blueberry jam	278	14	210	12	0.4
	dried mushrooms	7870	320	10100	10	4.0
	dried mushrooms	3366	122	n/a	n/a	1.4
	dried mushrooms	2111	142	3200	10	1.3
	dried mushrooms	1825	142	n/a	n/a	0.7
	dried mushrooms	12115	294	17500	10	7.0
	marinated mushrooms	24	16	n/a	n/a	0.01
	dried mushrooms	n/a	n/a	10400	10	4.2
Rokytne	dried mushrooms	n/a	n/a	10700	10	4.3

Table 3. Activity of radionuclides (in Bq/kg) and caesium-137 content (in Bq/kg) in samples of wild mushrooms and wild berries obtained from Dymer, Demydiv and Novi Sokoly in Kyivska Oblast; Rudnya Zherevetska, Narodichi, and Rosohivske in Zhytomyrska Oblast, Drozdyn and Rokytne in Rivnenska Oblast, Ukraine, March 2011.
*n/a – not analysed; * - data analysis by Greenpeace Research Laboratories, Exeter, UK; ** - data analysis by Ukrainian Institute of Agricultural Radiology (UIAR), Kiev, Ukraine; *** AL caesium-137 for dry wild mushrooms and berries- 2500Bq/kg , for marinated mushrooms and berries jam–500Bq/kg.*

Zhytomyrska Oblast

Three samples of mushrooms were obtained from Zhytomyrska Oblast, from which one sample of marinated mushrooms was below the AL caesium-137. Both samples of dried mushrooms were above the limit, particularly the sample from Narodichi with a caesium-137 content of 288000 Bq/kg, which is 115 times the limit for this food product. This sample had the highest caesium-137 content of all the samples considered in this study.

Berries from this area also showed elevated content of caesium-137, including frozen blueberries, blueberry jam and dried blueberries with 1.5, 4.4 and 4.8 times the limit for these products respectively. The activity of the dried blueberry sample measured by Becquerel monitor was almost twice as high as could be attributed to the content of caesium-137 in this sample. It is difficult to speculate about the cause for such a difference. The precision of the gamma-spectroscopic analysis was much higher than that using the Becquerel monitor in this particular measurement. On the other hand, the possibility of other radionuclides being present in this sample that may have been derived from the forest soil where the berries were grown cannot be ruled out. The sample of dried ash berry from Rosohivske village was well below the regulatory limit.

Rivnenska Oblast

Two marinated and seven dried mushroom samples and one sample of blueberry jam were obtained from Drozdyn village. Marinated mushroom samples and blueberry jam were below the AL caesium-137 of 500 Bq/l. One sample of dried mushrooms was donated for analysis in Kiev; this was said to have been harvested in Rokytne, Rivnenska Oblast, and brought to Kiev as a present for relatives. Rokytne is situated about 70km to the south of Drozdyn village. This sample from Rokytne exceeded AL caesium-137 by 4.3 times. Of the seven dried mushroom samples obtained from Drozdyn village, six exceeded the AL caesium-137 by a factor ranging between 1.3 and 7 times.

3. Root vegetables and other food products

Root vegetables were analysed only for caesium-137 content. None of the nine samples of beetroots from Drozdyn village exceeded AL caesium-137. Only one of eight samples of carrots considered in this study exceeded AL caesium-137, this by a factor of 1.3 times (from Drozdyn village). Results for potatoes analysed is presented in Table 4. A single sample from Demydiv, Kyivska Oblast, had levels of caesium-137 below detection level of 3Bq/kg. Of the 15 potato samples from Drozdyn village, four had elevated levels of caesium-137 in range of 1.2 to 1.7 times the AL caesium-137 for this product of 60Bq/kg.

	Sample type	Caesium-137, Bq/kg (UIAR)	Unc. (95%), % (UIAR)	Ratio to AL caesium-137 (60Bq/kg)
Demydiv	Potatoes	<3	-	-
Drozdyn	Potatoes	17	25	0.3
		50	14	0.8
		100	18	1.7
		80	12	1.3
		15	20	0.3
		60	22	1.0
		5	30	0.1
		48	15	0.8
		78	20	1.3
		44	14	0.7
		42	13	0.7
		73	12	1.2
		56	15	0.9
		37	15	0.6
		43	16	0.7

Table 4. Caesium-137 content (in Bq/kg) in samples of potato obtained from Demydiv, Kyivska Oblast and Drozdyn in Rivnenska Oblast, Ukraine, March 2011.

A single sample of each of the following food products: pork mincemeat, tomato puree, walnuts, onions, and dried beans, as well as three samples of honey that were purchased in Kyivska Oblast, did not exceed corresponding AL caesium-137.

Conclusions

The results of the analysis of foodstuffs sampled from areas known to have been contaminated by the Chernobyl reactor explosion in 1986 show that key foodstuffs sourced in the region are still subject to contamination with radioactivity. Caesium-137 appears to be the most important component of this contamination, but at least one of the samples suggested that other long-lived radionuclides could be present. Numerous instances of regulatory limits being exceeded, both for adults and for children, were identified in this current sampling exercise, which suggests that the ending of a regular surveillance monitoring programme may be premature.

References

Bondarenko OO. 2010. Ukraine of General dosimetric certification: verification of internal irradiation of population. http://knol.google.com/k/oleg-bondarenko/загальнодозиметрична паспортизація/5bcvesrsnaqi/4

Forberg S, Odsjö T & Olsson M. 1992. Radiocesium in muscle tissue of reindeer and pike from northern Sweden before and after the Chernobyl accident. A retrospective study on tissue samples from the Swedish Environmental Specimen Bank. Science of The Total Environmen 115(3): 179-189

Kalač P. 2001. A review of edible mushroom radioactivity. Food Chemistry 75(1): 29-35

Kashparov VO, Lundin SM, Lanshyn VP, Kadygrib OM, Khomutinin UV, Lazarev MM, Zhyrba MA & Pavlyuchenko VV. 2009. Bulletin of radiological situation on critical settlements in Ukraine contaminated by radionuclides. Institute of Agricultural Radiology, National University of Life and Environmental Sciences of Ukraine (UIAR). "НІЧЛАВА", Kiev, 2009, 106pp.

MESU. 2008. Ministry of Emergency Situations of Ukraine. Radiological status of the territories that are within the zone of radioactive contamination (in terms of areas). (eds. Kholosha VI). Kiev/Ukraine

MHU. 2006. Order of the Ministry of Health of Ukraine of Apr 03 2006 № 256. Acceptable levels of radionuclides Cs-137 and Sr-90 in food and drinking water. Public hygiene standards

Prister BS, Perepelyatnikov GP & Perepelyatnikova LV. 1993. Countermeasures used in the Ukraine to produce forage and animal food products with radionuclide levels below intervention limits after the Chernobyl accident. Science of The Total Environment 137(1-3): 183-198

Schwaiger M, Mueck K, Benesch Y, Feichtinger J, Hrnecek E & Lovranich E. 2004. Investigation of food contamination since the Chernobyl fallout in Austria. Applied Radiation and Isotopes 61(2-3): 357-360

Travnikova IG, Bazjukin AN, Bruk GJ, Shutov VN, Balonov MI, Skuterud L, Melhi H & Strand P. 2004. Lake fish as the main contributor of internal dose to lakeshore residents in the Chernobyl contaminated area. Journal of Environmental Radioactivity 77(1): 63-75

Tsvetnova OB & Shcheglov AI. 1994. Cs-137 content in the mushrooms of radioactive contaminated zones of the European part of the CIS. Science of The Total Environment 155(1): 25-29

Voors PI & Van Weers AW. 1989. Transfer of Chernobyl ^{134}Cs and ^{137}Cs in cows from silage to milk. Science of The Total Environment 85: 179-188

For more information, contact:
enquiries@greenpeace.org

Greenpeace International
Ottho Heldringstraat 5
1066 AZ Amsterdam
The Netherlands
Tel: +31 20 7182000

greenpeace.org