# Radioactive Contamination of Food in Stepanivka Village, Zhytomyr Region, Ukraine: in 1992 and in 2001

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**Abstract**

Two series of measurements of radioactive contamination in food samples were performed in 1992 and in 2001 in a village contaminated by the Chernobyl accident. The village, Stepanivka is located 120 km to the west of Chernobyl NPP and has a typical level of Cs-137 surface contamination around that area (3 – 5 Ci/km$^2$). The study was performed by the Independent Environmental Laboratory in Kyiv, jointly founded by the Ukrainian NGO "Green World", Greenpeace International and the International Renaissance Foundation.

It is shown that the Cs-137 contamination in milk in 2001 became 9 times lower than in 1992, while the Cs-137 contamination in wild mushrooms and berries remained at the same level. Annual intake of Cs-137 by the people in Stepanivka through food products and water was about 3 times lower in 2001 than in 1992. On the contrary to the trend of Cs-137, activity of Sr-90 in milk and dried berries was significantly higher in 2001 than in 1992.

## 1. Introductory note

The idea of the study was not merely scientific, but included also a social aspect. In 1992, general public usually did not trust "official" data on radioactive contamination because the Soviet era attempts of hiding the consequences of the Chernobyl disaster were still fresh in memory. Thus the results of an independent laboratory which was run by non-governmental organizations with strong "green" reputation would have an important social value. At that time (1991-1992), as became clear from later publications, many scientific organizations were studying radioactive contamination of food, but very few results were published yet. Of course, there were no attempts to make the results of the investigations available and understandable for general public. Only later results of investigation were presented at conferences, see, for example, [1].

The first research was undertaken in spring-summer of 1992 by the Radiological Laboratory of Greenpeace Ukraine (this laboratory was a joint project by Greenpeace International, Ukrainian NGO "Zelenyi Svit (Green world)" and the Kyiv-based International Renaissance Foundation. Part of the equipment was donated to "Green world" by two German universities).

The idea of the study included "on-site" measurements of food samples. This was very important to relieve possible feeling of insecurity in local communities. On-site measurements were possible because the laboratory possessed portable gamma-radiation monitors LB200 (manufactured by Berthhold, Germany) with the low limit of Cs-137 detection in 0.5-0.8 kg samples. Indeed, the attitude of the villagers was rather negative when the investigation began: "you are just another team that will fool us". Later we managed to build their trust. The people of Stepanivka and other villages nearby were informed about the results of the 1992 study through local newspaper and at various meetings.

The second research was conducted in summer of 2001, owing to a support from the grant of the Ministry of Education of Japan. The study would reveal some changes (first of all - radioactive contamination of food) that took place in Stepanivka village during almost 10 year period.

For both studies, analyses of Cs-137 and Sr-90 were performed by the Laboratory of the Radiation

Hygiene of the Ukrainian Institute of Hygiene and Medical Ecology. Cs-137 was measured using Camberra Ge spectrometer with the lower limit of detection 0.17 Bq (for 10,000 sec measurement). Sr-90 was detected by Y-90 radiochemical method.

**2. General information**

Village Stepanivka is located 120 km to the west of Chernobyl NPP. In 1992, there lived 369 people, including 75 children and 108 retired people. In 2001, the population slightly decreased and became older: 45 children, 145 retired. The main enterprise in the village is a collective (in 1992 - state) farm that produces milk, potato, hops and some other crops. Most officials (director of the farm, village Council Head, radiologist, agronomist) have been working in the same positions since 1992. Villagers have cows in private sector and produce potato and vegetables in their vegetable gardens for their own consumption. In 1992, many people collected and ate mushrooms (8 families out of 25 interviewed) and berries (15 out of 25) from nearby forests. They indicated that they were eating less mushrooms and berries than before the Chernobyl accident, because they knew about radioactive contamination. Several families ate fish from the small river Zherev.

Soils in the vicinity of the village are light sour turf-podzol and grey, with pH from 4.6-5.5. Soil samples were taken on plowed fields, from the upper layer 0-20 cm (same fields in 1992 and 2001). Several samples collected in 1992 by 5 cm layers showed a uniform distribution of radioactivity. In 2001, radiation levels on sites varied between 0.06 - 0.13 $\mu Sv\ h^{-1}$. Radioactive contamination of soil in 1992 and 2001 is summarised in Table 1.

The results of measurement of radioactive contamination of soil are close to the data provided by the local agrochemical service (surface contamination by Cs-137 between 3 - 5 $Ci/km^2$). Thus Stepanivka could be considered as a typical village for the areas not located directly on the so-called “Western plume of Chernobyl contamination”.

Dietary habits and local food consumption were investigated in 1992. Out of 100 families, 25 were interviewed (10 of them had children). Average consumption of main locally produced food products per person is summarised in Table 3. Milk products (usually - white cheese and sour cream) were re-calculated into milk (with the assumption that milk products retain all radioactivity that was in milk). The diet (milk-based) is characteristic for this region of Ukraine [2]. In 2001, the consumption patterns were the same. Bread, other cereals, fruits, soft drinks and beer are imported from different regions of Ukraine, and were not included in the study. In Table 3 we also included values of permissible levels (regulations of 1997) for Cs-137 and Sr-90 in food products included in the study [3].

Samples were collected and measured first on-site using LB200 gamma monitor (in 1992), and later in a laboratory. In 2001, on-site measurements were impossible due to low activities of samples. In 1992, milk samples were collected in two more villages of the same region.

**Table 1. Soil contamination in and around Stepanivka.**

| Year | Cs-137 | | Sr-90 | |
|---|---|---|---|---|
| | Number of samples | Activity (range), Bq/kg | Number of samples | Activity (range), Bq/kg |
| 1992 | 10 | 530 | 3 | 34 |
| 2001 | 4 | 485 (250-825) | 2 | 3.8 (2.0-5.5) |

## 3. Results and discussion

**Water.** Two types of drinking water supply are used in the village: centralised supply from 120 m deep artesian well and private water wells 1 - 3 m deep. Some people use both pipeline water and wells. Water from artesian well was rather radioactive (total gamma-activity by LB200 monitor about 100 Bq/1 - apparently radium, thorium and their daughter products - the region is known for its granite deposits). Average gamma activity of water in private wells (measured by LB200) was 59 Bq/1, ranging from 0 - 179 Bq/1. In this research, we had no opportunities for investigation of radioactivity of drinking water in details. In 1999, in the other study of villages in the same Polisse region and with similar level of radioactive contamination of soil (Cs-137 1.1 - 3.9 Ci/km$^2$), Cs-137 activity of water in wells varied from 0.06 - 2.6 Bq/l [4]. According to this study, activity of water in 1992 was 9 times higher than in 1999.

**Milk.** Results of analyses of milk are presented in Table 2. Average contamination of milk with Cs-137 in 2001 was 9 times lower than in 1992. In our study, in 1992 average activity of five samples of hay was 500 Bq/kg (dry weight, measured by gamma-monitor LB200) and in 2001 activity of Cs-137 in two samples of hay were 1,125 and 711 Bq/kg. It is not possible to conclude what is the main source of radioactive contamination of milk - more detailed studies are needed.

Radioactive contamination of food samples is summarised in Table 3.

**Meat, poultry, eggs and fish.** Only several samples of meat, poultry, fish and eggs were available for measurements, because these food products are scarce and people plan their consumption (usually this is connected with seasonal or family celebrations, and even in these periods they are not in abundance).

**Potato** is very important as a food product and also as forage for pigs and chickens. All consumed potato is produced locally, and daily consumption for food is higher than the average for Ukraine (0.63 and 0.36 kg/day, respectively).

**Mushrooms and berries.** Fresh, canned, dried mushrooms (many different species) and berries (mainly blackberry *Vaccinium Myrtillus*) are very important food products in Stepanivka. Most people harvest them in forests and eat. People know that these products are radioactive, but they constitute very significant additives of protein (mushrooms), minerals and vitamins (berries) that are unavailable from other sources. When filling up interview sheets in 1992, we re-calculated fresh and canned berries into dry berries. In 2001, consumption of mushrooms and berries was apparently higher than in 1992, but we used the same figures for our calculations.

**Calculation of intake of radionuclides.** The results of calculation of intake of Cs-137 and Sr-90 from the main food items in the investigated area are presented in Table 3. The shares of Cs-137 intake from the main food products are plotted on two diagrams in Fig.1.

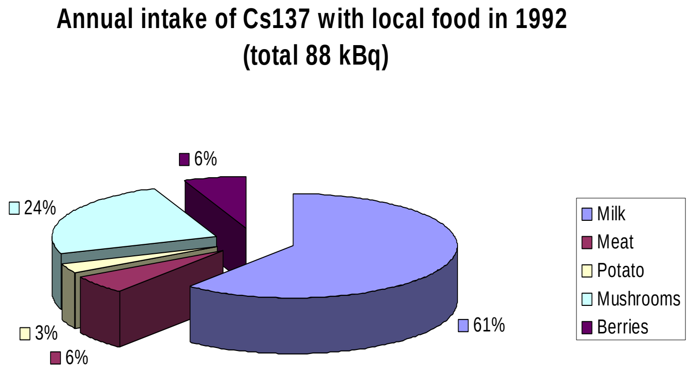
**Table 2. Average activity of Cs-137 in milk samples, Bq/l; n - number of samples.**

| Village | 1992 | | | | 2001 | | | |
|---|---|---|---|---|---|---|---|---|
| | Cs-137 | | Sr-90 | | Cs-137 | | Sr-90 | |
| | n | Activity (range) | n | Activity | n | Activity (range) | n | Activity (range) |
| Stepanivka | 51 | 228 (28-940) | 6 | 0.34 | 10 | 25.5 (7.1-43.8) | 4 | 1.00 (0.74-1.37) |
| Dibrova | 14 | 71 (14-150) | - | - | - | - | - | - |
| Rudnia Radovelska | 19 | 298 (45-720) | - | - | - | - | - | - |

**Table 3. Permissible levels of contamination (PL) and activity (Bq/l or Bq/kg) of water and food in Stepanivka, and average annual intake (Bq). Absent data are marked "na".**

| | Consumption (kg/pers/year) | Cs-137 | | | | | Sr-90 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PL (Bq/l, kg) | 1992 | | 2001 | | PL (Bq/l, kg) | 1992 | | 2001 | |
| | | | Activity (Bq/l, kg) | Intake (Bq) | Activity (Bq/l, kg) | Intake (Bq) | | Activity (Bq/l, kg) | Intake (Bq) | Activity (Bq/l, kg) | Intake (Bq) |
| Water | 365 | 2 | na | | 0.05 | 18 | 2 | na | | 0.25 | 91 |
| Milk | 256 | 100 | 210 | 53,800 | 25.5 | 6,528 | 20 | 0.34 | 87 | 1.0 | 256 |
| Meat, poultry | 80 | 200 | 62 | 5,000 | 43.9 | 3,512 | 20 | na | | 0.5 | 40 |
| Fish | 0.6 | 150 | 330 | 200 | 47 | 28 | 35 | na | | 2.2 | 1.3 |
| Eggs (pieces) | 300 | 6 | 1.5 | 450 | na | | 2 | na | | na | |
| Potato | 230 | 60 | 12 | 2,800 | 14.9 | 3,427 | 20 | na | | 0.5 | 115 |
| Dry mushrooms | 0.7 | 2,500 | 30,500 | 21,300 | 20,047 | 14,033 | 250 | na | | 4.8 | 3.4 |
| Dry berries | 0.3 | 2,500 | 18,000 | 5,400 | 17,650 | 5,295 | 250 | 4.5 | 1.4 | 56.6 | 17 |
| Total intake from local food | | | | 88,950 | | 32,841* | | | | | 523* |

*Including water



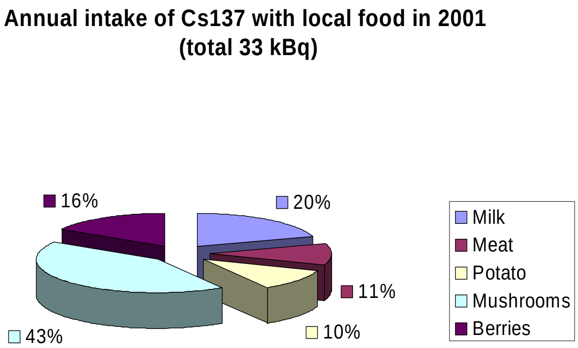




**Fig.1. Intake of Cs-137 from main food sources.**

**Discussion**

From the results of our study it is clear that average intake of Cs-137 in 2001 is almost three times lower than in 1992: 89 kBq and 33 kBq, respectively. In 1992, milk contamination accounted for 61 % of annual intake of Cs-137, and mushrooms and berries accounted for 30 % together. In 2001, the share of milk dropped to 20 % and the share of mushrooms and berries became 59 %. The content of Cs-137 in berries and mushrooms has been more or less stable in 1992-2001, as it was also shown in other studies (see, for example, [5] for the period 1991-1999).

Our results prove that Stepanivka is located in a rather "good" area, because in many other villages (even to the west of Stepanivka) radioactive contamination of milk remains significantly higher. In 1998, out of 34,233 samples of private sector milk in Ukraine, contamination of 19.7 % of them with Cs-137 was higher than permissible level 100 Bq/l [6].

It is also clear that contamination of food with Sr-90 increased significantly: almost three times for milk and 12 times for dry berries.  There exist numerous investigations which show that the migration of Sr-90 in plants increases with time due to chemical transformations of deposited fuel particles. (See, for example, a paper by Yu.O.Ivanov with quite comprehensive bibliography [7]).

In 1992, we used (to make a rough estimate) the results presented by Smoliar [2] that an intake of each kBq/year of Cs-137 results in an annual dose of 0.011 mSv/year. In this case the average dose in Stepanivka (from locally produced food) was 1.2 mSv/year in 1992. This dose was lower than 1992 permissible level of 5 mSv/year.

Later, several regulations on calculation of internal doses from food and other sources were published by international organizations and in Ukraine [see, for example, 8]. But, if we use the same assumption by Smoliar for Cs-137 intake results of 2001, then the annual dose from local food would be 0.37 mSv/year, which is lower than the permissible radiation dose for population - 1 mSv/year, stipulated by National Radiation Protection Norms. Of course, this calculation does not account for doses from incorporated strontium and alpha-emitters, as well as for inhalation and external irradiation doses. As it is shown in [3], for people living in similar environment, internal irradiation from food contamination by Chernobyl radionuclides comprises only about 40 % of the total internal dose, while 60 % of internal dose is formed by natural radionuclides such as Rn and Tn and their daughter products (results of the 1996-1997 studies; the paper provides a breakdown of the total intake of Cs-137 and Sr-90 from various food products).

It should be noted, however, that we did not investigate patterns of individual intake of radionuclides, which vary very significantly even for people living in the same village.

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