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Radioactive contamination of food, sampled in regions of the USSR affected by the Chernobyl accident, and of radioactive exposure in these regions

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ABSTRACT

Radioactive contamination of food, sampled in regions of the USSR affected by the Chernobyl accident,and of radioactive exposure in these regions

Report 91.45 September 1991

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From 21.10.1990 to 01.11.1990 a Netherlands humanitarian fact finding mission on aid to people affected by the Chernobyl disaster visited the USSR. The Netherlands Government reacted positively to a request from the USSR for such aid and the aim of the mission was to gather facts for a useful aid program. To this end authorities in Moscow, but also in the contaminated regions in the RSFSR, BSSR and UkSSR were visited. Local people were interviewed, and food products were sampled for radioactivity measurements in The Netherlands.
The mission focused on three items:
- medical aspects
- socio-psychological aspects
- agricultural/ food aspects.

This report deals with the results of radioactivity measurements on food products, sampled in the contaminated areas of the RSFSR, BSSR and UkSSR and discusses the radiation burden due to these products for the Soviet citizens.
The results of exposure measurements, performed in the contaminated areas, are also presented.

Keywords: Radioactivity, Food, Environment, Caesium-137, Caesium-134, Strontium-90, Chernobyl, USSR

CONTENTS

INTRODUCTION

In October 1990 a Netherlands humanitarian fact finding mission on aid to people affected by the Chernobyl disaster visited contaminated regions in the Russian Federation (RSFSR), Byelorussia (BSSR) and the Ukraine (UkSSR). The mission consisted of medical, socio-psychological and agricultural experts.
Local people posed two main questions:

- Can we eat our food products safely?
- Can we stay in our village or town safely?

To help answer these questions by independent investigations, food products were sampled and field radiation measurements were carried out.
The food products were taken to The Netherlands for radioactive measuring. The results are given in this report (Table 1A and 1B).

The radioactive contamination measured in milk, cheese, buttermilk, kasja, potatoes, cabbage, carrot, calabash, red beet and sugar beet ranged between 1 and 170 becquerel (0,3 x 10^{-10} and 45 x 10^{-10} curie) per kilogram fresh product for total radiocaesium, that is the sum of the radioactive nuclides caesium-137 and caesium-134. In a sample of water, radiocaesium could hardly be detected. As was to be expected, a sample of baby food, produced in Azerbeidzjan was not contaminated. Strontium-90, measured in a few samples, was found between 1,8 and 30 Bq/kg (0,5 to 8 x 10^{-10} Ci/kg).
The content of natural potassium-40 ranged from less than 1 to 192 Bq/kg (less than 0,2 to 52 x 10^{-10} Ci/kg) fresh product.
However, in agreement with expectations, mushrooms and reindeer moss were very highly contaminated: from 103 000 to 284 000 Bq/kg (28 000 to 76 500 x 10^{-10} Ci/kg) total radiocaesium in the fresh product. Strontium-90 in these samples was 7,8 to 1550 Bq/kg (2 to 420 x10^{-10} Ci/kg).
The maximum permitted post-Chernobyl levels in EC countries for total radiocaesium is 370 Bq/kg (100 x 10^{-10} Ci/kg) in milk and baby food and 600 Bq/kg (160 x 10^{-10} Ci/kg) for all other food products (1,2). These levels have been adopted by the USSR as well.

The caesium contamination of all food products was far below the stated limits, except for mushrooms. All food products investigated, except mushrooms, can be regarded as safe with respect to radioactive contamination.

More important for the population is not the contamination itself (expressed in becquerel or curie), but the possible harmful effects in the body. The measure for this is the *(equivalent) dose*, expressed in sievert (Sv) or millisievert (mSv). Extrapolating the results of the contamination measurements to the total food consumption, the radioactive burden due to food is estimated to be 0,2 mSv/year. This amount is within the variance of the radioactive burden due to natural sources.

In addition to sampling agricultural produce, field exposure measurements were also carried out. The measured values, expressed in equivalent doses, ranged from 1,8 to 14 mSv/year at a height of 1 metre, with a median value of about 4 mSv/y. On one 'hot spot' values of 21 to 39 mSv/year were measured.

Between the Soviet authorities and the mission, it was agreed that the results should be reported to the authorities and published in the local newspapers, so that the people in the contaminated areas will be informed about the results.

The lay-out of the following chapters is such that they can be published as a series of three articles.

Chapter 1 concerns the results as such.

Chapter 2 gives some background information on radioacivity, to make the meaning of concepts and units, used in radiology, understandable.

In Chapter 3 this knowledge is applied to the results of Part 1, which means that estimates are made about the risks of the reported contamination of food and environment for the population.

The experiences of the mission have led to a Netherlands Chernobyl aid project. The project consists of establishing a centre in Gomel, which will provide a policlinic for general medical diagnosis and psychosocial counselling. Further, activities in the contaminated areas will be organised, including information to physicians and the public.

1 MEASUREMENTS IN FOOD SAMPLES AND IN THE ENVIRONMENT

In October 1990 a Netherlands humanitarian fact finding mission on aid to people affected by the Chernobyl disaster visited contaminated regions in the RSFSR, BSSR and UkSSR. The mission consisted of experts in the field of medicine, socio-psychology and agriculture.
The members of the mission had the opportunity to speak with the local population in the contaminated areas. The people posed two main questions:

- Can we eat our food products safely?
- Can we stay in our village or town safely?

To help answer these questions, dr W.G. de Ruig, member of the fact finding mission in charge of the agricultural aspects, has sampled some agricultural products in the contaminated regions and has carried out exposure measurements in the environment.

1.1 Food samples

In total, 23 agricultural products were sampled, including milk and milk products, crops and mushrooms.

The products were sampled in the following areas:

Russian Federation (RSFSR):
In the Bryansk oblast at Novozybkov.
Further on a field at Starie Bobovitshi, in the Vischkov region, in the surroundings of Svjatsk and at Glubotska, which are all in the contaminated area between Novozybkov and the BSSR border.

Byelorussia (BSSR):
In the Gomel oblast at the evacuated village of Babtsjin in the forbidden zone.
In Krasnoye Ozero, a village that is nominated to be evacuated.

Ukraine (UkSSR):
In Lokotkov, in the neighbourhood of Chernigov.
In the surroundings of Kiev.

1.2 Results

The samples were measured by gamma spectrometry at the State Institute for Quality Control of Agricultural Products ("RIKILT-DLO") at Wageningen, The Netherlands. For the analysis the samples were first homogenised and then the gamma radiation was measured, using a multichannel gamma spectrometer with a germanium detector. The standard deviation of the counting was below 2,5% in all cases. This means that with a 95 per cent probability the true values are between the reported values ± 5%.
Some strontium-90 measurements were performed by the University of Bremen, Germany. The samples were ashed, yttrium-90, daughter of strontium-90, was isolated and counted in a gas-flow Geiger-Müller tube.
The results are reported in Table 1A (in becqerel per kilogram) and 1B (in curie x 10^{-10} per kilogram, a unit currently used in the USSR).

The gamma radiation in the samples investigated turned out to be due to caesium-137, caesium-134 and potassium-40. No other radioactive compounds were found. In mushrooms and a few other food products strontium-90 is determined. This radionuclide, and other radionuclides which do not emit gamma radiation, were not further determined. In view of the data available about the distribution of these radionuclides in the environment, it is unlikely, that these will contribute noticeably to the contamination of food. According to information, obtained from Soviet scientists, the strontium-90 content in food in the contaminated areas is 10 % or less than the radiocaesium content; the contribution of other radionuclides, if any, may be neglected.
The radioactive contamination measured in milk, cheese, buttermilk, kasja, potatoes, cabbage, carrot, calabash, red beet and sugar beet ranged between 1 and 170 becquerel (0,3 x 10^{-10} and 45 x 10^{-10} curie) per kilogram fresh product for total radiocaesium, that is the sum of the radioactive nuclides caesium-137 and caesium-134. The mean value was 48 and the median 37 Bq/kg. In a sample of well water

radiocaesium was almost completely absent. As was expected, a sample of baby food, produced in Azerbeidzjan was not contaminated.
The content of natural potassium-40 ranged from less than 1 to 192 becquerel per kilogram (less than 0,2 to 52 x 10^{-10} Ci/kg) fresh product, with a mean of 92 and a median of 62 Bq/kg.
However, mushrooms and reindeer moss turned out to be very highly contaminated. The highest levels were found in samples from the evacuated village of Babtsjin, in a forbidden zone in the BSSR: 284 000 Bq/kg (76 500 x 10^{-10} Ci/kg) total radiocaesium in the fresh product. The contamination of reindeer moss from the same area was 255 000 Bq/kg (68 800 x 10^{-10} Ci/kg). The radiocaesium was also very high in mushroom samples from an unrestricted forest near Svjatsk in the RSFSR, near the border with the BSSR, and from the liquidator's hospital near Kiev: 112 000 and 103 000 Bq/kg (30 200 and 28 000 x 10^{-10} Ci/kg), respectively. This was not unexpected, as it is well known that mushrooms and mosses accumulate caesium very strongly.
The strontium-90 content of milk, kasja and cheese was 3,6, 1,8 and 30 Bq/kg (1, 0,5 and 8 x 10^{-10} Ci/kg), respectively. Strontium-90 in the above mentioned mushrooms samples was 340, 42 and 7,8 Bq/kg (90, 11 and 2 x 10^{-10} Ci/kg), and in reindeer moss 1550 Bq/kg (420 x 10^{-10} Ci/kg). The strontium-90 to radiocaesium ratio was $<$ 0,1 to 4 %, except in cheese. In cheese manufacturing, the major part of strontium but very little of caesium enters into the cheese (84,7 % of strontium-90 and 1,8 % of caesium-137 (3, 4)).

Foodstuff intervention levels following the Chernobyl accident have been adopted by the E.C. Council of Ministers, with the following maximum permitted radiocaesium levels, applicable to the import of food into the E.C.: 370 Bq/kg (100 x 10^{-10} Ci/kg) for milk and baby food and 600 Bq/kg (160 x 10^{-10} Ci/kg) for all other products (1,2). Some 20 non-Member States, including the USSR, have also adopted these levels. The contamination of all food products investigated are far below these tolerance levels. The measured radioactive contamination is about half of the natural potassium-40 content. It can be concluded that it will be very unlikely that the radioactive content of the food products investigated will cause any injurious effect to the health of the consumers and thus they can be eaten safely with respect to radioactive contamination. This conclusion will be confirmed in Part 3 where the *effect* on man of the radioactivity in the food will be discussed. Of course, the conclusion is restricted to the small number of samples investigated. Therefore, it will be advisable to create the opportunity for individual people

to have their own products tested. Then, the results of such measurements, and their impact on health, can be compared with the conclusions of this study. According to information, obtained when implementing the Dutch Gomel Project, sufficient food measuring equipment is available in the USSR now.
Mushrooms, however, are an exception. The Soviet authorities have forbidden people to gather and to eat mushrooms. In the light of our results, this is a wise decision.

1.3 Radioactivity in the environment

Besides food sampling and measurement, the exposure due to gamma radiation in the environment was measured, using a FAG-radiameter. (The same apparatus was used by the authorities in the BSSR; in all cases we found corresponding results for twin measurements.) Unless otherwise specified the measurements were carried out at 1 meter above ground level, the normal standard procedure. The results are calculated in microsievert per hour and collected in Table 2. The results are also converted to a radiation burden per year, ranging from 1,8 to 14 mSv/y, with a median value of about 4 mSv/y. At one 'hot spot' values of 21 to 39 mSv/y were measured.
1 mSv = 1 millisievert = 0.001 sievert
1 μSv = 1 microsievert = 0,001 millisievert = 0,000 001 sievert.

1.4 Consequences

In this part, we have given results of radioactivity in becquerel per kilogram (Bq/kg) and in 0,000 000 000 1 curie per kilogram (10^{-10} Ci/kg) in food products and in microsievert per hour (μSv/h) and millisievert per year (mSv/y) for the environment.
However, for many readers these terms will be abracadabra, or at least, the meaning and the consequences are unclear.
In Part 2 of this series we will explain the meaning of the terms. In Part 3 the consequences of the reported levels for the population will be discussed.

1.5 The Netherlands Chernobyl aid project

Based upon the experiences of the fact finding mission, an aid project has been formulated, which has been approved by the Netherlands Council of Ministers and accepted by the BSSR Government. The contract was undersigned on 5 September 1991. The project consists of establishing a centre in Gomel. The centre will provide a policlinic for general medical diagnosis and psychosocial counselling. Further, activities in the contaminated areas will be organised, including information to physicians and public.

2 SOME BACKGROUND INFORMATION ON RADIOACTIVITY

In the field of nuclear energy, radioactivity and risks of radiation, there is an overwhelming number of concepts and units, which for laymen are more confusing than explainatory. Fortunately, in order to understand what happens with radioactive material, and what are the risks for a person who is affected by radiation, only two concepts are of interest: **activity** and **dose**.

All material consists of atoms, which are generally in a stable state. Radioactive material consists of atoms, which are unstable and which spontaneously disintegrate into other, stable, atoms while emitting energy ('radioactive radiation'). Such radioactive atoms are called 'radionuclides'. For the quantity of radioactive material, scientists have introduced the concept of *activity*. This activity is measured in units called *becquerel* (Bq), after the man who discovered the phenomenon. One becquerel means one disintegration of an atom in one second. An older unit, the *curie* is 37 000 000 000 times larger than the becquerel (1 Ci = 3,7 x 10^{10} Bq), and much too large for practical use. Our mission noticed that in the USSR it is common to use 0, 000 000 000 1 curie as a unit (10^{-10} Ci; therefore we have also used this unit in Part 1 of this series). Due to the conversion of radionuclides into stable atoms the activity gradually diminishes. The process continues until at the end all radonuclides have disappeared, having been converted into stable atoms.

Also, when one kilogram of food 'has an activity' of 600 becquerel = 160 x 10^{-10} curie, it means that in one kilogram of food in one second 600 radioactive atoms decay to other atoms and thus 600 times in a second a little bit of radiation energy is released. Unless we should remain very very close to the food for a long period, the noted activity does not have any effect on our body. But, when we eat the food, the release of radiation energy takes place inside our body - of course until the radionuclides have been excreted or have all decayed to stable ones.

How harmful is radioactive radiation for our body? And how can we quantify this harm? The amount of *activity* is not enough for that. We have to consider the *effect* of the radiation. To make this clear, we can compare radioactive radiation with somebody who is attacking us. How painful, how harmful is that? That depends not only on how heavy the hit is, but also where we get knocked: on our head, our arm, our stomach. Further whether the attacker is using his bare hands or a club or something else. Also how long it goes on. Depending all these circumstances, the *effect* can vary between a scratch and severe injuries!

The same holds for radioactive radiation. The same amount in becquerels or curies of one kind of radionuclide is much more or much less harmful for us than another. Factors of influence include:

- how rapidly or how slowly the atoms decay to stable ones;
- how long the radioactive atoms, when consumed, remain in our body;
- the kind and the energy of the radiation.

This is illustrated in Scheme 1.

Most of the radionuclides, released during the Chernobyl disaster, are seen by the human body as 'foreign' material and therefore, when consumed, are excreted very rapidly. Only some of them are accumulated in the body, e.g. iodine in the thyroid, caesium in all muscular tissues and strontium in the bone marrow. So, altogether, there is a complex mixture of factors that determines the amount of danger. How can we get an idea about the risk that an amount of radioactivity can cause?

This problem has been studied by scientists for many years. They investigated the effects of radioactive radiation under numerous circumstances. These studies have been collected and evaluated. As a result of these studies, conclusions could be drawn about the harm of a distinct amount of a distinct radionuclide. An international body of scientists, the International Commission on Radiological Protection (ICRP), is engaged in considering the risks of radioactive radiation since 1923 already. Keeping all relevant factors in mind, this commission has related the **activity** and the **effect** in man which are typical for a specified radionuclide (5,6).

The effect in man is called **equivalent dose**, or shortly **dose**, and is measured in units called *sievert* (Sv). So the sievert is the measure for possibly harmful effects that activity can cause in our body. In practice, the *millisievert* (mSv = 0,001 Sv) or *microsievert* (μSv = 0,000 001 Sv) is used.

ICRP (6) estimated that consumption of 50 000 becqerel of caesium-134 or caesium-137 will cause an equivalent dose of 1 millisievert (1 mSv). For strontium-90 30 000 Bq equals 1 mSv. For other radionuclides other factors have been calculated.

SCHEME 1 RELATION BETWEEN NATURE OF **ATTACK** AND ITS **EFFECT**	
The *effect* of a 'classical' attack depends on:	The *effect of radiation* on the human body depends on:
The *kind* of weapon bare hands club hammer	The *kind* of radionuclide iodine-131 caesium-137 strontium-90
How *heavy* the weapon is	The *activity*, in becquerels or curies
The *force* of the impact	The *energy* of the radiation
The *persistance* of the attack	The *decrease* of the amount of radionuclide in the body (expressed in 'half life') iodine-131 caesium-137 strontium-90 7.7 days* 99 days* 7.4 years*
The *target area* of the attack head arm stomach	The place where the radionuclide *accumulates* iodine: thyroid caesium: whole body strontium: bone marrow
Over-all *effect*: bodily harm: no little heavy	Over-all *effect* in the body: **dose** expressed in millisieverts (mSv), which is a measure for the harm

* This is the effective half life in the body. After 1 half life half of the original amount of radioactive material is left, after 2 half lifes half of the remaining half, thus one quarter of the original amount is left, etc.

In the preceding part of this publication, we presented the *activities* of caesium-134, caesium-137 and of strontium-90, measured in food. The factors presented here, gives us the tool, to calculate from these activities the *effect* on our body, when we eat such food. That will be done in Chapter 3. Then we shall also take other sources of radiation into account.

SCHEME 2 **ACTIVITY AND DOSE**

Activity = amount of radioactive material (e.g. in food)

New unit: becquerel (Bq)

Old unit: curie (Ci)

1 Ci = 37 000 000 000 Bq

(In the USSR 10^{-10} Ci is often used as a handy unit :

10^{-10} Ci = 0, 000 000 000 1 Ci = 3,7 Bq)

Maximum tolerance levels in food after 'Chernobyl', in EC and in USSR:

- milk and milk products 370 Bq/kg = 100 x 10^{-10} Ci/kg
- other products 600 " = 160 "

Equivalent dose = biological effect of the radiation absorbed in the body

Unit: sievert (Sv)

millisievert (mSv) = 0,001 sievert

Conversion of becquerel (or curie) into sievert, in case of consumption of caesium-134 or caesium-137 and of strontium-90

50 000 Bq or 13 500 x 10^{-10} Ci radiocaesium causes 1 mSv

30 000 Bq or 8 100 x 10^{-10} Ci strontium-90 causes 1 mSv

Maybe the whole story is still too complicated for you. But you have only to keep in mind:

1 **Becquerels or curies tell you how hard the knock is that a person gets by radioactive radiation.**

2 **Sieverts tell you the effect of such knocking (or: millisievert = 0,001 sievert).**

3 **For each kind of radionuclide there are factors available to calculate the effect of a knock, thus to calculate sieverts from ingested becquerels or curies.**

3 RISK OF CONTAMINATION

In the first part of this series on radioactivity and radiation, we gave the results of measurements, carried out in the Netherlands and Germany on USSR food samples. In the second part, we related the *amount* (in becquerels or curies) of radioactivity to its *effect* in man (in sievert).

To get an impression on the harmfulness of the reported radioactivity in food and the environment are to man, we can compare the radiation burden due to artificial radioactivity with the radiation burden of natural radiation.

3.1 Risk of actual artificial radiation burden of food

It may be somewhat unexpected to the reader, but radioactivity in food is not only artificial. Food contains radioactivity by nature as well, and as long as mankind existed, it has been exposed to natural radioactivity in food. In addition to this, artificial contamination of food has taken place: due to the Chernobyl disaster, but also from nuclear bomb experiments in the 'sixties.

The yearly dose equivalent that we get from natural radioactivity in food is about 0,2 millisievert, mainly due to intake of the natural radioactive potassium-40. The total amount of potassium-40 inside the body is constant, and is a natural source of radiation in our own body.
But that is only a small part of the natural radiation which we get. Other, still more important sources are: cosmic rays, terrestrial rays and natural radiation in the environment.
For the world population, the individual dose is approximately 2,4 millisievert per year per caput (7). Typical doses, exposed to individuals, range between 1 and over 5 millisievert per year. The individual exposure to man depends on a.o. kind of soil, housing and social habits. On granite the radiation is higher than on sandy grounds, in the mountains higer than at sea level and in concrete houses higher than in wooden.

SCHEME 3 **FOOD CONSUMPTION** AND **DOSE**

Annual food consumption in USSR	365 kg of milk
	430 kg of other foodstuffs
Tolerance level milk	370 Bq/kg = 100 x 10^{-10} Ci/kg
other foodstuffs	600 Bq/kg = 160 x 10^{-10} Ci/kg

Actual radiocaesium contamination in food samples, as measured

1 - 170 Bq/kg = 0,3 - 45 x 10^{-10} Ci/kg

Extrapolation to annual food consumption results in an ingestion of

10 000 Bq/year = 2700 x 10^{-10} Ci/year

This amount corresponds with an equivalent dose from food consumption

0,2 millisievert per year

For comparison:

Dose from natural sources	approximately 2,4 millisievert per year
	(1 to over 5 mSv/y)

According to information obtained from the All-Union Scientific Research Institute of Agricultural Radiology in Obninsk, the mean consumption of a Soviet citizen is 365 kg of milk and milk products and 430 kg of other food products per year. If we extrapolate the mean contamination we have measured to this food packet, then this amount of food would lead to the intake of about 10 000 Bq or 2700 x 10^{-10} curie of radiocaesium.

In Part 2 we have learned that 50 000 becqerel of radiocaesium corresponds with 1 millisievert; thus the effect of 10 000 becqerel is a dose of 0,2 millisievert. Other radionuclides, including strontium-90, will not contribute substantially to the equivalent dose. (In the food products measured, strontium-90 was $<$0.1 to 4 % of radiocaesium.)

SCHEME 4 RISK OF EATING MUSHROOMS

	Contamination of mushrooms Cs-134 Bq/kg	Cs-137 Bq/kg		Consumption of 1 kg will cause a radiation burden
Babtsjin (forbidden zone)	24 000	260 000	--->	1,5 mSv
Svjatsk (open to public)	12 000	100 000	--->	0,6 mSv
Near Kiev (open to public)	11 000	92 000	--->	0,6 mSv

Compared with the radioactive burden we receive due to natural sources, the dose from this food is less than one tenth of the yearly natural dose and is within the variations of the natural dose. So we can conclude that we were right in Part 1, when we stated, that the food we investigated, can be regarded as safe for human consumption from the viewpoint of radioactive contamination.

3.2 Mushrooms

The consumption of mushrooms, however, is a matter to be discussed separately.
As reported in Table 1 of Part 1, mushrooms sampled in Babtsjin contained 284 000 Bq/kg radiocaesium (76 500 x 10^{-10} Ci/kg). Eating 1 kilogram of such mushrooms will cause a radiation burden of 284 000/ 50 000 = 5,7 millisievert.
Batsjin is in the forbidden area, which is blocked by the army, so nobody can reach these mushrooms. However, the mushrooms sampled in Svjatsk and near Kiev were not in restricted areas, and the contamination of these samples were

Svjatsk:	112 000 Bq/kg radiocaesium
Near Kiev:	103 000 "

Consumption of 1 kilogram of these mushrooms will cause an equivalent dose of over 2 millisievert.
The strontium-90 contamination of mushrooms is very small with respect to radiocaesium: 0,1 % or less.

If our information is right, in the USSR lovers of mushrooms may eat several kilograms of mushrooms per year. If they gather these products from contaminated areas, they will give themselves an additional radiation burden, which could have been avoided. That will not be wise and therefore it is a good decision that gathering of mushrooms is forbidden.

3.3 External exposure

Besides food sampling, the exposure due to gamma radiation in the environment was measured at various places in the contaminated areas. The results are reported in Table 2. The measurements in the urban areas yielded values which are in the same range as those obtained for the normal background in Western European countries. Since it has never been demonstrated that radiation originating from natural sources causes any health damage, it may be assumed that it is safe to live in these areas as for as exposure to external radiation is concerned. Some 'hot spots' in a forest or in closed areas clearly exceed dose levels that are presently been accepted as safe. Nevertheless, even these higher dose levels are not in a range to expect major health effects upon incidental exposure.

4 CONCLUSIONS

Twenty three agricultural products, originating from regions the RSFSR, BSSR and UkSSR, contaminated due to the Chernobyl disaster, have been investigated. The samples were contaminated with radiocaesium, as could be expected. However, the levels in all samples, except mushrooms, were far below the tolerance levels. It is very unlikely that these levels will have any harmful effect on man, when the food is consumed.

Besides food sampling, the exposure due to gamma radiation in the environment was measured at various places in the contaminated areas. In the urban regions the values were in the same range as for normal background. Concerning external radioactive radiation, it may be assumed that it is safe to live in these areas. Even higher values, found in some 'hot spots' are not in a range to expect major health effects upon incidental exposure.

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Table 1A. Amounts of radioactive caesium-137, caesium-131, potassium-40 and strontium-90 in samples of agricultural produce, sampled in the RSFSR, BSSR and UkSSR, by a fact finding mission of the Netherlands Government, October 1990
Results expressed in becquerel per kilogram (Bq/kg)

Product	Sampling site	Origin	Date of production	Cs-134	Cs-137	K-40	Sr-90
Samples from the RSFSR, Bryansk Oblast							
Date of sampling: 1990-10-27							
Milk	Dairy combinate at Novozybkov	Kolchoze 'Snovskoje'	1990-10-26	4	37	59	
Milk	Dairy combinate at Novozybkov	Kolchoze 'Krasni Kljutsj'	1990-10-26	10	89	< 3	3,6
Cheese	Dairy combinate at Novozybkov		1990-09-09	3	24	25	30
Buttermilkpowder	Dairy combinate at Novozybkov		1990-10-25	170	1530	510	
Recalculated to buttermilk (= about 1 : 10)				± 17	± 150	± 50	
Milk	Foodshop in Novozybkov	Potsjop	?	< 0,1	1	41	
Babyfood (apple + sugar)	Foodshop in Novozybkov	Azerbeidzjan	?	< 0,5	3	31	
Kasja	Foodshop in Novozybkov	Foodcombinate Novozybkov	?	16	133	57	1,8
Cabbage	Starie Bobovitshi	Stari Bobovitshi	1990-10-27	6	56	85	
Potatoes	Combinate Vischkov	Surroundings of Vischkov	-	2	14	167	
Mushrooms	Surroundings of Svjatsk	-	1990-10-27	12 000	100 000	< 50	42
Milk	Glubotska	Glubotska	1990-10-27	10	83	46	

Samples from the BSSR

Date of sampling: 1990-10-28

Mushrooms*	Babtsjin, forest near pigs farm	-	-	24 000	260 000	< 50	340
Reindeer moss	Babtsjin	-	-	25 000	230 000	< 20	1550
Carrot	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	2	9	180	
Red beet	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	1	7	143	
Sugar beet	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	< 0,2	4	100	
Potatoes	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	1	13	192	
Calabash	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	< 0,2	3	73	

Samples from the UkSSR

Date of sampling 1990-10-30 and 1990-10-31

Milk	Lokotkov	(Surroundings of) Lokotkov	-	15	136	62	
Water	Lokotkov (waterwell of house)	(Surroundings of) Lokotkov	-	< 0,1	0,5	< 0,8	
Red beet	Lokotkov	(Surroundings of) Lokotkov	-	3	34	175	
Potatoes	Lokotkov	(Surroundings of) Lokotkov	-	4	33	176	
Mushrooms	Hospital near Kiev	-	-	11 000	92 000	320	7,8

* This sample consisted of a mixture of the following edible mushrooms:
Byely Grip (Dorovik) (Boletus edulis), Grip Poski, Zelyonka (Tricholoma flavovirens), Reshyetnik (Suillus bovinus) and Podzelyonka.

Table 1B. Amounts of radioactive caesium-137, caesium-131, potassium-40 and strontium-90 in samples of agricultural produce, sampled in the RSFSR, BSSR and UkSSR, by a fact finding mission of the Netherlands Government, October 1990
Results expressed in 10^{-10} curie per kilogram (10^{-10} Ci/kg)

Product	Sampling site	Origin	Date of production	Cs-134	Cs-137	K-40	Sr-90
Samples from the RSFSR, Bryansk Oblast							
Date of sampling: 1990-10-27							
Milk	Dairycombinate at Novozybkov	Kolchoze 'Snovskoje'	1990-10-26	1	10	16	
Milk	Dairycombinate at Novozybkov	Kolchoze 'Krasni Kljutsj'	1990-10-26	3	24	< 1	1
Cheese	Dairycombinate at Novozybkov	-	1990-09-09	1	6	7	8
Buttermilkpowder	Dairycombinate at Novozybkov	-	1990-10-25	46	410	140	
Recalculated to buttermilk (= about 1 : 10)				± 5	± 40	± 14	
Milk	Foodshop in Novozybkov	Potsjop	?	< 0,03	0,3	11	
Babyfood (apple + sugar)	Foodshop in Novozybkov	Azerbeidzjan	?	< 0,1	1	8	
Kasja	Foodshop in Novozybkov	Foodcombinate Novozybkov	?	4	36	15	0,5
Cabbage	Starie Bobovitshi	Stari Bobovitshi	1990-10-27	2	15	23	
Potatoes	Combinate Vischkov	Surroundings of Vischkov	-	0,5	4	45	
Mushrooms	Surroundings of Svjatsk	-	1990-10-27	3200	27 000	< 14	11
Milk	Glubotska	Glubotska	1990-10-27	3	22	12	

Samples from the BSSR

Date of sampling: 1990-10-28

Mushrooms*	Babtsjin, forest near pigs farm	-	-	6500	70 000	< 14	90
Reindeermoss	Babtsjin	-	-	6800	62 000	< 5	420
Ibid + ground		-	-	9200	84 000	< 14	
Carrot	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	0,5	2	49	
Red beet	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	0,3	2	39	
Sugar beet	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	< 0,05	1	27	
Potatoes	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	0,3	4	52	
Calabash	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	< 0,05	1	20	

Samples from the UkSSR

Date of sampling 1990-10-30 and 1990-10-31

Milk	Lokotkov	(Surroundings of) Lokotkov	-	4	37	17	
Water	Lokotkov (waterwell of house)	(Surroundings of) Lokotkov	-	< 0,03	0,1	< 0,2	
Red beet	Lokotkov	(Surroundings of) Lokotkov	-	1	9	47	
Potatoes	Lokotkov	(Surroundings of) Lokotkov	-	1	9	48	
Mushrooms	Hospital near Kiev	-	-	3000	25 000	86	2

* This sample consisted of a mixture of the following edible mushrooms:
Byely Grip (Dorovik) (Boletus edulis), Grip Poski, Zelyonka (Tricholoma flavovirens), Reshyetnik (Suillus bovinus) and Podzelyonka.

Table 2. Exposure by radioactive radiation (1 m height, unless otherwise specified)

Date	Place	Exposure	
		μSv/h *)	mSv/year *)
26-10-1990	Novozybkov	0,5 - 0,9	4,3 - 7,9
"	Stari Bobovitshi	1,5 - 1,6	13 - 14
"	Contaminated forest near Novozybkov ('hot spot')	2,4 - 2,8	21 - 24
"	Ibid.	3,5 - 4,5	31 - 39
"	Ibid., on ground surface **)	7	61
"	Forest near Glubotska	0,5	4,3
2-10-1990	Gomil, hotel Tourist	0,2 - 0,5	1,8 - 4,3
"	Forest, south of Gomil	0,4	3,5
"	Chojniki	0,2	1,8
"	Babsjin (entrance forbidden zone)	0,7	6
"	Babsjin, school (in forbidden zone)	0,5	4,3
"	Ibid., on ground surface **)	3	26
"	Babsjin, in forest	0,5	4,3
"	Ibid., in reindeer moss on ground surface **)	6	52
For comparison:			
	world		1 - 5
	The Netherlands		2,4
	Belgium		4,3
	France, granite areas		5 - 10
	In airplane, between the Netherlands and USSR	2	18
	Moscow	0,2	1,8

*) mSv = millisievert = 0,001 sievert

μSv = microsievert = 0,001 millisievert = 0,000 001 sievert

**) Not representative for average exposure