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Radioactive contamination of food in the USSR, sampled in regions contaminated by the Chernobyl disaster, and of radioactive exposure in these regions (Cs-137 and K-40 in food)

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ABSTRACT

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

Report 91.22 June 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, 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 and their radioactive contamination was measured by the Netherlands State Institute for Quality Control of Agricultural Products ("RIKILT") at Wageningen, The Netherlands.

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.

The content of natural potassium-40 ranged from 25 to 200 becquerel per kilogram (7 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.

The maximum tolerance levels in EC countries for total radiocaesium is 370 Bq/kg (100 x 10^{-10} Ci/kg) in milk and milk products and 600 Bq/kg (160 x 10^{-10} Ci/kg) in other food products (1). 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 contamination with radiocaesium.

More important for the population is not the contamination itself (expressed in becquerel or curie), but the probable harmful effects in the body. The measure for this is the equivalent dose, expressed in millisievert (mSv). Extrapolating the results of the contamination measurements to the total food consumption, the radioactive burden due to food is estimated to be 0,8 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 39 mSv/year at a height of 1 metre, with a median value of about 5 mSv/y. According to the Health Council of the Netherlands (2), for levels up to 5 mSv/y after a nuclear accident, no countermeasures are recommended, see Scheme 4.

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 polyclinic for general medical diagnosis and psychosocial counselling. Further, activities in the contaminated areas will be organised, including public information meetings and (mobile or fixed) facilities for the examination of any food which might be contaminated, including food from the local population. The equipment will offer the local population the opportunity of having the radioactive contamination of their own products measured.

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. Their radioactivity was measured in The Netherlands.

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

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%. The samples were measured at the State Institute for Quality Control of Agricultural Products ("RIKILT") at Wageningen, The Netherlands by T.D.B. van der Struijs.
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. Strontium-89 and strontium-90, and other radionuclides which do not emit gamma radiation, were not determined. However, in view of the data available about the distribution of these radionuclides in the environment, it is unlikely, that these will contribute substantially to the contamination of food.
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 25 to 200 becquerel per kilogram (7 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 and of reindeer moss with adherent soil was of the same order of magnitude. 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 (30 000 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.

According to the regulations of the twelve countries of the European Community, the maximum tolerance level for total radiocaesium is 370 Bq/kg (100 x 10^{-10} Ci/kg) in milk and milk products and 600 Bq/kg (160 x 10^{-10} Ci/kg) in other food products (1). These tolerance levels have been accepted by 23 other countries, including the USSR. The contamination of all food products inverstigated are far below these tolerance levels. Generally speaking, the contamination with radiocaesium is of the same level as 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 with radiocaesium. 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 good for people to get an opportunity of having the radioactive contamination of their own products measured, as is proposed in the Netherlands aid project.
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 39 mSv/y, with a median value of about 5 mSv/y.

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 USSR Government. The project consists of establishing a centre in Gomel. The centre will provide a polyclinic for general medical diagnosis and psychosocial counselling. Further, activities in the contaminated areas will be organised, including public information meetings and (mobile or fixed) facilities for examination of any food which might be contaminated, including food from the local population. As result of this project, the local population will get the opportunity of having the radioactive contamination of their own products measured.

2 A LITTLE BIT OF THEORY ABOUT 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 equivalent 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 particles or energy (= called '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. We 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 the energy we get from radiation with the energy we receive from somebody who knocks us. How painful, how harmful is such knock? That depends not only on the power of the knock, 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. Depending on the weapon and the place of attack, 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.

We saw above, that radioactive atoms spontaneously decay to stable atoms. When all atoms have decayed, there is no radioactivity left. Each specified kind of radioactive atom decays at a fixed velocity. The velocity is measured by the 'half-life' of that radionuclide, that is the time during which half of the original atoms have decayed. After two half-lives half of the half, that is one quarter is left, and so on. Half-lives can vary widely: from fractions of seconds to many millions of years. A few examples, which are of interest to us in the context of the Chernobyl disaster are: iodine-131 : 8,05 days; caesium-137: 30 years; caesium-134: 2,2 years; potassium-40: 1 300 000 000 years. (Chemists distinguish a number of elements, which are atoms of the same kind: iron, copper, oxygen, carbon, etc. But within one kind, the weight of the atoms or nuclides can differ, therefore, when relevant, this weight is indicated by a number after the name. It depends on its weight whether or not an atom is stable or radioactive. Here it is not neccessary to go into details, but for example for the element carbon the nuclide carbon-12 is stable, but the nuclide carbon-14 is radioactive. The normal, stable iodine is iodine-127, and for the element caesium the nuclide caesium-133 is stable, whereas iodine-131, caesium-134 and caesium-137 are radioactive nuclides.)

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 tissue and strontium in the bone marrow. Also the type and the energy of the radiation can vary, and is of influence as well. Scientists distinguish so-called alpha, beta and gamma radiation.

So, altogether, there is a complex mixture of factors which determines the amount of danger. How can we get an idea about the risk that a particular activity can cause?
Fortunately, there is an international body, the International Commission on Radiological Protection (ICRP), which has been engaged in considering the risks of radioactive radiation since 1923. Keeping all relevant factors in mind, this commission has related the activity and the effect in man which are typical for a specified radionuclide (3,4).
The effect in man is called equivalent 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 (4) estimated that consumption of 50 000 becqerel of caesium-134 or caesium-137 will cause an equivalent dose of 1 millisievert (1 mSv). For other radionuclides other factors have been calculated.

In the preceding part of this publication, we presented the activities of caesium-134 and of caesium-137, measured in food. The factor 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.

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.**

SCHEME 1

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, 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

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

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 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 of how harmful the reported radioactivity in food and the environment are to man, we can apply two approaches. The first is to compare the radiation burden due to artificial radioactivity with the radiation burden of natural radiation. Both burdens are expressed in millisievert. The second approach is to compare the actual radiation burden with decision criteria for countermeasures stated in the case of nuclear reactor accidents.

3.1 Actual artificial radiation burden compared with natural radiation burden

It may be somewhat unexpected to the reader, but radioactivity in food is not only artificial. Food contains radioactivity by nature as well, and since Adam and Eve until today man has eaten food containing radioactivity. This concerns mainly the radionuclides carbon-14 and potassium-40. In addition to this, artificial contamination of food has taken place nowadays: due to the Chernobyl disaster, but also from nuclear bomb experiments. The artificial radioactivity nowadays is mainly due to caesium-137 and caesium-134.

Shortly after an accident, short-lived radionuclides are dominant. But after some years the radioactivity of radionuclides having longer half-lives remains. 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 still only a part of the natural radiation which we get. Other, still more important sources are: cosmic rays, terrestrial rays and natural radiation in the environment.

Worldwide, the radiation in uncontaminated areas is approximately 2,5 millisievert per year, but is varying over a wide range between 2 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.

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 assume that all food should be contaminated at the tolerance level (i.e. 370 Bq/kg or 100 x 10^{-10} Ci/kg for milk and milk products and 600 Bq/kg or 160 x 10^{-10} Ci/kg for other foodstuffs), then this amount of food would lead to the intake of about 400 000 Bq or 100 000 x 10^{-10} curie of radiocaesium (365 x 370 + 430 x 600 Bq and 365 x 100x10^{-10} + 430 x 600x10^{-10} Ci, respectively).

However, what we have measured in the USSR food samples taken during our mission, is far below the maximum tolerance, roughly less than one tenth. So, when we extrapolate these results to the diet, the real yearly intake can be estimated at 40 000 Bq or 10 000 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 40 000 becqerel is a dose of 0,8 millisievert.

Compared with the radioactive burden we receive due to natural sources, the dose from this food is one third or less 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.

SCHEME 2

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

Measured radiocaesium contamination in food samples

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

Extrapolation of this figure gives an estimated equivalent dose from food consumption

0,8 millisievert per year

For comparison:

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

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. Thus eating 1 kilogram of such mushrooms causes a dose which is 7 x that of the normal diet intake in one year! 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, i.e. 2,5 x the radiation burden due to the yearly total diet intake.

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 unacceptable high radiation burden. That will not be wise and therefore it is a good decision that gathering of mushrooms is forbidden.

SCHEME 3

	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

3.3 Actual radiation burden in food compared with decision criteria in the case of nuclear reactor accidents

In many countries decision criteria have been stated for the implementation of certain countermeasures in the case of nuclear reactor accidents. In the Netherlands this has been done by the 'Health Council of the Netherlands' (2). In 1986 this committee specified 'intervention levels' with respect to the most important countermeasures, which are evacuation (and relocation), sheltering, iodine prophylaxis and the restriction of the consumption of foodstuffs and water.

For each countermeasure the committee proposes, similar to the recommendations of various international bodies, a range of intervention levels. Using information about the course of the accident and, where possible, the results of environmental measures, the equivalent dose for the individuals at risk in the absence of any countermeasures will be estimated. As long as the number of millisieverts of the dose remains below the lower bound of the intervention level range, the countermeasures will generally not be justified. When the dose exceeds the upper bound of the range of intervention levels, the countermeasures will be implemented in practically all cases. Where there is an intermediate value, considerations of feasibility will determine the excecution of the countermeasure.

The Dutch Health Council recommended a range of intervention levels of 5 to 50 mSv for sheltering and restriction of food and water intake and of 50 to 500 mSv for evacuation. (These levels are based on the dose in the whole body, as is the case for radiocaesium.) The Scheme 4 clarifies the relationship between dose levels and advised countermeasures.

We have found, that our results on food contamination, when extrapolated over the total diet, will cause a dose level of 0,8 mSv per year, which is small with respect to the intervention levels.

Thus from this approach also, it can be concluded that the food which we have investigated can be regarded as safe.

3.4 Actual exposure in the environment compared with decision criteria in case of nuclear reactor accidents

Regarding the measurements in the environment, the exposure by radioactive radiation varied between 1,8 and 39 millisievert per year, with a median value of about 5 mSv/y. According to the intervention levels of the Dutch Health Council, in most cases no countermeasure at all has to be considered. On some places the feasibility of the countermeasure 'restriction of food and water' could be considered. In practice, this means: consider the feasibility of supplying uncontaminated food. Nowhere a motive existed for the countermeasure 'evacuation'.

3.5 Conclusions

23 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 below the tolerance levels. It is very unlikely that these levels will have any harmful effect to 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 most cases there was no motive for countermeasures. On some places the feasibility of the countermeasure 'restriction of food and water', i.e. supplying of uncontaminated food could be considered. Nowhere, a motive for evacuation existed.

SCHEME 4

Intervention Levels of the Health Council of the Netherlands (2)

	Countermeasure	
Dose level	Sheltering Restriction of food and water	Evacuation
Less than 5 mSv	No	No
Between 5 and 50 mSv	Consider feasibility	No
Between 50 and 500 mSv	Yes	Consider feasibility
Over 500 mSv	Yes	Yes

TABLES

Table 1A. Amounts of radioactive caesium-137, caesium-131 and potassium-40 in samples of agricultural produce, sampled in the RSFSR, BSSR and UkSSR, by a fact finding mission of the Netherlands Government, October 1990
Results as measured by the Netherlands 'State Institute for Quality Control of Agricultural Products' by gamma spectrometry and expressed in becquerel per kilogram (Bq/kg)

No	Product	Sampling site	Origin	Date of production	Cs-134	Cs-137	K-40
	Samples from the RSFSR, Bryansk Oblast						
	Date of sampling: 1990-10-27						
1	Milk	Dairy combinate at Novozybkov	Kolchoze 'Snovskoje'	1990-10-26	4	37	59
2	Milk	Dairy combinate at Novozybkov	Kolchoze 'Krasni Kljutsj'	1990-10-26	10	89	< 3
3	Cheese	Dairy combinate at Novozybkov		1990-09-09	3	24	25
4	Buttermilkpowder	Dairy combinate at Novozybkov		1990-10-25	170	1530	510
	Recalculated to buttermilk	(= about 1 : 10)			± 17	± 150	± 50
5	Milk	Foodshop in Novozybkov	Potsjop	?	< 0,1	1	41
6	Babyfood (apple + sugar)	Foodshop in Novozybkov	Azerbeidzjan	?	< 0,5	3	31
7	Kasja	Foodshop in Novozybkov	Foodcombinate Novozybkov	?	16	133	57
8	Cabbage	Starie Bobovitshi	Stari Bobovitshi	1990-10-27	6	56	85
9	Potatoes	Combinate Vischkov	Surroundings of Vischkov	-	2	14	167
10	Mushrooms	Surroundings of Svjatsk	-	1990-10-27	12 000	100 000	< 50
11	Milk	Glubotska	Glubotska	1990-10-27	10	83	46

Samples from the BSSR

Date of sampling: 1990-10-28

21	Mushrooms*	Babtsjin, forest near pigs farm	-	-	24 000	260 000	< 50
22	Reindeer moss	Babtsjin	-	-	25 000	230 000	< 20
	Ibid + ground		-	-	34 000	310 000	< 50
23	Carrot	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	2	9	180
24	Red beet	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	1	7	143
25	Sugar beet	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	< 0,2	4	100
26	Potatoes	Krasnoye Ozero	(Surroundings of) Krasnoye Ozero	-	1	13	192
27	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

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

* 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 and potassium-40 in samples of agricultural produce, sampled in the RSFSR, BSSR and UkSSR, by a fact finding mission of the Netherlands Government, October 1990

Results as measured by the Netherlands 'State Institute for Quality Control of Agricultural Products' by gamma spectrometry and expressed in 10^{-10} curie per kilogram (10^{-10} Ci/kg)

No	Product	Sampling site	Origin	Date of production	Cs-134	Cs-137	K-40
Samples from the RSFSR, Bryansk Oblast							
Date of sampling: 1990-10-27							
1	Milk	Dairycombinate at Novozybkov	Kolchoze 'Snovskoje'	1990-10-26	1	10	16
2	Milk	Dairycombinate at Novozybkov	Kolchoze 'Krasni Kljutsj'	1990-10-26	3	24	< 1
3	Cheese	Dairycombinate at Novozybkov	-	1990-09-09	1	6	7
4	Buttermilkpowder	Dairycombinate at Novozybkov	-	1990-10-25	46	410	140
	Recalculated to buttermilk	(= about 1 : 10)			± 5	± 40	± 14
5	Milk	Foodshop in Novozybkov	Potsjop	?	< 0,03	0,3	11
6	Babyfood (apple + sugar)	Foodshop in Novozybkov	Azerbeidzjan	?	< 0,1	1	8
7	Kasja	Foodshop in Novozybkov	Foodcombinate Novozybkov	?	4	36	15
8	Cabbage	Starie Bobovitshi	Stari Bobovitshi	1990-10-27	2	15	23
9	Potatoes	Combinate Vischkov	Surroundings of Vischkov	-	0,5	4	45
10	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

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

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

* 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

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	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., on ground surface	6	52
For comparison:			
	The Netherlands		2
	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

LITERATURE

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