



Scientific Facts on the Chernobyl Nuclear Accident

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Level 2 - Details on the Chernobyl Nuclear Accident

Introduction.....	3
1. What was the extent of the Chernobyl accident?.....	3
2. How has human health been affected by the Chernobyl accident?.....	4
2.1 How much radiation were people exposed to?.....	4
2.2 What is the death toll of the Chernobyl accident?.....	5
2.3 What diseases are linked to the accident?.....	6
2.4 Have there been or will there be any effects on reproduction?.....	7
2.5 What was the psychological impact on exposed populations?.....	7
3. How has the environment been affected by the Chernobyl accident?.....	7
3.1 To what extent have urban areas been contaminated?.....	8
3.2 To what extent have agricultural areas been contaminated?.....	8
3.3 To what extent have forests been contaminated?.....	9
3.4 To what extent have water bodies been contaminated?.....	9
3.5 How did radiation affect plants and animals?.....	9
4. How are highly contaminated areas managed?.....	10
4.1 What has been done to reduce exposure in contaminated areas?.....	10
4.2 What has been done to confine the damaged reactor and nuclear waste?.....	11
4.3 What is the future of the restricted access area surrounding the site?.....	11
5. What are the social and economic costs of the Chernobyl accident?.....	12
5.1 What was the economic cost of the Chernobyl accident?.....	12
5.2 How has the local economy been affected?.....	12
5.3 How have local communities and individuals been affected?.....	13
5.4 What policies have governments adopted to help affected populations?.....	13
6. What are the current concerns and needs of affected people?.....	14
6.1 What worries people living in the affected regions?.....	14
6.2 What are the current needs of various affected groups?.....	15

This Digest is a faithful summary of the leading scientific consensus report produced in 2006 by the UN Chernobyl Forum:
"Chernobyl's legacy: Health, Environmental and Socio-Economic Impacts"

The full Digest is available at: <https://www.greenfacts.org/en/chernoby/>



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- Level 3 consists of the Source document, the internationally recognised scientific consensus report which is faithfully summarised in Level 2 and further in Level 1.

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Introduction

The Chernobyl nuclear facility is located in Ukraine about 20 km south of the border with Belarus. At the time of the accident, the plant had four working reactors (units 1, 2, 3, and 4).

The accident occurred in the very early morning of 26 April 1986 when operators ran a test on an electric control system of unit 4. The accident happened because of a combination of basic engineering deficiencies in the reactor and faulty actions of the operators. The safety systems had been switched off, and the reactor was being operated under improper, unstable conditions, a situation which allowed an uncontrollable power surge to occur. This power surge caused the nuclear fuel to overheat and led to a series of steam explosions that severely damaged the reactor building and completely destroyed the unit 4 reactor.

The explosions started numerous fires on the roofs of the reactor building and the machine hall, which were extinguished by firefighters after a few hours. Approximately 20 hours after the explosions, a large fire started as the material in the reactor set fire to combustible gases. The large fire burned during 10 days. Helicopters repeatedly dumped neutron-absorbing compounds and fire-control materials into the crater formed by the destruction of the reactor and later the reactor structure was cooled with liquid nitrogen using pipelines originating from another reactor unit.

The radioactive materials from the damaged reactor were mainly released over a 10-day period. An initial high release rate on the first day resulted from the explosions in the reactor. There followed a five-day period of declining releases associated with the hot air and fumes from the burning graphite core material. In the next few days, the release rate increased until day 10, when the releases dropped abruptly, thus ending the period of intense release. The radioactive materials released by the accident deposited with greatest density in the regions surrounding the reactor in the European part of the former Soviet Union.

1. What was the extent of the Chernobyl accident?

The Chernobyl accident is the most serious accident in the history of the nuclear industry. Indeed, the explosions that ruptured one of the reactors of the Chernobyl nuclear power plant and the consequent fire that started on the 26 April 1986 and continued for 10 days resulted in an unprecedented release of radioactive materials into the environment.

The cloud from the burning reactor spread many types of radioactive materials, especially iodine-131 and caesium-137, over much of Europe. Because radioactive iodine disintegrates rapidly, it largely disappeared within the first few weeks of the accident. Radioactive caesium however is still measurable in soils and some foodstuffs in many parts of Europe. The greatest concentrations of contamination occurred over large areas of the Soviet Union surrounding the reactor in what are now the countries of Belarus, the Russian Federation and Ukraine.

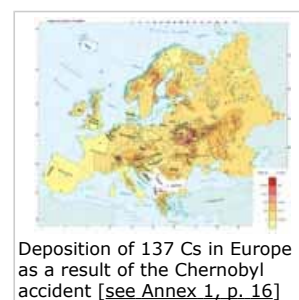
Since the accident, 600 000 people have been involved in emergency, recovery, containment, and cleaning operations although only a small proportion of them have been exposed to



Where is Chernobyl?
[see Annex 11, p. 22]



The destroyed reactor
Source: Chernobyl Forum



Deposition of ¹³⁷Cs in Europe
as a result of the Chernobyl
accident [see Annex 1, p. 16]

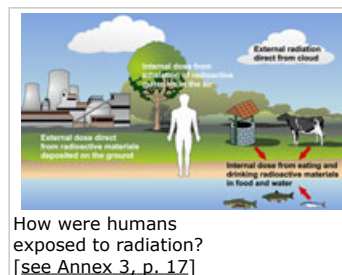
dangerous levels of radiation. Those who received the highest doses of radiation were the emergency workers and personnel that were on-site during the first days of the accident (approximately 1000 people).

More than five million people live in areas of Belarus, Russia and Ukraine that are significantly ¹ [see Annex 6, p. 19] contaminated with caesium-137 from the Chernobyl accident. 400 000 of these people lived in very contaminated areas classified as "areas of strict control" by Soviet authorities. Within this region, the area closest to the Chernobyl power plant was most heavily contaminated and has been designated as the "Exclusion Zone". The 116 000 people who lived there were evacuated in the spring and summer of 1986 to non-contaminated areas, and 220 000 more were relocated in the following years.

2. How has human health been affected by the Chernobyl accident?

People were exposed to radiation from the Chernobyl accident through two routes:

- Externally, directly from the radioactive cloud and from radioactive materials deposited on the ground.
- Internally, from breathing radioactive materials in the air or from eating and drinking radioactive materials in food.



Human exposure to ionizing radiation such as alpha, beta, gamma and other kinds of radiation, can be expressed as

- "absorbed dose", measured in gray (Gy [see Annex 8, p. 20]), which refers to the amount of energy absorbed by the body, or
- "effective dose", measured in millisieverts (mSv [see Annex 8, p. 20]), which reflects the health risk linked to the exposure (taking into account different types of radiation, its biological effectiveness, and the sensitivity of different organs).

For gamma radiation, for instance, 1 Gy [see Annex 8, p. 20] of absorbed dose is equal to 1 Sv [see Annex 8, p. 20] of effective dose.

2.1 How much radiation were people exposed to?

If the human body absorbs a dose of a few of grays [see Annex 8, p. 20] external radiation, it may cause acute radiation syndrome (ARS). Workers who were near the reactor at the time of the accident and shortly afterwards received high doses from external gamma radiation (2 - 20 Gy [see Annex 8, p. 20]), which were fatal to some of them.

The effective dose to which humans across the world are exposed as a result of natural background radiation typically ranges from 1 to 10 mSv [see Annex 8, p. 20] per year. In addition humans may be exposed to radiation from man-made sources and the recommended dose limit for the general public is 1 mSv per year.

With the exception of the on-site reactor personnel and the emergency workers who were present near the destroyed reactor during the time of the accident and shortly afterwards, most recovery operation workers and people living in the contaminated territories received relatively low whole-body radiation doses, comparable to background radiation levels.



Evacuees from the Chernobyl accident were exposed to average doses of 33 mSv [see Annex 8, p. 20] , and individual doses sometimes reached several hundred mSv. The majority of the five million people living in contaminated areas of Belarus, Russia and Ukraine currently receive an annual dose below the recommended limit for the general public. However, about 100 000 residents of the more contaminated areas are still exposed to doses higher than 1 mSv per year.

Through food containing radioactive iodine, some people received high internal doses of radiation, particularly in the thyroid gland. Indeed, the average effective dose of radiation observed in the thyroid of people living in contaminated areas ranged from 0.03 to 0.3 and reached up to 50 Gy in some individuals.

Children who had consumed milk from cows that had eaten contaminated grass were particularly affected, and many of them went on to develop thyroid cancer. Some people, such as those living in Pripjat, very near the Chernobyl power plant, were given stable iodine tablets which substantially reduced the amount of radioactive iodine accumulated by their thyroid glands.

Table: Average accumulated doses among liquidators, evacuees and local residents [see Annex 10, p. 21]

2.2 What is the death toll of the Chernobyl accident?

The number of deaths attributable to the Chernobyl accident has been of great interest to the public. Confusion about the impact of the accident has given rise to highly exaggerated claims that tens or even hundreds of thousands of persons have died as a result of the accident. In fact, since the accident, many emergency and recovery operation workers as well as people who lived in 'contaminated' territories have died of diverse natural causes that are not attributable to radiation.



Source: Chernobyl Forum

In 1986, 134 emergency workers who received high doses of radiation were diagnosed with **acute radiation syndrome** (ARS) and 28 of them died from it during the first months after the accident. However, the general population exposed to the Chernobyl fallout did not suffer from ARS, as the radiation doses received were relatively low.

Regarding possible **deaths from cancer**, an international expert group predicts that among the 600 000 persons receiving more significant exposures (liquidators working in 1986–1987, evacuees, and residents of the most 'contaminated' areas), the possible increase in cancer mortality due to this radiation exposure might be up to a few per cent, which might eventually represent up to four thousand fatal cancers. This estimate was made for public health planning purpose and mostly reflects the order of magnitude rather than a definite number.

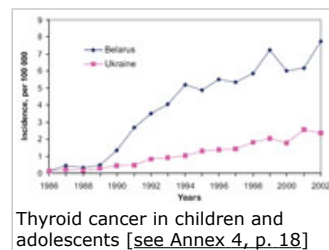
Among the general population living in other 'contaminated' areas, the doses received were much lower and any increases in cancer mortality are expected to be much less than one per cent. Between 1992 and 2002, among those who were children or adolescents at the time of the accident, 15 people died from thyroid cancer.

It is difficult to tell precisely how many deaths have been caused by the Chernobyl accident in the past 20 years as people who were exposed to additional low levels of radiation from the accident have been dying from the same causes as unexposed people. It is even harder

to predict the possible number of future deaths. Therefore the exact death toll of the accident is likely to remain unknown.

2.3 What diseases are linked to the accident?

2.3.1 The thyroid gland naturally accumulates iodine from the blood stream, as a normal functioning mechanism, and is the organ most likely to develop cancer after exposure to iodine-131. Because large amounts of radioactive iodine were released as a result of the Chernobyl accident, the thyroid glands of local residents received considerable doses through breathing and through consuming contaminated foods, especially milk. Children are particularly vulnerable and there has been a substantial increase in thyroid cancer among people who were exposed as children.



Thyroid cancer in children and adolescents [see Annex 4, p. 18]

More than 4000 cases of **thyroid cancer** were diagnosed in Belarus, Russia and Ukraine between 1992 and 2002 among those who were children and adolescents at the time of the accident. Most of these cancers can be attributed to radiation. The majority of those patients have been treated successfully. New cases are expected to be diagnosed for many more years. It should be noted that early mitigation measures (distribution of iodine tablets and evacuation) helped substantially to minimize the health consequences of the accident.

2.3.2 Ionizing radiation is an established cause of certain types of **cancer**, namely leukaemia (except Chronic Lymphocytic Leukaemia or CLL) and solid cancers. It may also increase the risk of **cardiovascular diseases** in population groups exposed to higher doses such as atomic bomb survivors or radiotherapy patients.

Between 1986 and 1996, the number of cases of non-CLL leukaemia doubled among Russian workers who had been exposed to external doses higher than 150 mGy [see Annex 8, p. 20]. However, the risk of radiation-induced leukemia is likely to decrease in the future, because it usually takes up to 10 years from the moment of exposure to develop radiation-induced leukemia.

Russian emergency and recovery operation workers also seem to have more solid cancers and possibly more cardiovascular diseases than the general population. However, the higher levels of cardiovascular diseases could also be caused by other factors such as stress and unhealthy lifestyles. Nonetheless, highly-exposed Chernobyl workers should continue to receive medical care and annual examinations.

In contrast, in the general population of the contaminated regions, there has been, so far, no convincing evidence that Chernobyl has had any effect on the leukaemia or solid cancers risk, except for childhood thyroid cancer.

An absence of evidence of increased cancer risk does not mean that this increase has not occurred. An increase like this would be very difficult to detect without large scale epidemiological studies, and that given the large number of people exposed, small variations in statistical projections can greatly affect the number of expected cancer cases.

2.3.3 People who have been exposed to radiation doses higher than 0.25 Gy [see Annex 8, p. 20] may develop cataracts. Continued follow-up studies of the Chernobyl populations will allow scientists to predict more accurately the risk of developing radiation-induced cataracts and any resulting vision problems.

2.4 Have there been or will there be any effects on reproduction?

There is no convincing evidence of any direct effects on fertility of exposure to radiation among the general population of Chernobyl-affected regions.

Because most people received relatively low doses of radiation, it is unlikely that any effects will be seen in future. Birth rates may be lower in contaminated areas because of concern about having children, the very high number of medical abortions, and the fact that many younger people have moved away.

The doses received are also unlikely to have any effect on the number of stillbirths, miscarriages, delivery complications, or the overall health of children of exposed parents. Since 1986, the number of reported cases of malformations in new-born babies in Belarus has increased in both contaminated and uncontaminated areas. This does not appear to be related to radiation and may be the result of people reporting these cases more readily.

2.5 What was the psychological impact on exposed populations?

The Chernobyl-exposed populations showed many of the symptoms that commonly appear following a traumatic accident or event: stress, depression, anxiety (including post-traumatic stress symptoms), medically unexplained physical symptoms, and subjective poor health.



Evacuation
Source: Chernobyl Forum

Many people were traumatized by the rapid relocation and the breakdown in social contacts, and in the absence of reliable information have experienced fear and anxiety about what health effects might result.

In addition, individuals in the affected population have come to be known as "Chernobyl victims" rather than "survivors", which encouraged them to perceive themselves as helpless, weak and lacking control over their future, thus to take on the role of invalids.

3. How has the environment been affected by the Chernobyl accident?

For 10 days following the April 26 explosion, the ruptured Chernobyl reactor continued to release major quantities of radioactive substances, amounting to a total of about 14 EBq [see Annex 8, p. 20]. The most significant radioisotopes released were iodine-131, caesium-137, strontium-90 and plutonium radioisotopes (see table on radioisotopes released [see Annex 7, p. 19]).



Deposition of radioactive caesium in Europe as a result of the Chernobyl accident [see Annex 1, p. 16]

More than 200 000 km² of Europe were contaminated above the level of 37 kBq [see Annex 8, p. 20] /m² of caesium-137¹ [see Annex 6, p. 19]. Over 70 % of this area lies in the three most affected countries, Belarus, Russia and Ukraine though the radioactive material was distributed unevenly. For example, radioactive deposits were larger in areas where it was raining when the contaminated air masses passed. Also, because radioactive strontium and plutonium particles are heavier than many other radioactive particles, they were deposited within 100 km of the destroyed reactor.

The half-life of radioactive material is the time taken for half the amount initially present to decay. Because many of the most significant radioisotopes have short half-lives in the

range of hours or days, most have decayed away by now. For the decades to come, the most important pollutant will be caesium-137 followed by strontium-90. Plutonium and its decay products (in particular americium-241) will remain in the environment over a longer term of hundreds to thousands of years though at low levels (see half-lives of radioisotopes emitted during the Chernobyl accident [see Annex 7, p. 19]).

3.1 To what extent have urban areas been contaminated?

Substantial amounts of radioactive materials were deposited in the urban areas near the power plant. However, their residents were evacuated quickly so that they avoided being exposed to high levels of external radiation. Other urban areas have received different levels of deposition, and their residents have received, and are still receiving, some amount of external radiation.



After the accident, radioactive materials were deposited mostly on open surfaces such as lawns, parks, roads, and building roofs, for instance by contaminated rain. Since then, the surface contamination in urban areas has decreased because of the effects of wind, rain, traffic, street washing and cleanup. However, this has caused the secondary contamination of sewage systems and sludge storage.

Levels of radiation measured in the air in most urban areas are now the same as before the accident, except above undisturbed soil in gardens and parks in some settlements of Belarus, Russia, and Ukraine where they remain higher.

3.2 To what extent have agricultural areas been contaminated?

After the accident, the deposition of radioactive iodine contaminated agricultural plants, grazing animals, and thus the milk produced in parts of Belarus, Russia, Ukraine and some other parts of Europe. This direct deposition on plants was of most concern during the first two months after the accident since radioactive iodine decays quickly.

After this early phase of deposition, an increasingly important concern was plant contamination through absorption of radioactive materials, such as caesium and strontium, from the soil through their roots.

During the first few years after the accident, the levels of radioactive materials in agricultural plants and animals decreased quickly because of factors such as weathering and decay. In the past decade, the radioactivity levels have still gone down, but much more slowly.

Today, the levels of caesium-137 in agricultural food products from Chernobyl-affected areas are generally below national and international action levels.

However, problems persist in some rural areas of the former Soviet Union with small private farms where dairy cows are grazing in pastures that are neither ploughed nor fertilized. In addition, the milk produced in some parts of Belarus, Russia and Ukraine may still have high levels of caesium-137.

For decades to come, most of the radioactive materials that people take in through food and drink in the affected areas will be caesium-137 present in milk, meat, and crops.

3.3 To what extent have forests been contaminated?

Because radioactive caesium is continuously taken up and passed on by organisms in forest ecosystems, the animals and vegetation in affected forests and mountains are particularly contaminated. Forest food products such as mushrooms, berries and game contain the highest recorded levels of caesium-137.

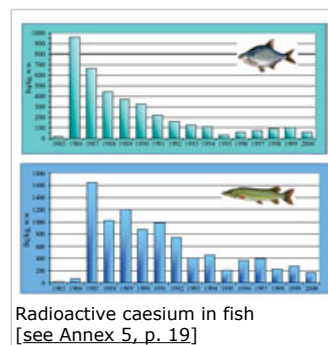
While people are getting progressively smaller amounts of radiation from agricultural products, the doses they receive from forest products are expected to remain high for decades to come, since the decrease in the level of radiocaesium will be very slow.

The high transfer of radioactive caesium from lichen to reindeer and from reindeer meat to humans has been demonstrated after the Chernobyl accident in the Arctic and sub-Arctic areas of Europe. The accident led to high contamination of reindeer meat in Finland, Norway, Russia and Sweden and caused significant problems for the indigenous Sami people.

3.4 To what extent have water bodies been contaminated?

Radioactive materials from Chernobyl deposited on rivers, lakes and some water reservoirs both in areas close to the reactor site and in other parts of Europe. The amount of radioactive materials present in water bodies decreased rapidly during the first weeks after the initial deposition because the radioactive materials decayed, were diluted or were absorbed by the surrounding soils.

Fish absorbed radioactive iodine very quickly but the levels decreased rapidly due to radioactive decay. Bioaccumulation of radioactive caesium along the aquatic food chain resulted in high concentrations in fish in some lakes as far away as Scandinavia and Germany. The levels of strontium-90 in fish did not lead to significant human exposure, particularly as it accumulates in bones rather than in edible parts.



Aquatic bodies are still being contaminated by runoff of long lived caesium-137 and strontium-90 released from contaminated soils. At present, the water and fish of rivers, open lakes and reservoirs have low levels of caesium-137 and strontium-90. However, in some "closed" lakes with no outflowing streams in Belarus, Russia and Ukraine both water and fish will remain contaminated with caesium-137 for decades to come.

Contamination levels of the Black and Baltic seas were much lower than those in fresh water because of greater dilution and distance from Chernobyl.

3.5 How did radiation affect plants and animals?

The radioactive materials released by the accident had many immediate harmful effects on plants and animals living within 20 to 30 km of the Chernobyl power plant at the time of the accident. However, there are no reports of any such radiation-induced effects in plants and animals outside this area, referred to as the Exclusion Zone. Each plant and animal responded differently to the accident depending on the dose of radiation received and sensitivity to radiation.

Overall, in plants and animals, when high doses were sustained at relatively close distances from the reactor, there was an increase in mortality and a decrease in reproduction. During the first few years after the accident, plants and animals of the Exclusion Zone showed many genetic effects of radiation. Still today there are reports of anomalies in plants and animals both in the Exclusion Zone and beyond.



A white-tailed eagle chick observed recently in the Chernobyl Exclusion Zone. Before 1986, these rare predatory birds have been hardly found in this area Source: Chernobyl Forum

Over the years, as the radioactivity levels decrease, the biological populations have been recovering from acute radiation effects. Following the initial reductions in numbers, some of the populations have recovered and grown because individuals reproduced or because plants and animals migrated from less affected areas. The fact that human activities such as agriculture or industry have stopped, has helped this recovery. Paradoxically, the Exclusion Zone has become a unique sanctuary for biodiversity.

4. How are highly contaminated areas managed?

4.1 What has been done to reduce exposure in contaminated areas?

The authorities of the Soviet Union and, later, of the Commonwealth of Independent States (CIS) introduced many short and long term environmental countermeasures to deal with the consequences of the accident. This involved huge human, financial and scientific resources.



Agricultural countermeasures Source: Chernobyl Forum

During the first years after the accident, settlements in contaminated regions of the USSR were cleaned up at great cost. However, this produced a disposal problem because it created a considerable amount of low-level radioactive waste.

Soon after the accident, the most effective agricultural countermeasures to avoid human exposure to radioactive iodine through milk were the use of "clean" fodder for cattle and rejection of contaminated milk. However, these early countermeasures were only partially effective because of the lack of timely information, particularly for private farmers.

In order to reduce long term contamination of milk and meat with radioactive caesium, the land used for fodder crops was treated and animals were given not only clean fodder but also chemicals that "trap" the radioactive caesium. These effective but costly countermeasures have been applied less often since the middle of the 1990s leading to increased levels of radioactive caesium in agricultural products.

Restrictions have also been applied to many forests of the former USSR and in Scandinavia, in terms of access, hunting, and harvesting of forest products such as berries, mushrooms, and firewood.

Many attempts were made to protect water systems from radioactive materials leaching from contaminated soils, but they were generally ineffective and expensive. The most effective countermeasure was switching to uncontaminated drinking water supplies. Restrictions on consumption of freshwater fish were only followed in some areas.

4.2 What has been done to confine the damaged reactor and nuclear waste?

Between May and November 1986, a Shelter was built to contain the damaged reactor, reduce the radiation levels on-site, and prevent further release of radioactive material.

However, problems have later arisen from the fact that the Shelter had to be erected quickly and under very difficult conditions, partly because the construction personnel were exposed to severe radiation levels. Some structural parts have corroded during the past 20 years, which could potentially lead to the collapse of the Shelter and thus to the release of radioactive dust into the environment.



To avoid the top of the Shelter collapsing, there are plans to strengthen unstable structures and to build a New Safe Confinement (NSC) that would cover the existing Shelter and last more than 100 years. The NSC would allow workers to dismantle the current Shelter, remove highly radioactive material from the damaged reactor, and eventually dismantle it altogether.

After the accident, the cleaning operations created a large volume of radioactive waste and this was placed in trenches and land-fills in the Exclusion Zone that do not meet current waste safety requirements. In addition, no clear method of managing the existing high-level and long-lived radioactive waste has yet been developed. It is important that the new radioactive waste that will be generated by the upcoming construction work is disposed of properly.

4.3 What is the future of the restricted access area surrounding the site?

The overall plan for the long term development of the Exclusion Zone is to make the less affected areas available for use by the public.

Because restrictions on food crops planting and cattle grazing apply to these areas, they are best suited for industrial use rather than for residential or agricultural purposes.



Industrial activities may include not only the construction of the New Safe Confinement and the decommissioning of the reactor, but also the processing and management of radioactive waste. Other potential activities include the development of natural reserves and environmental research.

5. What are the social and economic costs of the Chernobyl accident?

5.1 What was the economic cost of the Chernobyl accident?

The Chernobyl accident and the measures taken to deal with its consequences have cost the Soviet Union – and later Belarus, the Russian Federation and Ukraine – hundreds of billions of dollars, but economic losses were also incurred by other countries, for instance in Scandinavia.



Affected communities
Source: Chernobyl Forum

Costs include:

- direct damage caused by the accident.
- expenditures related for instance to sealing off the reactor, treating the Exclusion Zone and other affected areas, resettling people, providing health care and social protection for those affected, monitoring radiation, and disposing of radioactive waste.
- indirect costs linked to restrictions in the use of agricultural land and forests, and to the closure of industrial and agricultural facilities.
- increased energy costs resulting from the closure of the Chernobyl plant and the cancellation of Belarus's nuclear power programme.

The level of government spending linked to Chernobyl is a huge burden on national budgets and is unsustainable, particularly in Belarus and Ukraine. At present, most of the money is being spent on social benefits for some 7 million people and the share spent on capital investments has declined sharply. With limited resources, governments thus face the task of streamlining Chernobyl programmes to provide more focused and targeted assistance, with an eye to helping those most at risk in terms of health and those living in poverty.

5.2 How has the local economy been affected?

The agricultural sector is the area of the economy that was worst hit by the effects of the Chernobyl accident. Large areas of agricultural land were removed from service, and timber production was stopped in many forests. In addition, many farmers could not sell foodstuffs because they were contaminated.



Local market
Source: Chernobyl Forum

“Clean food” production has remained possible in many areas thanks to remediation efforts, but this food was not only expensive to produce, but also difficult to sell. Many consumers refused to buy products from contaminated areas and this has particularly affected the food processing industry.

The region's economy suffered not only from the aftermath of the accident but also from the great economic turmoil of the 1990s: the disruption of trade linked to the collapse of the Soviet Union, the introduction of market mechanisms, recession, and Russia's rouble crisis of 1998. All agricultural areas have been affected by these events. The situation in the affected regions is particularly bad, with lower wages, less private investment, and higher unemployment than elsewhere. The proportion of small and medium-sized businesses is also far lower there than in other areas, partly because many skilled and educated workers have left the region.

Therefore, in order to solve the region's economic problems, it is important to address not only the issues of radioactive contamination but also the generic problems that affect many

agricultural areas, by encouraging the development of small and medium sized companies (SMEs) and the creation of jobs outside agriculture.

5.3 How have local communities and individuals been affected?

5.3.1 Since the Chernobyl accident, more than 330 000 people have been relocated outside the most severely contaminated areas. This has reduced their exposure to radiation, but for many, it has been a deeply traumatic experience.



Informing local communities
Source: Chernobyl Forum

Today, many resettlers are unemployed and believe they have little control over their own lives and no place in society. Many resettlers would like to return to their native villages and some older people may never adjust.

People who remained in their villages have coped better psychologically with the accident's aftermath than have those who were resettled to less contaminated areas. However, as a result of resettlement and voluntary migration, the percentage of elderly people in contaminated areas is abnormally high. The population is aging, which means that the number of deaths exceeds the number of births, and this has encouraged the belief that the areas concerned were dangerous places to live. Moreover, because a large proportion of skilled, educated and entrepreneurial people have left the region, the chances for economic recovery are reduced and schools, hospitals and many other organisations are short of qualified specialists, even when pay is relatively high.

5.3.2 The psychological distress caused by the accident and its consequences has affected the behaviour of individuals and whole communities. To date, the impact on mental health is the largest public health problem resulting from the accident.

The affected populations are very anxious about the effect of radiation on health and, through their behaviour, they may transfer that anxiety to their children. Many people believe that those exposed to radiation are inevitably condemned to a shorter life expectancy. Paradoxically, although they are worried about their health, many residents take risks such as eating food from contaminated forests, smoking and drinking.

Rather than any radiation-related illnesses, the main causes of death in the Chernobyl-affected region are the same as in other regions: cardiovascular diseases, injuries and poisonings. The most pressing health concerns are poor diet, alcohol and tobacco use, as well as poverty and limited access to primary health care.

Added to exaggerated or misplaced health fears, a sense of victimization and dependency created by government benefit systems is widespread in the affected areas. This dependency culture is a major barrier to the region's recovery. Therefore, affected individuals and communities need measures that give them control over their own lives.

5.4 What policies have governments adopted to help affected populations?

The Soviet Union undertook far-reaching measures in response to the Chernobyl nuclear accident.

The government adopted a very low threshold for the level of radioactive contamination that was considered acceptable for inhabited areas. Cautious zoning principles determined

where people were permitted to live and pursue farming and other activities. However, as the level of radiation declined over time, and knowledge on the nature of the risks improved, limitations on activities in the less affected areas became more of a burden than a safeguard.

A massive investment programme was set up to build houses, schools, hospitals and infrastructure for resettled populations, as well as to develop methods to cultivate "clean food". Because such a huge level of expenditure is unsustainable, funding has fallen steadily over time, leaving many projects half completed.

Table: Chernobyl-related construction, 1986–2000 [see Annex 9, p. 21]

The Soviet government also created a large system of compensation payments. Today, some 7 million people are entitled to special allowances, pensions and health care privileges because they have been considered to be affected in some way by the Chernobyl accident. Some of the benefits have no relation to the impact of radiation and reach many citizens who have only been mildly affected by the accident. The system has also created perverse incentives. For example, some people have returned to the affected areas with their families in order to be able to claim a higher level of benefits.

As the economic crisis of the 1990s deepened, many people registered as a victim of Chernobyl because this was the only way of getting an income or any health provision, including medicines. Therefore, rather than declining, the number of people claiming Chernobyl-related benefits soared over time. Corruption also played a role.

At present, with inflation and increasing budget constraints, the value of many individual payments has become insignificant. Yet, because there are so many eligible people, the sums involved are so enormous that even small improvements in efficiency could significantly increase the money available for those whose health has actually suffered from the catastrophe and the truly needy.

Regarding information provision, the fact that the Soviet government initially delayed any public announcement that the accident had occurred, and only provided limited information has left a legacy of mistrust surrounding official statements on radiation.

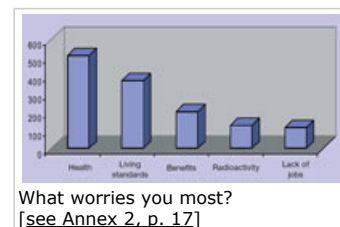
6. What are the current concerns and needs of affected people?

6.1 What worries people living in the affected regions?

People living in the areas affected by the Chernobyl accident are uncertain about the impact of radiation on their health and surroundings, and do not know how to lead a healthy life in the region.

There are many misconceptions and myths about the threat of radiation that make residents feel powerless and unable to change their destinies. This has led both to excessively cautious behaviour linked to constant anxiety about health, and to reckless conduct such as eating forest products from areas of high contamination.

Therefore, Chernobyl-affected populations need clear, comprehensive, and unambiguous information about the accident and radiation, delivered in such a way that it overcomes the existing widespread mistrust.



Surveys show that the main worry of residents of the Chernobyl area is their own health and that of their children. However, they are also very concerned about socio-economic problems such as low household incomes and high unemployment. Therefore, the affected populations need measures that will help develop the region's economy.

6.2 What are the current needs of various affected groups?

The people affected by the accident can be classified into three groups:

- The **group requiring** most help includes people who continue to live in severely contaminated areas and who are unable to support themselves adequately, resettlers who are unemployed, and people whose health is most directly threatened, for instance by thyroid cancer. These 100 000 to 200 000 people are caught in a downward spiral of isolation, poor health and poverty; and need substantial material help to rebuild their lives.
- The **second group**, numbering several hundreds of thousands of individuals, consists of those whose lives have been directly and significantly affected by the consequences of the accident but who are already in a position to support themselves. These people **need help to reintegrate society** as a whole and to normalise their lives as fully and as quickly as possible.
- The **third group** consists of several millions of people whose lives have been influenced by the accident mainly in that they have been labeled, or perceive themselves as victims of Chernobyl. These people **need full, truthful and accurate information** on the effects of the accident based on dependable and internationally recognised research. In addition, they need access to good quality health care, social services, and employment.



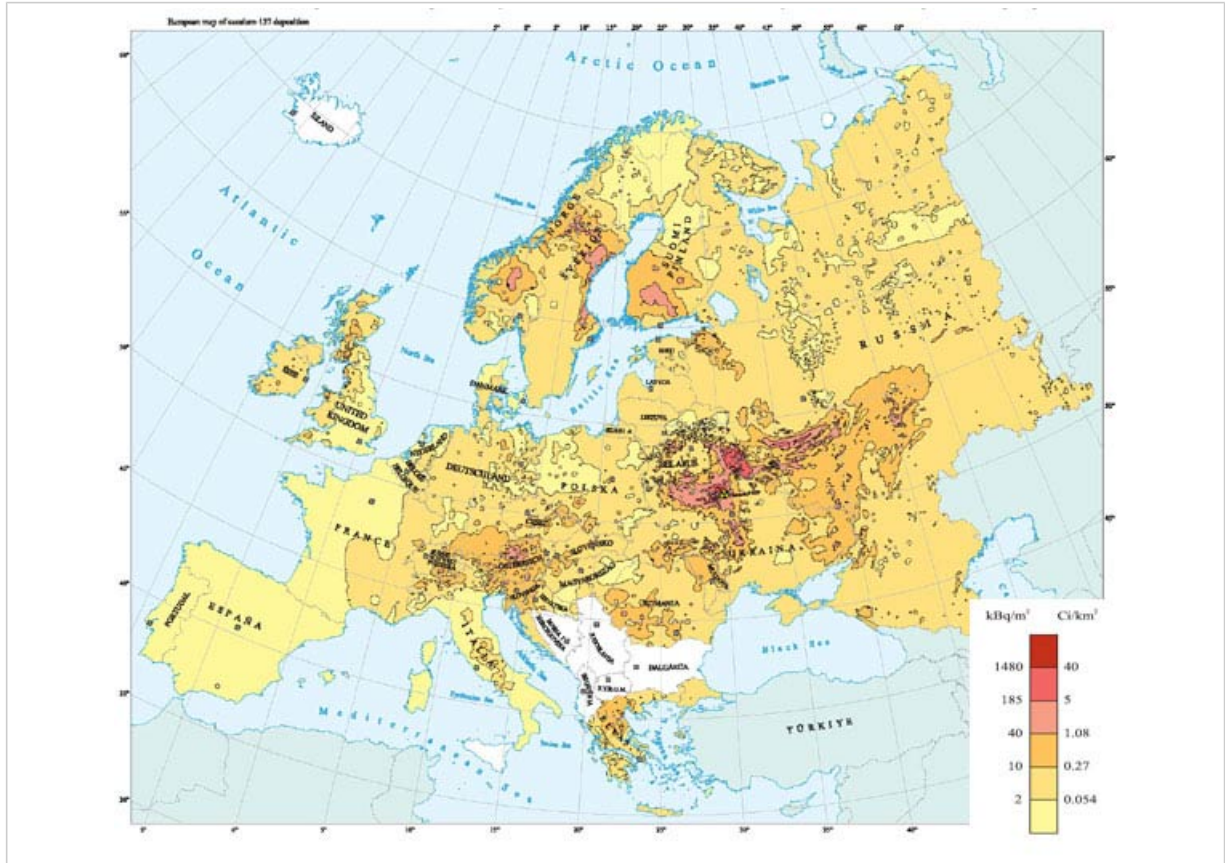
What are their needs?
Source: Chernobyl Forum

The approach of defining the most serious problems and addressing them with special measures, while pursuing an overall policy of promoting a return to normality, should apply to the affected territories as well as to the affected individuals and communities. Within the available budgets it is really the only alternative to the progressive breakdown of the recovery effort, continuing haemorrhaging of scarce resources and continuing distress for the people at the centre of the problem.

Annex

Annex 1:

Figure 1. Surface-ground deposition of ^{137}Cs throughout Europe as a result of the Chernobyl accident (De Cort et al. 1998)



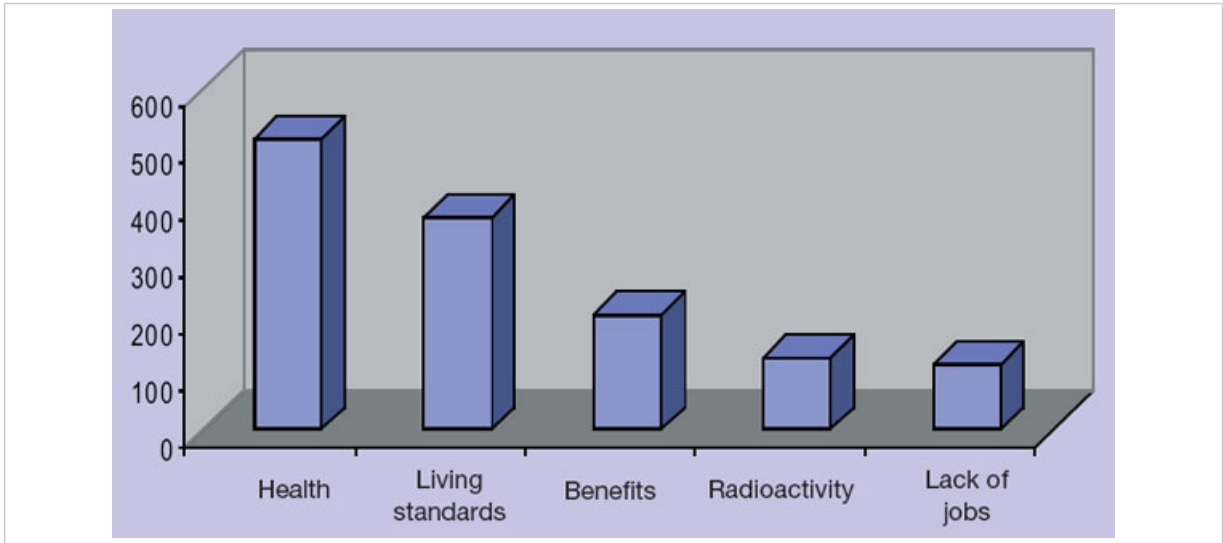
Source: UN Chernobyl Forum

Chernobyl's Legacy: Health, Environmental and Socio-economic Impacts (2006) [see <http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf>], p.10

Annex 2:

Figure 10. What worries you most today?

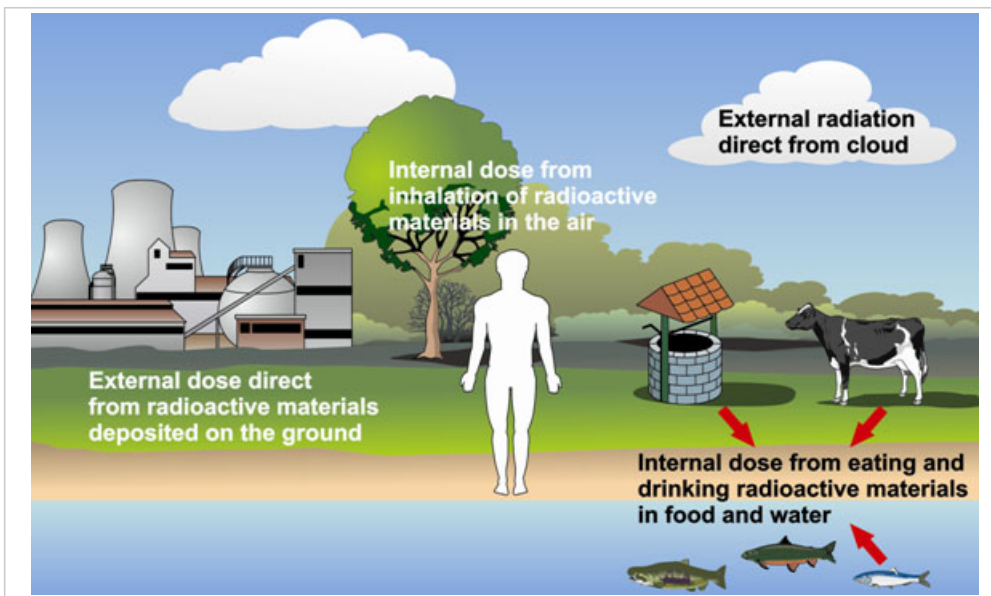
Data from 2003 Russian survey, 748 respondents, multiple responses allowed.



Source: UN Chernobyl Forum Chernobyl's Legacy: Health, Environmental and Socio-economic Impacts (2006) [see <http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf>], p.42

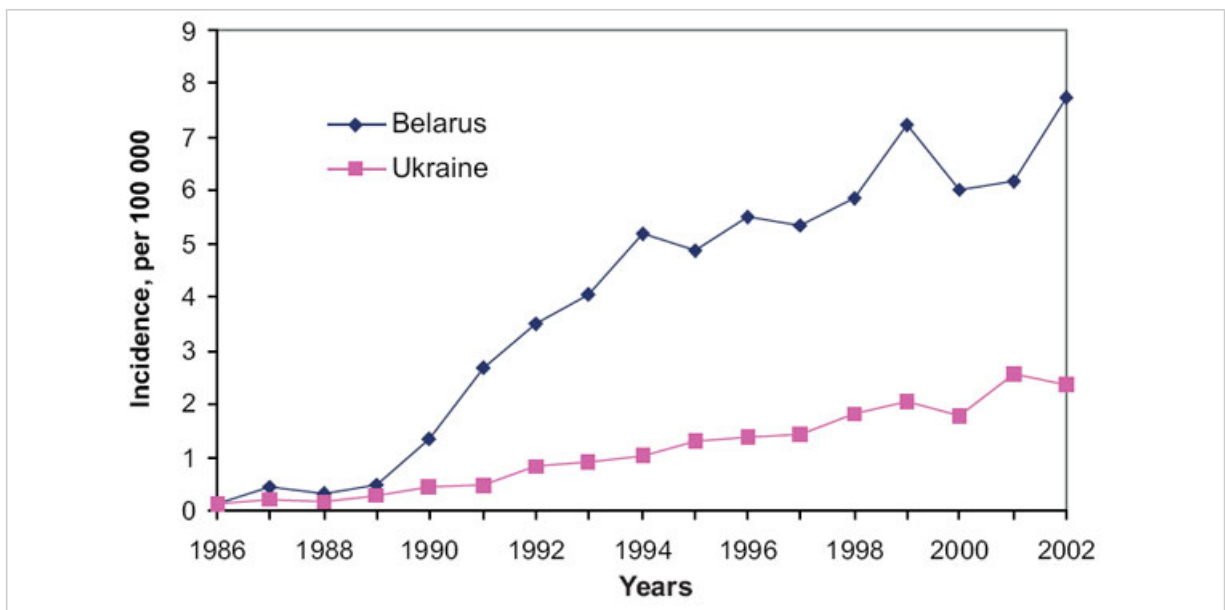
Annex 3:

Figure 2. Pathways of exposure to man from environmental releases of radioactive materials



Source: UN Chernobyl Forum Chernobyl's Legacy: Health,

Environmental and Socio-economic Impacts (2006) [see <http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf>], p. 13

Annex 4:**Figure 3. Incidence rate of thyroid cancer in children and adolescents exposed to ^{131}I as a result of the Chernobyl accident (Jacob et al.,)**

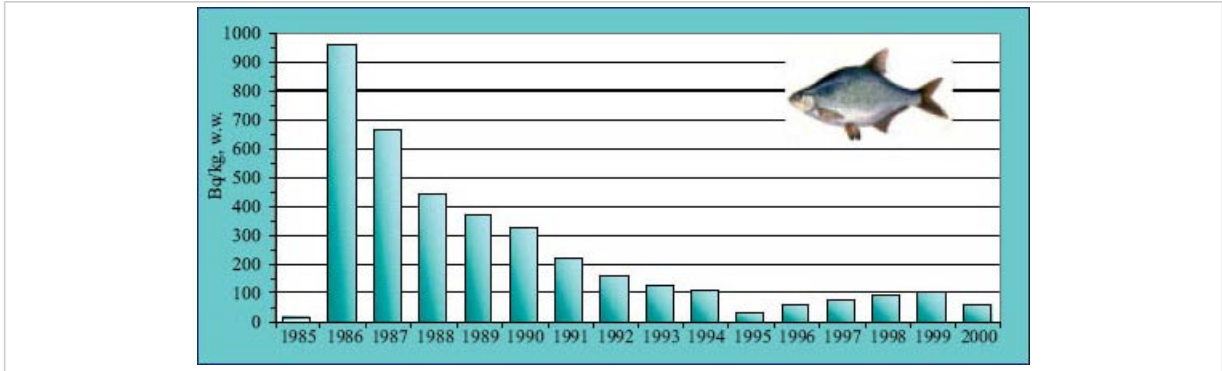
Source: UN Chernobyl Forum

Chernobyl's Legacy: Health, Environmental and Socio-economic Impacts (2006) [see <http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf>], p. 17

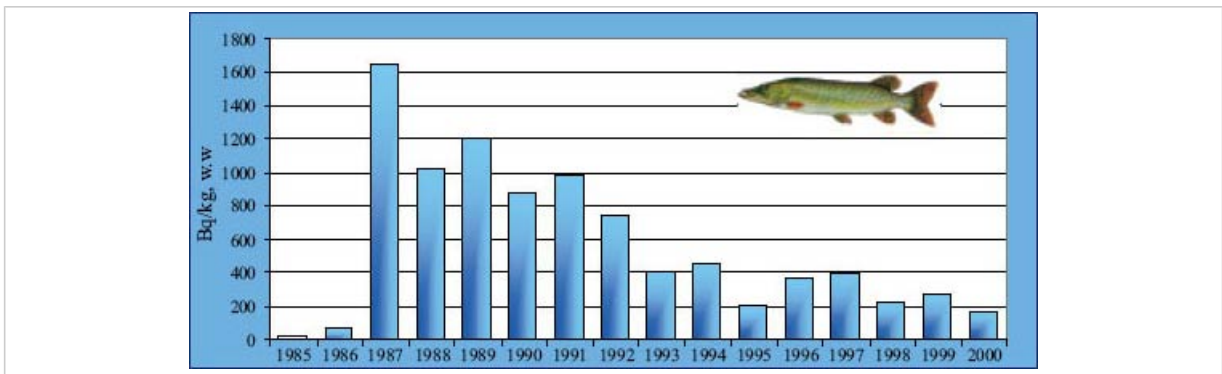
Annex 5:

Figure 6. Averaged ¹³⁷Cs activity concentrations in fish from Kyiv reservoir (UHMI 2004)

- in non-predatory fish (Bream)



-in predatory fish (Pike)



Source: UN Chernobyl Forum Chernobyl's Legacy: Health, Environmental and Socio-economic Impacts (2006) [see <http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf>], p.26

Annex 6:

Footnote

"Soil deposition of ¹³⁷Cs equal to 37 kBq m⁻² (1 Ci km⁻²) was chosen as a provisional minimum contamination level, because

(1) this level was about ten times higher than the ¹³⁷Cs deposition in Europe from global fallout, and

(2) at this level, the human dose during the 1st year after the accident was about 1 mSv and was considered to be radiologically important."

Source & © UN Chernobyl Forum - Environmental Consequences of the Chernobyl Accident and Their Remediation, 2.1.5, page 32 [see http://www.iaea.org/NewsCenter/Focus/Chernobyl/pdfs/ege_report.pdf]

Annex 7:

Major radioactive substances released by the Chernobyl accident

with quantities expressed in exabecquerel (**EBq [see Annex 8, p. 20]**)

Radioactive substance	half-life	EBq [see Annex 8, p. 20]
iodine-131	8.04 days	1.760
caesium-137	30 years	0.085
strontium-90	29.12 years	0.010
plutonium-241 (which decays into Americium-241)	14.4 years 430 years	0.003
others		~ 12.140
Total radioactivity released		14

For more complete information on the principal radioisotopes released during the Chernobyl accident, see the full report [see http://www-pub.iaea.org/MTCD/publications/PDF/Pub1239_web.pdf] of the UN Chernobyl Forum Expert Group 'Environment', Table 3.1, p.19

Annex 8: Radiation Units

Measuring:

- radioactivity
- exposure to radioactivity

Measuring radioactivity

The nuclei of certain atoms are unstable and spontaneously disintegrate emitting radiation (alpha-particles, beta-particles or gamma rays). This changes the nature of the nucleus, and so the atom transforms (decays) into a different type of atom. The radioactivity of a given amount of material is the number of nuclear decays that take place per unit of time.

Radioactivity units used:

- **becquerel (Bq)** is the SI unit of radioactivity equal to one nuclear decay per second. $1 \text{ Bq} = 1 / \text{s}$
- Therefore, an amount of material that produces one nuclear decay per second, is said to have a radioactivity of 1
- **Bq exabecquerel (EBq) = 10¹⁸ Bq**

Measuring exposure to radioactivity

Ionizing radiation (such as alpha, beta and gamma radiation) is a very high-energy form of electromagnetic radiation, and can strip electrons from the atoms in the material through which it passes. This may damage human cells, causing death to some cells and modifying others. Dose is a measure of the amount of energy from ionizing radiation deposited in a specified material.

Absorbed dose is the absorbed energy per unit mass.

Unit of absorbed dose used:

- gray (Gy) is the SI unit of absorbed dose, which is a joule per kilogram (J kg^{-1})

Effective dose is the absorbed dose multiplied by a factor that takes into consideration the type of radiation and the susceptibility of various organs and tissues to development of a severe radiation-induced cancer or genetic effect. Moreover, it applies equally to external and internal exposure and to uniform or non-uniform irradiation.

Units of effective dose used:

- **sievert (Sv)** is the SI unit of effective dose. Its units are J kg⁻¹.
- **millisievert (mSv)** 1 mSv = 0.001 Sv

Source & © Further information on the International System of Units (SI) is provided by the International Bureau of Weights and Measures (BIPM) www.bipm.fr/en/si/derived_units/2-2-2.html [see http://www.bipm.fr/en/si/derived_units/2-2-2.html]

Annex 9:

Table: Chernobyl-related construction, 1986-2000

	Belarus	Russia	Ukraine	Total
Houses and flats	64 836	39 779	28 692	130 307
Schools (number of places)	44 072	18 373	48 847	111 292
Kindergartens (number of places)	18 470	3 850	11 155	33 475
Outpatient health centres(visits/day)	20 922	8 295	9 564	38 781
Hospitals (beds)	4 160	2 669	4 391	11 220

Source: UN Chernobyl Forum

Chernobyl's Legacy: Health, Environmental and Socio-economic Impacts [see <http://www.iaea.org/Publications/Booklets/Chernobyl/Chernobyl.pdf>] (2006), p.38

Annex 10:

Table: Summary of average accumulated doses to affected populations from Chernobyl fallout

Population category	Number	Average dose (mSv [see Annex 8, p. 20])
Liquidators (1986-1989)	600 000*	~100
Evacuees from highly-contaminated zone (1986)	116 000	33
Residents of "strict-control" zones (1986-)	270 000	>50
Residents of other 'contaminated' areas (1986-)	5 000 000	10-20

* including 240 000 who worked in 1986-87.

Source: UN Chernobyl Forum

Chernobyl's Legacy: Health, Environmental and Socio-economic Impacts (2006) [see <http://www.iaea.org/Publications/Booklets/Chernobyl/Chernobyl.pdf>], p.14

Annex 11: Where is Chernobyl located?

