Ten years after Chernobyl: What do we really know?
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Introduction: Sorting out the Facts

Few names around the world are better recognized than "CHERNOBYL." And few events have evoked greater controversy among scientists, government officials and the public. Over the decade since explosions destroyed the nuclear power plant in Ukraine, the accident and its aftermath have been studied extensively. Today, there is a common understanding among experts about what happened, why it happened and the major implications. But to much of the broader public around the world, the accident remains an enigma—a phenomenon that is feared, but little understood.

Chernobyl was by far the most devastating accident in the history of nuclear power. Radioactive fallout was mainly concentrated in the three former Soviet Republics States closest to the plant, but it also came down at lower concentrations over much of the entire Northern Hemisphere. What do we now know about the health and environmental impacts of this massive discharge of radioactive material?
This booklet attempts briefly to bring to light what has been learned after ten years of examining the consequences of the accident, reviewing both its immediate and long-term human health and environmental impacts. It is based principally upon the results of an international conference, "One Decade After Chernobyl: Summing Up the Consequences of the Accident," which brought together more than 800 experts from 71 countries in Vienna in April 1996 under sponsorship of the European Commission (EC), the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA).¹

Today, people in the countries most affected by the accident—Belarus, Russian Federation and Ukraine and Belarus—continue to live with the consequences. This booklet aims to help both them and the broader public to separate the facts from the fears, and the scientific evidence from the science fiction.

¹This conference took into account the results of major projects performed over the last ten years, including the International Chernobyl Project carried out in 1990-91, a 1995-96 IAEA project on the prospects for the contaminated territories, the WHO IPHECA (International Programme on the Health Effects of the Chernobyl Accident), and the Research Projects sponsored by the European Commission in collaboration with scientists in Belarus, Russia and Ukraine.
Facts:

The accident was by far the most devastating in the history of nuclear power

- Chernobyl’s No. 4 reactor was completely destroyed by explosions that blew the roof off the reactor building and released large amounts of uranium fuel and other radioactive material into the environment. The reactor’s remains are currently contained within a larger structure known as the shield or “sarcophagus” built in the months following the accident. One of the four original reactors at the site is in operation.

- Large amounts of radioactive material—12 trillion ($10^{18}$) international units of radioactivity, termed “becquerels” — were released into the environment, particularly during the first ten days. The discharge included over a hundred, mostly short-lived radioactive elements, but iodines and caesiums were of main relevance from a human health and environmental standpoint. Radioactive material from the plant was detectable at very low levels over practically the entire Northern Hemisphere.
• Compared with other nuclear events: The Chernobyl explosion put 400 times more radioactive material into the Earth's atmosphere than the atomic bomb dropped on Hiroshima; atomic weapons tests conducted in the 1950s and 1960s all together are estimated to have put some 100 to 1,000 times more radioactive material into the atmosphere than the Chernobyl accident.

• An estimated 200,000 workers (known as “liquidators”), from the local police and fire services, the Army and volunteers, were initially involved in containing and cleaning up the accident in 1986 and 1987, either in the front lines or administratively. Later, the number of people who became registered as liquidators rose to between 600,000 and 800,000 although many so listed received only low doses of radiation.

• An “exclusion zone” initially some 30 kilometers in radius was established around the site and about 116,000 people within it were evacuated to less contaminated areas in the months following the accident. The exclusion zone was later extended and now covers 4,300 square kilometers containing the areas with the highest amounts of radioactivity.

• Potassium iodide or iodate tablets were reportedly provided for 5.3 million people, of whom 1.6 million were children, although the efficiency of this distribution has not been quantified. The first to receive this preventive treatment were reported to be those from within the 30-km zone.

• The town of Pripyat (pop. 45,000), home to most of the plant personnel, was completely evacuated and a new town, Slavutich, was constructed outside the exclusion zone.

• In the years following the accident, an additional 210,000 people in the Republics of Ukraine, Belarus and Russia were evacuated from their homes under government orders and resettled in less contaminated areas.
Emergency workers were exposed to high doses of radiation; the surrounding population to far less

- A total of 237 occupationally exposed people were admitted to hospitals and 134 were diagnosed with "acute radiation syndrome." Of these, 28 died within the first three months, while at least 14 additional patients have died over the past ten years although these were not necessarily associated with radiation exposure. Two other people died in the explosion, and one more presumably of heart failure.

- Some 200,000 people involved in the initial clean up of the plant received average total body radiation doses of the order of 100 millisieverts (mSv)—a millisievert is a unit of radiation dose equivalent to about 10 general chest X-rays. This dose is about five times the maximum annual dose limit currently permitted for workers in nuclear facilities (20 mSv per year). Average worldwide natural "background" radiation is about 2.4 mSv annually.

An evacuated home within the 30-km exclusion zone
credit: Eric Voice
• Some 20,000 liquidators received doses of the order of 250 mSv; a few per cent of them received doses of 500 mSv; and several dozen people received potentially lethal doses of a few thousands of millisieverts.

• Fewer than 10 percent of the 116,000 people evacuated from the "exclusion zone" received doses greater than 50 mSv; fewer than 5 percent received more than 100 mSv.

• More than 400,000 people lived in areas contaminated with more than 555 kBq/square meter—classified by Soviet authorities as areas of strict control, requiring decontamination measures and restrictions on the use of locally produced foods.

• In Belarus, where an estimated 70 percent of the radioactive releases were deposited, about 20 percent of the population (2.2 million people) continue to live in areas where contamination initially exceeded 37 kBq/square meter—a low level not requiring decontamination and other control measures.

• For people outside the former USSR, the highest (national) average radiation dose during the first year after the accident was 0.8 mSv, that means an additional dose equal to about one third of the dose due to natural background radiation in that year.

^levels of radioactive contamination in this report are given in kBq per square meter. The Becquerel is equal to one atomic disintegration per second. 1 kBq = 1000 disintegrations per second.
An increased number of radiation-related thyroid cancers is now evident

- The radioiodines released by the accident delivered radiation doses to the thyroid glands of people, especially children, in heavily contaminated areas. The short-lived iodines (particularly iodine-131 with a half-life of 8 days) were ingested in foodstuffs, mainly contaminated milk, and also inhaled from the initial radioactive cloud. Radioiodines accumulate in the thyroid, thus irradiating the gland from the inside.

- A sharp increase in thyroid cancer among children from the affected areas is the only major public health impact from radiation exposure documented to date. At the end of 1995, about 800 cases in children under 15 years of age had been diagnosed, mainly in the northern part of Ukraine and in Belarus. Three children among the diagnosed cases are known to have died of the cancer by then—which generally can be successfully treated surgically and by medication.
Based upon the current epidemiological projections, an increase in the incidence of thyroid cancer in adults who received radiation doses as children could occur, with the total number of cases possibly in the order of a few thousands.

The incidence of thyroid cancer among children born more than six months after the accident has remained at the low levels expected in unexposed populations. This confirmed that the risk of thyroid cancer was only increased among those receiving high thyroid doses in 1986 and not among those exposed only to the continuing low levels of exposure since then.
Other than thyroid cancer, long term health impacts from radiation have not been detected

- There are numerous reports of increases in incidences of specific malignancies in people living in contaminated zones and among liquidators. These reports are inconclusive, and require further investigation.

- No increase has been detected either in the rate of leukaemia or in the incidences of any malignancies other than thyroid carcinomas because of the accident. Only ten years have passed, however, and cancers other than leukaemia do not usually occur until several years after exposure. Cancer registries need to be monitored and careful studies carried out to determine ongoing public health impacts and confirm predictions.

- There are significant psychological health disorders and symptoms among the populations affected by the accident including anxiety, depression, fatalistic attitudes and psychosomatic disorders caused by mental distress. However, it is very difficult to separate these effects from those caused by the economic decline and the dissolution of the former USSR. What is clear is that these effects are not caused by radiation exposure.
Severe environmental impacts were short term

- Lethal doses of radiation were received by some animals and plants, especially coniferous trees and some small mammals, living within 10 km of the reactor site in the first few weeks after the accident. Because of rapid radioactive decay, however, dose rates around the plant had already declined by a factor of 100 by the Autumn of 1986. Moreover, the natural environment in even these localities had begun to recover visibly by 1989, and no sustained impacts on populations or ecosystems have been observed.

- Direct radiation injury to plants and animals was reported only in local areas within the 30-km exclusion zone. In some cases, chronic dose rates may have reduced the fertility of some animal species inside the zone. But in most instances, long-term effects on plants or animals could not be demonstrated.

- There have been some reports of birth defects among farm animals; but other evidence supports general recovery from radiation damage. The possibility of long term genetic effects remains to be studied.

A farm in the village of Opachichi, within the exclusion zone
credit: Eric Voice
Low-level radioactive contamination will persist for decades

- Short-lived radioiodines were the greatest radiological concern during the first few weeks after the accident. But almost 30,000 square kilometers in Belarus, Russia and the Ukraine were also contaminated with relatively high levels of Caesium 137 (in excess of 185 kBq per square meter), a nuclide with a half-life of some 30 years.

- Radioactive caesium was deposited on the ground, including in agricultural and forested areas. Thus, initially many crops and forest products were heavily contaminated. Subsequently, as radiocaesium was absorbed into the soil and the roots of plants, low levels of contamination could still be found in new crops.

- Drinking water supplies from some rivers and reservoirs near the plant were contaminated with caesium and strontium radionuclides during the month immediately following the accident, but levels fell rapidly. Regular monitoring since 1986 shows that there has been a steady decline in the radionuclide contents in these water bodies. Bottom deposits and banks of the Pripyat and Dnieper Rivers contain caesium, strontium, plutonium and other radioactive elements. During spring flooding, concentrations of radioactive

Collecting sediment samples at Savachi, Belarus for IAEA laboratory analysis credit: Mouchkin/IAEA
materials increase by up to four times in these rivers, whose main drainage basins are in the most contaminated areas. Current contamination levels in reservoirs are well below the criteria that indicate degraded water quality.

- Forest occupies 30-40 percent of the most contaminated area, and has played the role of filter in intercepting the fallout. Up to 90 percent of the fallout is concentrated in leaf litter. Caesium continues to be concentrated in wood, but concentrations in disbarked wood from most territories affected by the Chernobyl accident do not exceed admissible levels. Wood from the exclusion zone may require special treatment to meet these levels, and may for decades to come.

- Game animals that graze in natural zones, and wild foods consumed by people, such as berries and mushrooms, continue to show elevated caesium levels that may surpass nationally adopted standards in the affected Republics. This is also the case in parts of the Nordic countries and the United Kingdom.
Chernobyl-type reactors have been upgraded for safety

- After 10 years of detailed analysis by Belarussian, Russian, Ukrainian and international experts, the principal causes of the Chernobyl accident are well understood. The accident occurred because of severe deficiencies in the design of the reactor compounded by the violation of operating procedures.

- The lack of a "safety culture" in the responsible organizations of the former Soviet Union resulted in an inability to remedy such design weaknesses, even though they had been known before the accident.
The most serious deficiencies in other operating RBMK reactors are being addressed through safety upgrades. Between 1987 and 1991, a first stage of upgrading was performed on all RBMK units to eliminate the design deficiencies which contributed to the Chernobyl accident, to improve shutdown mechanisms and heighten general safety awareness among staff. There are plans for further safety improvements.

The "sarcophagus" that was constructed over the destroyed reactor has met the protection objective over the past 10 years. In the long term, however, its stability and the quality of its confinement are in doubt. A collapse of the structure could lead to a release of radioactive dust and radiation exposure to workers at the site, but widespread effects would not be expected.
Assistance for affected areas and populations remains essential

- The Chernobyl accident and its aftermath have had a major impact on the social and economic development and wellbeing of people in the most affected areas of Belarus, Ukraine and Russia. Radioactive contamination of vast areas has impeded normal industrial and agricultural production.

- Addressing the post-accident situation has been complicated by political, economic and social changes over the past decade. This situation was compounded in the years after the accident by incomplete and, at times, inaccurate public information about the accident and alleviation measures.

- The psychological stress of residents in contaminated areas continues to be characterized by high anxiety, irritability, general feeling of hopelessness, fear about the future and inability to adjust. Such psychosocial effects have profound effects on the economic situation and on resources for health care. Training and education on radiation effects in the region need to be further strengthened in order to promote economic and social recovery.
The affected areas face a set of challenges in social and economic revival similar to those in other countries of the former USSR:

- successfully operating farms and agro-industries while supplying the population with safe food products;
- assuring ecological safety; and
- improving social and economic infrastructure, including radically upgrading health and social support services.

Over the past decade, much work has been directed toward protection of the populations and rehabilitation of the affected lands. Such rehabilitation efforts, carried out with support from the international community, have been directed toward economic, ecological and human health objectives:

- In radiation protection: work is continuing on radiation protection measures to reduce the present doses received by people in contaminated areas.

- In agriculture and food supply: efforts have been underway to modify cropping techniques to lower the radioactive content in food products to acceptable levels. Efforts to reduce contamination of milk and meat products have been successful by adding the "Prussian Blue" cleansing compound into ruminant’s feed. Experiments also are being carried out to test and introduce alternative crops (such as rapeseed) that can be used to produce industrial products, rather than foodstuffs.

- In public health: medical monitoring systems have been established in the countries to facilitate early diagnosis and treatment of thyroid cancer, leukaemia and other
malignancies in the affected population. Medical and dosimetry registries have been set-up to carry out epidemiological studies in order to provide decision makers with information for planning on health care systems in contaminated territories. Social and psychological education centres have been established at numerous sites in all three countries to rehabilitate affected populations.

- In the energy sector: sizeable grants and loans have been provided for promoting nuclear safety, for examining the decommissioning of Chernobyl and for rehabilitation of the energy sector.
Principal examples of assistance activities in the United Nations system:

The International Atomic Energy Agency (IAEA) has provided support for a wide variety of technical activities related to radiation safety, environmental monitoring and protection, power plant management and safety, agricultural rehabilitation and nuclear waste management.

The World Health Organization (WHO) has supported a major effort, the International Programme on the Health Effects of the Chernobyl Accident, in collaboration with other international and national organizations, to provide humanitarian support and improved health care to the affected countries. A follow up programme is underway focused on thyroid disease, accident recovery workers, dose reconstruction and psycho-social effects.

The Food and Agriculture Organization (FAO), together with the IAEA, has contributed technology and expertise on agricultural counter-measures to reduce radioactive contamination and has helped in improving knowledge of the migration of radionuclides in soils, forests and water bodies to facilitate restoration of contaminated areas.

United Nations Educational, Scientific and Cultural Organization (UNESCO) has established nine social/psychological rehabilitation centres (locally known as "centres of trust") with support from the United Nations Children's Fund (UNICEF) and a variety of bilateral donors.

The United Nations Development Programme (UNDP) has been coordinating the aid activities related to Chernobyl within the three countries and assisting with improving environmental monitoring capacities.

The United Nations Department of Humanitarian Affairs (UNDHA) has played a coordination role in the UN Inter-Agency Task Force on Chernobyl, which ensures that all major donors are aware of assistance being provided and includes the European Commission.
Assistance from other
International Organizations

The European Commission's (EC) Radiation Protection Research Action programme has implemented two thyroid research projects under the EC/Commonwealth of Independent States (CIS) scientific collaboration agreement, and the EC's Humanitarian Office (ECHO) has supplied specialist equipment and medicines for the diagnosis, treatment and follow-up of the children suffering from thyroid cancer for Belarus and Ukraine. EC technical assistance has included training for CIS medical staff, facilities for producing L-thyroxin tablets in the Chernobyl affected regions and measures to improve the production and distribution of iodized table salt in the affected regions. Other research projects include environmental problems and emergency preparedness.

The G7 has proposed a solution for the ultimate closure of the Chernobyl complex, short-term safety upgrades for units still in operation, plans for a new Chernobyl sarcophagus and waste retrieval facility and completion of two new reactors at other sites to replace Chernobyl units 1 and 3.

The European Bank for Reconstruction and Development (EBRD) has created a special Nuclear Safety Account devoted to supporting safety upgrades and improvements for Soviet-designed nuclear reactors, with priority going to "high risk" designs such as the RBMK.

The World Bank has been providing concessional loans for energy development including conventional power generation, policy reforms, coal mining and electricity market development.