The Chernobyl Nuclear Reactor Accident

On April 26, 1986, during a testing operation, one of the four reactors at the Chernobyl nuclear power plant went out of control and exploded. Due to the explosion and subsequent 10-day fire at the site large amounts of radioactive substances were released into the atmosphere. The major radioactive contaminants of concern were iodine (^{131}I) and caesium (^{134}Cs and ^{137}Cs). The plume moved predominately northward and then over western Europe. 70% of the radioactive material was deposited over Belarus.

The total amount of radioactive material that was released had an activity of 3 millions TBq. 46 000 TBq had a long half-life (caesium, strontium and plutonium).

Human body and radiation

When uranium (U-235) nuclei are split in a nuclear reactor, various radioactive fission products arise. In terms of harmful impact, the most relevant of these are iodine-131, caesium-137, strontium-90 and plutonium-239. These elements are spread via aerosols (dust particles in the air) and may be inhaled, deposited in the earth by rainfall and water, or enter the food chain via plants.

Iodine-131, caesium-137, strontium-90 and plutonium-239 are radioactive elements, hence emit radiation. When the cells of the body are exposed to such radiation, unstable, extremely reactive particles called free radicals are produced.

These free radicals or ions may impair cellular function. Damage may be caused to the DNA in the cell nucleus, which carries the genetic blueprint for cellular replication, structure and function. It is now scientifically recognised that such damage to the DNA can cause cancer and other genetic abnormalities.

Not all organs are equally sensitive to radiation. The cells of the embryo in uterus, the lymphatic system (lymph glands), the bone marrow, intestinal tract, thyroid, female breast and egg cells are considered to be particularly vulnerable to the effects of radiation.

In addition, the accumulation of radionuclides is particularly marked in certain organs. Radioactive iodine is stored primarily in the thyroid, an organ that regulates energy metabolism, physical and mental development, and the growth of embryos, children and adolescents. Radiation may impair these functions and also lead to thyroid cancer.

Caesium-137, which accumulates throughout the body and in specific organs, is also believed to be a potential cause of cancer. Strontium is stored in teeth and bones. Since new blood cells are formed in the bone marrow, this may lead to leukaemia.

Health consequences of the accident

Acute effects

People exposed to a high dose of radiation over a short period show acute effects. These are to be distinguished from so-called late effects, such as tumours or genetic mutations, which often only appear decades later.

A dose greater than 0.5 sievert (Sv) is considered to be a high dose of radiation. Above this threshold, adverse effects become apparent immediately or after a few days at most. The immune system is weakened, changes in blood count occur, and the digestive tract, lungs, other internal organs and the central nervous system are all damaged. With absorbed doses of 1 to 2 Sv and above, mortality is expected to be about 20%, according to radiation medicine specialists above a dose of 7 Sv the survival rate is zero.

Of the 600 power station personnel and fire-fighters who were in the vicinity of the burning reactor directly after the accident, 134 received doses of 0.7 to 13 Sv. These include the 31 people who died in the first 3 months after the accident despite intensive treatment.

Of the 800 000 soldiers and firefighters involved in clean-up operations at the reactor complex in the years after the accident 30 000 are reported to have received doses of more than 0.5 Sv. According to figures issued by government agencies in the three former Soviet States affected, about 25 000 liquidators have so far died they suffered from conditions including lung cancer and leukaemia, cardiovascular diseases and inflammation of the digestive tract.

Thyroid cancer in children

This type of cancer is caused by the thyroid gland taking up large quantities of radioactive iodine-131. Iodine-131 leads to pathological cell modifications in this organ. This process is exacerbated in areas – such as Belarus, southwest Russia and Ukraine – where iodine deficiency is endemic. Radioactive iodine was thus absorbed particularly avidly in these countries.

In the first 10 days following the Chernobyl accident, massively increased levels of iodine-131 were measured in the whole of Belarus (and parts of Russia and Ukraine). Particularly high levels were recorded around the regional capital, Gomel, in Belarus. The number of children with this type of cancer has increased particularly markedly in Belarus.

While this tumour is otherwise very rare in children and adolescents – in Belarus before the accident, seven children contracted the disease in ten years – the incidence in 1990 was already 30 times higher.

The latest report from the United Nations Development Programme (UNDP) and the United Nations Children's Fund (UNICEF) shows that the number of thyroid cancer cases has also increased dramatically in Ukraine. A direct link between the accident and this type of cancer was only recognised by the World Health Organization (WHO) in 1995.

In view of the pattern of cases reported to date, the WHO predicts that one third of all the children from the area around Gomel aged between 0 and 4 at the time of the accident will develop thyroid cancer during their lifetime - a total of 50,000 children in this group alone.

Leukaemia in children and adults as a consequence of the Chernobyl accident

In leukaemia, diseased (malignant) cells proliferate in the bone marrow, suppressing the production of normal red and white blood cells. Usually, the malignant cells also enter the bloodstream and may infiltrate lymphatic tissue, such as lymph nodes, weakening the body's immune system.

In the Gomel region an increase in leukaemia cases of about 50% compared to the period before the disaster was recorded in both children and adults, according to the clinics responsible. These figures run counter to the Conclusions of the 3rd International Conference "Health Effects of the Chernobyl Accident", held in Kiev in June 2001. There, many researchers reported that there was no significant increase in cases of childhood or adult leukaemia in the contaminated territories of the three countries affected. Nevertheless, it was pointed out in Kiev that, particularly among the Russian liquidators who worked in the power station complex in 1986 and 1987, a statistically significant rise in the number of leukaemia cases had been observed.

There is evidently a need for further research, in order to be able to draw firm conclusions about the number of and increase in cases of childhood and adult leukaemia in the three countries affected, and among the liquidators.

Breast cancer and the effects of radiation on pregnancy

In women, breast cancer has been particularly prominent: the incidence of this tumour has increased continuously around Gomel over the last 10 years. The number of cases doubled between 1988 and the end of 1999. The causal link between clusters of this disease and the nuclear disaster has been internationally recognised and has been corroborated by epidemiological studies, especially for women who were breastfeeding in the weeks following the accident.

The less specialised cells have a high rate of duplication and the more rapidly they divide, the more vulnerable they are to radiation. This is the reason why the embryo/fetus is particularly at risk. Exposure of the mother to radiation can lead to severe organ and brain damage in the newborn.

Within a short time after the nuclear disaster, a sharp increase in reproductive disorders - predominantly affecting pregnancy - was noted in Ukraine and Belarus. For the 1986–1990 period, the Ministry of Health in Ukraine recorded an increased number of miscarriages, premature births and stillbirths, as well as three times the normal rate of deformities and developmental abnormalities in newborns.

New research findings presented at the "Health Consequences of Chernobyl Children" symposium in Basel in 2003 show that infant mortality and the incidence of stillbirths and birth defects rose significantly in parts of Germany and other European regions exposed to high levels of radiation following the reactor disaster.

Other diseases

It is widely recognised that a general weakening of the immune system can be observed in the population affected by Chernobyl. The latest report from UNDP and UNICEF on the consequences of the Chernobyl accident also leaves no room for doubt that the health of the people in the regions affected by the accident is very poor.

The Ukrainian government agency Chernobyl Interinform comes to the sobering conclusion that of the approximately 3 million people who received increased doses of radiation, 84 per cent have since become ill. Among the liquidators this rate is as high as 92 per cent. Diseases of the cardiovascular and endocrine system, the airways and gastrointestinal tract predominate.

At the 4th international conference "Chernobyl Children – Health Consequences and Psychosocial Rehabilitation", latest research results and scientific recommendations were reviewed and discussed. Health studies on children have shown a growth in cases of nervous system diseases, mental disorders and congenital diseases. Rare forms of genetic abnormalities are observed among children born to the Chernobyl accident liquidators, the Conference Resolution Draft reports. According to the same source, the first generation of the irradiated people living in radioactively contaminated territories have an increased risk for birth of offspring with congenital and hereditary diseases .

An analysis of Belorussian health statistics by the United Nations Children’s Fund (UNICEF) showed that between 1990 and 1994 disorders of the nervous system increased by 43%, cardiovascular diseases by 43%, gastrointestinal diseases by 28%, disorders of bone, muscle and connective tissue by 62%, and diabetes by 28%.

Consequences for Norway

Between 26 April and 5 May 1986, as a result of variable wind conditions, clouds of radioactive fallout were carried from Chernobyl first to Scandinavia, and then over Poland, Czechoslovakia, Austria, southern Germany and northern Italy. Within these

countries, the soil was contaminated to varying degrees, according to where local showers fell.

A few percent of the total release found its way to Central Norway (Nord-Trøndelag) and Eastern Norway (Østlandet). It is calculated that the Norwegian people receive 2-3 % extra of the yearly dose as a consequence of the Chernobyl accident. Some groups, like the reindeer herders in middle part of Norway have received much higher doses. Norwegian Radiation Protection Authority (NRPA) has estimated that in a 50-years period there will be 100-150 extra cases of cancer as a consequence of the Chernobyl accident.

An average Norwegian person gained 0,23 mSv as an extra dose the first year after the accident. 0,15 mSv comes from the food and 0,08 mSv comes from external γ-radiation.

The Chernobyl accident will give the Norwegian people a total dose of 2 mSv over a 50 years period. In the same period we will receive about 200 mSv from the natural radiation sources.

Whether the fallout from Chernobyl will produce long-term health effects in Western Europe is a highly controversial issue.

Wile no one can question the seriousness of the accident, still after many years there is no agreement about the effect it has had or will have on public health.

References

Torstein H. Garmo and Tor B. Gunnerød. Radioaktiv nedfall fra Tsjernobyl-ulykken. *Følger for norsk landbruk, narurmiljø og matforsyning*. Sluttrapport fra NLVFs forskningsprogram om radioaktivt nedfall 1988-1991.

http://www.chernobyl.info

http://www.fi.edu/guide/wester/problems.html

http://www.ecolo.org/documents/documents_in_english/TchernoJR-11_01-Aurengo/TchernoJR-11_01-Aurengo.en.htm

http://www.envimed.com/emb17.shtml