

THE CHERNOBYL DISASTER AND HUMAN HEALTH

Vladislav NAVRÁTIL

Abstract: The accident at the Chernobyl nuclear power plant in 1986 was a tragic event for its victims, and those most affected suffered major hardship. Some of the people who dealt with the emergency lost their lives. About 200 000 people (“liquidators”) from all the former Soviet Union were involved in the recovery and clean up of destroyed region. The plants seem to be protecting themselves from radiation ^{137}Cs and other radioactive elements. Similar conclusions as to the plants can be set also as to the animals. New generations of them is more tough against radiation damage in comparison with the first generation survived in Chernobyl

Keywords: Chernobyl disaster, nuclear power, radioactive elements, contamination, human health

1. Chernobyl disaster (history and reasons)

The Chernobyl disaster was a nuclear reactor accident in the Chernobyl Nuclear Power Plant in Ukraine, at that times part of the Soviet Union (The Power Plant was situated nearby small city Pripyat, at about 100 km from Kiev, capital of Ukraine – Fig.1). It is considered that the Chernobyl disaster was the worst nuclear power plant disaster in the history (nō 7 according to International Nuclear Event Scale)



Fig.1 The surrounding of Chernobyl

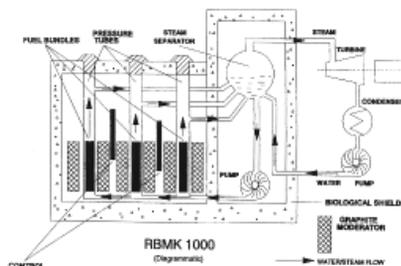


Fig.2 Scheme of RBMK nuclear reactor



Fig.3. Nuclear power plant after the explosion.

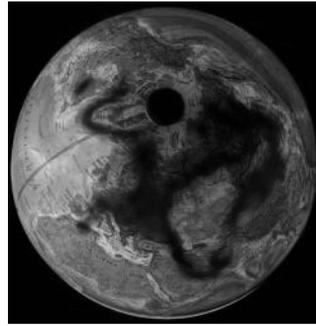


Fig.4. The radioactive cloud a week after the disaster.

On the April 26, 1986, the reactor crew at Chernobyl – 4 nuclear power plant was been preparing for a test to determine how long turbines would spin and supply power following a loss of main electrical power supply. Such experiment was proposed to test a safety emergency core cooling feature during the shut down procedure. The reactor RBMK (Fig.2) is consisted of about 1600 individual fuel channels and each operational channel required huge amount of cooling water (at about 28 tons per hour). There was concern that in case of an external power failure the power station would overload, leading to an automated safety shut down in which case there would be no external power to run the plant’s cooling water pumps. For this purpose there were three backup diesel generators, required 15 seconds to start up and at 60–75 seconds to attain full speed and required power (together 90 seconds so called “power blackout”). This more than one minute power gap was considered to be unacceptable and it was suggested that the mechanical energy of the steam turbine could be used to generate electricity to run water pumps, while they were spinning down. Because generator voltage decreases with this spinning down, a special device (voltage regulating system) was to be tested during the simulated blackout. Every nuclear reactor is designed in such a way that in case of an failure, the reactor would be automatically scram. For this purpose control rods would be inserted and stop the nuclear fission process and other generators. According to detail analysis, the Chernobyl experiment was performed at the most dangerous point in the reactor cycle. For the experiment the reactor was set at a low power setting (50 %) and the steam turbine run up to full speed. At this low power output a phenomenon called xenon poisoning by which high levels of ^{135}Xe absorb neutrons and thus inhibit nuclear reaction, become predominant. To increase power, control rods were pulled out of the reactor core, automatically control system was switched out and staff had to use manual control.

The result of these very unstable conditions was the first steam explosion. It blew the 2000 ton heavy cover damaged the top of the reactor hall. Second, more powerful explosion occurred about two second after the first. It was caused by the hydrogen which had been produced by steam – zirconium or hot graphite – steam reaction. Very hot parts of ejected material caused a fire and the smoke arising from the burning radioactive graphite blocks contaminated great areas (Fig.4). In order of high irradiation most of the staff of the reactor died within three weeks.



Fig.5 Dropping a material



Fig.6 Firemen on the roof of the power plant.

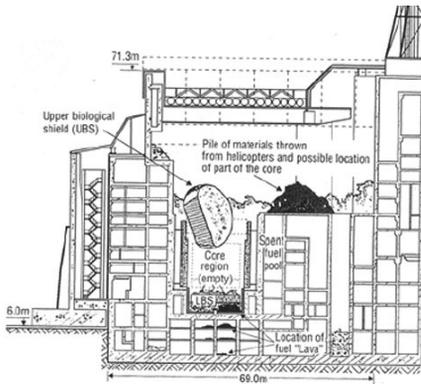


Fig.7 Reactor after the disaster (scheme).

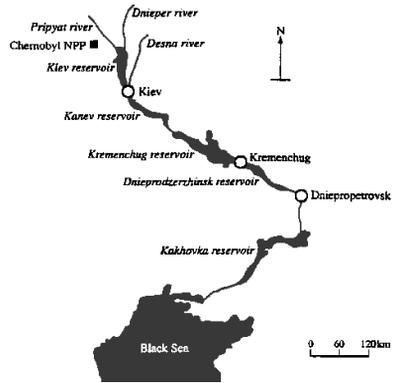


Fig.8 Water and radioactivity

The first priority for firefighters was to extinguish fires on the roof of the station. Many of the firefighters received high doses of radiation because they thought that the fire was only regular electrical fire and did not use any protective gear. The fire was extinguished by a combined effort of helicopters dropping over 5000 tons of materials like a sand, lead, clay and boron onto the burning reactor and injection of liquid nitrogen (Fig.5). The explosion and fire threw particle of the nuclear fuel and dangerous radioactive elements like ^{137}Ce , ^{131}I , ^{90}Sr into the air. The molten core (high radioactive uranium and metals) melted down the Earth surface and there was a danger to reach water rich layer (underground sea) below the reactor. To reduce the possibility of catastrophic steam explosion it was decided to freeze the earth beneath the reactor. Using oil drilling equipment, injections of liquid nitrogen were used (25 tons of liquid nitrogen per day kept the soil frozen at $-100\text{ }^{\circ}\text{C}$).

At about 30 hours after the catastrophe the evacuation of inhabitants began. In order to reduce the baggage the residents were told that the evacuation would be temporary, lasting approximately three days. As a result, Pripyat still contains personal belongings (Figs.13–20).

The reactor was covered with bags containing sand, lead and boric acid and large concrete sarcophagus had been erected to seal off the reactor and its contents (Fig.5). Many of vehicles used by the liquidators remain parked in a field of Pripyat area (Figs 27-29) over 20 years after the disaster (their initial radioactivity was 0,1–0,3 Gy /hr).

About 200 000 people (“liquidators”) from all the former Soviet Union were involved in the recovery and clean up of destroyed region. They received high doses of radiation from 100 to 500 mSv (predominantly from ^{131}I and ^{137}Cs). About five million people lived in areas contaminated above 37 kB / m² by ^{137}Cs . In this years 210 000 people were resettled into less contaminated areas.

After the accident all work on the unfinished reactors 5 and 6 was halted three years later. However the disaster in reactor 4 was followed by the fire in the turbine building of reactor 2. In 1991. Reactor 1 was decommissioned in the year 1996 and on December 2000 president of Ukraine personally turned off Reactor 3 and this act represented end of Chernobyl Nuclear Power Plant. Workers and their families now live in a new town Slavutich, 30 km from the plant (built following the evacuation of Pripyat).

The Chernobyl reactor is now enclosed in a large sarcophagus. A new safe confinement structure will be built by the end of 2011 by help of the Chernobyl Shelter Fund which is organized by the European Bank for Reconstruction and Development and funds from donors and projects are gathered by this institution.

2. Health and Environmental Effects of Chernobyl disaster.

2.1. Plants.

Trees, bushes and vines overtake abandoned streets in Pripyat, near the Chernobyl nuclear power plant (Fig.10). Despite the devastation, local flora did not change or improved its property. According to Martin Hajduch, a plant biologist at the Slovak Academy of Sciences in Nitra, soybeans, planted inside of 30-kilometer restricted zone have three times more cysteine synthase, then soybeans, planted on 100 kilometers remote field. Cystein synthase protect protects plants by binding heavy metals. Chernobyl soybeans also have 32 % more betaine aldehyde dehydrogenase, compound found to reduce chromosomal abnormalities in human blood exposed to radiation.



Fig.9 Restricted zone



Fig.10 Abandoned house overgrown by vine



Fig.11 School building



Fig.12 Pripyat today

What is the conclusion? The plants seem to be protecting themselves from radiation (^{137}Cs and other radioactive elements), but nobody knows how these proteins changes translate into survival, i.e. if future generations of soybeans (and generally also their plants) will have the same amount of proteins. It can be expected that also other plants mobilized evolutionary mechanisms enabled them higher level of radiation.



Fig.13 Russian wheel



Fig.14 School library



Fig.15 The inkpot



Fig.16 Soviet politicians



Fig.17 No comment



Fig.18 Very sad figure



Fig.19 Teachers room



Fig.20 Room in hospital



Fig.21 Pripyat today



Fig.22 Pripyat today

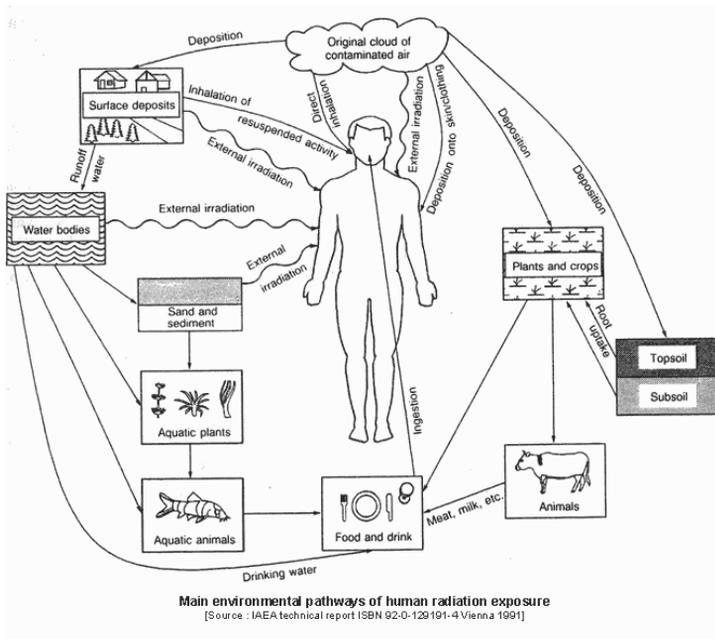


Fig.23 Human radiation exposure

2.2. Human and animals health damage.

For the last two decades, attention has been focused on investigation of relations between irradiation caused by radionuclides and thyroid cancer in children. Particularly dangerous are highly radioactive compounds that accumulate in the food chain, such as some isotopes of iodine and strontium. Of 600 workers present on the site during the early morning of April 26, 134 received high doses (0,7–13,4 Gy) and suffered from radiation sickness. Of these 28 died in the first three months and another 19 died in 1987–2004 of various causes not necessarily associated with radiation exposure. In addition, according to the UNSCEAR 2000 Report, during 1986 and 1987 about 450 000 recovery operation workers received doses of between 0,01 Gy and 1 Gy. That cohort is at potential risk of late consequences such as cancer and other diseases and their health will be followed closely. More than 4000 thyroid cancer cases had been diagnosed in the group of children. It is expected that the increase in this type of cancer due to Chernobyl disaster will continue for many years.

Among workers (liquidators) exposed by high doses of radiation (more than 150 mSv) there was emerging some increase of leukemia. But it is expected incremental decrease of these type of cancer. No other increase of other cancers were not observed.

Similar conclusions as to the plants can be set also as to the animals. New generations of them is more tough against radiation damage in comparison with the first generation survived in Chernobyl. As a result, at present time the 30 km “forbidden zone” seems to be an “animal paradise” for deers, wolfs, rabbits, hares, foxes, beavers, wild Převalsky horses, many kinds of birds and fishes (Figs 24–26). New generation of these species are more resistant against radiation.

The radioactive contamination of aquatic systems became a major issue immediate after the accident. In the most affected areas level of radioactive elements ^{131}I , ^{137}Cs and ^{90}Sv in drinking water was some months relatively high. But after this period the radioactivity decreased below guideline limits for safe drinking water.

Accumulation of radioactive elements in fish were significantly above guideline maximum levels for consumption (which is 1 kBq / kg). For example in the Kiev reservoir in Ukraine it was at about ten times higher. Similar situation can be expected also as regards of animals.



Fig.24 Wild Převalsky horses



Fig.25 People living in restricted zone



Fig. 26 Fish in Kiev lake.



Fig.27 Irradiated helicopter in Pripyat.



Fig 28 Pripyat „parking site“



Fig.29 Pripyat „parking site“

3. Conclusion

The accident at the Chernobyl nuclear power plant in 1986 was a tragic event for its victims, and those most affected suffered major hardship. Some of the people who dealt with the emergency lost their lives. Great arrangements to avoid similar disasters have been made. All of the RBMK reactors have now been modified by changes in the control rods, adding neutron absorbers and consequently increasing the fuel enrichment from 1,8 % to 2,4 % ^{235}U , making them much more stable at low power and also automatic shut – down mechanisms now operate faster together with automated inspection equipment which has been also installed. Since 1989 over 1000 nuclear engineers from the former Soviet Union have visited Western nuclear power plants and other mutual visits have been realized. The IAEA (International Atomic Energy Agency) safety review projects for each particular type of Soviet reactor and consult it with the aim to focus on safety improvements. The Nuclear Safety Assistance Coordination Centre database lists western aid for more than 700 safety – related projects in former Eastern Block countries. According to a German Nuclear Safety Agency report a repetition of the Chernobyl accident is now virtually impossible.

KATASTROFA V ČERNOBYLSKÉ JADERNÉ ELEKTRÁRNĚ A JEJÍ DOPAD NA PŘÍRODU A LIDSKÉ ZDRAVÍ

Abstrakt: Černobylská jaderná katastrofa, ke které došlo v roce 1986, se stala tragickou událostí s mnoha oběťmi, z nichž některé nesou následky dodnes. Její materiální škody jsou obrovské a jejich odstranění znamenalo pro Ukrajinu značné zatížení. Likvidace škod jaderné exploze v Černobylské elektrárně se zúčastnilo asi 200 000 osob (“likvidátorů”) z celého tehdejšího Sovětského svazu. U rostlin, vystavených záření od ^{137}Cs a ostatních radioaktivních prvků. Stejně závěry jako pro rostliny platí i pro živočichy. Jejich nové generace jsou odolnější proti účinkům záření ve srovnání s těmi, kteří jí byli zasaženi v době katastrofy.

Klíčová slova: černobylská katastrofa, nukleární energie, radioaktivní prvky, kontaminace, lidské zdraví