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Chernobyl Accident and Its Impact on the Plants

The Chernobyl Forum Expert Group on Environment (EGE) has suggested that the impacts of the Chernobyl accident should be studied within specific time periods. Three distinct phases of radiation exposure have been identified in the area that is local to the accident in Chernobyl. In the first 20 days radiation exposures were essentially acute because of the large quantities of short-lived radio nuclides present in the passing cloud. Most of highly radioactive nuclides deposited onto the plant and ground surfaces, resulting in gamma radiation dose. However, there was a considerable additional dose rate due to the beta radiation from the deposited radio nuclides for the surface tissues and small biological targets (for example, mature needles and growing buds of pine trees). High doses in the thyroids of the vertebrate animals also occurred during the first days and weeks following the accident due to the inhalation and ingestion of radioactive isotopes of iodine and their radioactive precursors.

The second phase of radiation exposure extended through the summer and autumn of 1986, when the short-lived radio nuclides decayed and the longer-lived radio nuclides were transported to different components of the environment by physical, chemical and biological processes. Dominant transportation processes included rain that induced the transfer of radio nuclides from the plant surfaces onto soil and bioaccumulation through plant tissues. Dose rates on the soil surface reduced to less than 10% of the initial values due to radioactive decay of the short-lived radio nuclides, but damaging total doses were still accumulated. Approximately 80% of the total radiation dose was accumulated by plants and animals within 3 months of the accident, and over 95% was due to beta radiation exposure. Measurements made with thermoluminescent dosimeters on the soil surface at sites within the 30-km exclusion zone indicated that the ratio of beta to gamma dose was about 26:1.

EGE has also defined a third (and continuing) phase of radiation exposure with chronic dose rates less than 1% of the initial values and derived mainly from 137 Cs. The decay of the short-lived radio nuclides and the migration of the remaining 137 Cs into the soil meant that the contributions to the total radiation exposure from the beta and gamma radiations tended to become more comparable. The balance depended on the degree of bioaccumulation of 137 Cs in the organisms and the behaviour of the organism in relation to the main source of external exposure resulting from 137 Cs in the soil.

Doses received by the plants arising from the deposited radio nuclides were influenced by the physical properties of various radio nuclides (for example, their half-lives, radiation emissions, etc.), the physiological stage of the plant species at the time of the accident, and the different species-dependent propensities to take up radio nuclides into the critical plant tissues . The occurrence of the accident in late April 1986 was thought to have enhanced the damaging effects of the deposition because it coincided with the period of accelerated growth and reproduction of the plants.

The deposition of beta-emitting radio nuclides onto the critical plant tissues resulted in their significantly larger dose than animals living in the same environment. Large apparent inconsistencies in the dose-response observations occurred when the beta-irradiation component was not appropriately taken into account.

Coniferous trees known to be among the most radiosensitive plants and the pine forests which are 1.5–2 km west of the Chernobyl nuclear power station received sufficient doses, more than 80 Gy, at dose rates that exceeded 20Gy/d. The first signs of radiation injury appeared during the summer of 1986 and were yellowing and needle death in pine trees in close proximity to the nuclear power station. The colour of the dead pine forest refers to as the “red forest”.

Tikhomirov and Shcheglov found that mortality rate, reproduction, viability, and re-establishment of the pine-trees were dependent on the absorbed dose. Acute irradiation of Pinus silvestris at doses of 0.5 Gy caused detectable cytogenetic damage; at doses of more than 1 Gy, growth rates were reduced and morphological damage occurred; and, at more than 2 Gy, the reproductive abilities of the trees were altered. Doses of less than 0.1 Gy did not cause any visible damage to the trees. The radio sensitivity of the spruce trees was observed to be greater than that of the pines. At absorbed doses as low as 0.7–1Gy, the spruce trees had malformed needles, buds and shoot growth.

About 90% of the absorbed dose to critical parts of the trees was due to beta irradiation from the deposited radio nuclides with the remaining 10% from gamma irradiation. By 1987, recovery processes were evident in the surviving tree canopies and the forests were re-establishing themselves where the trees had perished. In the decimated pine stands, a sudden invasion of the pests occurred that later spread to the adjoining areas. Grassland, with a slow invasion of self-seeding deciduous trees, has now replaced the deceased pine stands. Four distinct zones of radiation-induced damage to the conifers were discernible.

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