Short Communication

Nuclear power plant accidents and its environmental, ecological and genetic impact

Harshini Sarojini
Price Institute of Surgical Research, Hiram C Polk Jr. MD Department of Surgery, University of Louisville, and Noveratech LLC of Louisville, KY, USA

Corresponding author: Harshini Sarojini, E-mail: harshini.sarojini@louisville.edu

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Abstract

The largest radioactive power plant accident happened in Chernobyl. The residents were evacuated from the area 24 hours after the accident and the area was declared prohibited for inhabitation. The radioactive material from the accident contaminated the land and water in and around the Chernobyl area. From the contaminated land and water bodies the radioactive materials entered the plants and other living organisms through the food chain. The radioactive contaminants have adversely affected the survival of plants, caused an increase in mortality of animals and created genetic abnormalities. The radioactivity decay over the years has helped to develop a unique nature preserve for biodiversity by allowing the biological populations to survive, reproduce and recover in the area.

Keywords: Radioactive, Chernobyl, genetic abnormalities, biodiversity.

Introduction

The Chernobyl nuclear power plant accident on April 26, 1986 in Ukraine was the largest uncontrolled radioactive release recorded in history. This uncontrolled radioactive release contained enormous amounts of radioactive Iodine-131, Cesium-134 and Cesium-137 deposited near the nuclear power plant in Ukraine, as well as in Belarus and Russian Federation, the two neighbouring countries. [1] Approximately 200,000 km^2 were contaminated by radionuclides with a total released radioactivity of 5300 PBq. [2] The day after the explosion, residents living within 30 km around the damaged nuclear power plant were evacuated within 30 hours by the Soviet authorities and declared the area prohibited for inhabitation. In addition to this, people outside the 30km zone were also evacuated. Over all 350,000 people suffered the overnight evacuation and relocation.[2]

Environmental impact

The effects of radioactive fall outs due to the Chernobyl power plant accident were most obvious in Ukraine, Belarus and Russia. These areas were extensively contaminated by the enormous amounts of radioactive materials. Subsequently most of these materials have transformed into stable, non-radioactive materials over time but some still can remain radioactive for an extended period of time. In the areas near the reactor which were heavily contaminated during the accident had subsequently shown a decrease in surface contamination, the radiation levels in the air being the same as before the accident. The major concern in the early months after the accident was the presence of short-lived radioactive iodine contamination in the crops, meat and milk. But the major concern, for now and decades to come, is the contamination due to longer-lived radioactive caesium. Caesium contamination is expected to remain high for several decades in forest food products such as berries, mushrooms etc and they are still reported to remain in higher levels. The radioactive materials contaminated the water bodies and fish; but this contamination was soon reduced due to the decay and dilution of the radioactive materials. Up till now some of the radioactive materials can be trapped in the soils surrounding the contaminated rivers and lakes. Recently, in most water bodies and fish less radioactivity levels were detected, while in some closed lakes the radioactivity still remains high. The heavy radioactive fallout affected numerous plants and animals within 30 km of the site. High mortality, reduced levels of reproduction and genetic abnormalities were reported in those plants and animals. Now 30 years later, the radioactivity levels decreased over the years allowing the biological populations to survive, reproduce and recover in the area and has become a unique nature preserve for biodiversity. [3]

Ecological implication

Ionizing radiation from Chernobyl nuclear accidents has diminished the diversity and species abundance of the ecosystem. The resurgence in studies focusing on radiobiology and radioecology, specifically on the low dose effects of ionizing radiation emerged after Chernobyl nuclear power plant accident. The effects of low dose radiation on non-human biota are seldom studied. Møller, Mousseau and colleagues have conducted a significant amount of field studies on the effects of the low doses of radiation on non-human biota especially in Chernobyl birds. The emphasis on the study was based on high metabolic rates, high survival rates and a high diversity of bird species with variable life history, migratory propensity and dispersal. The richness, abundance and population density of breeding birds were reported to decrease with increasing radiation levels. [4] Similar results were observed for the invertebrates in the uppermost soil layer of Chernobyl. [5] Chernobyl birds were found to have impaired brain development interrelated to oxidative stress, subsequently resulting in smaller head volume. [6] High frequency of cataracts independent of bird age was also reported. [7] Elevated frequencies of abnormalities, such as partial albinism, deformed toes, and tumors have been reported in barn swallows from Chernobyl. [8]

However, it has been debated that the ambient dose rates in the contaminated regions are too low to certify significant impacts. [9,10] Correspondingly no standardized census subsists for common animals in relation to the radiation. [11] Hence, the query of the ecological effects of radiation essentially remains unresolved. Even though, the precise dose determination under field conditions can be challenging, the maximum dose rate for terrestrial plants to reproduce and long-term survival in natural populations is considered to be 400 mGy/h. [12] However, these lower doses of ionizing radiation can induce stress responses in an irradiated organism. [13,14] The comprehensive molecular mechanisms of adaptation to chronic radiation exposure by plants still remain unresolved. [15-18] The ionizing radiation exposure dose at which the response occurs depend on the species, age, plant morphology, physiology and genome organization. [19] Ionizing radiations have differential effects on plant growth and development; stimulatory effects at low doses, harmful effects for vegetative growth at medium levels, and pronounced reduction in reproduction and yield at higher radiation levels. [20] In rapid growing plants the radionuclides were absorbed to by young leaves. This mechanism of active translocation and absorption of the water-soluble radioactive elements through the leaves were reported by Coughtrey and Thorne (1983). Conversely, plants also absorb radionuclides through their roots from the soil. Rain fall helped to clear the atmosphere from radionuclides, which were consequently transferred to the soil. Several studies have reported that rain can carry more radioactivity deposition than a radioactive cloud settling.[22] Marine organisms have low radioactivity concentrations due to their dilution of radioactive fall outs in sea water. Mosses, fungi and lichens are reported to be collectors of a variety of heavy metals and toxic substances from their environment. [23] Finally, in fruit-bearing trees, higher radioactivity is clearly observed in the leaves than in the fruit, due to a greater surface exposed to contamination.[23]

The biodiversity loss is a serious concern, since they play a vital role in long term ecosystem functioning. [24] Hence, research focused on the biodiversity spatial distribution is essential.

Genetic significance

The genetic studies conducted in Chernobyl showed higher rates of genetic impairment and mutation. Ionizing radiation can induce diverse effects at the genetic level, and this can vary from simple base pair substitutions to single- or double-stranded DNA breaks. [25] The population sizes in highly radioactive parts of the Chernobyl Exclusion Zone were found to be reduced among most of the investigated *taxonic* groups (i.e., birds, bees, butterflies, grasshoppers, dragonflies, spiders, mammals). One of the initial tests for radiation on mutation rates at Chernobyl used microsatellite markers to examine de novo mutation rates in barn swall *Hirundorustica*. [26] The mutation rates in this study were 2 to 10-fold higher for birds in Chernobyl than the control populations from Ukraine and Italy. Amid the earliest visible signs of radiation exposure were the appearance of white spots on the bird feathers and the mammalian furs. These "partial albinos" have been reported for Chernobyl barn swallows [26,27] and other bird species. [28] Møller *et al*. (2004) reported that the frequency of abnormal sperms in barn swallows was up to 10 times higher for Chernobyl birds as compared to sperms from males living in control areas. They also reported that the abnormality rates were interrelated to the reduced levels of antioxidants in the blood, liver, and eggs of these birds, thereby postulating the hypothesis that antioxidants play a significant role in DNA protection from the direct/indirect radionuclides exposure. Møller *et al*. (2008) found that sperm behaviour was negatively affected by radiation levels while Bonisoli-Alquati *et al*. (2011) found that plasma oxidative status could predict sperm performance from the effects of ionizing radiation. Overall, these studies provide convincing evidence that low dose radiation results in male infertility and this may be the explanation for the smaller population sizes of many species in the Chernobyl region. The number of visible tumors on birds was significantly higher in radioactive areas. This could be due to the higher mutation rates in the somatic tissues. [7]

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Conflict of interest

There are no conflicts of interest.

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