GUIDE-LINES FOR AN EARLY EVALUATION OF A NUCLEAR ACCIDENT, CALCULATED WITH THE COMPUTER MODEL PARK

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Introduction

For a nuclear accident where large areas are contaminated, it is necessary to predict the exposure of the population as early as possible in order to plan appropriate countermeasures. The radioecological computer model PARK (Program System for the Assessment and Mitigation of Radiological Consequences) [1,2] is part of the German decision support system IMIS (Integrated Measurement- and Information System for the Surveillance of Environmental Radioactivity) [3] for a fast assessment of contaminations and doses. In this paper PARK is used to investigate the dose relevance of the exposure pathways, of ingested radionuclides, and of foodstuffs in relation to the date of the event.

Model Description

The following example is based on an assumed nuclear accident with core melting according to the release category no. 2 (FK-2) of the 'Deutsche Risikostudie Kernkraftwerke' [4]. Major portions of the activity inventory of a 1300 MW_{el} nuclear power plant are released into the environment by a leak in the containment of 30 cm in diameter. Within the scope of this scenario, the entire inventory of noble gases is released one hour after the end of nuclear fission. The respective percent portions are: 40 % iodine, 29 % caesium, 19 % tellurium, 3 % strontium and 0,26% lanthanides and actinides, res..
For approximating the atmospheric transport a dispersion model developed by NRPB [5] is used. The radioactive cloud is reaching the investigated distance 11 hours later, at a distance of approximately 200 km from the reactor, since the IMIS system is designed for long range contamination, and not short range distances. Physical decay and production of daughter nuclides are being considered. The ratio between the fraction of elemental iodine, aerosol bound and organic bound iodine is assumed to be equal.
These assumptions lead to an integrated activity concentration of 10^6 Bq·h/m³ for I-131, $7 \cdot 10^4$ Bq·h/m³ for Cs-137, and $1{,}5 \cdot 10^7$ Bq·h/m³ for total activity at the investigated distance. These values are used as input for PARK which then estimates the effective dose by all exposure pathways without countermeasures and change in living habits. PARK is based on the radioecological model ECOSYS [6], and therefore takes into account the state of plant growth and the effects of food processing. As a result, a total effective dose of about 700 mSv is calculated assuming a dry deposition taking place on July 1st. The figures however are scaled, so that this dose corresponds to a value of 1. In the case of wet deposition, it is assumed that the activity in air is entirely deposited on the soil and vegetation.

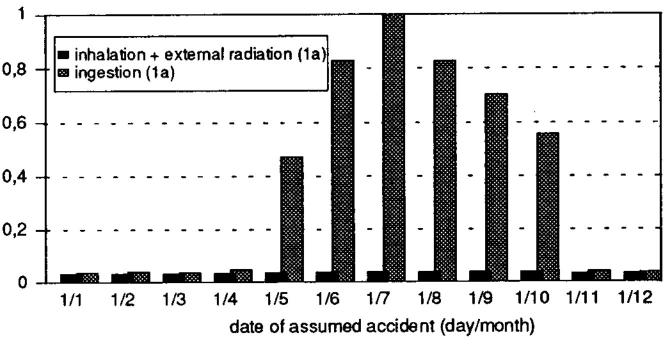

Fig. 1: Effective dose due to inhalation and external radiation (1 year) and from ingestion of contaminated foodstuffs over the first year following the assumed accident at a distance of 200 km, for adults and standard German living habits.

Relevance of Exposure Pathways

Different radiation pathways are considered: external exposure from the cloud and from the surface as well as internal exposure from inhalation and ingestion. Fig. 1 shows the results from the assumed accident occurring in different months of the year. Ingestion is identified as the most relevant pathway in case of a nuclear accident during the period between May and October, whereas during the remaining months ingestion doses are assessed to be nearly of the same magnitude as those of the external exposure and inhalation.

Relevance of Ingested Radionuclides

Subdividing the ingestion dose into the proportions of radionuclides, only Cs-134, Cs-137 and I-131 are essentially contributing, altogether by more than 90 percent. This result is unexpected, since a set of 30 radionuclides has been included into the calculations [7] but may be understood by regarding the radiological transfer processes and dose coefficients.

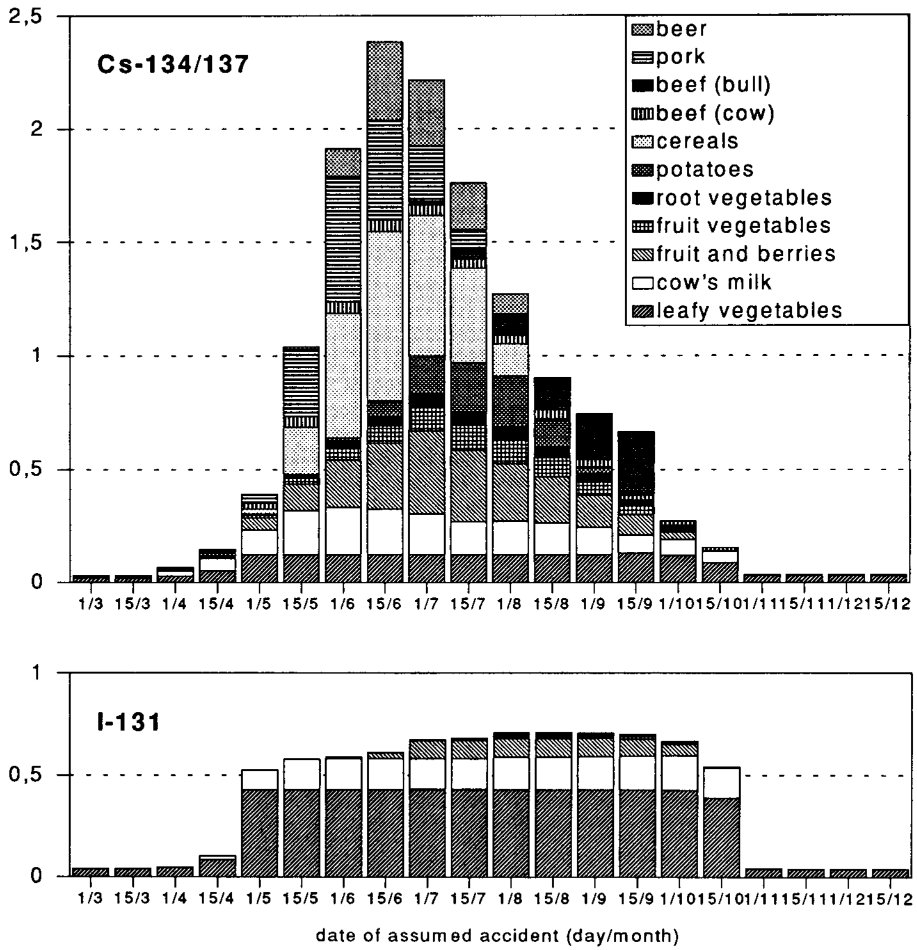

Fig. 2: Effective dose following an ingestion of contaminated foodstuffs during the first year after an assumed nuclear accident at a distance of 200 km. Average consumption rates for German adults are presumed.
Note: This diagram does not show a time series but shows each bar as representative of the life time dose related to the given date of the accident

Relevance of Ingested Foodstuffs

Fig. 2 shows the expected contribution from main foodstuffs to the effective dose from the ingestion of radiocaesium and radioiodine at given dates of wet deposition during the first year. For the purpose of comparison the same scale is used for Fig. 1 and Fig. 2. It is obvious that the dose from ingestion varies by more than one order of magnitude with time of the event [8]. The highest doses can be expected in summer when the vegetation is developed. During this period, the contamination of the plant surface and translocation are predominant compared to the root uptake. Following an accident in spring, the contamination subsequently is reduced by the increased mass of the plant. The dose from the ingestion of leafy vegetables does not vary much between May and October because surface contamination is here the main factor. The dose contribution from other products, however, varies in a wide range and causes the maximum of the total dose during summer. This is most pronounced from products such as cereals, beer (brewn from summer barley), pork (fed with winter barley), beef (fed with corn) and fruits, which are easily contaminated with radiocaesium in summer from wet deposition.

Discussion and Conclusions

Between May and October, scenarios are possible where only limits for contamination of food products are exceeded while the other pathways contribute very little to the total dose. In this situation, countermeasures affecting the agriculture, e.g. restricting the consumption of fresh products, are very important. The results have been verified by using the radiation doses determined for several regions of Germany [9] after the Chernobyl accident which happend in the end of April. With values for the ingestion doses taken from Fig. 2, it is evident that the highest dose contribution results from iodine in combination with leafy vegetables and milk. The dose from caesium was also reduced by countermeasures that were taken. Severe consequences, especially from the caesium contamination, must be faced if such an event is taking place during summer. Our results show that it is not recommendable to rely on the experience from the Chernobyl event only, when assessing consequences from future radiological accidents.

Literature

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