Transfer of Radiocesium from Plants to Venison

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SUMMARY

The spatial distribution of the fallout of radiocesium caused by the reactor accident of Chernobyl was contrary to that of the nuclear weapon experiments of the fifties and the early sixties very inhomogeneous. The Cs in the atmosphere was washed out to the leaves and needles by rain and airflows, and deposited on the soil. The uptake of radiocesium by plants was influenced by several specific plant parameters. The highest contamination of radiocesium occured in the forest ecosystems, mainly in coniferous woods. The radioactivity of the plants growing on agricultural areas was often near the detection limits. Subsequently venison of game living on agricultural areas was and is less contaminated than that of animals living exclusively in coniferous forests. The contamination of game differs with regard to its habits of food selection. Wild boars contain the highest amounts of Cs of all game species investigated, followed by roe deer. The lowest content is found in red deer. Wild boar is an omnivorous animal which likes to root in the soil. Soil is the highest contaminated part of a biotope.

INTRODUCTION

The reactor accident of Chernobyl has caused a widespread radioactive contamination in Germany. Contrary to the nuclear weapon tests with its radioactive nuclids in the stratosphere the radioactive nuclids of the Chernobyl accident only raised to the troposphere. So the fallout distribution was very inhomogeneous depending on the different trajectories of the clouds, the intensity of the rainfall and other local conditions. The most important radionuclides remaining today in the biosphere are the two cesium isotopes Cs-134 and Cs-137. Other artificial nuclides decayed by their short physical half live or have been deposited only near by the Chernobyl reactor. The ecosphere was contaminated twice, by the fallout (deposition of radiocesium on soil and vegetation) and by the washout (leaching of the isotopes from clouds or from the leaves respectively needles to the soil).

MATERIALS AND METHODS

1.Plants: The plants and fungi were collected in the Bavarian Forest. In the cases of shrubs and trees only the radioactivity of the leaves was investigated. With herbs the whole plant was measured. The fresh plants were dried at 100°C. The needles of the spruce were sampled for investigations of the retranslocation of the radiocesium during the growth and development period of the needles. The dried plant samples were ashed in a muffle furnace during two or three days at 450°C. The ash was dissolved by 37 % hydrochloric acid and dist. water followed by heating until boiling. Then the clear sample solution was filled in a polyethylene beaker and measured by gammaspectroscopy.

2.Fungi: The fungi were determined to a species with the key of BESL and BRESINSKY (1985) and MOSER (1983). The fungi were dried in glass dishes at 50°C until weight constancy. Only the activity concentration of dried fungi is comparable, because of the wide variation of water of the fungi (about 70 - 95 %). The fungi were milled and suspended in distilled water before the measurement.

3.Venison: The venison samples (200 to 500 g) were sent to our institute by mail. Fat and connective tissue were removed from the muscles and pure muscle meat was homogenized. The sample was filled in a polyethylene beaker to a definite height and measured.

4.Gammaspectroscopy: The samples were measured in a gammaspectrometer using Li drifted or pure crystal Ge-detectors. The calibration was done by a standard solution which contained a defined amount of the two isotopes. Cs-137 and Cs-134 were determined in definite geometries. The samples were filled up to a certain height in standardized polyethylene beakers which were put in fixed geometric positions during measurement.

5. Statistical methods: The results of the gammaspectroscopy were coded with sample characteristics, put in a data bank and finally evaluated using the SPSS statistic programme package. The distributions of the data are presented by the so called Box-Whiskers plots. For presentation see fig. 1.

RESULTS and DISCUSSION

1. Uptake by plants

Radiocesium was deposited on the soil by the fallout of the radioactive clouds and the washout of leaves and needles. At the present time the radiocesium is found in the litter and humus layer. The uptake of radiocesium from soil to the plants depends on the depth of the roots into the soil, because the penetration of Cs into the soil is very slow. Roots in great depth are less contaminated. Furthermore there are big differences in the uptake of ions by the plants. K^+ and Cs^+ ions are chemically and physiologically very similar. So, probably some plants take up Cs with K. Also the conditions of the soil are significant to the mobility of radiocesium. In acid soils Cs is not fixed and can be easily dissolved from the humus particles . In soils with high pH-values Cs is fixed by clay and humus particles and is not available to the plant roots. In these cases radioactive contamination does not enter the food chains, i.e. the plants. In agricultural areas furthermore Cs was carried to the deeper layers by ploughing, and furthermore the pH is higher by fertilizers.

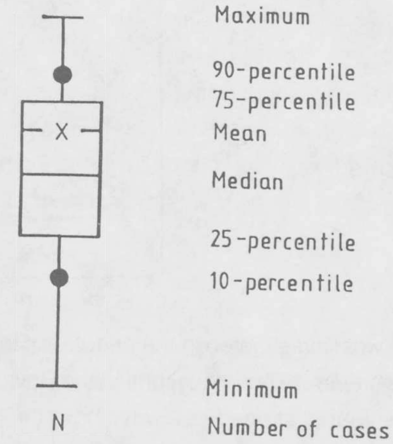


Fig. 1: Scheme of a Box-Whiskers-Plot

So the contamination of the food plants for the game is very different. In general it can be stated that forest ecosystems show a higher contamination level than the agricultural areas. We have selected some browse plants of game to investigate their content of radiocesium.

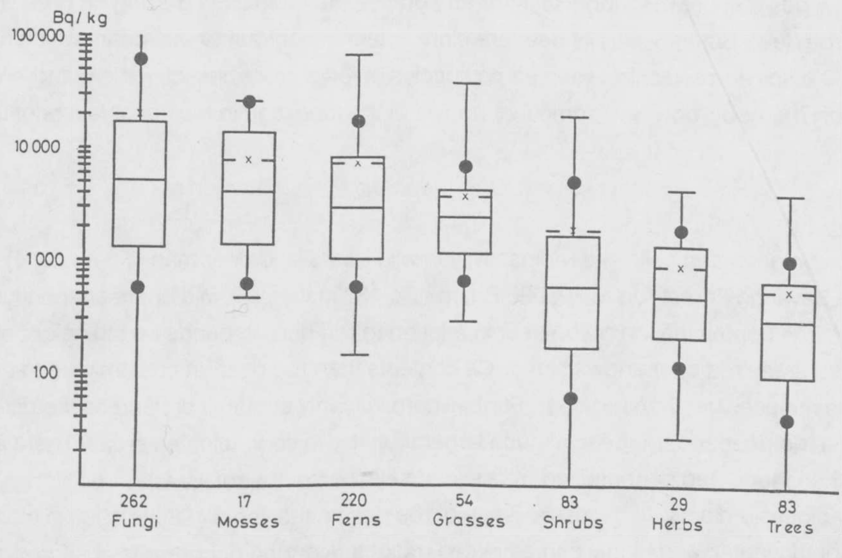
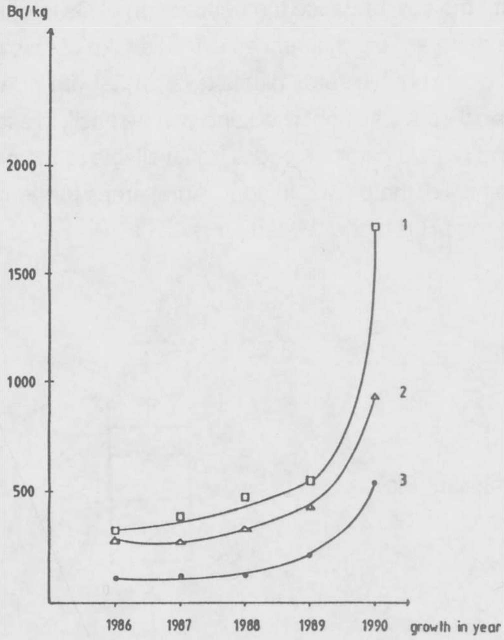


Fig. 2: Radiocesium activity concentration of dry matter of different plant groups from the Bavarian Forest (1987-1990)

In fig.2 several plants are summarized with regard to their growth form or systematic botanic group. The highest contamination is found in fungi with a median of 5000 Bq/kg, the scattering range is very large. Some species show a very low activity, other species like cepe (Xerocomus badius) are very high contaminated. Also high contaminations are stated in mosses showing a median of about 4000 Bq/kg. A significant content of Cs-137 can be found in the ferns with a median of 3000 Bq/kg. In grasses, e.g. hair grass (Deschampsia flexuosa) and wood rush (Luzula sylvatica) were examined. They are rather highly contaminated with a median of 2500 Bq/kg. Shrubs are less contaminated with a median of 600 Bq/kg. The highest value with shrubs were found in leaves of blueberries (Vaccinium myrtillus). A few species of herbs were examined which show a median of 500 Bq/kg. The lowest contamination is found in trees (about 300 Bq/kg), thoroughly examined in beech (Fagus sylvatica) and larch (Larix decidua) (fig. 3).

Fig. 3:

Cs-137 activity concentration of various age-classes of spruce needles from three different sampling locations (1 - 3) in the Bavarian Forest after the needle shoot in 1990



The retranslocation of radiocesium was investigated in the needles of the spruce (Picea abies). The age grouped needles of the last five years (1986 - 1990) were studied. Three locations in the Bavarian Forest were selected. The results given in fig.3 show that the shoots respectively the youngest needles always have the highest radiocesium concentrations. This is correspondence to the finding that potassium is accumulated in the tips of the coniferous trees (SIEGHARDT,H. 1987). The tips of spruce twigs are a preferred food of game, especially roe deer.

There is also a considerable seasonal variation in the content of radiocesium in the needles. In summer the radioactivity increases and decreases again in autumn. Also the other examined plants show a considerably varying radiocesium content during the year.

The composition of the browse during the year varies depending on the seasonal offer and occurence of the different plant species. The food habits amongst wild animals are also considerably different. Roe deer is a feed selector choosing a lot of plants. Red deer represents a position between food selector and grass-eater. It is often grazing on green lawns and does not nibble in such an extent as roe deer. Both species of deer are plant eaters in contrast to wild boars which are omnivorous animals. They like to root in the soil and select between some species of fungi, fruits, insects, snails and even mice. The biggest amount of the radioactivity of Chernobyl now is in some fruit bodies of the fungi and in the upper layers of the soil which wild boars are rooting in.

2. Contamination of venison

In Bavaria in areas with less contaminated soils, the radioactivity in wild boars is smaller than in deer (fig.4). In contrast, in highly contaminated areas like the Bavarian Forest (up to 100000 Bq/m^2 Cs-137 in the soil) wild boars are nearly ten times higher contaminated than roe deer. The contamination of roe deer in relation to red deer depends on the height of the contamination of the area. In low contaminated areas red deer shows higher Cs contents than roe deer. In contaminated and highly contaminated areas roe deer contain more radiocesium than red deer. Furthermore in highly contaminated areas the difference in the radiocesium activity between red deer and roe deer is much larger than it is in contaminated areas. There is also the radiocesium content of roe deer higher than that of red deer caused by the feed selection of the roe deer.

In fig.5 the trends of the radiocesium activity in muscle tissue of roe deer in the years 1986 to 1990 is plotted for three kinds of areas: low contaminated, contaminated and highly contaminated regions. A strong decrease is observed in roe deer originating from low contaminated areas. The radioactivity declined nearly ten times within the observed period of time. In contaminated and highly contaminated areas the decline of radioactivity is not as significant as in low contaminated areas. The decrease amounts only to 30 - 50%. But the general tendency is in any case that the radioactivity is declining. It can be expected that in low contaminated areas the content of radiocesium will decrease much faster than in contaminated ones.

Especially in coniferous ecosystem radiocesium will be retained in the biological cycles for several decades, as it is not fixed so strongly to the soils. The fall of leaves and needles causes year by year an additional contamination of the soil. Cs is taken up by the roots of the plants, which will be eaten by the different animals. Cs returns to the soil again by excretion of urine and faeces, so it remains in the biocycles and no or only a small decline will occur which is above the physical decay.

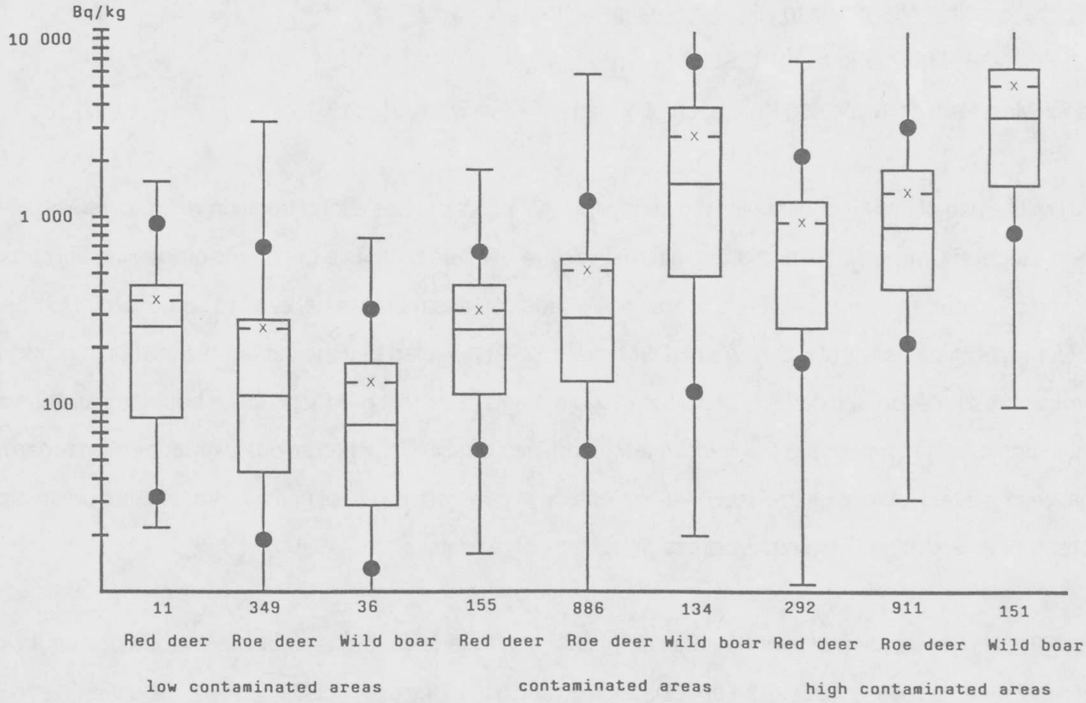


Fig.4: Comparison of the radiocesium activity concentraiton of fresh muscle tissue of three different game species coming of three differently high contaminated areas of Bavaria (1987 - 1990)

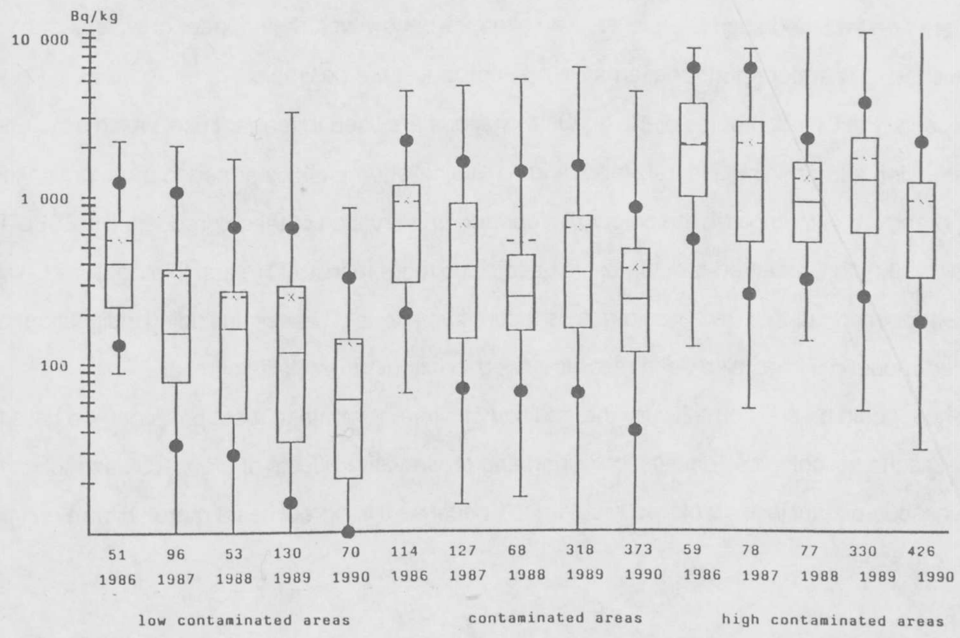


Fig. 5: Trend of the radiocesium activity of fresh muscle tissue of roe deer from 1986 - 1990 in three differently high contaminated areas of Bavaria

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