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Time-dependence of ^{137}Cs activity concentration in wild game meat in Knyszyn Primeval Forest (Poland)

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ABSTRACT

Wild game meat samples were analysed from the region of the Podlasie province (Knyszyn Primeval Forest). ^{137}Cs content in meat was determined by gamma spectrometry in 2003 (33 samples), 2009 (22 samples) and 2012 (26 samples). The samples were collected in the autumn of 2003, 2009 and 2012 and were compared with data from 1996. Mean concentrations of ^{137}Cs in the respective years were as follow: 42.2 Bq kg^{-1}, 33.7 Bq kg^{-1} and 30.5 Bq kg^{-1}, respectively. On the basis of mean values of ^{137}Cs in the meat samples of red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and wild boars (*Sus scrofa*) between 1996/2012, the effective half-life of ^{137}Cs was determined for specific species. For red deer equaled 8.9 years, for roe deer 11.6 years while for wild boar it exceeded the physical half-life and equaled 38.5 years. Mean value CR obtained for all three species equaled 1.7 ± 1.5 out of 102 measurements in animals muscles.

1. Introduction

Radiocaesium has been introduced into the natural environment by means of nuclear weapon testing, discharge of nuclear waste, as a result of the 1986 disaster at the Chernobyl nuclear plant, etc. Forest is a particular environment in which contamination is maintained for decades. Tests conducted after the Chernobyl disaster in the contaminated forest region of central Sweden (Fawaris and Johanson, 1994) demonstrated that 85% of radiocaesium within the soil profile was found to be in the organic layer. The distribution of radiocaesium in the soil is influenced by a great number of factors such as: the thickness of the organic layer, density of the soil and type of underbrush (Kubica et al., 2004). Mietelski et al. (1996) suggest that radiocaesium contamination in the forest floor litter is detectable for at least 30 years. It is accessible for wild animals for a long time after a nuclear plant accident in moss, mushrooms (Amundsen et al., 1996), and lichens (Holleman et al., 1971), which are very good radiocaesium bioindicators. The type of soil and chemical form of caesium are key factors affecting the storage of ^{137}Cs in the terrestrial environment (Niesiobędzka, 2000). Wild animals, due to their diet, also tend to be good indicators of contamination (Howard et al., 1991; Marowić et al., 1992). The radioactive caesium content in their tissues is a sensitive indicator of contamination of their habitat (Ahman et al., 2001; Strebl et al., 1996). As Howard et al. (1991) reported ^{137}Cs activity concentration levels in game meat in the 5 years following the Chernobyl accident in a few European countries (Austria, UK, Sweden, Ireland, Norway) were 50–100 times higher than Cs activity concentration levels in wild animal tissues at the time of nuclear weapons testing in the 1950s and 1960s. Zibold et al. (2001) suggested that radioactivity in contaminated forest food products will decrease with the effective half-life close to the physical half-life of ^{137}Cs (30.2 y).

The measurements of ^{137}Cs activity concentration levels in game meat which were obtained in the northeastern region of Poland in 1986 after the Chernobyl accident showed the arithmetic mean (AM) value in roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*) to be 290 Bq kg^{-1} and 120 Bq kg^{-1} respectively, with maximum values of 4357 Bq kg^{-1} and 436 Bq kg^{-1} respectively

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(Grabowski et al., 1994). The measurements recorded in 1996 in the region of Knyszyn, Augustów, and Białowieża Primeval Forests showed the mean values of ^{137}Cs in red deer (*Cervus elaphus*), wild boar, and roe deer to be 29 Bq kg^{-1}, 96 Bq kg^{-1}and 41 Bq kg^{-1} respectively (Kapała, 1999). According to subsequent analyses performed in 2001, the activity concentration levels of radiocaesium in red deer muscle tissue in Warmia and Mazury (neighbouring part of North-East Poland) the mean value were 20 Bq kg^{-1} (Zalewski and Szymczyk-Kobrzańska, 2005). The latest measurements of ^{137}Cs activity in game meat were obtained in Warmia and Mazury by Rachubik in 2007 and their approximate mean values were 14 Bq kg^{-1} in roe deer and 21 Bq kg^{-1} in wild boar (Rachubik, 2008). The analysis of Poland's radiological maps (Strzelecki et al., 1993) revealed that the aforementioned area studied did not display anomalous levels of caesium contamination.

Higher concentration of radiocaesium in forest regions result in ^{137}Cs concentration levels several times higher in the meat of wild animals than ^{137}Cs concentration levels in farmed animals reared in rural regions (Holleman et al., 1971).

The presence of radiocaesium in game meat impacts on the human dose of radiocaesium. For example, Eskimo and Laplander reindeer breeders, for whom reindeer meat is an important food source, display a far higher whole-body content of ^{137}Cs than the rest of the Lapp population. This is due to the fact that the reindeer ingest considerable quantities of moss and lichens, which are good accumulators of radiocaesium (Westerlund et al., 1987).

The aim of this study was to analyse temporal trends in ^{137}Cs activity concentration levels in the tissues of the wild boar, red deer, and roe deer in Knyszyn Primeval Forest between 2003 and 2012. Research results obtained in the same region in 1996 (Kapała) have been included in the paper in order to extend the analysis and discussion.

2. Materials and methods

2.1. Terrain description

Samples were collected in the autumn of 2003, 2009 and 2012 from the wild game purchasing centre in Bialystok and from the Forestry Management outlet in Supraśl. All the sampled animals were hunted in the region of Knyszyn Primeval Forest situated in the north-eastern part of Poland, bordering Białystok (Fig. 1). The Forest covers an area of 1050 km^2. It consists of 78% woodland, 13% arable land, 7% meadows and pasturage while other areas (buildings, road and waters) comprise 2%. Knyszyn Primeval Forest is dominated by coniferous trees: Scots pine (70%) and spruce (11%), and the remaining 19% is mixed stand (oak, birch, alder) (RDSF, 2013).

The predominant type of soil in the Forest is a type of rusty soil (63%). Secondly, peat soils are characteristic of wetland (5.8%). Podzolic (4.1%) and brown soils constitute a relatively large percentage of the soil types found in the area (4.3%). Moreover, soil types such as muck (2.7%) and ground-gley (2.2%) constitute a significant part of all types of soil present in the Forest. Deluvial and alluvial types of soil are the least-represented in the area (RDSF, 2013).

The measurements of ^{137}Cs activity concentration in the top 10 cm layer of soil in the region obtained in 2000 (Zalewski et al., 2002b) showed a lower value of AM = 3.1 kBq m^{-2} (SD = 2.6 kBq m^{-2}) while the higher ^{137}Cs deposition was found in the forest soil (AM = 4.4 kBq m^{-2}). A slightly higher arithmetic mean of ^{137}Cs activity concentration in the soil in the same region was determined by the Institute of Geology in 1993 (AM = 5.7 kBq m^{-2}, SD = 2.6 kBq m^{-2}) (Strzelecki et al., 1994).

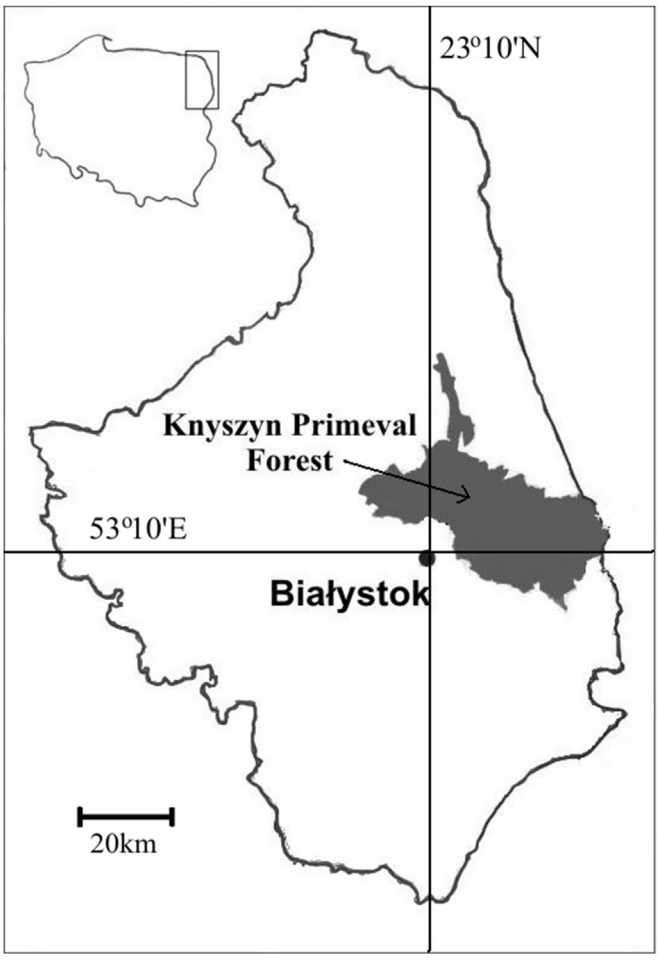

Fig. 1. Knyszyn Primeval Forest location.

2.2. Gamma-ray spectrum analysis

Samples (≥1000 g FM – fresh mass) of muscle tissue of wild game of both sexes, differing body mass and ages were collected. The samples were cleared of fat and connective tissue. The meat was subsequently ground in a mincing machine and transferred to a 450 ml Marinelli beaker geometry for a high-resolution gamma-ray spectrometry. The samples were stored at the temperature of -20°C until analysed. The sample geometry was identical to that of the source used for the detector calibrations for both measurements sets.

Activity measurements were performed by means of semiconductor detectors. In 2003, 2009 a coaxial germanium detector (relative efficiency: 15% model GC1520) was used and in 2012 a coaxial germanium detector having a proprietary thin-window contact (relative efficiency 30% model GX3020) was used. The spectra obtained were analyzed by Genie2000 Canberra software. ^{137}Cs concentration was calculated from the photo peak at 661.6 keV. The detectors were placed in the shielded house built from low-background lead 10 cm thick, lined with sheet copper (thickness 1.5 mm) and sheet aluminium (0.5 mm thick) to avoid soft X radiation, which occurs as a result of interaction between gamma radiation and lead.

Low detection limits, with Marinelli geometry use, counted with Lloyd A. Currie method (Currie, 1968) for the 661.67 keV line was 0.06 (for detector GX3020) and 0.3 (for detector GC1520) Bq kg^{-1} level for ^{137}Cs. The samples were counted for 90 000 s.