Evaluation of radioactivity in chanterelle (*Cantharellus cibarius*) and health implications

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The contamination, accumulation, spatial distribution, and potential health risk of ^{137}Cs, ^{210}Po, ^{210}Pb, and ^{40}K in chanterelles collected across Poland were examined using validated methodology and gamma-ray and alpha-particle spectrometric measurements. The values of anthropogenic ^{137}Cs activity concentration in mushrooms were between 118 and 1647 Bq·kg^{-1} dry weight (dw), while for natural ^{40}K from 1316 to 1895 Bq·kg^{-1} dw. The activity concentrations of ^{210}Po in chanterelles were between 2.23 and 8.57 Bq·kg^{-1} dw and in forest topsoil between 11.4 and 83.0 Bq·kg^{-1} dw. Corresponding values for ^{210}Pb were 1.50-6.14 and 7.74-46.1 Bq·kg^{-1} dw, respectively. An assessment of the annual radiation doses and cancer risk related to ^{137}Cs, ^{40}K, ^{210}Po and ^{210}Pb consumed with chanterelle showed that ^{137}Cs and ^{210}Po give a similar risk, but 2-3 orders of magnitude higher than ^{40}K and ^{210}Pb.

The results for ^{137}Cs, ^{40}K, ^{210}Po, and ^{210}Pb activity concentrations of golden chanterelles and ^{210}Po and ^{210}Pb in topsoil substrate are presented in Fig. 1. The obtained results varied significantly – the highest values of activity concentrations were determined for ^{40}K, while the lowest were for ^{210}Po and ^{210}Pb. ^{137}Cs is an anthropogenic contaminant present in the environment as a result of global atmospheric fallout. ^{40}K is a naturally occurring potassium radioactive isotope, and mycelia easily absorb monovalent biologically essential ions such as K^+ from the soil. The accumulation of ^{40}K is related to the potassium essential biological function in mushrooms. The highest values of ^{40}K activity concentrations were observed in chanterelles collected in the mountain area, namely Zakopane (1895 ± 79 Bq·kg^{-1} dw), while the lowest was measured in samples from north-eastern Poland, the Augustów Forest (1316 ± 40 Bq·kg^{-1} dw) (Fig. 2). The highest ^{210}Po and ^{210}Pb activity concentrations were observed in chanterelles from Włoszczowa (8.57 ± 0.50 and 6.14 ± 0.40 Bq·kg^{-1} dw, respectively) (Fig. 3 and 4). In contrast, the lowest concentrations of analyzed radionuclides were measured in samples from Porażyn (2.23 ± 0.12 Bq·kg^{-1} dw for ^{210}Po) and Włocławek (1.50 ± 0.11 Bq·kg^{-1} dw for ^{210}Pb). The highest activity concentrations determined in forest topsoil were at Borucino, reaching 83.0 ± 3.8 Bq·kg^{-1} dw and 46.1 ± 1.0 Bq·kg^{-1} dw, for ^{210}Po and ^{210}Pb, respectively. The lowest levels were recorded in forest topsoil from Tuszynki (11.4 ± 0.9 Bq·kg^{-1} dw for ^{210}Po) and Dziemiany (7.74 ± 0.40 Bq·kg^{-1} dw for ^{210}Pb). The highest ^{137}Cs activity concentrations were observed in chanterelles from Ciechocinek (1647 ± 12 Bq·kg^{-1} dw) and the lowest were measured in samples from Tuszynki (118 ± 2 Bq·kg^{-1} dw) (Fig. 5). The content in fruit bodies in the research strictly depended on the sampling location radioactive pollution. Studies have shown that lamellae mushrooms such as chanterelles may contain higher activity concentrations of ^{210}Po and ^{210}Pb than tubular mushrooms, but a broader study is recommended.

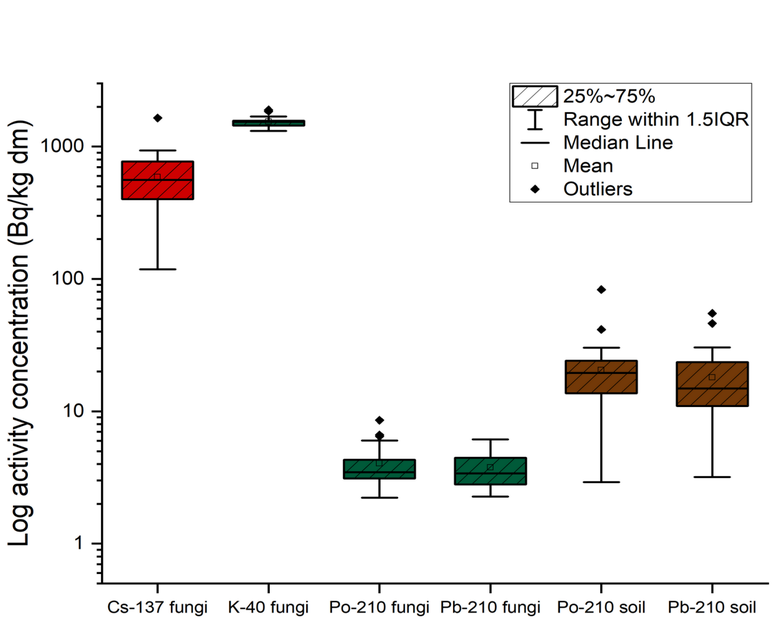

Fig. 1. Log activity concentrations of ^{137}Cs, ^{40}K, ^{210}Po, ^{210}Pb in analyzed mushroom and topsoil

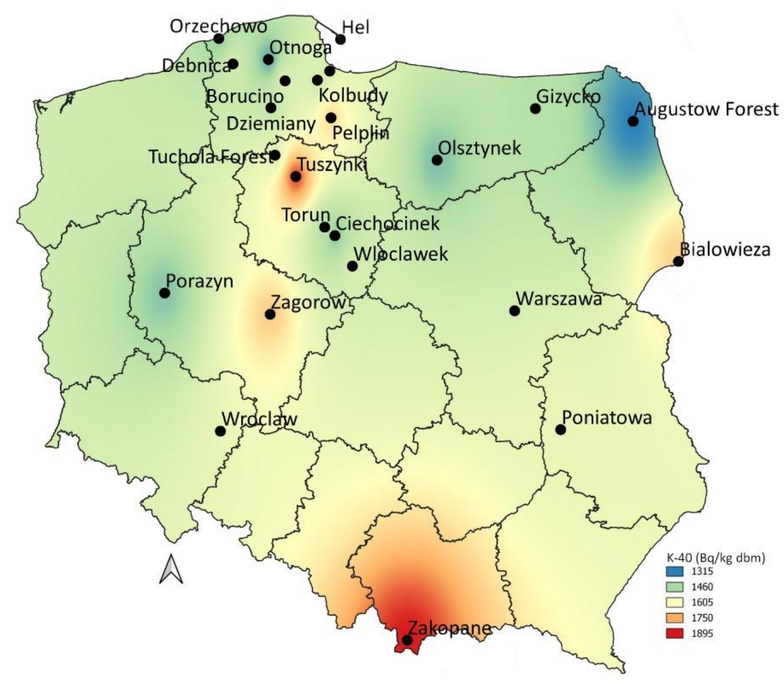

Fig. 2. Interpolation map for ^{40}K activity concentrations in chanterelle

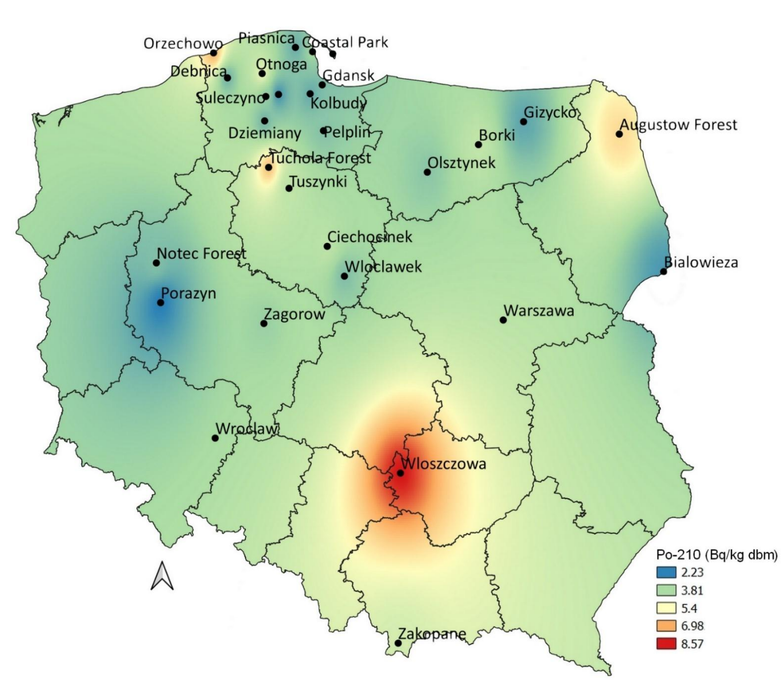

Fig. 3. Interpolation map for ^{210}Po activity concentrations in chanterelle

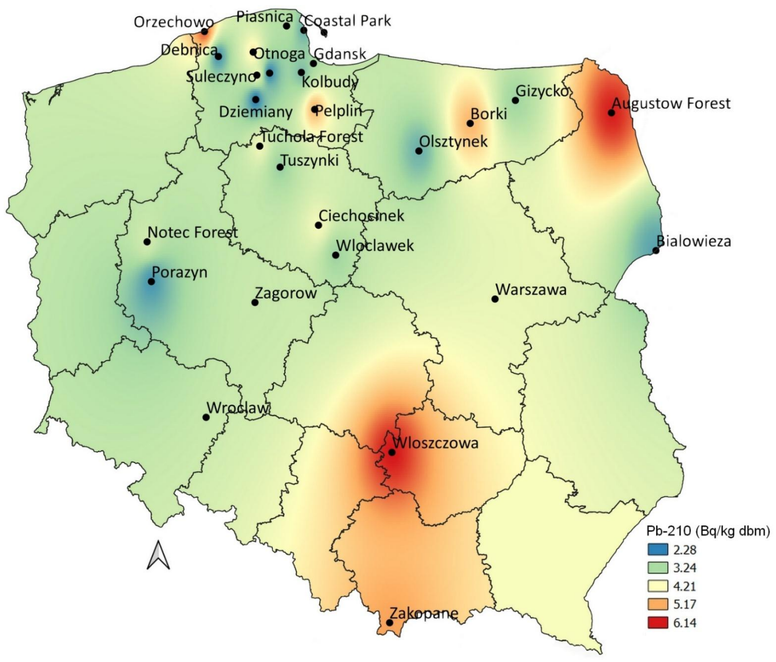

Fig. 4. Interpolation map for ^{210}Pb activity concentrations in chanterelle

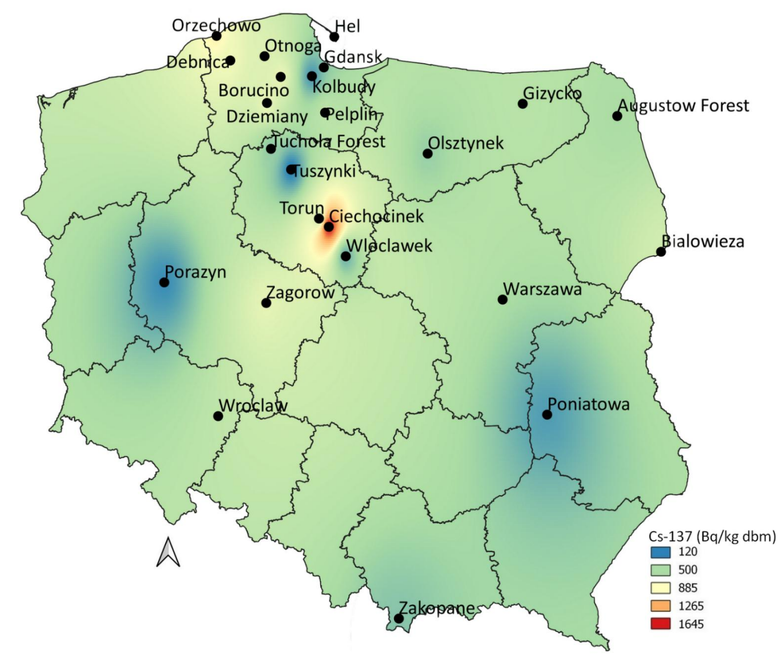

Fig. 5. Interpolation map for ^{137}Cs activity concentrations in chanterelle

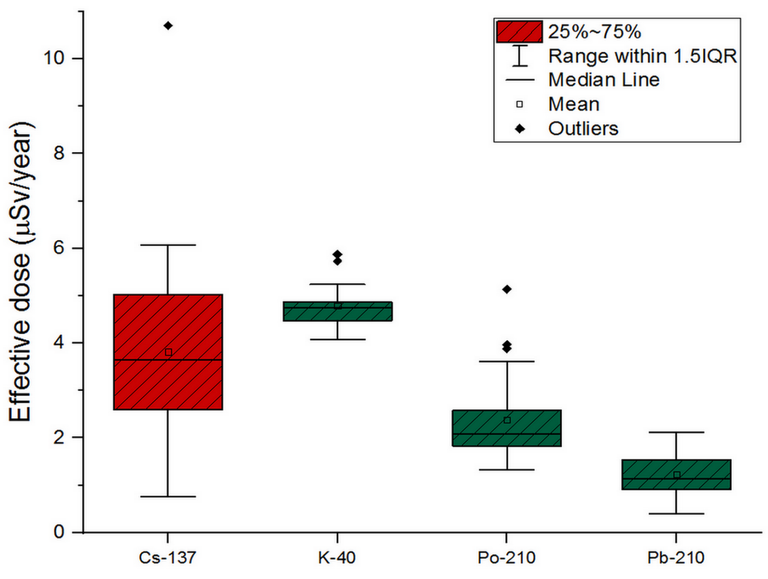

Fig. 6. Annual effective dose from ^{137}Cs, ^{40}K, ^{210}Po, ^{210}Pb ingested with analyzed mushrooms

The annual effective doses were calculated to assess the potential radiotoxicity of the chanterelles based on previously determined ^{137}Cs, ^{40}K, ^{210}Po and ^{210}Pb activity concentrations. Based on the determined ^{210}Po and ^{210}Pb activity concentrations, the typical meal containing 100 g of fresh chanterelles would provide 1.18-16.5 Bq of ^{137}Cs, 13.2-18.9 Bq of ^{40}K, 0.022-0.086 Bq of ^{210}Po and 0.011-0.061 Bq of ^{210}Pb and give 132-477 nSv in total. An average mushroom consumer in Poland ingests about 5 kg of fresh mushrooms annually, wild-growing and cultivated. Assuming the consumer uses only golden chanterelle, the ingestion may result in an annual effective dose of 0.77-10.7 µSv from ^{137}Cs, 4.08-5.87 µSv from ^{40}K, 1.34 to 5.14 µSv from ^{210}Po decay and 0.78 to 2.12 µSv from ^{210}Pb; thus 6.97-23.4 µSvyear^{-1} altogether (Fig. 6).

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