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VERTICAL DISTRIBUTION OF ^{137}Cs IN THE UNDISTURBED SOIL PROFILES IN THE BASIN OF PČINJA RIVER, SOUTHEASTERN SERBIA

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ABSTRACT

The ^{137}Cs activity concentrations in six undisturbed soil profiles collected during 2013 in the basin of Pčinja River, southeastern Serbia, were determined gamma-ray spectrometrically. Average value of six undisturbed soil profiles by layers was calculated and vertical distribution of ^{137}Cs activity concentration at 5 cm interval samples was shown by average profile. The ^{137}Cs activity concentrations varied between 0.29 and 70.9 Bq kg^{-1} with a mean of 10.7 Bq kg^{-1}. Even 27 years after Chernobyl accident 74% of deposited ^{137}Cs was found in the first 20 cm of the soil.

INTRODUCTION

Knowledge of ^{137}Cs vertical distribution in soil, which is the ^{137}Cs main reservoir, is very important for an assessment of external dose. The ^{137}Cs vertical migration in soil is influenced by the physico-chemical properties of soils, quantity and intensity of precipitation fallen since ^{137}Cs deposition, absorption and re-deposition by plants and biological characteristics of soils [1]. In the undisturbed soil the ^{137}Cs shows very slow vertical migration. Different characteristics (physical, chemical and biological) of individual soil horizons influence the migration and retention of ^{137}Cs through the profile.

Until 1986 the ^{137}Cs activity concentrations in soil of Serbia was < 5 Bq kg^{-1}, and in most plants, except mosses and lichens, have been below detection limits [2]. Immediately after the Chernobyl accident ^{137}Cs activity concentrations were up to 50 kBq kg^{-1} in soil [3], with very inhomogeneous spatial distribution, and in some plant species reached 3 kBq kg^{-1} [2].

Due to strong denudation and fluvial erosion in the basin of Pčinja River southeastern Serbia, soils are washed out from certain locations, especially

from those at higher slopes. The aim of this study was to present the vertical distribution and behavior of ^{137}Cs activity concentration in these soils, based on collected undisturbed profiles.

EXPERIMENTAL

A total of six undisturbed soil profiles were collected during 2013 in the basin of Pčinja River, southeastern Serbia. Soil samples were collected at 5 cm intervals from the uppermost layer down to 50 cm. All samples were dried to constant weight at room temperature. Dried samples were mechanically homogenized, sifted through a 2 mm mesh sieve, packed into 0.5 L Marinelli beakers and weighed.

The ^{137}Cs activity concentration were measured using HPGe gamma-ray spectrometer ORTEC-AMETEK (34% relative efficiency and 1.65 keV FWHM for ^{60}Co at 1.33 MeV). The ^{137}Cs activity concentration of each sample was measured for 3.6 ks. The energy calibration and relative efficiency calibration of the gamma-ray spectrometer were carried out using 0.5 L Marinelli calibration source MBSS2 supplied by Czech Metrological Institute. Gamma Vision 32 MCA emulation software was used to analyzed the gamma-ray spectra [4]. The ^{137}Cs activity concentration was determined from its gamma-ray line at 661.6 keV. The software package SPSS 16.0 (Statistical Package for the Social Sciences) for Windows was employed for descriptive statistics of the results [5].

RESULTS AND DISCUSSION

In order to reveal general behavior of ^{137}Cs in soil in the basin of Pčinja River vertical distribution of ^{137}Cs activity concentration at 5 cm interval samples was shown by average profile (Fig. 1.) which represents calculated average value based on the measured values of ^{137}Cs activity concentration for six undisturbed soil profiles by layers.

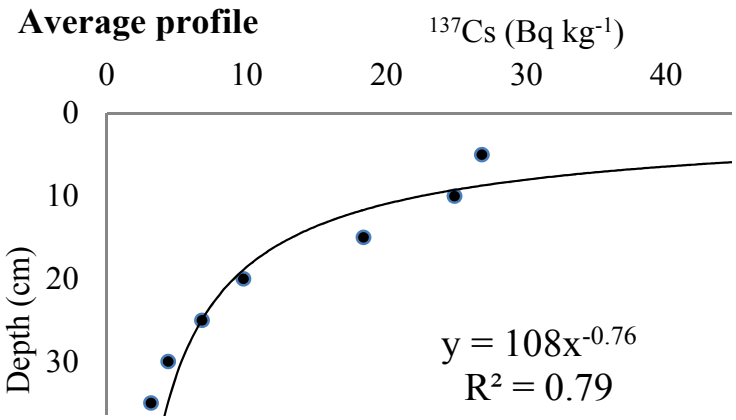
It was noted that ^{137}Cs activity concentration decreased with soil depth up to 40 cm and then slightly increased down the profile. The re-distribution of ^{137}Cs in deeper soil layers could be consequence of number of factors. For that reason, further investigation, which would include the influence of e.g. type of soil, chemical properties, organic matter content, biological activity of microorganisms in soil, and climatic conditions (such as rainfall, temperature, or humidity) on the ^{137}Cs distribution in soils are required.

Basic descriptive statistics of ^{137}Cs activity concentration across all six undisturbed soil profiles (all soil layers are consider as equal) is presented in Table 1. The mean value of ^{137}Cs activity concentration was 10.7 Bq kg^{-1}, with a range of 0.29 to 70.9 Bq kg^{-1}.

Petrović et al. (2013) and Dragović et al. (2012) reported mean ^{137}Cs activity concentration of 15.3 and 18.5 Bq kg^{-1}, respectively, for Belgrade area [6-7], and Dugalic et al. (2010) reported average ^{137}Cs activity concentration of 36.4 Bq kg^{-1} for the territory of western Serbia [8], which is higher than the mean value of ^{137}Cs in soil obtained in this study.

Table 1. Basic descriptive statistics of ^{137}Cs activity concentration in soil in the basin of Pčinja River.

Parameter	^{137}Cs (Bq kg^{-1})
Mean	10.7
Mode	0.80
Standard deviation	14.5
Range	70.6
Minimum	0.29
Maximum	70.9



cm	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
Bq kg^{-1}	2.19-55.6	0.80-70.9	0.83-52.3	0.61-25.0	0.40-16.8	0.80-14.1	0.44-9.53	0.56-7.46	0.31-7.47	0.29-29.7

Figure 1. Vertical distribution of ^{137}Cs activity concentration in soil in the basin of Pčinja River.

Based on the results for the average profile the highest amount of total ^{137}Cs in the soil (25%) was in the first soil layer (0-5 cm), while the lowest one (2.46%) was in the eighth soil layer (35-40 cm). The 74% of the total ^{137}Cs in the soil in the basin of Pčinja River was found in the first four soil layers

(0-20 cm) and only 26% was found in the last six soil layers (20-50 cm), which indicates the slow migration of ^{137}Cs in the deeper soil layers. Clouvas et al. (2007) indicated that the vertical migration of ^{137}Cs in soil is a very slow process [9]. Karadeniz and Yaprak (2008) found 42-97% of the ^{137}Cs deposition in the first 10 cm of soil in Izmir, Turkey 18 years after Chernobyl accident [10].

CONCLUSION

From average profile, it is clear that ^{137}Cs activity concentration decreases with the soil depth. Mean value of ^{137}Cs activity concentration in soil was 10.7 Bq kg^{-1}. About 74% of the ^{137}Cs deposition was determined in the first 20 cm of soil profile in the basin of Pčinja River, southeastern Serbia.

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