Multivariate Analysis of Eight Radionuclides Using the Soil Monitoring Network Data

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Abstract

In this paper, the data from the Serbian National Soil Radioactivity Monitoring network were used to study the regional distribution of 8 radionuclides. Eight different sampling locations in four regions were chosen for the study. PCA was applied to training dataset in order to examine the influence of the radionuclides on regional characterization of the soil. Scattering matrices based dimension reduction technique was applied to the same dataset for soil sample classification - according to radionuclide content, and also to monitor the significant patterns during the time.

The obtained results show that the pattern recognition techniques applied are viable tools for such monitoring.

Introduction

The main objectives of radioecological monitoring are: investigation of the sources of radioactive substances, transmission of radionuclides in the environment and their influence on terrestrial and aquatic ecosystems and implies a system of vertical analysis: air - fallouts - soil - waters - plants - animals - man. The goal of radioecological monitoring is to prevent unacceptable damage to the human health and environment. Systematic analysis of samples is defined by national regulations, harmonized with International standards [1].

Soil is the basic environment of migration of radionuclides into plants, wherefrom they reach people and animals through food, which implies that radioecological monitoring of soil has the most important place. A huge amount of the date obtained in the monitoring process is a very good base for a) establishing patterns between monitored parameters (some of the relevant patterns could stay unnoticed); b) extraction of the specific features (relevant for characterization of the soil or for the monitoring process); c) classification (established classification could allow the detection of possible irregularities, i. e. possible contamination).

This study is aimed to examine the soil radioactivity monitoring network data in order to determine the characteristic radionuclides for a particular region and to perform the regional classification of the soil according to radionuclide contents. The goal of such a classification is to monitor possible contamination of the soil and to identify the possible source of contamination.

Materials & Methods

The 108 different samples were chosen for this study: Central Serbia (25 samples from three sampling location), North and East Serbia (22 samples from two sampling location each) and West Serbia (39 samples from one sampling location). Sampling locations were the same during the sampling period (twice a year, during six years). Soil samples were taken from 0-5 cm deep, uncultivated soil layers, during the spring and autumn, plants and rocks were removed from the samples, which were than dried at 105°C-110°C to constant weight for 24 - 48 h. Thereupon, the samples were ground, passed through a 2 mm mesh sieve to homogenize and put into specific geometry vessels for measurement. The period of at least 30 days was necessary to establish the equilibrium between 238U and 226Ra in samples, before the measurements were carried out.

Pure germanium detector by EG&G "ORTEC"-efficacy 24% and resolution 1.85 keV (at 1.332 MeV) was used to perform the measurements of the eight (137Cs, 238U, 235U, 232Th, 7Be, 214Bi, 226Ra and 40K) radionuclide activity. All samples were measured for 20000 sec.

The measured activity in 108 different samples formed the 108x8 matrix which was used as a input dataset for pattern recognition methods. PCA was performed in order to identify the radionuclides that are characteristic of specific location. Additional, scattering matrices based dimension reduction technique was applied to examine possible classification and influence of particular radionuclides on such a result.

Results

The PCA was applied to the dataset formed of standardized data from training dataset. The first three PCs (corresponding to three eigenvalues higher than 1) explained 90.81% of the total variance among eight variables, where the first component (PC1) contributed 67.63% and the second component (PC2) contributed 13.85% of the total variance. The standardized component loadings revealed 137Cs and 40K-stongly correlated with 238U and 226Ra as the most characteristic nuclides, responsible for regional distinguishing between soils. The result obtained after applying PCA onto standardized training dataset is presented in Fig. 1. As it can be seen the soil samples from the central and particularly from the west region of Serbia are well separated. Slightly worst classification is achieved in the group of east and north region samples. Such results were encouraging for further examination. The result of applied scattering matrices based dimension reduction technique is shown in Fig 2. As it can be seen the regional grouping is possible – all regional groups are clearly separated. The nuclides responsible for such classification are 232Th and 40K (along the x-axis) and 137Cs and 214Bi (along the y-axis).

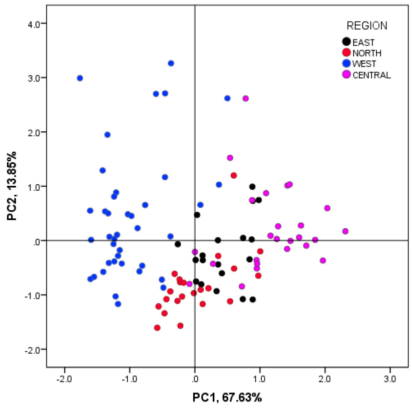

Fig. 1; Score plots of PC1 and PC2 illustrating regional classification of soil samples

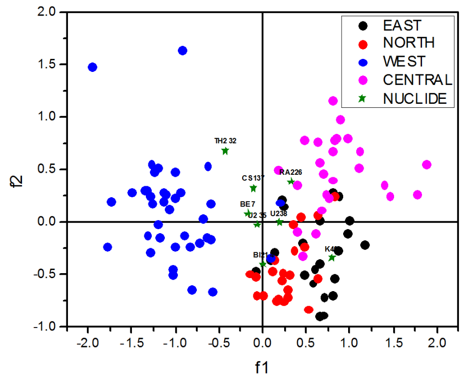

Fig. 2; Projection of soil samples from 4 different regions in the space formed after scattering matrices based dimension reduction (f1 and f2 are linear combinations of original features)

Conclusions

According to the results of multivariate analysis of the monitoring data the following conclusions can be drawn. Applied pattern recognition techniques are viable tool in classification of the soil according to radionuclide content and regional distribution. Such satisfactory classification enables easy identification of the possible irregularities and consequently possible contamination and its source.

The extracted radionuclides, 137Cs, 232Th, 40K and 226Ra, are the most responsible for the classification and can be considered as radioecological markers. For some locations the artificial contamination by 137Cs is still main characteristic comparing to other location for which the geology factors are dominant [2, 3].

References

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