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Significant radioactive contamination of soil around a coal-fired thermal power plant

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Abstract

Soil samples were collected around a coal-fired power plant from 81 different locations. Brown coal, unusually rich in uranium, is burnt in this plant that lies inside the confines of a small industrial town and has been operational since 1943. Activity concentrations of the radionuclides ^{238}U, ^{226}Ra, ^{232}Th, ^{137}Cs and ^{40}K were determined in the samples. Considerably elevated concentrations of ^{238}U and ^{226}Ra have been found in most samples collected within the inhabited area. Concentrations of ^{238}U and ^{226}Ra in soil decreased regularly with increasing depth at many locations, which can be explained by fly-ash fallout. Concentrations of ^{238}U and ^{226}Ra in the top (0–5 cm depth) layer of soil in public areas inside the town are 4.7 times higher, on average, than those in the uncontaminated deeper layers, which means there is about 108 Bq kg^{-1} surplus activity concentration above the geological background. A high emanation rate of ^{222}Rn from the contaminated soil layers and significant disequilibrium between ^{238}U and ^{226}Ra activities in some kinds of samples have been found.

Keywords: Radioactive contamination; Soil; Coal-fired power plant; ^{238}U; ^{226}Ra

1. Introduction

Energy production from coal is one of the major sources of increased exposure to man from artificially perturbed natural radioactivity. Coal contains primordial radionuclides ^{40}K, ^{232}Th, ^{235}U, ^{238}U and the members of the decay series of the last

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three nuclides. In the process of combustion, these radionuclides are distributed in solid and gaseous combustion products and are discharged to and accumulate in man's environment. Most of the radionuclides accumulate in the ash. The overwhelming majority of the ash is the so-called bottom ash or slag that can be kept under control. But some small proportion of the ash, called the fly ash, is discharged through the stacks to the environment without any control.

The radioactive contamination of the environment from the above source is expected to be concentrated around the centers of extraction and utilization of coal. Nevertheless, UNSCEAR (1988) noted that significant increases in the activity concentrations (ACs) of natural radioisotopes in samples of air, precipitation, soil or vegetation have not been found experimentally nor even in the territories surrounding coal-fired power plants (CPPs) that are the most intensive sources of combustion products.

In general, ACs of primordial radioisotopes in coal are of the same order as those in common rocks and soils, on average (35 Bq kg^{-1} for ^{238}U, UNSCEAR, 2000). Occasionally, however, high ACs of some radioisotopes, in particular of uranium, can be found in coals. The occurrence of rich-uranium coal is not very rare but it happens very rarely that quite a large amount of uraniferous coal is extracted and utilized within a small territory. However, the radioactive contamination of the environment could be revealed experimentally only in cases of this kind.

The authors of this paper investigated the radioactivity of soil around a CPP. This CPP burns coal unusually rich in uranium and has been operational for more than half a century. Although it is a small CPP in respect of its power, radioactive contamination of its environment reached such a high level that it can be measured easily. This CPP lies inside the confines of a small industrial town called Ajka. The authors have already given an account of some results on the radiation environment of Ajka (Papp & Daróczy, 1997; Papp, 1998) and some preliminary results on the contamination of soil around Ajka were also published (Daróczy et al., 1993; Papp, Dezső, & Daróczy, 1997). In the last few years, the authors investigated the radioactive contamination of soil around Ajka more intensively. The results of these investigations are presented in this paper. The objectives of this work were to appraise the radioactive contamination and to obtain data on its origin and basic characteristics.

2. Area description

Ajka lies in a valley between the hills of the Bakony-Mountains, 30 km north of Lake Balaton, Hungary. Three villages are located within 5–6 km from Ajka. Their names are Ajkarendek, Bakonygyepes and Padragkút.

Beds of brown coal were found within 5 km south of Ajka between 1865 and 1870. Extraction began in 1872. High radioactivity in the coal was discovered only in 1950 by Szalay (1954). Average ACs of ^{238}U (AC_U) and ^{226}Ra (AC_{Ra}) in Ajka coal nowadays are about 300–500 Bq kg^{-1} (Bódizs, Gáspár, & Keömley, 1992; Nikl & Végvári, 1992) but reached 800–900 Bq kg^{-1} in the fifties (Szalay, Almássy, Pesti, &