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Vertical distribution of ^{226}Ra and ^{210}Po in agricultural soils in Buyuk Menderes Basin, Turkey

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Abstract

The vertical distribution of ^{226}Ra and ^{210}Po was investigated in the cultivated soils of the Buyuk Menderes Basin in Turkey. Five soil cores down to a depth of about 50 cm were taken from each site and divided into strata of 2–3 cm intervals. The samples were analyzed for their ^{226}Ra and ^{210}Po activity concentrations using radioanalytical methods. Down-core concentration profiles of ^{226}Ra and ^{210}Po in the soil cores from five sites are obtained. The activity concentrations of soil cores range from 80 to 1170 Bq kg^{-1} for ^{226}Ra and from 10 to 870 Bq kg^{-1} for ^{210}Po with the depth. Analysis of the vertical soil profiles indicate that the activity concentrations of ^{226}Ra and ^{210}Po for soil strata at all the sites have not extremely changed with depth.

Keywords: Radium-226; Polonium-210; Gross alpha activity; Vertical distribution; Soil texture

1. Introduction

Soil is the upper layer of the unsaturated zone of the earth, and very diverse in composition and behaviour. The soil phase consists of mineral particles of various sizes, shapes and organic matter in various stages of degradation. Soil is one of the important components in the evaluation of radionuclide migration behaviour and distribution of uranium series radionuclides in a terrestrial ecosystem. Migration of heavy natural radionuclides has been studied in rocks, drainage water, bottom sediment, soils and plants in different regions by determination the natural distributions of radionuclides [1–4].

The analysis of radium isotopes is of great concern in geochemistry since four radium isotopes (^{223}Ra, ^{224}Ra, ^{226}Ra, ^{228}Ra) of the uranium and thorium decay series can be used as natural geochemical tracers to investigate important processes in the bio- and geospheres [5]. Radium rarely occurs alone and the environmental distribution of radium varies depending on its origin [2]. The behaviour of Ra in soils is important because of the hazard of its daughter products. ^{226}Ra has always attracted particular attention from the view point of its health hazard to the public.

The ^{210}Po in soils may originate either as a product of the radioactive decay of radionuclides of ^{238}U series present in the soil or the result of the precipitation of radon decay products from the atmosphere. ^{210}Po occurs widely in nature and gives an important contribution to man's natural radiation background. The ^{210}Po content of soil varies with soil type. The levels of ^{210}Pb and ^{210}Po contained in the top layer of soil can be correlated with the amount of atmospheric precipitation. In soils, ^{210}Po is in equilibrium with ^{210}Pb, suggesting that the ^{210}Pb in the soil is the main source of ^{210}Po. Parfenov has reported that ^{210}Po is very immobile in soil and that it is likely irreversibly sorbed on clay and organic colloids [6]. Polonium is also a particle reactive element, but its geochemical pathways appear to be different from lead. ^{210}Po behaves more like the nutrient elements [7].

The purpose of this study was to determine the ^{226}Ra and ^{210}Po activity concentrations using radiochemical methods for five core soil samples and to present an overview of their vertical distributions in agricultural soil of the Buyuk Menderes Basin where is one of the most important plain in the Aegean Region of Turkey and has agricultural lands and localities, and the largest river in the Aegean Region flows along the study area. The data were evaluated statistically. Special attention was paid to these sites where known uranium anomalies identified in the West part

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of the Basin by the researchers and our previous study [8–10]. The average grade of these uranium deposits in the Basin is ranged from 0.02 to 0.08% U_3O_8.

2. Material and methods

2.1. Study area

The sampling sites in Buyuk Menderes Basin have been selected since it is the one of the most important Basins in Aegean Region, which has the widest agricultural lands under cultivation for a long time, at least for 3000 years [11]. The east–west trends of the Buyuk Menderes Basin appear to have been evolving since the late Pliocene, and this area includes the oldest alluvial sediment. The soil types in the Buyuk Menderes Basin are as following: Alluvial, limeless brown soil, colluvial, reddish Mediterranean soil, regosol, brown forest soil, salty, alkaline and alkaline+salty in the eastern part of the Buyuk Menderes Basin and alluvial, colluvial, limeless brown soil, brown forest soil, rendzina, red-brown Mediterranean soil, regosol in the western part of the Basin [12,13].

The Basin is located in the Aegean region (37°25′ N to 38°10′ N and 27°00′ E to 29°10′ E) in Turkey. There are farming activities in the Basin, and the area covers the agricultural lands about 714.000 ha. The crops grown in this land are cotton, clover, wheat, rye, fig, peach, orange and olive. The Basin also has the largest river (Buyuk Menderes River) of the Aegean Region, which is 450 km in length and passes the Basin in the east–west direction. The river collects 6 rivulets from the Basin and drains out to Aegean Sea.

Soil texture includes the proportions of sand, silt and clay particles in the soil. The terms sand, silt and clay refer to different size fractions of the soil's mineral content. The sizes of clay, silt and sand are <0.002 mm; 0.002–0.06 mm and 0.06–2 mm, respectively. The soil texture of the Buyuk Menderes Basin in our previous study was recorded as 1–13% for clay, 1–42% for silt and 58–99% for sand content. In addition, the organic matter and pH value of soil samples were also determined in the range of 1.2–13.0% and 5.65–8.35, respectively [14].

The main agricultural product at the west part of the Buyuk Menderes Basin where the core samples was taken the core samples is cotton. For soil homogeneity before planting cotton in autumn, the soil was cultivated in 20–25 cm depth to grow the crops.

Cotton production estimated by USDA in this area in 2000/2001 was 1.20 tonnes/ha. The cotton area in this region in 2000/2001 was estimated in the range of 210.000–230.000 ha. Percentage of total cotton production in this region in Turkey was 4–9% [15].

2.2. Sample collection and preparation

The core soil samples were collected at the five sites from cultivated lands of the Buyuk Menderes Basin of Turkey shown in Fig. 1 using a box corer of Ø: 5 cm in June 2000 and divided into strata of between 2- and -3 cm intervals. In addition, uncultivated soil sample was collected from the site far from cultivated lands within the same region in order to compare for the activity of radionuclides. The depth intervals of soil samples varied from 0 to 30 cm for Site-1, Site-3 and Control Site, 0–27.5 cm for Site-2, 0–40 cm for Site-4, 0–50 cm for Site-5.

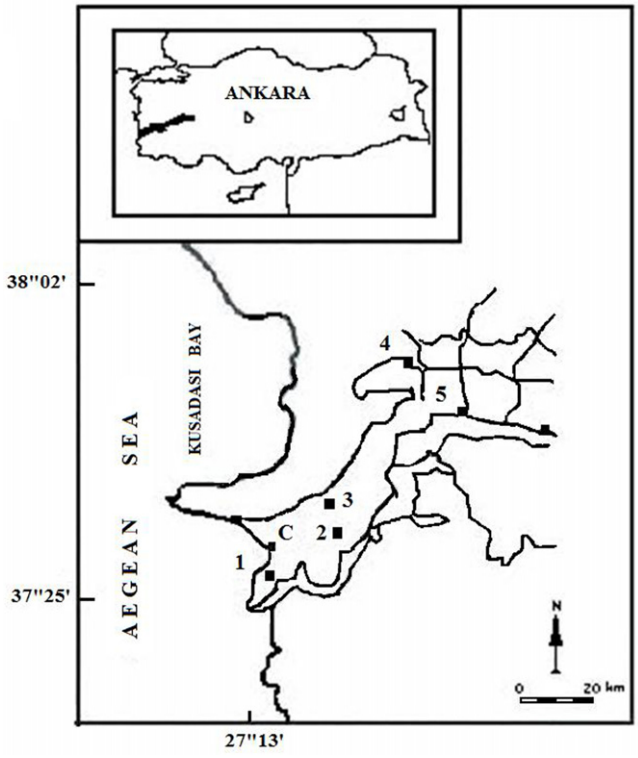

Fig. 1. The sampling sites in the Buyuk Menderes Basin.

The sampling sites coordinates were determined by a Global Positioning System (Garmin, GPS XL-45). The core samples were transferred to the laboratory in pre-cleaned polyethylene vials for further treatment and analyses. The core samples were oven-dried until they achieved a constant dry weight and were prepared in a powdered form of approximately <200 mesh size. The ^{226}Ra and ^{210}Po activities were measured by α-counting technique after the radiochemical processing. The samples were analyzed about 2 years later so that secular equilibrium between ^{210}Pb and ^{210}Po is attained.

All samples were carefully processed following the standard procedures. Soils were well mixed after removing extraneous materials such as roots, pieces of stones and gravel. Each soil sample was first air-dried, and then placed in an oven at 105 °C for 24 h until their weight remains constant [16].

2.3. ^{226}Ra measurements

A conventional radiochemical method was used to determine the activity concentration of ^{226}Ra. All chemicals used for the preparation of solutions were of analytical-reagent grade. After waiting for about 20 days allowing ^{224}Ra to decay, 1 g of soil sample was dissolved in H_2SO_4 and HNO_3 acid mixture. Barium carrier was added to the acid solution. The $Ba(Ra)SO_4$ was precipitated, centrifuged, washed with some H_2SO_4 and distilled water and then dissolved in EDTA. $(NH_4)_2SO_4$ was