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Determination of natural radioactivity levels of beach sand samples in the black sea coast of Kocaeli (Turkey)

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HIGHLIGHTS

- The radiation hazard parameters were evaluated in beach sands of Black Sea coast of Kocaeli, Turkey.
- The level of the natural radioactivity in Kocaeli Black Sea beaches does not exceed the norm.
- The obtained results will serve as a baseline data in future for assessing the radiation exposure.

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ABSTRACT

The natural radioactivity due to the presence of ^{238}U, ^{232}Th, ^{40}K and the artificial radioactivity due to ^{137}Cs in beach sand samples from the Black Sea coast of Kocaeli (Turkey) have been measured by a gamma ray spectroscopy. Activity concentrations of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs varied in the ranges from 4.41 ± 0.03 to 14.04 ± 0.04, from 2.62 ± 0.02 to 16.55 ± 0.03, from 11.60 ± 0.25 to 513.32 ± 3.44 and from 0.56 ± 0.02 to 5.43 ± 0.03 Bq kg^{-1}, respectively. The gamma dose rate in air due to ^{238}U, ^{232}Th and ^{40}K in the samples has been estimated to be in the range between 4.10 and 36.80 nGy h^{-1}. The radium equivalent activity values of all sand samples are calculated and found lower than the world limit of 370 Bq kg^{-1}. In addition, the calculated values of external hazard indexes varied from 0.0244 to 0.2019, and are lower than unity.

1. Introduction

Natural background radiation levels are from a combination of terrestrial (^{40}K, ^{226}Ra, ^{232}Th, etc.) and cosmic radiation (photons, muons, etc). Terrestrial radiation and cosmic radiation arising out of earth's crust and building materials used for construction of houses and buildings cause the external exposure while inhalation or ingestion of natural and man-made environmental radionuclides give rise to the internal exposure.

In order to determine the level of public exposures, the information about the concentration and distribution of natural and anthropogenic radionuclides in environmental sites plays an important role. Therefore, measurements of radioactivity in beaches are of a great interest in the last two decades for many researchers throughout the world, which led to worldwide national surveys (Radhakrishna et al., 1993; Navarro and Roldan, 1994; Ahmad et al., 1997; Alam et al., 1999; De Meijer et al., 2001; Kannan et al., 2002; Karakelle et al., 2002; Mohanty et al., 2004; Freitas and Alencar, 2004; Gonzalez-Chornet and Gonzalez-Labajo, 2004; Alencar and Freitas, 2005; El-Arabi, 2005; Lakshmi et al., 2005; Vassas et al., 2006; Veiga et al., 2006; Örgün et al., 2007; Harb, 2008; Xinwei and Xiaolan, 2008; Karayel, 2009; Malik et al., 2010; Malain et al., 2010). Moreover such investigations can be useful for keeping reference data records to ascertain possible changes in environmental radioactivity due to nuclear, industrial and other human activities.

The aim of this paper is to establish levels of natural (^{232}Th, ^{238}U and ^{40}K) and artificial (^{137}Cs) radioactivity for the beaches of Kandıra (the Black Sea coast of Kocaeli), through the analysis of gamma dose rates by a hyper pure germanium (HPGe) gamma ray spectroscopy. The gamma dose rate in air due to the presence of ^{238}U, ^{232}Th and ^{40}K in the samples have also been calculated after determining the activity concentrations in the beach sands. In order to assess the radiological hazard of the natural radioactivity, the radium equivalent activity and external hazard index were also calculated. The obtained data will be used as reference information to track any change in the radioactivity background levels in this area.

2. Materials and methods

2.1. Study area

Kandıra is a district on the Black Sea coast in Kocaeli province. Kandıra neighbors are Kaynarca (Sakarya) to the east, Adapazarı (Sakarya) to the southeast, İzmit (Kocaeli) to the south and Şile

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(İstanbul) to the west. Kandıra coast stands from 41°08′02″ to 41°11′41″ north latitudes and from 30°01′14″ to 30°19′55″ east longitudes. The coast of Kandıra has several beaches and widths of the beaches vary from approximately 150–2000 m. There are 10 different beaches studied which are named Bağırganlı, Seyrek, Sarısu, Kerpe, Kumcağız, Kovanağzı, Cebeci, Uzunkum, Çamkonak and Dikili. Locations of the beaches are shown in Fig. 1.

2.2. Sample collection and preparation

A total of 20 sand samples of 10 different beaches were collected. The number of sampling sites collected from each beach was different (Table 1) depending on the beach length. The final results of activities and sand characterization of the sample from each beach were determined by taking the weighted average of those of sampling sites. The sand sample taken from each site was obtained from four sub-samples collected by employing a template method from 1 m^2 area with a depth of 5 cm. The four sub-samples were mixed thoroughly, and approximately 2 kg sample profiles were prepared. After collection, all the samples were dried in an oven at 60 °C for 48 h and then sieved through a 1-mm mesh-sized sieve in order to remove stones, pebbles and other macro-impurities. The homogenized sample was placed in a 170 ml airtight PVC container. These containers were sealed tightly with parafilm to prevent the escape of gaseous ^{222}Rn and ^{220}Rn from the samples and kept aside for about 30 days in order to ensure radioactive equilibrium of ^{226}Ra and ^{232}Th with their daughter products (Schotzig and Debertin, 1983).

2.3. Sand characterization on Kandıra beaches

First, the dimensional analysis of the samples has been carried out by FRITSCH sieve system. The samples were sieved for 40 min and divided into four different sizes: $>500\,\mu m$, $>250\,\mu m$, $>125\,\mu m$ and $>63\,\mu m$. They were dried at 85 °C for 24 h and dry masses were determined.

On the other hand, each beach sand samples divided into three aliquots to determine total organic matter (TOM) and carbonate content ($CaCO_3$). Three aliquots were filtered through 47 mm Whatman membrane filters of 0.45 μm pore size. For desalting, they were rinsed three times with 250 ml distilled water and were dried at 55 °C during 24 h, and weighed. To determine the total organic matter and carbonate content, the dissolution method was applied at 85 °C for 5 h with 1% Na_2CO_3 and 0.5 N HCl solutions, respectively (Ergül and Topçuoğlu., 2009; Kılıc et al., 2008 and references therein). Also, pH value was determined by a pH-meter on 1:2.5 sand/water suspension.

The obtained results of pH value, the total organic matter and the carbonate are presented in Table 1. Grain size results of 10 different sand samples are presented in Table 2. The total organic matter and carbonate content were found to range from 1.85 to 6.71% and 10.50 to 42.33%, respectively.

2.4. Gamma-rays analysis

Gamma spectroscopy measurements were performed at Kocaeli University with a coaxial HpGe detector (ORTEC, GEM25P4–70 model) of 25% relative efficiency and 1.71 keV resolution at the 1332 keV gamma energy of ^{60}Co. The detector was shielded in a 10 cm thick lead shield internally lined with 1 mm Sn and 1.5 mm Cu to reduce the background of the system. Energy and efficiency calibrations of the spectrometer were determined by using a 170 ml PVC container multinuclide standard source (Eckert & Zeigler Company Isotopes Products), which contains ^{210}Pb, ^{241}Am, ^{109}Cd, ^{57}Co, ^{139}Ce, ^{203}Hg, ^{113}Sn, ^{85}Sr, ^{137}Cs, ^{88}Y and ^{60}Co peaks, covering the energy range between 47 keV and 1836 keV.

HPGe gamma-ray spectrometry laboratory at Kocaeli University has participated to the world-wide proficiency test IAEA-CU-2009-

Table 1
The obtained averaged results of pH value, the total organic matter (TOM), and the carbonate ($CaCO_3$) with the number of sampling sites used in the analysis.

Sampling location	Number of sampling sites	pH	TOM (%)	$CaCO_3$ (%)
Bağırganlı	1	9.77	2.34 ± 0.20	17.56 ± 0.11
Seyrek	1	9.77	4.79 ± 0.17	42.33 ± 2.39
Sarısu	1	9.85	6.71 ± 0.03	11.96 ± 0.82
Kerpe	1	8.83	1.85 ± 0.84	10.50 ± 1.06
Kumcağız	3	9.18	4.98 ± 0.33	28.35 ± 0.68
Kovanağzı	1	9.46	2.05 ± 0.42	33.88 ± 0.07
Cebeci	4	10.04	3.75 ± 0.26	19.82 ± 0.02
Uzunkum	3	9.7	2.77 ± 0.19	11.86 ± 0.39
Çamkonak	2	9.62	4.94 ± 0.18	15.11 ± 1.18
Dikili	3	9.28	3.07 ± 0.15	13.98 ± 0.13

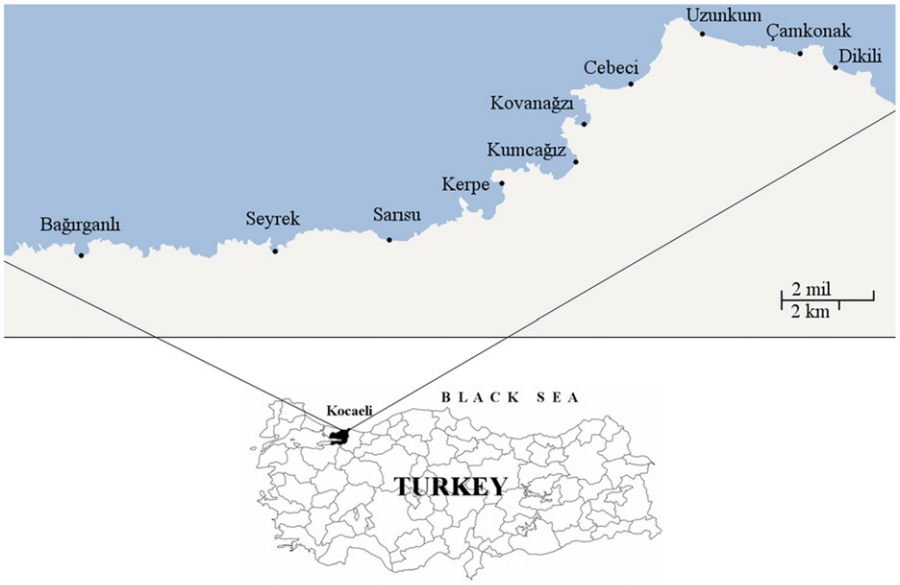

Fig. 1. Map of coast locations in Kocaeli/Turkey where the sand samples were collected.