Special issue of the 2nd International Conference on Computational and Experimental Science and Engineering (ICCESEN 2015)

Investigation of Natural Radioactivity of Surface Soil Samples in the Vicinity of Edirne-Turkey

N. Zaim[a,*], A.B. Tugrul[b], H. Atlas[a], B. Buyuk[b], E. Demir[b], N. Baydogan[b] and N. Altinsoy[b]

[a]Trakya University, Science Faculty, Physics Department, Balkan Campus, 20030, Edirne, Turkey

[b]Istanbul Technical University, Energy Institute, Nuclear Researches Division, Ayazaga Campus, 34469, Istanbul, Turkey

The study was carried out to determine radioactivity concentrations in surface soil samples of the city of Edirne in connection with the potential radiological hazards due to Chernobyl event. The natural radionuclide ((226)Ra, (232)Th and (40)K) contents were determined for nine different locations in nine different towns of the Edirne city. Radiation levels were measured. Natural beta-ray activity was also determined for the same locations. The average estimated activity values were determined and compared with reported values for other cities in Turkey and also for many countries of the world. The studied areas do not pose radiological risks to the inhabitants due to harmful effects of the ionizing radiation from the natural radioactivity of the soil.

DOI: 10.12693/APhysPolA.130.64

PACS/topics: 07.88.+y, 89.60.–k

1. Introduction

Human beings are exposed to radiation arising from such sources as cosmic rays, natural radionuclides in water, air, soil and plants; and the artificial radioactivity originating from medical applications and the fallout after nuclear testing. The radioactivity of the soil is important since it disperses into water and air and also through the plants and other leaving beings.

Natural radioactivity levels depend on geological aspects, mainly on rocks and soil [1, 2]. Natural radionuclides in the soil are responsible for the background radiation exposure of the population. The terrestrial component of the natural background radiation is dependent on the compositions of the soils and rocks, which contain natural radionuclides [3]. In the recent years, studies of the high background radiation areas in the world have been of prime importance for the risk estimation due to long term low-level whole body exposure of the population. The high radiation levels are due to the presence of large quantities of naturally occurring radioactive minerals in the rocks, soils and sediments [3, 4]. On the other hand, agricultural fertilizer products contain various trace elements, such as uranium and thorium decay series members and (40)K [5]. The use of fertilizers in agricultural areas can increase the concentration of these natural radionuclides in soil and affects vegetation, forests and climate. For example, the potassium content of soil of arable lands is strongly influenced by the use of fertilizers [6]. Therefore, global changes are affected by altering the radioactivity levels in nature. Radioactivity levels can be determined by measuring any of the characteristic radiations, such as beta-ray and gamma-ray radioactivity [7]. The aim of the present survey was focused on comparison of gamma-ray and beta-ray radioactivity, measured in soil samples from Edirne-Turkey.

*corresponding author; e-mail: nnimetzaim@yahoo.com.tr

2. Geology of Edirne

Edirne is located in the west of Turkey in the Tharace region. The city is located at the border with Greece and Bulgaria. Soil types of Edirne region are derived from biotite, chist, granated chist, biyotite gnaiss, alcali granite and cut of the aplite pegmatite, created before the Permian period and called Tekedere formation. There are some discrepancies concerning the Oligosen rocks and vulcanite of the Eosen older units in the sedimentary structures [8]. Edirne has nine municipality regions including the center of the city municipality from which samples were collected. Figure 1a and b show the administrative and seismic map of Edirne.

3. Experimental procedures

Ten samples were collected from each municipality region of Edirne. Samples, which were taken on the surface of the soil, were prepared for the experiments [9–11]. The plastic containers, containing 200 g of samples, were hermetically sealed with adhesive tape for at least 30 days so as to allow for (238)U and its short-lived progenies to reach secular radioactive equilibrium before beta-ray and gamma-ray counting.

Gamma-ray radioactivity measurements were performed by gamma-ray spectrometer, employing a scintillation detector with dimensions of 3×3 inches. Its hermetically sealed assembly which includes a high resolution NaI (Tl) crystal, photomultiplier tube an internal magnetic/light shield, aluminium housing and a 14 pin

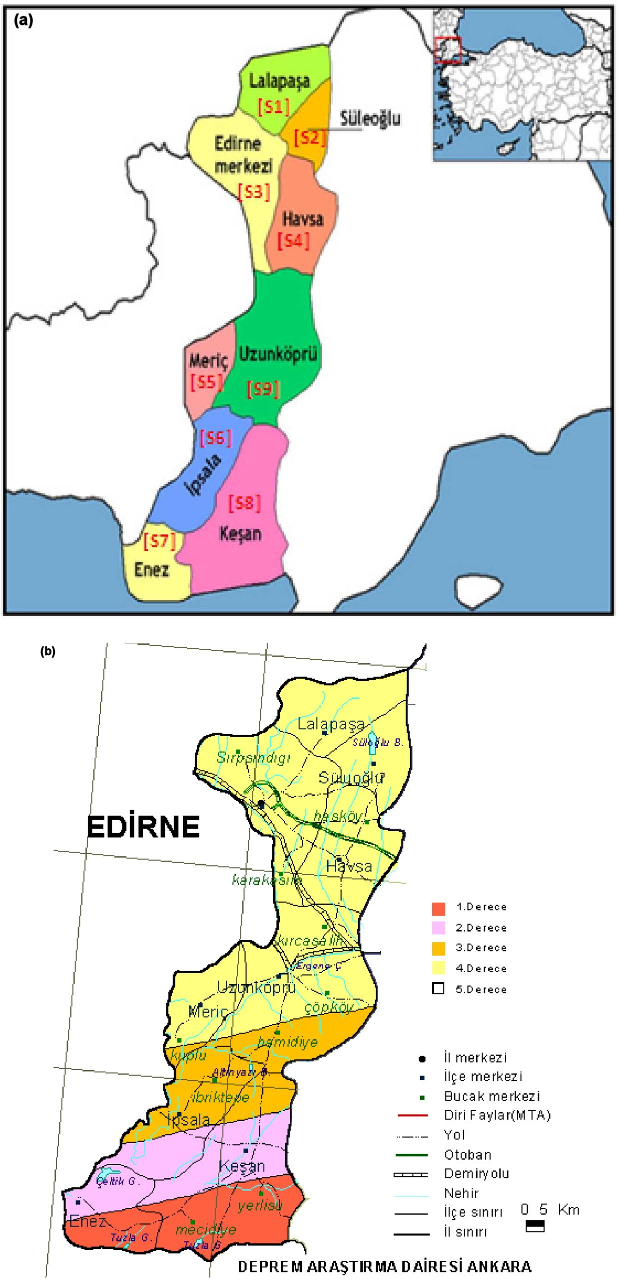

Fig. 1. Maps of Edirne: (a) administrative map, (b) seismic map.

connector coupled to PC-MCA. To reduce gamma-ray background, a cylindrical lead shield with a fixed bottom and movable cover was used.

Beta-ray radioactivity measurements were observed by using a detector system PMK with scintillation detector including no window system. Aluminium covered by lead shield was used for shielding against the background.

In order to eliminate the background signal from the environment, the radioactivity of an empty sealed beaker was measured in the same manner and in the same geometry as the samples. The calibrations of the gamma-ray and beta-ray systems were carried out using reference standard source material. Cs-137 and Co-60 were used as calibration sources for gamma-rays and for beta-rays St-90 was used.

For determination of beta-radioactivity, first the calibration curve was drawn, according to measurements of KCl containing K-40 reference radioisotope, used for beta-ray radioactivity calculations [12–15]. Then the beta-ray radioactivity for the samples A_β was calculated according to

$$A_\beta = [\alpha N_\beta M_\beta]/N_{\beta 0}, \quad (1)$$

where N_β is the net count rate of sample, M_β is the mass of sample (in mg/cm^2) and $N_{\beta 0}$ represents the value from KCl calibration curve via mass of sample and α is efficiency of detector (0.96).

The measurement of gamma-ray activity levels of radionuclides in samples was carried out by comparative method, using the references materials of IAEA-RGK-1 potassium sulfate, IAEA-RGTh-1 thorium ore, IAEA-RGU-1 uranium ore and IAEA-434 phosphogypsum, as standard samples. All processing for measurement of the activity levels of radionuclides in samples and standards was carried out under the same conditions.

The activity concentration in each sample was calculated using Eq. (2) [16]:

$$A_{\mathrm{sam}}\left(\frac{\mathrm{Bq}}{\mathrm{kg}}\right) = A_{\mathrm{ref}}\left(\frac{\mathrm{Bq}}{\mathrm{kg}}\right)\frac{\frac{S_{\mathrm{sam}}}{t_{\mathrm{sam}}}-\frac{S_{\mathrm{fon}}}{t_{\mathrm{fon}}}}{\left(\frac{S_{\mathrm{ref}}}{t_{\mathrm{ref}}}-\frac{S_{\mathrm{fon}}}{t_{\mathrm{fon}}}\right)m_{\mathrm{sam}}}, \quad (2)$$

where A_{sam}, A_{ref} are activity of the sample of interest and of the reference, respectively (in Bq kg^{-1}), S_{sam}, S_{ref} and S_{fon} are the photo peak areas for sample, reference and the background in the gamma-ray peak of E_γ, during the counting time (dimensionless), t_{sam}, t_{ref} and t_{fon} counting time for the sample, reference and background in the gamma-ray peak of E_γ (in seconds) and m_{sam} is the mass of sample (in kg).

The uncertainty of the activity concentration was calculated using the following equation:

$$U = A_{\mathrm{sam}}\left[(u_{\mathrm{A,ref}})^2 + \frac{(u_{\mathrm{sam}})^2+(u_{\mathrm{fon}})^2}{(C_{\mathrm{sam}}-C_{\mathrm{fon}})^2} + \frac{(u_{\mathrm{ref}})^2+(u_{\mathrm{fon}})^2}{(C_{\mathrm{ref}}-C_{\mathrm{fon}})^2}\right]^{\frac{1}{2}}. \quad (3)$$

The net counts for samples C_{sam}, reference C_{ref} and background C_{fon} in the γ-ray peak of radionuclide are given by Eq. (4)

$$C_{\mathrm{sam}} = \frac{S_{\mathrm{sam}}}{t_{\mathrm{sam}}} - \frac{S_{\mathrm{fon}}}{t_{\mathrm{fon}}},\ C_{\mathrm{ref}} = \frac{S_{\mathrm{ref}}}{t_{\mathrm{ref}}} - \frac{S_{\mathrm{fon}}}{t_{\mathrm{fon}}},\quad C_{\mathrm{fon}} = \frac{S_{\mathrm{fon}}}{t_{\mathrm{fon}}}, \quad (4)$$

where $u_{\mathrm{A,ref}}$ is the relative uncertainty of reference activities, u_{sam}, u_{ref} and u_{fon} are the uncertainties of the count rates of sample, reference and background, respectively. The relative error (%) of these calculations is 4%.

4. Results and discussion

Experimental results for gamma-ray and beta-ray measurements are shown in Table I.

The gamma-ray and beta-ray activity concentration values for the regions in the vicinity of Edirne-Turkey are shown graphically in Fig. 2 and Fig. 3, respectively.

TABLE I

Experimental results.

Code	Sample place	Gamma ray measurement [Bq/kg]	Beta ray measurement [Bq/kg]
S1	Lalapaşa	529.18	206.78
S2	Süloğlu	544.84	356.70
S3	Edirne(center)	512.01	342.43
S4	Havza	446.15	253.67
S5	Meriç	475.30	195.11
S6	İpsala	461.05	413.77
S7	Enez	592.16	499.38
S8	Keşan	474.72	199.75
S9	Uzunköprü	488.87	199.75
Average		**502.70**	**296.37**

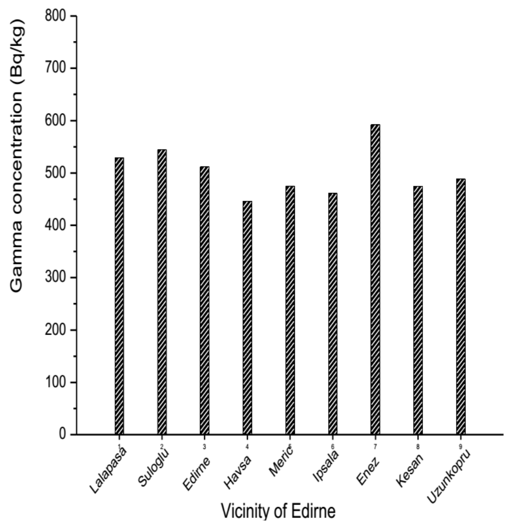

Fig. 2. Gamma activity levels for regions in the vicinity of Edirne.

5. Conclusions

The results of the study show that the average effective activity value is in accordance with the activity levels of the world [17–24]. For comparison, the average gamma-ray activity in Edirne was found to be 502.70 Bq/kg, against gamma-ray levels of 1112 Bq/kg in Malaysia [17], 691 Bq/kg in Macedonia [18], 635 Bq/kg in Bangladesh [19] and 309–615 Bq/kg in Nigeria [20]. The average beta-ray activity in Edirne was found to be 296.37 Bq/kg against 432.1 Bq/kg in Nigeria [21], 762 Bq/kg in Italy [22], 745 Bq/kg in Spain [23] and 139 Bq/kg in Japan [24]. If we consider the measured gamma-ray activity levels in Enez, Süloğlu, Lalapaşa and center of Edirne, these are higher than in the other regions. Enez, İpsala, Süloğlu and center of Edirne have also a higher beta-ray activity than other studied places. Therefore, Enez, center of Edirne and Süloğlu have higher activities of both gamma and beta-rays. Especially the

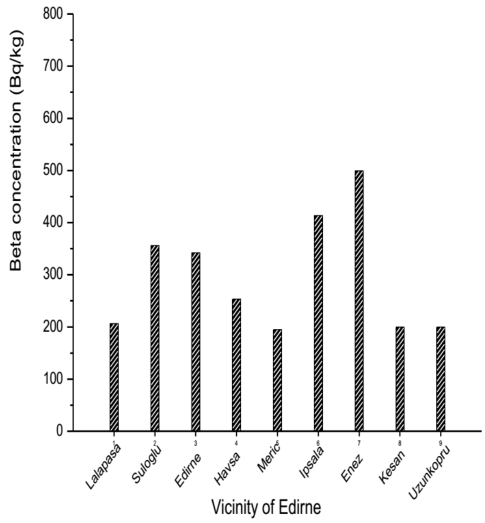

Fig. 3. Beta activity levels for regions in the vicinity of Edirne.

radioactivity level is higher in the south sites of the city. It can be said that the more seismically active regions, as can be seen in Fig. 1b and also the vicinity of the fault zone in Thrace region [25], have higher radioactive levels. However these levels are at acceptable levels for either health of the people or environmental pollution. Consequently, it can be said that determined gamma and beta-ray radioactivity levels reflect the changing situation of the terrestrial distribution. These results will provide background data on the natural radioactivity isotopes and environmental pollution.

Acknowledgments

This study has been supported as a Research Project by Scientific Research Department of Trakya University in Turkey (Project No:2013/150). We are grateful to them for supporting our studies.

References

[1] J.A. Santos Jr., J.J.R.F. Cardoso, C.M. Silva, S.V. Silveria, R. dos Santos Amaral, *Brazilian Arch. Biol. Technol.* **48**, 221 (2005).

[2] M. Tzortzis, H. Tsertos, *J. Environ. Radioactiv.* **27**, 325 (2004).

[3] F.A. Mir, A.A. Rather, *J. Radiat. Res. Appl. Sci.* **8**, 155 (2015).

[4] S. Singh, D.K. Sharma, S. Dhar, S.S. Randhawa, *Radiat. Meas.* **41**, 482 (2006).

[5] *Radiation exposure of the U.S. population from consumer products and miscellaneous sources*, NCRP report no. 95, Washington DC 1987.

[6] M. Eisenbud, T. Gessel, *Environmental radioactivity*, Academic Press, New York 1997.

[7] D. Ghosh, A. Deb, S. Bera, R. Sengupta, K.K. Patra, *Environ. Geochemidtry Health* **30**, 79 (2008).

[8] `http://edirne.web.tr/jeo.asp` (26.08.15).

[9] R. Veiga, N. Sanches, R.M. Anjos, K. Macario, J. Bastos, M. Iguatemy, J.G. Aguir, A.M.A. Santos, B. Mosquare, C. Carvalho, M. Baptita Filho, N.K. Umisedo *Radiat. Meas.* **41**, 189 (2006).

[10] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), *Sources and effects of ionizing radiation, Annex B — Exposures from natural radiation sources*, United Nations, New York 2000.

[11] E. Meriç, N. Avşar, M.B. Yokeş, A.B. Tuğrul, S. Bayarı, N. Özyurt, İ.F. Barut, N. Balkış, K. Uysal, E. Kam, *Micropaleontology* **54**, 241 (2008).

[12] H. Alkan, M.Sc. Thesis, Istanbul University, Istanbul 1989.

[13] A.B. Tugrul, E. Meriç, N. Avşar, F. Baytas, N. Altınsoy, B. Ayaz, N. Dogan, S. Sahin, I. Yilmaz, *Semposium on Haliç-2001*, Istanbul, Turkey 2001, p. 253, (in Turkish).

[14] E. Escareño-Juárez, H.R. Vega-Carrillo, *Rev. Mex. Fis.* **58**, 211 (2012).

[15] S. Tuncer, A.B. Tuğrul, *First Tataristan Symposium on Energy, Environment and Economics, 4–9 Aug., 1992*, Kazan, Tataristan 1992, p. 182.

[16] Turkey Atomic Energy Agency (TAEK), *Gamma Spectroscopy Calibration Workshop*, 2009.

[17] O.S. Ajayi, *Radiat. Environm. Biophys.* **48**, 323 (2009).

[18] L. Guidotti, C. Franca, R. Riccardo, G. Marina, R.M. Cenci, G.M. Beone, *J. Environ. Radioactiv.* **142**, 36 (2015).

[19] A. Baeza, M. Delrio, C. Miro, J.M. Paniagua, *Radiat. Prot. Dosim.* **45**, 261 (1992).

[20] H. Ryuta, S. Kiyoshi, *Indonesia. Environment Asia* **2**, 45 (2009).

[21] S. Kuan Lee, H. Wagiran, A.T. Ramli, *Radiat. Prot. Dosim.* **162**, 345 (2014).

[22] S. Dimovska, T. Stafilov, R. Sajn, *Radiat. Prot. Dosim.* **148**, 107 (2012).

[23] S.R. Bose, T.G. Williamson, U. Mudler, M.A. Rab Molla, *Health Phys.* **65920**, 200 (1993).

[24] U.L. Anekwe, G.O. Avwiri, O.E. Abumere, Am. J. Scientific Industrial Res. **4**, 546 (2013).

[25] D. Perinçek, *7th Biannual Petroleum Congress of Turkey*, Ankara 1987, p. 11.