Original Article

The Effect of Soil Radioactivity in Pollution

Abbas Hosseini*[1], Masoumeh Fasih Zaban[1]

[1]. Department of Medical Physics Lecturer and Researcher, Zahedan University of Medical Sciences, Zahedan, Iran

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Abstract

Introduction: The purpose of this article is to determine the contribution of absorbed dose rate, Radium equivalent activity, external hazard index, annual gonad dose equivalent and annual effective dose equivalent of soil in soil pollution.

Materials and Methods: The soil was chosen as a site for studying radiation doses. Soil samples were collected from twelve and thirteen sites in western and eastern sites respectively in the region and then dried. Then After that, the soil samples from twelve and thirteen sites in east and west were mixed separately to make one big group of soil sample. The measurement of Radionuclide concentration in soil samples was made by gamma spectrometer.

Results: The natural radioactivity doses of soil in the studied samples resulted in 42.92 ±4.03 nGy h-1 (average absorbed dose rate), 86.79±8.26 Raeq per Bqkg-1 (radium equivalent activity), 8231.86±327.76 (the external hazard index), and 322.9±31.6 ÏSvh-1 (the annual gonad dose equivalent) and193.15ÏSvh-1 (the annual effective dose equivalent). The results of the study were also compared with the international recommended values and radioactivity measurements in soils of different countries.

Conclusion: The contribution of natural radioactivity in the area was low, in comparison with ICRP was low.

Keywords: Radio nuclides, Radiation, Pollutions, Radioactive material, Soil

[1]**Corresponding author: Tel**: 09155408625, **Email:** sepehrhssn@yahoo.com

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Introduction

The radiation workers, the general public and the environment against the dangers of ionizing radiation were protected by the responsible authority. The gamma radiation was emitted by natural radioactivity in soil [1]. Some soils characteristic caused to disperse around natural radioactivity [2].

The naturally occurring radio activity material was not harmful for human health [3]. As the radioactivity concentrations migrates from a point source, it was ascending rather than descending and there was a questionable risk in the assumptions of models regarding continuous dilution of released contaminants [4]. The activity concentrations of natural radio nuclides in waste material of some places could be several times higher than in the adjacent soil [5]. The radiation of radio nuclides in soils are measured [6]. Many factors contributed to radio nuclides dose in soil [7, 8]. In recent years the additional dose to marine biota in the region, due to the past natural radioactive discharges, was of the same order of magnitude as the natural back ground [9].

As there were few data about on natural ecosystem of Chahbahar, in Sistan & Baluchistan of Iran, Knowledge about radioactivity was important in improving people health. The aims of this study is to determine contribution of the natural radio nuclides concentration in soil as adsorbed dose rate, external hazard index, annual gonad dose equivalent and annual effective dose equivalent to the public in soil.

Materials and Methods

Sampling points

The soil samples were collected in Chahbahar, Sistan and Baluchistan, in Iran. There was little rain, little plant covering, and with a maximum temperature of 35^0 C of temperature as some features of Chahbahar. Although there were mines, forests and sea in this region, the sampling locations were deliberately selected in places far from these spots. The type of Chahbahar soil was fine sand- clay.

Twenty five subsamples of soil were collected from 25 different places around and in the Center of city. Twelve and thirteen sub-samples were provided respectively from the western part and thirteen of subsamples from eastern part of Chahbahar were provided and then mixed combined producing two groups of samples.

The sub-samples were collected before any rain falling during the summer or autumn. Soil samples were 20 cm x 20 cm-soil blocks with deep depth from of zero to 30 cm. These blocks were then mixed with each other. After drying at room temperature, the soil was passed through a 2mm sieve in order for the stones to remove stones and all subsequent performed on the less than 2 mm fraction. All subsamples were dried at room temperature. Each sub-sample was sealed for 30 days to reach radioactive equilibrium where the decay rate of the daughters becomes equal to that of the parents [10]

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Gamma-spectrometry

The samples are measured in a small polyethylene beaker with a volume of 500 mm^3 located in Iran Atomic Energy Organization, They were tested by a high resolution gamma spectroscopy system with a HPGe detector, it was Automatic Gamma Counting system with the Serial No.GM1 8335 S 307, and the manufacturer name KONTRON. The soil samples are measured in a certain detector of 70% relative efficiency and computerized multi-channel analyzer of 8192 channels in a total spectrum area of 2870 kev. This set was calibrated by a standard activate solution of radio iodine and the curves were compared with the standard ones. The measurement time was - took more than 8 hrs. The minimum detection activity (MDA) using the counting method is determined with a confidence level of 95%. Indicative values for the MDAs of the most important radio nuclides for an 8 hr.-measurement are: 0.4 Bq/L for Co-60, Cs-137, Cs-134. This counting method was chosen considering that it was not so important to identify the radio nuclides involved into the reactions, since the objective was to shift all the isotopes producing significant doses of radiation.^{125}I activity concentrations were corrected for variation in sample self-absorption [11] and converted to area activities with the total weight of the sample fraction less than 2 mm and the total sampling area. Duplicate sampling shows that the relative error due to homogenization and analysis is less than 10%. Surveys of natural radiation background were often conducted to characterize a site before it was used for an activity that involved radiation. Counting errors varied with sample activity at 95% confidence level.

Total measurement

The adsorbed dose rate in air (D), radium equivalent activity (Raeq), annual gonad dose equivalent (AGDE), and external hazard index (Hex), were calculated by the following formulas [12] respectively:

$$Hex=A_U/370+A_{Th}/259+A_K/4810\leqslant 1$$

D was the absorbed dose rate at 1 m above the ground, A_U, A_{Th} and A_K were the activity concentrations of 238U, 232Th and 40K, respectively in the samples. The conversion factors of 238U, 232Th and 40K were 0.427 nGy/h, 0.662 nGy/h and 0.0432 nGy/h per Bq/kg, respectively [13]. If a radionuclide activity was known, then, its exposure dose rate in air at 1 meter above ground could be calculated [13, 14]. A_{Ra}, A_{Th} and A_K were the activity concentration of 226Ra, 232Th and 40K in Bq/kg, respectively. Radium equivalent activity (Raeq) was calculated for the samples by applying the [12] formulae. Activities of organs like bone marrow and bone surface cells for the annual gonad dose equivalent were suggested by [14] UNSCEAR (1988). Therefore, the Annual gonad dose equivalent (AGDE) due to the specific activities of 226Ra, 232Th and 40K was calculated by AGDE formulae [14]. The UNSCEAR (2000) suggested AEDE (μSv/year) formulae using a value of 0.7 Sv/Gy for the conversion coefficient from absorbed dose in air for effective dose received by adults, and 0.2 for

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the outdoor occupancy factor [15].

Results

The naturally occurring radioactivity of soil in different areas of Chahbahar has been shown in Table 1. The highest amount of radioactivity of potassium-40 in soil was 483±34.9 Bq/Kg and the lowest was 417±34.5 Bq/Kg. The average amounts of Uranium -238 and Thorium-232 in soil were as 23.5±2.5 and 20.2 Bq/Kg respectively in soil.

Table 1: Concentration of radio nuclide radioactivity in soil sample

Samples	**Major elements of naturally occurring radioactivity**		
	Potassium-40	Uranium -238	Thorium-232
	Bq/Kg	Bq/Kg	Bq/Kg
12 sites in east	483±34.9	23±2	21.4
13 sites in west	417±34.5	25.5±3	19..0
Average	450±34.8	24±3	20.2

Table 2 shows the absorbed dose rate in air (D). Average absorbed dose rate (D) was 42.92 ±4.03 nGy h^{-1}in airs. The radium equivalent activity (Raeq) and external hazard index (Hex) were also represented in table 2. The amount 86.79±8.26 for radium equivalent activity (Raeq), and 8231.86±327.76 for external hazard index (Hex) were calculated for soil. The annual gonad dose equivalent (AGDE) was measured (Table 2).

Table 2: The absorbed dose rate (D) in (nGy/h), radium equivalent activity

Sites in	**The annual effective dose equivalent (AEDE) (ÏSv/h)**	**The absorbed dose rate (D) (nGy/h)**	**Radium equivalent activity (Raeq) (Bq/kg)**	**The external hazard index (Hex)**	**The annual gonad dose equivalent (AGDE) (ÏSv/h)**
East	190.092	44.37±	89.38±	5231.86±	356.88±
		4.03	8.30	569.80	27.87
West	196.22	4151±	84.20±	5231.86±	288.916±
		4.08	8.53	595.70	35.33
Average	193.15	42.92	86.79±8.26	8231.86±327.76	322.9±32
		±4.03			

(Raeq) (Bq/kg), the external hazard index in (Hex), the annual gonad (AGDE) in (ÏSv/h) dose equivalent, the annual effective dose equivalent (AEDE) in (ÏSv/h) of radio nuclide in each part of soil sample

The amount of annual gonad dose equivalent (AGDE) was 322.9±31.6 µSv/year and the minimum amount was 247.29±44.43 in the center of the city. The average value of the annual effective dose equivalent (AEDE) was 193.15 µSv/h. These values were lower amounts of radiation in comparison to ICRP. The average radio nuclides of 238U, 232Th, and 40K were 20.2±2.3 Bq/kg, 23.6±2.5 Bq/kg, and 450±34.8 Bq/kg respectively in soil samples of Chahbahar city. Our results showed that the mean activity concentrations of these radio nuclides were comparable with the worldwide concentrations 40, 40, 540 Bq/kg.

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Discussion

In Chahbahar, some sampling places were selected near forests or the sea with respect to soil type and vegetation, where the climate was sultry. In general there was a faster decline of activity concentrations [16]. Potassiumñ40 in the western site of Chahbahar was more than the other sites (576±57.4Bq/kg), and the minimum value relative to the eastern part of the city was 396±38.4Bq/kg (Table 1). These figures showed suggested an approximate radioactivity difference of 200 Bq/kg in soil of Chahbahar city approximately. The radioactivity of potassium-40 in the western part (without forests) of the city was higher than eastern part (near forests). In particular, reduction of radiation was influenced by little plant covering varieties used for animal feeding, the plants' growing cycles and harvests, the animal feeding practices, and human consumption rates [17, 18]. According to table 1, there was no risk of radio nuclide in the soil of Chahbahar, especially, I-131, Csñ137, and Puñ239, 240.Eastern Desert of Egypt with 493.8 Bq/kg [19], southeast of Eskisehir-Turkey with 366.9 Bq/kg [20, 21], and Xiazhuang Granite Area- China with 266 Bq/kg had lower values than the measured ones -cases of this work. In all cases, the activities were lower than the ICRP standards [21]. Table 2 showed that the gonad dose equivalent (AGDE) of natural occurring radioactivity in western site of Chahbahar city was less than in other sites. The annual gonad dose equivalent (AGDE) of natural occurring radiation in the center of Chahbahar city was 322.9±31.6 µSv/year The AGDE in Turkey was variable and it ranged from 143.6 to 1244.7 µSv/ year, while the average value was found to be 550.5 µSv/year [22]. This value in Eastern Desert of Egypt was 2398 µSv/year [22] which was nearly two times bigger than the AGDE in Chahbahar. The annual effective dose equivalent in the soil of Chahbahar city was lower than the average AEDE of the world. Compared to the values in soil of other European countries [23], the values were low in this study. The annual effective dose equivalent (AEDE) of Chahbahar was 220.752 µSv/year - 190.09 µSv/year and the average value was 205 µSv/year. In Turkey the annual effective dose rate varied from 23.4 to 184.9 µSv/year and the average value was found to be 88.7 ÏSv/year. The average AEDE value was calculated 152 µSv/year in the Xiazhuang Granite Area in China [22], 69.8 µSv/year in Istanbul-Turkey [22]. It was 314.1 µSv/year in the Southeast of Eskisehir-Turkey [23]. This average value was higher than in Chahbahar. They were from different sources. So, the future for this region may not be at risk due to low radiation in this area, because the absorbed dose rate in Chahbahar soil samples is 42.92 ±4.03 nGy/h. The AEDE from outdoor terrestrial gamma radiation was 70 µSv/year in the World [24, 25], and in Chahbahar it was 193.15 µSv/year, which shows that the obtained values of the latter was nearly three times bigger than the world average value. The values were at least three orders of magnitude lower than 1 mGy per day. The distribution of Uranium-238 and Thorium-232 in soil was similar. Much The high density of moisture in

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the area supported the equilibrium in Uranium-238 and Thorium-232 [26].

The regulations relating to the sources of radiological radiation were not available relating to radiological quality of soil. No systematic radiological monitoring of the aquatic environments was consequently applied in this city. Project of natural radioactive were limited and much contradiction was found in them [27].

Conclusion

Natural occurring radiation was low in the soil of Chahbahar city. This study could also be used as a baseline for future investigations; also, the data obtained in this study was useful for natural radiation mapping.

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