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NATURAL RADIOACTIVITY IN SOIL ALONG CHASHMA BARRAGE, PAKISTAN

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Natural radioactivity due to ^{226}Ra, ^{232}Th and ^{40}K has been measured in the soil samples collected from Kundian area (along Chashma Barrage) of district Mianwali, Pakistan. The activity was measured using high purity germanium (HPGe) gamma ray detector with a computerized multichannel analyzer (MCA). The activity was measured at the time when the Nuclear Power Reactor was being installed in that area. Keeping in view of the importance of the area being designated as project area, the natural radioactivity in the soil of this area was measured to assess the consequences to the human health. No enhanced radiation levels were observed for the surveyed area. Thus the soil of Kundian region does not pose significant radiation hazard.

Keywords : ^{226}Ra, ^{232}Th and ^{40}K, Soil, Kundian, Gamma ray spectrometry.

1. Introduction

Uranium and thorium belong to a group of primordial radionuclides, as they have always been present in the earth. The radionuclides ^{238}U, ^{235}U and ^{232}Th which decay with three distinct series of radionuclides are of great importance in the nuclear fuel cycle and radiation protection studies. The knowledge of distribution of natural radionuclides in soil is important in bio and geosciences research [1].

In the radiological survey of any area, these nuclides are systematically analyzed to know the natural radiation background in that area [2]. The knowledge is useful to reveal any occasional change in the normal situation and to understand the role of ^{226}Ra, ^{232}Th and ^{40}K in the soil environment. Low level natural radiation has been measured in many countries on a large population. The exposure to natural radiation can be internal as well as external. The external component is mainly due to cosmic rays and gamma radiation emitted by nuclei present in the earth's crust. Internal radiation is received by the intake of food, water and air. Radon and its decay products account for considerable part of natural radiation dose to the population living in the congested areas of conducive atmosphere. The effect of low level radiation on the carcinogenesis have been investigated on a large scale during recent years [3, 4].

Some countries of the world have done considerable work on this aspect. The study reported here is about the radioactivity in the soil of Kundian along Chashma Barrage, District Mianwali, Pakistan. The soil samples were collected to determine ^{226}Ra, ^{232}Th and ^{40}K concentrations in the area under investigation. The study was a part of our research programme to investigate the concentration of naturally existing radionuclides in soil of the area where a nuclear reactor was under construction.

This study gives a base line of radioactivity in the area and will be helpful to correlate the radioactivity measured after operation of the reactor.

2. The Area Under Study

The area under study is Kundian site along the Chashma Barrage. This site lies in the Thal desert which forms part of the Punjab plains lying between the rivers Indus and Jhelum. The site is bounded on east and south by the Punjab Plains, on the north by Salt Range trending in the north west – southeast direction and on the west by Marwat and Khisor Ranges trending in the

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Table 1. Gamma ray and radium equivalent activities due to ^{40}K, ^{226}Ra and ^{232}Th in the soil samples collected from Kundian along Chashma Barrage, district Mianwali, Pakistan.

Range	Activity (Bq kg^{-1})				Ratio
	^{40}K	^{226}Ra	^{232}Th	Ra_{eq}	^{232}Th / ^{226}Ra
Minimum	344	19	26	83	1.4
Maximum	766	55	94	248	1.7
Average	481	34	55	150	1.6

northeast – southwest direction.

The site lies on the alluvium which is of fluvial origin deposited by the river Indus in subsiding through. The alluvium estimated to be about 150 to 400 meters thick at the site consists mainly of poorly graded sub – angular, to sub – rounded sand particles with occasional thin lenses of clay, silt and gravel. The sand is generally fine grained. The silt and clay are gray in colour, and stiff to hard in consistency.

3. Experimental Method

Forty samples of soil were collected randomly at different locations from the site. Each sample was taken at a depth of about 6 cm by removing the upper surface of the earth. This was done to avoid the activity due to fallout from the atmosphere. The samples were properly coded. The list of samples is given elsewhere [5] with codes and distance from the site alongwith remarks.

The collected material was brought to the sample preparation section of the Low Level Activity Measuring Laboratory of PIEAS, which was apart from the low level gamma ray activity measuring facility. The material samples were crushed to small pieces, weighed and placed in a microprocessor controlled furnace to remove the moisture contents. The furnace was operated at 110^{o}C and samples were dried in the furnace at 110^{o}C until the constant weight. The samples were cooled in a moisture free environment. The material was pulverized and the powder was sealed in radon impermeable plastic containers. The geometrical dimensions and the packing of the samples were kept identical to that of the reference material of known activity (Soil – 6 obtained from IAEA). These prepared samples and reference materials were stored for more than 40 days to bring ^{222}Rn and its short lived daughter products in secular equilibrium with ^{226}Ra [6].

Specific activity of soil samples was determined using HPGe based gamma ray spectrometer in the low level activity measuring facility. The spectrometer consisted of a PC based MCA with INTERGAMMA software for spectrum analysis. Details about the facility and measurements are given elsewhere [7 – 10].

4. Results and Discussion

Specific activity was calculated for every sample from the gamma spectrum of the sample measured with HPGe spectrometer. The minimum, maximum and average values of the specific activity are given in Table 1. The maximum value of specific activity of ^{40}K is almost double than that of its minimum value. The maximum value of ^{226}Ra and ^{232}Th are almost triple than that of their minimum values. A great variation in the measured values is due to geology and topography of the area under study.

The results of the present study were compared with those determined for other areas of Pakistan. The comparison is shown in Table 2 where the average values of activity of soil of Islamabad / Rawalpindi, Lahore and that for Kundian are given. The specific activity due to ^{40}K, ^{226}Ra and ^{232}Th is larger for Lahore area and smaller for Kundian area whereas it is intermediate for the Kundian area. The value of ^{232}Th activities of Islamabad / Rawalpindi and of Kundian areas are almost equal.

To determine the radiological impact of this soil on the residents of the area it is useful to determine the radium equivalent activity (Ra_{eq}) and hazard indices (H_{ex} is external hazard index and H_{in} is internal hazard index). These are defined as follows [11]:

Table 2. Comparison of gamma ray and radium equivalent activities of Kundian area with other areas of Pakistan.

Area	Activity (Bq kg^{-1})				Ratio	Reference
	^{40}K	^{226}Ra	^{232}Th	Ra_{eq}	^{232}Th / ^{226}Ra	
Isl. / Rwp	565	42	56	211	1.6	[6]
Lahore	848	51	65	252	1.3	[6]
Kundian	481	34	55	248	1.6	Present work

$$Ra_{eq} = A^{RA} + \frac{10}{7}A^{Th} + \frac{10}{130}A^{K}$$

$$H_{ex} = \frac{A^{RA}}{370} + \frac{A^{Th}}{259} + \frac{A^{K}}{4810}$$

$$H_{in} = \frac{A^{RA}}{185} + \frac{A^{Th}}{259} + \frac{A^{K}}{4810}$$

where A's represent the specific activities in Bq kg^{-1}. For safe use, the values of these indices must be less than unity and radium equivalent activity should be less than 370 Bq kg^{-1} [11]. The calculated values of radium equivalent activities as may be seen from Tables 1 and 2 even for maximum observed specific activities are well below the limiting values. The values of hazard indices were also calculated and found to be less than unity. Therefore, the soil of Kundian region does not represent a significant radiation hazard.

5. Conclusions

There is a great variation in the specific activity values of ^{226}Ra, ^{232}Th and ^{40}K in the area under investigation. The calculated radiation hazard indices and radium equivalent activity are lower than the limiting values.

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