ASSESSMENT OF ENVIRONMENTAL GAMMA DOSE IN NORTHERN RECHNA DOAB IN PAKISTAN

by

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Environmental gamma radiation levels in northern Rechna Doab, Pakistan, were measured as a part of systematic study aimed at the establishment of the background data base of radiation and radioactivity levels. The measurements reported in this paper were made with portable radiation monitor which employed GM tube and was calibrated against secondary standard dosimetry system. The average absorbed dose rate in air was determined to vary from 86.0 nGy/h to 139.1 nGy/h with the mean value of 109.1 nGy/h. The annual effective dose remained within the range of 105.47 Sv to 170.54 Sv with its average value of 133.73 Sv. These environmental radiation doses in the area were comparable with those reported for other countries. It was concluded that the prevalent radiation levels did not pose any significant radiological health hazard to the population.

Key words: environmental radiation, gamma radiation, radiation monitoring, gamma dose, Rechna Doab

INTRODUCTION

The province of Punjab comprises eight administrative divisions extending over an area of 205.346 sq. km (97.192 sq. miles). According to the results of 1998 census, the population of the province stands at 71.5 million (about 55% of the total population of Pakistan) compared with 47.12 million of 1981 population census figures. The population density in the province is about 348 persons per sq. km. The province of Punjab is the most populous one, and therefore the assessment of radiation doses is a relatively important issue.

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Punjab consists mostly of plains north and south of the ancient Salt Range, which stretch from east to west. Punjab can be divided into five major physical regions: (I) Northern Mountains, (II) South-Western Mountains, (III) Potohar Plateau, (IV) the Upper Indus Plain, and (V) the Deserts. In the north, there are the outer ranges of the Himalayas: Murree and Kahuta hills in the north and the Pubbi hills of Gujrat in the south [1].

Agriculture is the most important industry in Punjab. Wheat, rice, sugarcane, fruit, tobacco, cotton, and many other crops flourish in the soil of Punjab. The province of Punjab is criss-crossed by canals as a result of which the area is now a huge oasis where there are hundreds of new settlements.

Study area

The Rechna Doab can be classified as one of the main regions of Punjab. Plain areas of Punjab are divided into natural regions based on its various rivers, since the name Punjab is based on its 5 main rivers. Rechna Doab, comprising about 28.500 square kilometers, is enclosed by the river Chenab and river Ravi on the northwest and southeast, respectively, with the piedmonts near the Jammu and Kashmir boundary in the northeast. Its longitude is 71° 48' to 75° 20' E and latitude 30° 31' to 32° 51' N. Rechna Doab is about 403 km long in southwest direction and has a maximum width of about 113 km [2].

The area is interfluvial and is southwesterly sloped. In the upper part of the Rechna Doab, the slope is about 380 cm/km to about 9 cm/km [3]. Physiographically, the Rechna Doab can be characterized by the following units:

– Kirana hills – though minor when compared with the alluvial complex, but very prominent,
– active flood plains in the vicinity of the rivers Ravi and Chenab,
– abandoned flood plain, and
– bar upland – an elevated land beyond the reach of flood waters of the rivers.

Geology

The consolidated exposed rocks near Chiniot, Sangla, and Shahkot represent the remnants of the buried ridge of metamorphic or igneous rocks forming the basement of the alluvial deposits in Rechna Doab. These indurated rocks are known as Kirana hills and are of the precambrian age. These rocks cover the central part of Rechna Doab making the longitudinal section across its width. The unconsolidated alluvial deposits are of the pleistocene to recent in age and are overlying the precambrian basement rock. These were deposited in a subsiding trough by the ancestral and present tributaries to the river Indus. The alluvial fill is more or less homogeneous in nature, and has little continuity vertically or laterally, indicating diverse depositional environments from time to time caused by constant change in the stream courses [4].

The alluvial sediments consist mainly of gray, grayish brown, fine to medium sand, silt, and clay. Gravel or very coarse sand is uncommon. Kankers, a calciumcarbonate material of secondary origin is associated with fine-grained strata. Clay is generally found in lenses. The origin of clay has not been ascertained but presumably it is repeatedly reworked loess. Of the alluvial complex, sand forms the areas of fairly transmissive aquifer material in which ground water occurs under water table conditions [2].

When the Earth was formed, the materials from which it was made contained radioactive elements. About 70 radionuclides have been found in nature. These can be divided into two main categories: cosmogenic radionuclides produced by cosmic rays, *e. g.* ^{3}H, ^{7}Be, ^{14}C *etc*., and primordial radionuclides, which are of two types. First being singly occurring radionuclides with long half lives *e. g.* ^{40}K, ^{87}Rb, found in all rocks, soil, water, and living organism even the humans. The second type consists of the members of the families of radioactive heavy elements produced in ^{238}U, ^{235}U, and ^{232}Th decay series [5].

External exposures outdoors arise from terrestrial radionuclides present at trace levels in all soils and from cosmic radiations. The specific levels in soils are related to the types of rocks from which the soils originate. Higher radiation levels are associated with igneous rocks, such as granite, and lower levels with sedimentary rocks. There are exceptions, however, as some shales and phosphate rocks have a relatively high content of radionuclides. Many surveys have been made to determine the background levels of radionuclides in soils, which can in turn be related to the absorbed dose rates in air. The later can easily be measured directly, and the results of such measurements provide an even more extensive evaluation of the background exposure levels in different countries [6]. The cosmic exposure which is the secret component of the background radiation dose is related to the altitude of the place of interest.

Gamma dose measurements have been conducted in different areas of the country through soil radionuclides, but not in a systematic way. Like the large-scale surveys done in many other countries of the world, this first systematic and extensive study of this nature was done by using a calibrated dose rate meter which gives instantaneous results.

The objective of the present study was to develop the base line natural background radiation dose data for various regions of northern Rechna Doab, comprising districts Sialkot, Gujranwala, Narowal, and Hafizabad. A detailed radiation survey was made by using a quite sensitive and well calibrated radiation dose rate meter. For unknown measurement pattern the northern Rechna Doab was divided into grids of 24 28 sq. km, covering the whole area under the study. The results have been prepared and presented in this paper.

MATERIALS AND METHODS

Radiological monitoring was performed by using the radiation dose rate meter of FAG, Germany, model FH40F4 (fig. 1). It employed a GM tube as the active detector having energy independent response from 45 keV to 1.3 MeV. The measurement with FAG dose rate meter, owing to the instantaneous results and the easily portable nature with almost nil transport charges, was preferred over thermoluminescent dosimeter (TLDs) technique which required longer exposure times (in months) to record background radiation levels and thereafter required the indirect evaluation of the results in the laboratory. The reliability of the dose rate meter results was assured by its calibration in the Secondary Standard Dosimetry Laboratory (SSDL), PINSTECH, Pakistan, whose measurements are traceable to Primary Standard and are ensured by the International Atomic Energy Agency (IAEA) through the postal dose intercomparison [7]. The measurements were made

Figure 1. A view of FAG dose rate meter used during present study

during the period of April-June 2008, at a reference height of 1 meter above the ground level in the open air. The present study area, northern Rechna Doab (fig. 2), was divided into 24 × 28 sq. km spatial grids to evenly distribute the data collection points. It was assured that reading at every data point was a true representation of the radiation level. Ten to fifteen readings were taken at each location for this purpose and their mean value was converted to the absorbed dose rate in air [8]. The minimum, maximum, and mean value of the absorbed dose rate in air and the outdoor effective annual dose from terrestrial origin derived from these measurements are mentioned in tab. 1.

The average absorbed dose rate in air, D, was calculated using the following relation:

$$D\,[\text{nGyh}^{-1}] = 9.15 \times dose\,[\mu\text{Rh}^{-1}]$$

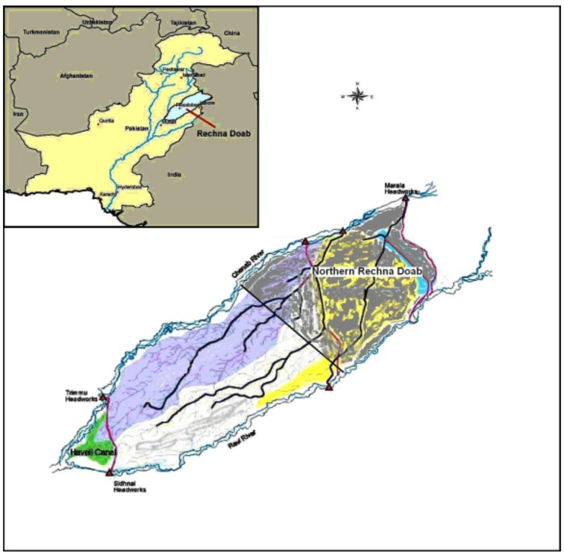

Figure 2. Map of study area, northern Rechna Doab, Pakistan

The annual effective dose, AED, was estimated using the following conversion

$$AED\,[\mu\text{Sv}] = D \times 24 \times 365 \times 0.7 \times 0.2 \times 10^{-3}$$

Table 1. Environmental gamma radiation levels in northern Rechna Doab, Pakistan

Location	Latitude	Longitude	Average absorbed dose rate in air [nGyh^{-1}]	Annual effective dose [μSv]
Gujranwala	32° 09' N	74° 07' E	133	163
Wazirabad	32° 28' N	74° 05' E	121	148
Aiman Abad	32° 01' N	74° 13' E	113	138
Dhaunkal	32° 23' N	74° 08' E	106	130
Ahmad Nagar	32° 20' N	73° 59' E	114	140
Head Khanki	32° 22' N	73° 59' E	93.3	114
Rasul Nagar	32° 19' N	73° 47' E	87.8	108
Kalianwala	32° 17' N	73° 44' E	113	139
Kot Hara	32° 16' N	73° 41' E	123	150
Rasulpur Tarar	32° 03' N	73° 27' E	105	129
Gajar Gola	32° 04' N	73° 43' E	105	129
Uddowali	32° 06' N	73° 54' E	96.9	119
Killah Didar Singh	32° 07' N	73° 59' E	124	151
Noshehrah Virkan	31° 59' N	74° 09' E	131	160
Kamoke	31° 56' N	74° 13' E	86.0	105
Sadhuke	31° 53' N	74° 14' E	89.7	110
Manguke	31° 47' N	74° 01' E	86.9	107
Hafizabad	32° 03' N	73° 42' E	113	138
Pindi Bhattian	31° 53' N	73° 15' E	120	147
Wainkay Tarar	32° 13' N	73° 35' E	123	150
Chak Bhatti	32° 05' N	73° 24' E	103	126
Jalalpur Nau	32° 03' N	73° 23' E	96.9	119
Sukhayki	31° 49' N	73° 35' E	93.3	114
Kishan Garh	31° 47' N	73° 26' E	126	155
Sialkot	32° 27' N	74° 33' E	130	159
Sambrial	32° 30' N	74° 20' E	114	140
Kulu Wal	32° 34' N	74° 21' E	94.2	116
Head Marala	32° 40' N	74° 28' E	103	126
Chaprar	32° 34' N	74° 29' E	114	140
Chuvinda	32° 21' N	74° 37' E	86.9	106
Mundeki	32° 17' N	74° 32' E	139	171
Daska	32° 17' N	74° 21' E	103	127
Dharam Kot	32° 11' N	74° 22' E	105	129
Sutra	32° 09' N	74° 28' E	115	141
Merajke	32° 24' N	74° 46' E	102	125
Norowal	32° 06' N	74° 51' E	96.1	118
Zafarwal	32° 20' N	74° 55' E	131	160
Chak Amro	32° 15' N	74° 08' E	112	137
Noor Kot	32° 11' N	74° 06' E	120	147
Jassar	32° 05' N	74° 55' E	98.8	121
Talwindi Bhindran	32° 06' N	74° 40' E	105	129
Minimum			**86.0**	105
Maximum			**139**	171
Average			**109**	134

where 0.7 is Gy to Sv conversion factor, and 0.2 is the occupancy factor.

RESULTS AND DISCUSSION

As shown in tab. 1, the absorbed dose rate in air (including cosmic ray contribution) in northern Rechna Doab has been found to vary from 86.0 nGy/h to 139.1 nGy/h with the mean value of 109.1 nGy/h.

The mean annual external effective dose due to the natural exposure of population to the external terrestrial ionizing radiation (^{40}K and decay products of ^{238}U and ^{232}Th) [9] with the contribution of cosmic radiation in the annual effective dose comes out to be 133.73 μSv. The radiation levels as shown in tab. 1 indicate the non-existence of any hot spots and the variation is considered quite normal. Although this data set is a very preliminary one, it gives a suggestion that the radiation levels are favourably low not only for the dwellers but also for any future construction of nuclear power plants near the rivers of the area.

Table 2 summarizes the results of similar studies which had been carried out in different areas of the world. The world average annual effective dose has been reported as 70 μSv [5]. The annual effective dose in the northern Rechna Doab was found to be relatively higher as compared to the world average as well as southwestern Nigeria and southeastern Turkey [9, 10]. However, it was comparatively lower when compared with similar values in Hong Kong, Malaysia, western Sudan, and Costa Rica [11-14], as shown in tab. 2 and plotted in fig. 3. These comparisons show that the annual effective dose in the northern Rechna Doab lies in the same range as reported for various parts of the world.

To the best knowledge of the authors, this is the first study of its nature in Rechna Doab. It is believed that the data collected and presented in this paper will act as a ready reference for any future activity/development wherein each study is a regulatory requirement, *e. g.* the construction of a nuclear power plant for the electricity generation. Although the grid selected in the study is quite big, it leaves the opportunities for any future researcher to fill the gap by reducing the grid area.

Table 2. Comparison of annual effective dose with different countries of the world

Country	Annual effective dose [μSv]	Reference
Nigeria	21.8	R.K Odunaike *et al.* (2008)
World average	70	UNSCEAR (2000)
Southeastern Turkey	74.7	A. Bozkurt *et al.* (2007)
Northern Rechna Doab, Pakistan	134	Present study
Hong Kong	198	W. Man-Yin *et al.* (1992)
Malaysia	210	A.T. Ramli *et al.* (2005)
Western Sudan	270	A. K. Sam *et al.* (2002)
Costa Rica	740	P. Mora *et al.* (2007)

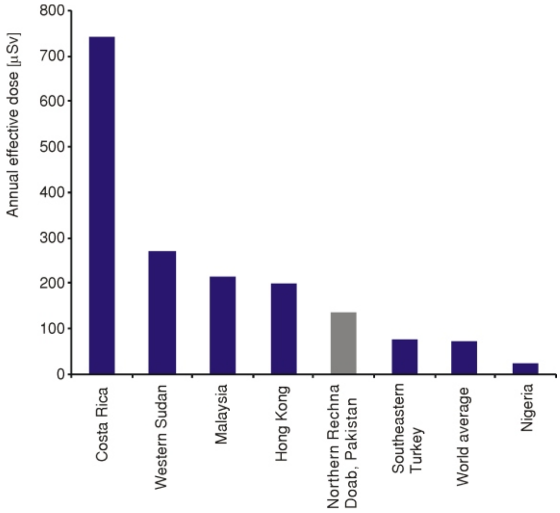

Figure 3. Comparison of annual effective dose with different countries of the world

The south Asian and east Asian regions are witnessing a gradual but fast promotion of nuclear power. Pakistan is eager to fill the supply and demand in the energy gap with the development of nuclear energy. The area under study, as already indicated, lies between two independent rivers, and may have more than one site for nuclear power reactor installations. Putting the present study in this perspective further enhances its importance as well as the need for future similar studies in the area to cover the gap left due to unexplored areas.

CONCLUSIONS

We conclude for our studies that the annual effective dose in northern Rechna Doab, Pakistan, lies in a wide range reported for various places in the world. We also conclude that the environmental dose is primarily due to the primordial radionuclides and cosmic radiation since no enhanced radiation levels were found anywhere.

RECOMMENDATION

For any future work in the same area, it is recommended that the grid size should be reduced to obtain the background radiation levels which will better cover the area.

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Абдул ЦАБАР, Аршад С. БХАТИ, Сајед С. АХМАД, Вахид АРШЕД, Первин АКХТЕР

ОЦЕНА ДОЗЕ ГАМА ЗРАЧЕЊА ОКОЛИНЕ У СЕВЕРНОЈ ОБЛАСТИ РЕХНЕ ДОАБ У ПАКИСТАНУ

У северној области Рехне Доаб у Пакистану измерени су нивои гама зрачења у околини као део систематског проучавања коме је циљ да се успостави база података основног нивоа зрачења. У овом раду извештава се о мерењима која су обављена са преносивим монитором зрачења који користи ГМ бројач калибрисан секундарним дозиметријским стандардом. Утврђено је да се јачина средње апсорбоване дозе у ваздуху мења од 86,0 nGy/h до 139,1 nGy/h, са средњом вредношћу од 109,1 nGy/h. Годишња ефективна доза кретала се у распону од 105,47 Sv до 170,54 Sv са средњом вредношћу од 133,73 Sv. Ове дозе зрачења околине у овој области упоредиве су са подацима за друге земље. Закључено је да преовлађујући нивои зрачења не представљају никакав радиолошки здравствени ризик за становништво.

Кључне речи: зрачење у околини, гама зрачење, мониторинг зрачења, гама доза, Рехна Доаб