Measurement of Gamma Activity in Soil Samples of Charsaddah District of Pakistan

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(Received October 4, 1993, revised March 1, 1994)

Summary: Gamma activity of soil samples, collected from agricultural lands of Chrsaddah district of North West Frontier Province (N.W.F.P., Pakistan), have been determined using gamma-ray spectrometry. The average values of the measured activities in $Bq.kg^{-1}$ were 57.1 ± 9.2 (radium-226), 60.1 ± 9.9 (thorium-232), 387.4 ± 49.4 (potassium-40) and 7.1 ± 2.0 (cesium-137). The common index of these radionuclides in terms of radium equivalent activity was 170.8 ± 22.3 $Bq.kg^{-1}$, which is comparable with the values for other countries of the world. The external and internal hazards due to gamma-rays from radium-226, thorium-232 and potassium-40 were found to be less than unity and the concentration of cesium-137 was also very nominal. Thus these radioactivity levels in soil samples do not pose any environmental health problem, however, the presented data provide a general background of the detectable radionuclides for the surveyed area and can be helpful in any radiological emergency.

Introduction

Radionuclides have been essential constituents of the earth since its creation. After four and a half billion years, the earth interior is still being heated through the decay of long-lived isotopes of uranium, thorium and potassium [1]. These radionuclides are present in the lithosphere, hydrosphere, atomosphere and biosphere. The radioactivity of natural origin arises mainly from primordial (associated with the formation of the earth) radionuclides. Although about 15 primodial radioactive species are presently known in nature and their half-lives vary from 704 million years (uranium-135) to 8×10^{15} years (samarium- 148), three among them (uranium, thorium and potassium) contribute significantly to the background radiation [2]. Thus man's exposure to these radionuclides can not be denied.

Because of the increased public concern and awareness about radioactive pollution, estimation of ^{226}Ra, ^{232}Th and ^{40}K contents of soil samples, collected from cultivated agricultural lands of Charsaddah (Pakistan) was carried out in the present. In addition to these naturally occuring radionuclides the present investigations also revealed the presence of ^{137}Cs, which was also measured quantitatively. In order to ascertain the degree of risk and deleterious effects to the public health the results are discussed and presented on the basis of a criterion formula for the external and internal hazards [3].

Results and Discussion

In the gamma-spectrometric analysis of soil samples, ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs were quantitatively measured. The activity determination of ^{226}Ra is based on 295.2 (18.2%) and 351.9 (35.1%) keV gamma-rays from ^{214}Pb and 609.3 (44.6%), 1120.2 (14.7%) and 1764.5 (15.1%) keV gamma-rays from ^{214}Br. Thorium content of the samples is estimated from the intensities of 238.6 (43.6%) keV gamma-rays from ^{212}Pb, 338.4 (12.%), 911.2 (29%) and 968.8 (17.4%) keV

gamma-rays from ^{228}Ac and 583.0 (86%) keV gamma-rays from ^{208}Tl. The activity of ^{40}K, is based on 1460.8 (10.7%) keV gamma-ray energy from ^{49}K, while the concentration of ^{137}Cs is calculated from the intensity of the 661.66 (85%) keV peak from ^{137}Cs [5].

Table 1 shows the concentration of ^{26}Ra, ^{232}Th, ^{40}K, and ^{137}Cs for the individual soil samples in terms of Bq.kg^{-1}. It can be seen from the table that the activity levels for ^{224}Ra, ^{232}Th and ^{40}K vary from sample to sample. This is because in soils the concentration of naturally occurring radionuclides vary widely due to their uneven distribution in the earth. Moreover the use of different types of fertilizers also affect the radionuclides concentration to a large extent. In addition, soil samples also revealed the presence of ^{137}Cs, however the activity levels were found to be very small. This indicates that the surveyed area might have received some fallout radioactivity from Chernobyl accident or any other sources, like Chinese test explosions in the past years.

Table 1: Concentration of gamma-emitting radionuclides in soil samples collected from various localities of Charsaddah (Pakistan).

Sample No.	Concentration of radionuclides (Bq.kg^{-1})			
	^{226}Ra	^{232}Th	^{40}K	^{137}Cs
1.	67.6±14.0	68.3±12.2	424.7±29.8	8.2±2.4
2.	68.6±14.4	68.9±12.2	428.0±32.3	8.6±2.6
3.	49.5±13.5	55.3±12.5	408.2±30.8	5.8±2.4
4.	50.8±11.9	50.4±13.1	454±730.8	6.3±2.3
5.	69.1±14.8	65 1±2.3	467.1±30.4	5.4±2.3
6.	68.3 ±15.2	70. 9±12.0	386.6±340.3	5.8 ±2.4
7.	45.2 ±12.8	50.3 ±11.5	386.5±30.4	6.7±2.4
8.	48.5 ±13.3	45.6 ±11.2	348.3±30.4	3.7±1.3
9.	61.8 ±14.5	68.2 ±12.2	436.9±31.5	5.4±2.4
10.	64.7±12.8	69.7 ±12.1	283.3 ±26.1	12.0 ±2.5
11.	49.3 ±13.2	53.5 ±12.6	316.2±25.6	10.8± 2.3
12.	48.4 ±11.9	40.3 ±11.3	383.6±30.0	5.8 ±2.3
13.	51.5 ±14.5	50.3±12.2	398.9±30.5	7.9 ±2.5
14.	50.8 ±11.5	51.4 ±13.1	318.3±30.9	5.0±2 2.4
15.	55.7 ±12.9	52.1 ±12.9	411.2±29.6	7.2 ±2.4
16.	60.9 ±12.8	60.3 ±12.9	394.0 ±32.0	5.4 ±2.2
17.	65.1 ±12.7	71.4 ±12.3	390.0 ±30.4	6.1 ±2.4
18.	70.8 1±1.2	75.3 ±9.8	369.6 ±30.3	4.5 ±1.5
19.	47.6 ±12.5	60.3 ±10.9	393.2 ±23.7	7.2 ±1.9
20.	46.3±12.3	50.1±13.1	366.0 ±29.8	6.4 ±2.4
21.	48.7 ±12.6	55.4 ±12.5	384.3 ±26.2	6.87 ±2.3
22.	45.5 ±11.7	62.1 ±12.3	312.4±25.7	5.5 ±2.2
23.	51.51±4.2	60.2 ±12.3	395.5±30.4	8.2 ±2.4
24.	60.3 ±14.5	70.5 ±12.0	320.3±30.9	6.3 ±2.3
25.	69.4 ±11.8	49.5 ±11.2	514.5±29.6	7.3 ±2.2
26.	45.3± 13.2	57.3 ±12.5	397.6±32.0	11.1 ±2.4
27.	71.6 ±11.2	79.3 ±9.3	370.1±30.3	10.9 ±2.2
28.	64.7±12.8	70.4 ±9.4	387.9±30.4	7.4 ±1.9

In order to compare the specific radioactivities of soil samples that contain Ra, Th and K, a common index is normally defined to get the sum of activities. This index, known as the radium equivalent activity, Ra_{eq}, was also calculated by using the following relationship [3]:

$$Ra_{eq} = AR_a + (A_{Th} X 1.43) + (A_k X 0.077)$$

where A_{Ra}, A_{Th} and A_K are the average activity levels of ^{226}Ra, ^{232}Th and ^{40}K respectively. Mean values of the activity levels due to Ra, Th and K along with their common index (Ra_{eq}) and mean activity for Cs in these soil samples are given in Table 2.

Table 2: Mean activity levels due to ^{226}Ra, ^{232}Th, ^{40}K, Ra_{eq} and ^{137}Cs long with their ranges in soil samples of Charsaddah.

S.No.	Radio-nuclide	Average conc. *(Bq.kg^{-1})	*Range (Bq.kg^{-1})
1.	^{226}Ra	57.1±9.2	45-72
2.	^{232}Th	60.1±9.9	40-79
3.	^{40}K	387.4±49.4	283-514
4.	Ra_{eq}	170.8 ±22.3	135-213
5.	^{137}Cs	7.1±2.0	4-12

*Average of 28 values with standard deviation

The average concentration of Ra_{eq} was also compared with the data available in the literature for other countries of the world [3,6,9,10] as shown in Figure 1. It was found that our results are quite comparable (within the experimental error) with most of these reported values. However, for some areas, such as Australia, Bangladesh, Canton (Ohio), Finland, Germany, Norway and Sweden, the Ra_{eq} concentrations are higher than our results (in some cases by a factor of 2 or more).

To check the hazards associated due to gamma-rays from Ra, Th and K, the internal and external hazard indices were also calculated using most acceptable models from the literature [1]. These indices were found to be less than unity and thus clearly indicating that the soil in the Charsaddah area of N.W.F.P. is not a major source of radiation hazard.

Conclusions

The average value of the measured activity of ^{226}Ra, ^{232}Th and ^{40}K in terms of Ra_{eq} concentration is comparable with the data available

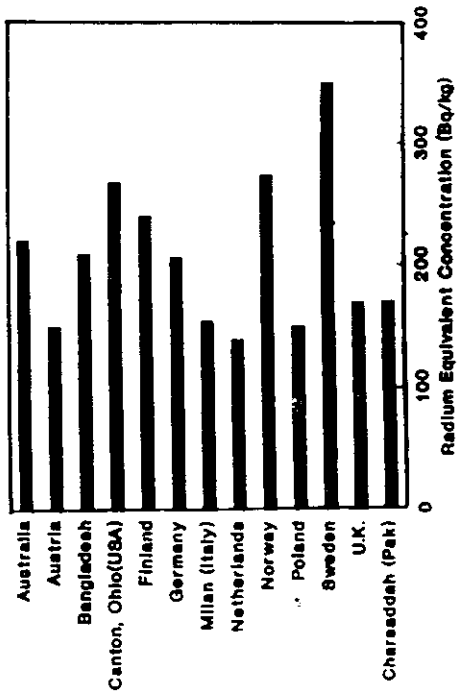

Fig.1: Bar diagram showing mean radium equivalent activities of Charasaddah district of Pakistan compard with different countries of the world [3,6,9,10].

in the literature. In these soils the values of internal and external hazard indices are lower than unity. The concentration of ^{137}Cs found in the soil samples of Charsaddah is also very nominal and is not significant from health hazard point of view. Thus it may be concluded that the soils of Charsaddah (N.W.F.P.) do not pose any environmental health problem. However the presented data may provide a general background of the detectable radionuclides for the surveyed area and may be helpful for further studies in any radiological emergency.

Experimental

Samples of soil analysed in the present work were collected from various cultivated agricultural lands of Charsaddah district of N.W.F.P. These samples, collected from the surface to a depth of 10 cm, were spread out on trays and plastic sheets and were allowed to dry for few days at room temperature. The dry mass of the soil before and after the removal of stones, vegetation etc. was recorded. The soil samples were then crushed, grounded and pulverized and were passed through a sieve of 2 mm mesh size [4,5]. Suitable aliquots were then taken from the dry powdered soil and were sealed in leak proof plastic containers. The volume of the soil sample used for gamma spectrometry was kept the same as the volume of an IAEA standard soil sample, soil-6 (163.46 cm^3). The samples were packed in a container identical to IAEA soil-6 container and then stored for about 30 days in order to bring the concentration of radon and its daughter nuclides in equilibrium with the parents [6,7].

Gamma-spectrometry of soil samples

For the measurement of gamma-emitting radionuclides in these soil samples, a High Purity Germanium (HPGe) detector [8] (Model EGPC-20, Intertechnique, France) couled with a computer based high resolution Multichannel Analyser (Series-85, Canberra Model 8503) with 4096 data channels, available at the Health Physics Division, PINSTECH, Islamabad, was used. The detector had a relative efficiency of 20% and its resolution (FWHM) for full energy peak of 1332.5 keV gamma-rays of ^{60}Co was 2.0 keV. The detector was first calibrated using a sealed IAEA standard soil samples (soil-6) with known radioactive contents. For each sample the counting was carried out separately and the activities of radionuclides were reported in Becquerel per kilogram ($Bq.kg^{-1}$) [8].

References

1. P.H. Santschi, B.D. Honeyman, *Radiat. Phys. Chem.*, **634**, 213 (1989).
2. I.G. Draganic, Z.D. Draganic, J.P. Adloff, Radiation and Radioactivity on Earth and Beyond, Ist edn. CRC Press, Inc. Florida ch 8. (1990).
3. J. Beretka, P.J. Matthew, *Health Phys.*, **48**, 87 (1985).
4. J.H. Barley, Environmental Measurement Laboratory, EML Procedures Manual (HASL-300) U.S. Department of Energy, New York (1972).
5 IAEA, Measurement of Radionuclide in Food and Environment, Technical Report Series No. 295, IAEA, Vienna 27 (1989).
6. M. Tufail, N. Ahmad, H.A. Khan, M. S. Zafar, *Radiat. Prot. Dosim.*, **37**, 197 (1991).
7. U.C. Mishra, S. Sadasivan, *Int. J. Appl. Radiat.* Isot, **22**, 256 (1971).
8. K. Khan, Radioactive Contamination of Food. M.Phil thesis, University of Peshawar (NCEPC), (1992).
9. A.S. Mollah, G.U. Ahmad, S. R. Hussain, M. M. Rahman, *Health Phys.*, **50**, 849 (1986).
10. R.D. Cliff, B.M.R. Green, J.C.H. Miles, *Sci. Total Environ.*, **45**, 181 (1985).