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Measurement of environmental radioactivity for estimation of radiation exposure from saline soil of Lahore, Pakistan

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Abstract

Radioactivity, natural and man made, is omnipresent in the earth's crust in different amounts. The soil on the earth's crust is a source of continuous exposure to human beings. The amount of radioactivity in soil depends upon the type of soil and its uses. The soil of barren area should show different amount of radioactivity when compared with that of the cultivated soil. For the investigation of amount of radioactivity in the barren soil, an area of about 60 h of saline soil was selected in Rakh Dera Chal near the city of Lahore in the Punjab province of Pakistan. The technique of gamma ray spectrometry was applied using high purity germanium gamma-ray detector and a PC based MCA. Activity concentration levels due to ^{40}K, ^{137}Cs, ^{226}Ra and ^{232}Th were measured in 125 saline soil samples collected at a spacing of about 4 ha at the depth level of 0–25 cm with a step of 5 cm depth. Activity concentrations of the concerned radionuclides were as follows: ^{40}K, 524.84–601.62 Bq kg^{-1}, ^{137}Cs, not detected (less than the lower detection limit), ^{226}Ra, 24.73–28.17 Bq kg^{-1}, and ^{232}Th, 45.46–52.61 Bq kg^{-1}. Before the radiometric measurements, chemical analysis for concentration of Na, Ca and Mg was also carried out along with the measurement of electrical conductivity and Ph of soil samples.

Keywords: Saline soil; HPGe detector; Gamma spectrometry; Environmental radioactivity; ^{40}K, ^{137}Cs, ^{226}Ra, ^{232}Th

1. Introduction

Man is dependent on soils and good soils are dependent upon man and the use he makes of them. Soil is a mixture of natural bodies on the earth surface containing living matter and supporting plants. Soil consists of three-phase system as solids, liquids and gasses (Bool et al., 1976).

Soil is a collection of natural bodies on the surface of the earth, containing living matter and supporting or capable of supporting plants (Russal, 1957). Soil is a complex substance because of its extreme variability in physical and chemical composition. It contains small but significant quantities of organic and inorganic compounds, which are essential for the growth of plants. There are many types of soil depending upon the physical and chemical composition. The soil is classified as saline, saline sodic and alkali, etc. (Brady et al., 1990). In saline soil, the concentration of salts is increased to the level at which the crop growth is adversely affected. Saline soils have a high content of natural salts and have pH generally above 7.3 and not over 8.5.

Soil not only consists of organic and inorganic compounds but also radionuclides, i.e. uranium, thorium, radium, potassium—40, etc. (Zahid et al., 1999), which occur in nature as a complex of oxides, hydrated oxides, carbonates, phosphates, sulphates, vanadates and silicates. Nuclear fission in connection with atomic weapons testing provides another source of soil contamination. Direct fall out from the atmosphere on the vegetation was the primary source of contamination (IAEA, 1989). The fission product ^{137}Cs is strongly absorbed and retained by soil particles, as are the natural radionuclides which are found randomly distributed at different depths of soil (COXM and Eank Hauser, 1994; Zahid

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et al., 2001). The subject of radioactive contamination gained considerable public importance because of Chernobyl accident. Naturally occurring radionuclides (uranium and thorium series, etc.) are the largest contributors to radiation doses received by human beings. Because of increased public concern and awareness about radioactive pollution, this study has been carried out to measure the amount of radioactivity and assessment of radiation dose from the saline soil of Lahore area.

2. Materials and methods

The area under investigation consisted of 60 ha of saline soil in the Rakh Dera Chal 30 km from the historical city of Lahore in the Punjab province of Pakistan. The location of the area is 31°6′N and 74°7′E. In this area, a Bio Saline Research Station has been established by Nuclear Institute of Agriculture and Biology (NIAB) in 1980. The area was almost barren until 1980. Proper cultivation started after the establishment of the institute in 1980.

Soil sampling was carried out in the month of May–June in 2002. Sampling from the saline patches was done using the Soil Sampling pattern recommended by the various agricultural agencies (Samual et al., 1970). The area was divided into 25 sites. The distance between every point was about 15–17 m. From every point (site), 5 samples were taken at a step of 5 cm depth covering 25 cm depth. In this way 25 points (sites) were covered and the total number of samples was 125. The samples were properly marked, catalogued and brought to Health Physics Laboratory at NIAB, Faisalabad, Pakistan, for processing before analysis.

Prior to the chemical analysis, electrical conductivity (EC) was measured with EC meter and pH was measured with pH meter. Chemical analysis was performed for the determination of concentrations of Na, Ca and Mg. Titration and flame photometer techniques were applied for the analysis.

For radiometric analysis, the soil samples were first dried in the sun for 7 days. The samples were then crushed to small pieces and dried in a temperature controlled oven at 100°C until the moisture of the soil removed completely. The dried samples were ground, powdered and passed though a sieve of mesh size 200 μm. Plastic containers were used for filling and packing of the soil samples. The container material was chemically resistant for the elements and compounds of soil. The containers were thick enough for permeation of radon (Lee et al., 2001). Empty containers were weighed. The containers were filled with soil from the samples and weighed again. The net weight of the soil was noted. The containers were closed by screw caps and plastic tapes over the caps. The same procedure was applied for the reference material, Soil 6 obtained from IAEA. The samples and standards were stored for more than 40 days to achieve secular equilibrium between ^{222}Rn and ^{226}Ra.

The technique of gamma-ray spectrometry was applied for the determination of radioactivity of the samples under investigation. The spectrometry system consisted of a high purity germanium (HPGe) detector and an MCA card (both purchased from ORTEC, USA) with inbuilt power supply and amplifier. The card was installed in a PC (personal computer).

Table 1
Gamma-ray energies used for the calibration of spectrometer and for the measurement of activity of the radionuclides of interest

Parent nuclide	Daughter nuclide	γ-ray energy (keV)	Abundance (%)
^{226}Ra	^{214}Pb	241.98	7.12
	^{214}Pb	395.21	19.20
	^{214}Pb	351.92	35.10
	^{214}Bi	609.32	44.60
	^{214}Bi	768.30	4.76
	^{214}Bi	1120.28	14.70
	^{214}Bi	1238.11	5.78
	^{214}Bi	1764.52	15.10
^{228}Th	^{228}Ac	202.39	3.81
	^{212}Pb	238.63	43.50
	^{228}Ac	338.42	11.26
	^{228}Ac	463.10	4.50
	^{208}Tl	583.19	30.58
	^{212}Bi	727.33	6.64
	^{208}Tl	860.56	4.50
	^{228}Ac	911.16	26.60
	^{228}Ac	964.64	5.05
	^{228}Ac	968.97	16.23
	^{208}Te	2641.60	35.80
^{40}K		1460.80	10.67

Table 2
The lowest limit of detection (LLD) for the radionuclides for ^{40}K, ^{137}Cs, ^{232}Th and ^{226}Ra

Nuclide	Lowest detection limit (Bq kg^{-1})
^{40}K	59
^{137}Cs	1.3
^{226}Ra	3.3
^{232}Th	3.3

Soil 6 of IAEA was used as a reference material for calibration of the spectrometer. Spectrum of every soil sample was collected for 65,000 s. Areas under the energy peaks, given in Table 1, were used for drawing the peak efficiency curve between log of efficiency versus log of peak energy. A polynomial was fitted to the curve and polynomial was stored in the computer for further use.

The lowest limits of detection (LLD) for ^{40}K, ^{137}Cs, ^{232}Th and ^{226}Ra were determined and are given in Table 2. Spectrum for every sample was collected for 65,000 s. Spectrum analysis was done with the help of the computer software Gene 2000, and activity concentration for ^{40}K, ^{137}Cs, ^{226}Ra and ^{232}Th was determined.