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Characterization of ^{137}Cs in Riyadh Saudi Arabia Soil Samples

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ABSTRACT

The current study was conducted primarily to investigate and estimate ^{137}Cs activity concentrations and the external dose rate due to fallout radionuclide ^{137}Cs. Soil samples were collected from different 25 locations at Riyadh Province and analyzed using low level γ-spectrometry equipped with HPGe-detector. ^{137}Cs activity concentrations and calculated dose rate were found in the range of 0.8 - 3.1 Bq·kg^{-1} and 0.05 to 0.8 nSv·h^{-1} with an average value of 1.70 ± 0.7 Bq·kg^{-1} and 0.11 ± 0.05 nSv·h^{-1} respectively. The measured ^{137}Cs activity concentration range was compared with the reported ranges in the literature from some of the other locations in the world. Results obtained in this study show that ^{137}Cs concentration is of a lower level in the investigated area. However, the range of ^{137}Cs concentrations observed in this study is significantly high relative to similar data reported from Libya. The average value of estimated external effective dose rate is found far below the dose rate limit of of 1.0 mSv·y^{-1} for members of the general public recommended by ICRP as well as the external gamma radiation dose of 0.48 mSv·y^{-1} received per head from the natural sources of radiation assessed by (UNSCEAR, 2000). It is concluded that ^{137}Cs soil contamination does not pose radiation hazards to the population in the investigated areas.

Keywords: ^{137}Cs; Riyadh; Soil; Activity Concentration; Dose Rate; Annual Effective Dose

1. Introduction

Radiation is present in every environment of the Earth's surface, beneath the Earth and in the atmosphere. According to [1] about 87% of the radiation dose received by mankind is due to natural radiation sources and the remaining is due to anthropogenic radiation. The presence of artificial radionuclides in the environment is an important source of radiation exposure for human beings [15]. Artificial radioisotopes may be released into the environment during the testing of nuclear weapons, nuclear explosions and discharge of effluents from nuclear facilities. Artificial radioisotopes released from these sources are retained by environmental materials, including soil [10]. Worldwide contamination from artificial radioisotopes was partially caused by nuclear tests conducted by different countries from time to time and nuclear accidents such as Chernobyl nuclear power plant disaster which took place in 1986.In Chernobyl accident about 3.8 × 10^{16} Bq of ^{137}Cs was reportedly released into the environment. Activity concentration of ^{137}Cs in soil and emission of gamma rays from ^{137}Cs therefore contributes to the external gamma radiation exposure levels [11]. Measurements of the artificial radionuclides in soil samples provide a better understanding of the causes of fluctuation in dose rates of environmental radiation in the investigated areas and help tailor public radiation protection programmers on sound scientific bases. This study is part of nationwide programme to survey environmental radioactivity with the aim of building up abroad database on natural and man-made radionuclides for producing a radiation map of the country to be used as a reference in the event of any radiological accident of global dimesion.

2. Materials and Methods

2.1. The Study Area

Riyadh is the capital city of the Kingdom of Saudi Arabia with an area of about 1554 km². It is located centrally in the Najd region with a population that is expected to reach over 5.2 million in 2007, (**Figure 1**). Riyadh is the major part of Riyadh Province. It is situated in the centre of the Arabian Peninsula on latitude 34˚ - 38˚ north and longitude 46˚ - 43˚ east 600 m above sea level.

2.2. Samples Collection and Preparation

A total of 25 Soil samples were collected from different sites of. Riyadh Province All sampling sites were preferred to be undisturbed and none eroded without any

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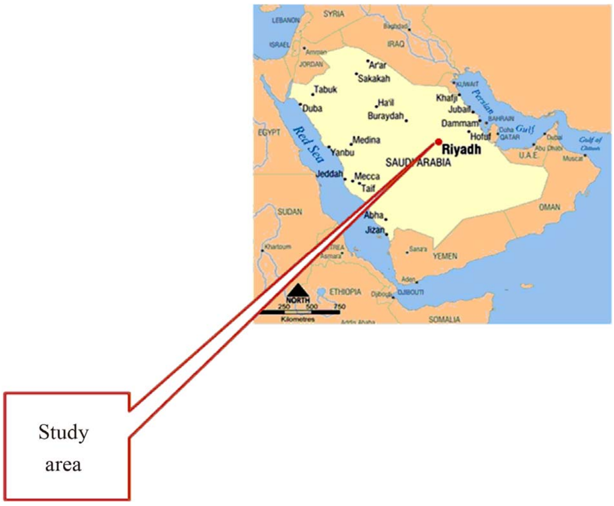

Figure 1. Map Kingdom of Saudi Arabia showing the study area.

influence of man-made structures to ensure that samples were representatives of the sites from where they were taken. From each site, 3 - 5 soil samples were collected from an area of 0.5 m × 0.5 m up the depth of 25 cm. In this way, a total of 105 soil samples were collected from all 25 sites using a clean trowel, placed in plastic bags and labeled. Soil samples were passed through a 2-mm mesh sieve to remove stones and other materials. Samples were then air-dried and sieved through a 1-mm mesh sieve. Each sample containing soil grain weighing about 200 g was stored in the standardized polyethylene containers.

2.3. Gamma-Spectrometric Measurement

^{137}Cs activity concentration was measured using high-purity germanium-detector based gamma ray spectrometer with an efficiency of 25% was employed. HPGe detector was coupled with a Canberra multi-channel analyzer (MCA). The resolution (FWHM) of the spectrometry system was 1.8 keV at 1332 keV gamma-ray line of ^{60}Co. Spectrum of every sample was collected for 54,000 second (15 h). Spectrum analysis was done with help of computer software and activity concentration ^{137}Cs was determined. To reduce the background effect, the detector was shielded in 10 cm wall lead covering lined with 2 mm copper and 2 mm cadmium foils. Standard reference materials obtained from IAEA were used for calibration of the spectrometer. The system was calibrated for energy and efficiency on regular basis. ^{137}Cs activity concentrations were measured directly using their respective photo peaks at 1460 and 662 keV. The environmental gamma background at the laboratory site was determined with an empty plastic container washed with dilute HCl and distilled water. The background was measured under the same conditions of sample measurement. It was later subtracted from the measured gamma-ray spectra of each sample. The net integral counts under selected photo-peaks were determined by subtracting from the total counts under these photo-peaks the integral count above the baseline over the same region obtained from background runs. The activity concentration of ^{137}Cs was finally measured in Bq·kg^{-1}. The total uncertainty of the measured activity concentration, absorbed dose rate and other indices were within 3% - 8%.

3. Results and Discussion

The activity concentrations of fallout radionuclide ^{137}Cs in soil samples are shown in **Table 1**. The activity concentrations of ^{137}Cs ranged from 0.8 - 3.1 Bq·kg^{-1} with an average value of 1.70 ± 0.69 Bq·kg^{-1}. Spatial distribution of the measured ^{137}Cs concentrations **Figure 2** the results obtained indicate that the location 10, 11, 13, 14, 15 and 25, the concentration of ^{137}Cs is extremely on the lower side having values even less than the mean value of 1.70 ± 0.69 Bq·kg^{-1}. However, as appears from **Figure 2**, activity concentrations of ^{137}Cs vary from location to location and are not uniform. It is well documented in the literature that ^{137}Cs concentration in soil varies due to topographic differences, geomorphology ,and meteorological conditions of the region .Upon comparing the results with global data it was found that the obtained values are far below the reported range from Spain 10 - 60 Bq·kg^{-1} [5], Egypt 1.6 - 19.1 Bq·kg^{-1} [6], Yugoslavia 1.5 - 28.4 Bq·kg^{-1} [7], USA 5 - 58 Bq·kg^{-1} [8], 1.1 - 5.3 Bq·kg^{-1} [4] and Sudan 2 - 26 Bq·kg^{-1} [9]. However, the range of ^{137}Cs concentrations observed in this study is significantly high relative to similar data reported from Libya 0.9 - 1.7 Bq·kg^{-1} study conducted by Shenber [10].

Table 1. Statistical summary of ^{137}Cs activity concentration Bq·kg^{-1} and absorbed dose rate nGy^{-1}.

Distractive	Sample size	Mean ± Std	Minimum	Maximum
^{137}Cs	25	1.70 ± 0.7	0.8	3.1
Dose	25	0.14 ± 0.15	0.05	0.8

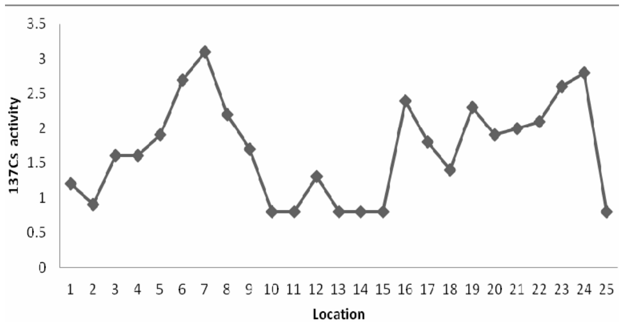

Figure 2. Location-wise distribution of fallout radionuclide ^{137}Cs concentration.

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To compute the gamma-ray dose rate owing to external exposure on account of ^{137}Cs activity concentration in the ground soil, consider a smooth and uniform semi-infinite plane made of soil containing ^{137}Cs contamination and a volume element of soft tissue is under the influence of a constant photon flux (φ) originating from ^{137}Cs source concentration in the soil plane. Considering the photon flux due to single prominent energy peak of 661.6 keV with 85.12% abundance, the estimated external effective dose rate in a volume element of soft tissue at 1 m height from the ground is given by using the formula (1) and (2) [8,11,12].

$$D(E) = 0.576 \times E \times \phi(E) \times \left(\frac{\mu a(E)}{\rho}\right)^{\text{tissue}} \quad (1)$$

where $D(E)$, in Equation (1), represents external effective dose rate in nSv·h^{-1}, E is gamma photon energy in (MeV), $\phi(E)$ is the mean gamma-ray flux at energy E and $(\mu_{a(E)}/\rho)^{\text{tissue}}$ is the energy dependent mass absorption coefficient in cm^2·g^{-1} for a small volume element of soft tissue. For the conservative estimate of the maximum dose on the ground surface owing to source concentration in the soil, the photon flux $\phi(E)$ is defined as under [8,13].

$$\phi(E) = \frac{\gamma FA \times A}{2\left(\frac{\{\mu a(E)}{\rho}\right)^{soil}} \quad (2)$$

In Equation (2), γ_{FR} is fractional abundance of gamma rays, A is experimentally determined activity concentration in Bq·kg^{-1} of a radionuclide and $(\mu_{s(E)}/\rho)^{soil}$ represents the energy-dependent mass attenuation (scattering) coefficient in cm^2·g^{-1} of soil containing gamma-ray emitting radionuclide of energy 661.6 keV. Soils vary considerably in chemical composition, but their relative shielding effectiveness depends mainly on density and water content and, therefore, mass attenuation coefficient varies with different water contents (%) of soil and gamma-photon energy. Mass attenuation coefficient for a typical soil of density 1.625 g·cm^3 containing 30% water content by weight and 20% air by volume against gamma-ray energy of 661.6 keV for ^{137}Cs has been calculated to be 0.0780 cm^2·g^{-1} from the given data available in the literature [14]. The x of constant photon flux considered in the present study, the mass absorption coefficient is determined to be 0.0316 cm^2·g^{-1} at 661.6 keV energy using the reported data [12]. Obviously dose build up factor is not considered here as the same is very small for air thickness of one meter and small volume element of soft tissue. Calculated values of external dose rate falls within the range of 0.05 nSv·h^{-1} to 0.21 nSv·h^{-1} with an average value of 0.11 ± 0.05 nSv·h^{-1} (**Figure 3**).

To avoid the radiation hazards, the dose rate limit recommended by the International Commission on Radiological Protection (ICRP)for members of the general public is 1 mSv·y^{-1} [15]. The average external gamma-ray dose rate computed in this study is found to be very small as compared with the dose rate limit of 1.0 mSv·y^{-1} as well as the average external gamma dose of 0.48 mSv·y^{-1} received per caput from natural radiation sources assessed by UNSCEAR [16].

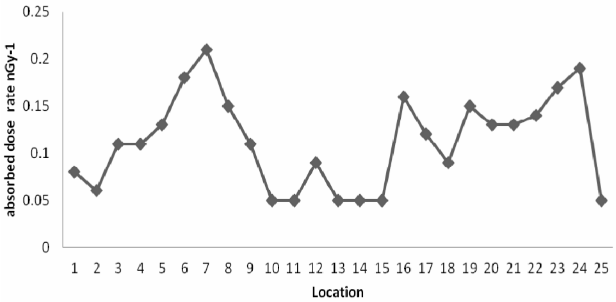

Figure 3. Calculated external dose.

4. Conclusion

There is no abnormal elevation seen in the level of ^{137}Cs activity concentrations in the soil of the Riyadh. The values are typical of a normal background level. ^{137}Cs activity concentrations in Riyadh area is lower than the worldwide data .The ranges of ^{137}Cs concentrations in soils are fairly normal compared with those reported for most of the regions of the world. However, the range of ^{137}Cs concentrations observed in this study is significantly high relative to similar data reported from Libya. Further study is necessary in order to draw a detailed radiation map of Saudi Arabia. There is a need to initiate a comprehensive nation-wide program of environmental radioactivity monitoring to bring under regulatory control all the associated sources.

5. Acknowledgements

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REFERENCES

[1] UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation), "Sources and Effects of Ionizing Radiation," Report to the General Assembly with Scientific Annexes, United Nations, New York, 1993.

[2] UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation), "Effects and Risks of Ionizing Radiation," Report to the General Assembly, with Annexes, English, Publishing and Library Section, United Nations Office, 1988.

[3] A. Noureddin, B. Baggoura, J. J. Larosa and N. Vajda,

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"Gamma and Alpha Emitting Radionuclides in Some Algerian Soil Samples," *Applied Radiation and Isotopes*, Vol. 48, No. 8, 1997, pp. 1145-1148. doi:10.1016/S0969-8043(97)00046-8

[4] S. N. A. Tahir, K. Jamil, J. H. Zaidi, M. Arif and N. Ahmed, "Activity Concentration of 137Cs in Soil Samples from Punjab Province (Pakistan) and Estimation of Gamma Ray Dose Rate for External Exposure," *Radiation Protection Dosimetry*, Vol. 118, No. 3, 2006, pp. 345-351. doi:10.1093/rpd/nci351

[5] E. Gomez, F. Garcias, M. Casas and V. Cerda, "Determination of 137 Cs and 90Sr in Calcareous Soils: Geographical Distribution on the Island of Majorca," *Applied Radiation and Isotopes*, Vol. 48, No. 5, 1997, pp. 699-704. doi:10.1016/S0969-8043(96)00330-2

[6] R. H. Higgy and M. Pimpl, "Natural and Man-Maderadioactivity in Soils and Plants around the Researchreactor of Inshass," *Applied Radiation and Isotopes*, Vol. 49, No. 12, 1998, pp. 1709-1712. doi:10.1016/S0969-8043(98)00009-8

[7] P. Vukotic, G. I. Borisov, V. V. Kuzmic, N. Antovic, S. Dapcevic, V. V. Uvarov and V. M. Kulakov, "Radioactivity on the Montenegrin Coast, Yugoslavia," *Journal of Radioanalytical and Nuclear Chemistry*, Vol. 235, No. 1-2, 1998, pp. 151-157. doi:10.1007/BF02385954

[8] B. Karakelle, N. Ozturk, A. Kose, A. Varinlioglu, A. Y. Erkol and F. Yilmaz, "Natural Radioactivity Insoil Samples of Kocaeli Basin, Turkey," *Journal of Radioanalytical and Nuclear Chemistry*, Vol. 254, No. 3, 2002, pp. 649-651. doi:10.1023/A:1021635415222

[9] E. H. Bashier, I. Salih and A. K. Sam, "Gis Predictive Mapping of Terrestrial Gammaradiation in the Northern State, Sudan," Radiation Protection Dosimetry Advance Access, 15 March 2012.

[10] M. A. Shenber, "Fallout 137 Cs in Soils from North Western Libya," *Journal of Radioanalytical and Nuclear Chemistry*, Vol. 250, No. 1, 2001, pp. 193-194. doi:10.1023/A:1013224122677

[11] K. Jamil, S. Ali, M. Iqbal, A. A. Qureshi and H. A. Khan, "Measurements of Radionuclides in Coal Samples from Two Provinces of Pakistan and Computation of External Gamma-Ray Dose Rate in Coal Mines," *Journal of Environmental Radioactivity*, Vol. 41, No. 2, 1998, pp. 207-216. doi:10.1016/S0265-931X(97)00094-5

[12] J. R. Lamarsh, "Introduction to Nuclear Engineering," Addison-Wisley, New York, 1983.

[13] S. Ali, M. Tufail, K. Jamil, A. Ahmad and H. A. Khan, "Gamma-Ray Activity and Dose Rate of Brick Samples Fromsome Areas of North West Frontier Province (NWFP), Pakistan," *Science of the Total Environment*, Vol. 187, No. 3, 1996, pp. 247-252. doi:10.1016/0048-9697(96)05109-1

[14] P. Jacob and H. G. Paretzke, "Gamma-Ray Exposure from Contaminated Soil," *Nuclear Science and Engineering*, Vol. 93, No. 3, 1986, pp. 248-261.

[15] International Commission on Radiological Protection, "1990 Recommendations of the International Commissionon Radiological Protection," *Annals of the ICRP, ICRP Publication* 60, Vol. 21, No. 1-3, Pergamon Press, Oxford, 1991.

[16] United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources and Effects of Ionizing Radiation," Report to the General Assembly, New York, 2000.

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