Measurement of Gross Alpha Contamination in Soil Sample by Using Solid State Nuclear Track Detector (SSNTD) Technique

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Abstract: ***The measurements of gross alpha contamination(or radiation) in soil samples collected from various locations in the environment of shahjahanpur District was carried out by using LR-115 type II solid state nuclear track plastic detector. Observed result shows that the overall average value of gross alpha contamination was found varies from 20.10Bq/m^3 to 36.90Bq/m^3 with an average value of 29.06Bq/m^{3}and standard deviation is 8.53 Bq/m^3.The value of gross alpha contamination was found maximum (34.32Bq/cm^3) at location P and minimum (21Bq/m^3) at location R. The present study indicates that the nature of soil in the study area has a very low level radiation. Measured values of gross alpha contamination in soil samples collected from different locations in the study area were found below the world action level (137Bq/m^3). Thus the study area is safe from radiation protection and as far as the health hazard effect point of view.***

Keywords: Soil sample, LR-115 type II plastic detector, gross alpha contamination, Radon

1. Introduction

Naturally occurring radiation can be found all around us. Radiation can be found in soil, in our air and water and in us. Because it occurs in our natural environment, we encounter it every day through the food we eat, the water we drink and the air we breathe. It is also in building materials and items we commonly use. The radiation in the soils and rocks, called primordial or terrestrial ([1], [2]). Next to air and water, soil is generally considered as the third main environmental component. In practice soil provides basis, also in literal sense, of a substantial part of the collected life on the earth via the capture of sun's energy by green plants. Soil pollution could be typified as a malfunctioning of soil as an environmental component following its contamination particularly as a result of human activates. The determination of pollutants in soil is of great importance owing to the facts that plant roots are one of the ways of incorporating them into the food chain. Most of the radiation dose we receive is from naturally occurring sources- most of this is from radon. Radon is a colorless and odorless radioactive gas and its decay product are the main source of natural radiation exposure ([3], [4]). On a global scale, about 80% of the radon emitted in to the atmosphere comes from the soil that derived from rocks. Radon gas can enter a home from the soil under the house by process of diffusion through concrete floors and walls, and through cracks in the concrete slab, floors, or walls, construction joints and cracks or pores in hollow-block walls. The emanation from the soil allows radon to diffuse into buildings directly from the ground, on which the building is located. Many houses are built with a concrete foundation with enclosed soil covered with a thick concrete pad. The measurement of radon in man's environment is of interest because of its alpha emitting nature ([5]-[7]). There have been many surveys to determine gross alpha contamination levels of radionuclides in soils, which can in turn be related to the absorbed dose rates in air. The decay product of radon of ^{222}Rn (^{218}Po, ^{214}Pb, ^{214}Bi, and ^{214}Po) attach to a surface, typically of aerosols, which can be inhaled. They then deposit on epithelial surfaces within the lung, and shortly decay because of its half life. The result is that the sensitive surfaces of the bronchi are irradiated by these decays, the most energetic and destructive of which are the heavily ionizing, short range particles from the polonium isotopes ^{214}Po and ^{218}Po. As the chronic (long-term) exposure to radium and indoor radon concentration in humans being is hazardous to health. Therefore, the measurement of gross alpha contamination in soil sample is important to take care of the inhalation indoor radon dose to the general population of the region. The measurement of gross alpha contamination in soil samples in the study area is helpful to study radon health hazard such as lung cancer due to alpha radiation internally and gamma radiation from soil externally.

2. Study Area

The measurement of gross alp alpha contamination (Radiation) in soil sample was carried out in Shahjahanpur District of Uttar Pradesh. Shahjahanpur is a city and headquarters of the District. Geographically, it is situated at 27.35 N latitude and 79.37 E longitudes. Its geographical area is 4575 sq. kilometers with an elevation of 472 feet above sea level. The different locations that we have taken in the study area are Baragaon, Rosa, Chandapur, Shahjahanpur, Jalalabad, Tilhar, Powayan, Allaganj, Khudaganj and Nigohi. These locations are respectively coded as B, R, C, S, J, T, P, A, K and N in the observation table1.

3. Experimental Technique

The experimental setup for the measurement of gross alpha contamination (^{222}Rn) in the soil sample is shown in figure 1. LR-115 type-II solid state nuclear track plastic detector was used for the measurement of gross alpha contamination

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(^{222}Rn) in soil sample. These are passive, low cost, long term method, most widely used for measuring radon and can be used for site assessment both indoor and outdoor. SSNTDs are sensitive to alpha particles in the energy range of the particle emitted by Radon. These are largely insensitive to beta and gamma rays but sensitive to alpha particle and it is almost unaffected by humidity, low temperatures, moderate heating and light. They of course do not require an energy source to be operated since their detecting property is an intrinsic quality of the material. From each location, ten (10) samples of the soil were taken at the depth of one meter from the earth surface and the sample weight equal one kilogram. The soil samples are placed in a plastic cup with plastic cover containing LR-115, Type-II Solid State Nuclear Track Detector (SSNTDs). The diameter of the cover equal 8 cm and the height of the cup is 12cm as shown in figure1. The detector film is fixed inside the cover facing the soil sample.

LR-115, Type-II SSNTD is used to measure gross alpha contamination or ^{222}Rn in soil air at the collected sample. Each sample was divided to two parts and each part of the sample was put inside the cup as shown in figure1.Hundred (100) detectors were exposed to fifty (50) samples which concern with the study area. The detectors distribution is based on the nature of the soil type and geological location. The detector films are left for a period of 90 days during the months October, November and December of a calendar year. This is the exposure time to allow radon gas to come to an equilibrium level. When alpha particles from the decay of radon and its progeny strike the detector, they cause damage tracks. After the completion of exposure time, the detector was removed and subjected to a chemical etching process in 2.5N NaOH solution (etching solution) at 60 ^{0}C for 70 minutes in a constant temperature water bath. After that the etched detectors are thoroughly washed and dried. The resulting alpha tracks on the exposed face of the detector were counted using the spark counter and the gross alpha contamination is determined ([8]-[10]).We counted the average number of tracks in 1cm^2.

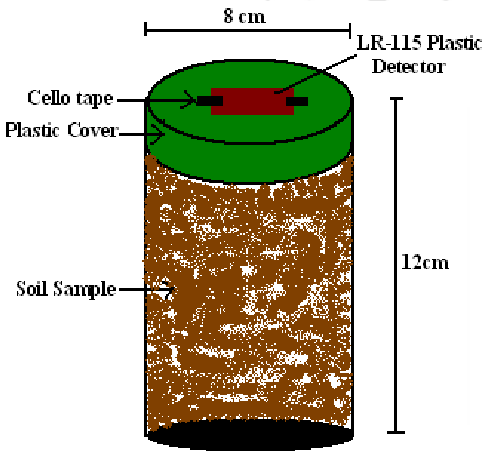

Figure 1: Technique for the measurement of gross alpha contamination

The gross alpha contamination in terms of Bq/m^3 in soil air is done by the following equation ([11],[12])

$$C_s = (C_r T_r/\rho_r) \times (\rho_s/T_s)_{det} \quad \text{--------- (1)}$$

Where C_R is the total exposure of radon source (^{226}Ra) in term of Bq/m^3, ρ_r is the number of track per cm^2 i.e. density of detectors exposed to ^{226}Ra, T_R is the exposure time (in days) of detectors exposed to ^{226}Ra, ρ_s is the Track density number of track/cm^2 i.e. track density of distributed detectors, and T_s is the exposure time (in days) of detectors. The above equation may also be written as

$$C_s = K\times (\rho_s/T_s)_{det} \quad \text{--------- (2)}$$

Where K is called the calibration factor and is given by K=23.36(Bq.day.cm^2/track.m^3) and standard deviation (S.D.) error was 10.5%. The overall uncertainty calibration was estimated to be ±5% [13].Substituting the value of calibration factor K in equation (2), then gross alpha contamination is given by

$$C_s = 23.37\times (\rho_s/T_s)_{det} \quad \text{--------- (3)}$$

The standard deviation σ_n (S. D.) is given by the following equation

$$\sigma_n = [\ \textstyle\sum_k^n (X - \bar{X})^2/(n-1)]^{1/2} \quad \text{------- (4)}$$

The above equation (3) was used to determine the gross alpha contamination in the present paper

4. Result and Discussion

The results of gross alpha contamination (or ^{222}Rn) in the soil samples collected from different locations in the study area are given in the table. It was found that the values of gross alpha contamination in the soil samples are different at different locations and there is a considerable difference in the values of gross alpha contamination. This is due to the nature of soil and the parameters on which it depends such as the radioactive disintegration of ^{226}Ra to produce radon, the direction of recoil of radon in the grain, the interstitial soil moisture condition in the vicinity of the ejected radon atom and its diffusion in the pore space [14]. There is a relation between gross alpha contamination and various types of soil samples.

Table1: Measured values of gross alpha contamination of the soil samples collected from different locations

Location	No. of Detectors (samples)	Min. Con. (Bq/m^3)	Max. Con. (Bq/m^3)	Cs (Bq/m^3)	S.D.(σ_n) (Bq/m^3)
B	10	19	31	24.62	5.30
R	10	17	25	21.00	2.82
C	10	21	42	32.95	4.02
S	10	12	38	30.58	7.17
J	10	18	30	25.00	26.15
T	10	21	36	27.23	8.42
P	10	25	42	34.32	9.01
A	10	23	45	34.00	7.16
K	10	25	36	30.65	4.53
N	10	20	44	30.32	10.75
Average		20.10	36.90	29.06	8.53

The value of gross alpha contamination at different locations B, R, C, S, J, T, P, A, K and N was found varies respectively from 19Bq/m^3 to 31Bq/m^3 with an average value of 24.62Bq/m^3, 17Bq/m^3 to 25Bq/m^3 with an average value of 21Bq/m^3, 21Bq/m^3 to 42bq/m^3 with an average value of 32.95Bq/m^3, 12Bq/m^3 to 38Bq/m^3 with an average value of 30.58Bq/m^3, 18Bq/m^3 to 30Bq/m^3 with an average value of 25Bq/m^3, 21Bq/m^3 to 36Bq/m^3 with an average value of 27.23Bq/m^3, 25Bq/m^3 to 42Bq/m^3 with an average value of 34.32Bq/m^3, 23Bq/m^3 to 45Bq/m^3 with an average value of 34Bq/m^3, 25Bq/m^3 to 36Bq/m^3 with an average value of 30.65Bq/m^{3}and 20Bq/m^3 to 44Bq/m^3 with an average value of 30.32Bq/m^3.The overall average value of gross alpha contamination was found varies from20.10Bq/m^3 to 36.90Bq/m^3 with an average value of 29.06Bq/m^{3}and standard deviation is 8.53 Bq/m^3.The value of gross alpha contamination was found maximum (34.32Bq/cm^3) at location P and minimum (21Bq/m^3) at location R. The higher of value gross alpha contamination may be due to the different geographical area, different type of soil, porosity permeability and moisture contents as well as meteorological and seasonal variation [15]. We see that the gross alpha contamination is different at different locations. The change of the gross alpha contamination at different measuring locations is due to the difference type of soil and moisture contain. The variation of gross alpha contamination at different locations and S.D. are shown graphically in figure2.

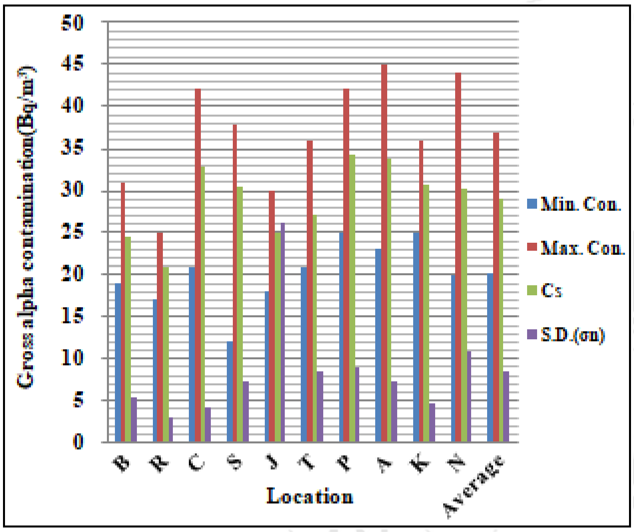

Figure 2: Variation of gross alpha concentration at different locations and S.D.

5. Conclusions

In this paper we measured gross alpha contamination (i.e. radiation) in soil samples in the region of shahjahanpur District of U.P. Results obtained shows that there a considerable variation in the values of gross alpha contamination at different locations. This variation is due to the nature of soil and the parameters on which it depends such as the radioactive disintegration of ^{226}Ra to produce radon, type of soil, porosity, the direction of recoil of radon in the grain, the interstitial soil moisture condition in the vicinity of the ejected radon atom and its diffusion in the pore space. The present study indicates that the nature of soil in the study area has a very low level radiation. This subject due to the small contents of radioactive materials in the soil. The present result shows that the gross alpha contamination in the study area is well below the recommended action values. Thus the study area is safe from radiation protection point of view and as far as the health hazard effects. Further more investigations are required about radioisotopes at different places and to map the gross alpha contamination in soil in the study area. The present work could be taken as the base model for coming investigations in study area.

6. Recommendations

The present work suggests that more investigation about the gross alpha contamination at different locations in the study area is required and to map the gross alpha contamination in soil related to the concern area. Further more investigations are required to study the gross alpha contamination in soil by using different technique. The technique used in the present work motivates us to improve it in the future by getting more other equipments.

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