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Natural radionuclide and radiological impact assessment of teak plantation, University of Ilorin, Kwara State

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Natural radionuclide and radiological impact assessment of teak plantation, University of Ilorin, Kwara State

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Abstract. The amount of naturally occurring radionuclide in Teak plantation was measured using gamma ray spectrometer RS-125. This device gave an in-situ measurement of radioactivity concentration of ^{40}K, ^{232}Th, ^{238}U and dose rate. The data was taken in 20 locations, the overall mean dose rate (DR) is 47.8150 Gyh^{-1}. The overall mean activity concentrations for ^{40}K, ^{232}Th, ^{238}U are 456.1975 BqKg^{-1}, 29.0245 BqKg^{-1} and 26.2080 BqKg^{-1} respectively. It was also observed that only the estimated outdoor dose rate D of ^{40}K at study location L1 exceeded the world limit of 57nGyh^{-1}. This could be due to its closeness to the university main gate with lots of possible interfering human activities around the gate area. However, further study on detailed geochemical investigation is required to reach at some conclusion. By comparing the mean values of the activity concentrations and their radiological risks with the several world standards, it can be concluded that the Teak plantation is highly rich in Potassium.
Keywords: Background Radiation, Conversion factors, Activity Concentration.

1. Introduction

The general population has always been visible to background ionizing radiation from natural environmental sources [1]. The elements potassium, uranium and thorium are the major sources of natural radioactivity. Since many people resides along/around the Teak plantation, basic knowledge of radiological parameters and radioactive contents in the earth crust around the area is important, since it allows the calculation of the external exposure of radiation. It also serves as a necessary factor in the safety measurement, scientific research and guiding principle for using and managing of environmental resource materials [2]. The sources of radioactivity in farm plantation is usually due to all-embracing use of fertilizer with high concentrate of phosphates [3]. The extensive application of the Teak plant locally and pharmacologically makes it necessary to determine the radionuclide content present in the plantation and the effective dose absorbed by the population actively working in the plantation and around the area. The aim of the research work is to carry out radioactivity and radiological hazards assessment from University of Ilorin Teak plantation located within University of Ilorin, Kwara state, Nigeria. Background radiation studies have been carried out in diverse ways and varying parts of the world. Common areas of economic interests that has attracted such study are mining, plantations and tourism attraction sites. In the study of Ramasamy [5], Natural radioactivity measurement in beach sediments from north east coast of Tamilnadu, India, was done and concentration of radionuclide head such as potassium, uranium and thorium were evaluated. Another

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study evaluated the level of radionuclides in Western Ghats. The natural occurring isotopes activity concentration in soil samples was high, hence the elevated result obtained from the background radiation in Western Ghats area. The study aimed at assessing environmental radioactivity, and this was done with the use of gamma-ray spectrometry [6]. Here in Nigeria, Usikalu et al [7] studied background radiation in selected locations of Ota and its health inference on dwellers. The study concluded that there is no immediate radiological risk on dwellers. The studies of [8 - 15] on natural radionuclide, background radiation and its health burden emphasized the need to monitor our environment to ensure radiological safety of dwellers in an area. The current study therefore, focused on assessing the background radiation of teak plantation and the radiological impact of natural radionuclides measured in the area.

2. Materials and Method

2.1. The Study Area
The Teak plantation is located within the University of Ilorin, Ilorin, Kwara state. It lies entirely within the North Central region of Nigeria bounded within longitude 4°38' and 4°39'E and latitudes 8°28' and 8°29'N and an elevation ranging from 310 to 313 m. The study area has easy access such that car can drive through, that made the field work easy. The plantation is bounded to the south by the Date plantation and University of Ilorin senior staff quarters and to the North west by university of Ilorin junior staff quarters, to the west by the university of Ilorin Zoo and to the North by a vast area of plain land. The plantation consists of 530 hectares of Teak established since 2008 (Ilorin.info). Figure 1 is a map showing the Teak plantation in university of Ilorin, with P1 to P20 used as notation for sample location L1 to L20.

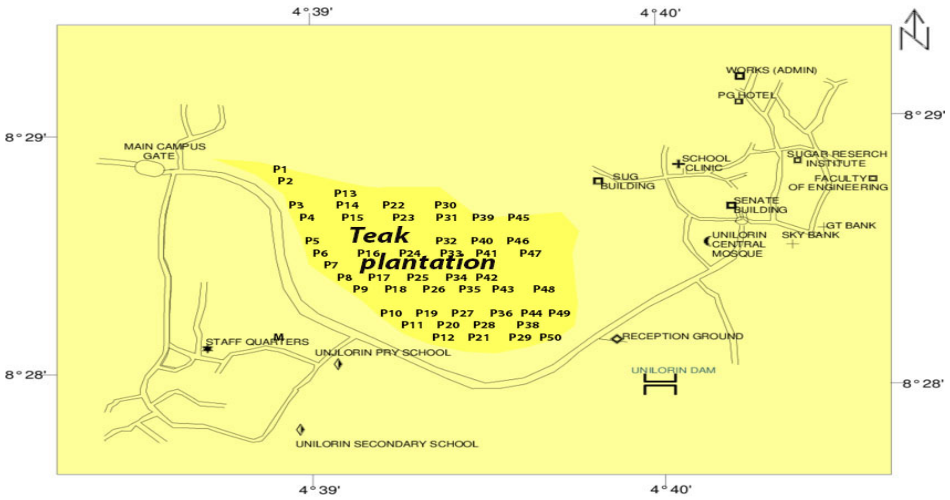

Fig 1. Map of university of Ilorin showing the Teak Plantation and sample collection points

2.2. Materials used for the survey
Material used to carry out the data survey includes: RS-125 spectrometer, GPS device and rechargeable batteries.

2.3. Field Survey
In situ measurement for activity concentration of ^{40}K, ^{232}Th, ^{238}U, and the gamma dose rate was taken over the Teak plantation in the University. The data were taken in 20 location using a grid method with a portable gamma radiation hand detector device called the RS-125 gamma spectrometer, held 1 meter above the ground during measurement. The elevation and coordinate of each sampling point was taken using a global positioning system known as GPS (a hand held GPSmap 62s Garmin product). Sampling was done 2 meters apart. Each reading was taken 4 times and the mean was calculated to improve the accuracy of the results. The detector has high sensitivity with large 2.0 x 2.0 sodium iodide (NaI) crystal. Measurement was done by direct Assay readings. Automatic stabilizing on naturally radioactive elements was done for average of 5 minutes on each sampling point. Result presented in assay mode are % K, ppm of U and Th. Conversion factors were used to convert % and

ppm to $BqKg^{-1}$: 1ppm of 238U equals to□12.35□Bq□Kg^{-1}; 1ppm of ^{232}Th □= □4.06□Bq□Kg^{-1}, and 1% of ^{40}K□=□313□Bq□Kg^{-1}. For 40K in ppm, 1Bq Kg^{-1} = 32.3ppm and 1 ppm of ^{226}Ra equal to 11.1 $BqKg^{-1}$. The principal method of risk assessment and health effect evaluation is via the calculation of the radiation absorbed dose rate. Biological, clinical and radiological effects have direct association to the obtained absorbed dose rate [5, 11- 18].

2.4. Absorbed dose rate

The outdoor absorbed dose rates in air at a height of 1 m above the ground surface to which the workers in the area and farmlands are exposed were estimated based on the formula provided by United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [16]. The formula given in equation 1 was used for the calculations

$$D=0.462C_U+0.604C_{Th}+0.041C_K \quad (1)$$

Where C_U, C_{Th}, C_K are the radioactivity concentrations in $BqKg^{-1}$ and C_U, C_{Th}, and C_K are dose conversion factors which are 0.462, 0.604 and 0.0417 for 238U, 232Th and 40K respectively. Average value is given as $57nGyh^{-1}$ [7, 16].

2.5. Annual Effective Dose

The sternness of any radiological danger to humans is estimated based on the annual radiation dose that is absorbed by a person working/living in the ionizing radiation environment. To estimate the annual effective dose for outdoor, equation 2 was put into use. The conversion coefficient from absorbed dose in air to effective dose of 0.7 $SvGy^{-1}$ and the outdoor occupancy factor of 0.2 were used in the calculation. The dose rate $D(nGy^{-1})$ is the data obtained from the activity concentrations of natural radionuclides in Teak plantation., on the average, an adult spent ~ 20% of their time outdoor, and ~ 80% indoor in Nigeria, hence the 0.2 factor (20%) in equation 2 [8].

$$AED= D(nGy^{-1}) \times 24h \times 365d \times 0.7SvGy^{-1} \times 0.2 \quad (2)$$

2.6. Excess lifetime cancer risk (ELCR)

The Excess Lifetime cancer risk (ELCR) was calculated using the following equation:

$$ELCR=AED \times DL \times RF \quad (3)$$

Where, AED is the Annual Equivalent Dose, the average duration of life, DL, is estimated to 70 years, and Risk Factor (RF) with the unit Sv^{-1} is taken as 0.05 as recommended by ICPR for stochastic effects on general public in calculations [8]. World average value of ELCR is given as 0.2×10^{-3} [16].

3. Results and Discussion

The dose rate and activity concentrations of the three primordial radioisotopes ^{232}Th, ^{238}U and ^{40}K were measured and an average dose rate of 47.815 $nGyh^{-1}$ was obtained for the twenty studied locations. The mean activity concentration for ^{40}K is 456.1975 $BqKg^{-1}$ and that of ^{238}U and ^{232}Th are 29.025 and 26.208 $BqKg^{-1}$ respectively as shown in table 1. Figure 3 shows the annual effective dose (AED) with study location L1 exceeding the world average of $0.07mSvy^{-1}$. It was also observed that only the estimated outdoor dose rate D of ^{40}K at study location L1 exceeded the world limit of $57nGyh^{-1}$, as shown in figure 4. This could be due to its closeness to the university main gate with lots of possible interfering human activities around the gate area. However, further study on detailed geochemical investigation is required to reach at some conclusion. The Excess Life Cancer risk was calculated average ELCR is 0.206×10^{-3} as shown in table 1. This value is just at the borderline of the world average of 0.2×10^{-3}. This ELCR value infers that the likelihood of developing cancer over a lifetime, assuming that an adult lives seventy years on the average on earth, is 50/50 (which is not high, nor low, but just on the border line).

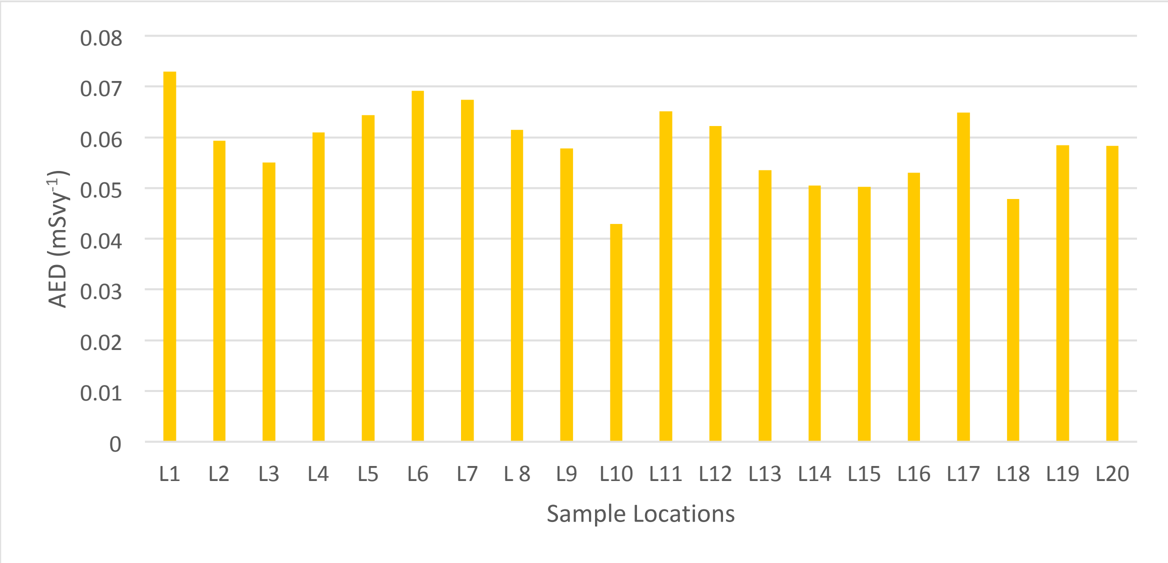

Figure 2. Annual Effective Dose (AED)

Table 1. Dose Rate Activity Concentration and ELCR of Radionuclide Heads

SAMPLE CODE	Latitude □N	Longitude °E	D.R (nGyh^{-1})	^{40}K (BqKg^{-1})	^{238}U (BqKg^{-1})	^{232}Th (BqKg^{-1})	ELCR
L1	8□28.867'N	4□38.511'E	29.100	203.450	60.520	38.370	0.255
L2	8□28.867'N	4□38.525'E	26.900	281.700	34.580	34.510	0.208
L3	8□28.880'N	4□38.525'E	28.600	438.200	18.530	30.450	0.193
L4	8□28.886'N	4□38.531'E	13.900	328.650	23.470	42.020	0.213
L5	8□28.899'N	4□38.523'E	58.000	438.200	18.530	43.040	0.225
L6	8□28.914'N	4□38.526'E	23.800	266.050	53.110	34.710	0.242
L7	8□28.899'N	4□38.538'E	24.300	532.100	25.320	35.530	0.236
L 8	8□28.886'N	4□38.550'E	54.800	500.800	35.200	22.130	0.215
L9	8□28.869'N	4□38.552'E	80.700	297.350	27.790	36.540	0.202
L10	8□28.865'N	4□38.565'E	59.600	328.650	27.790	14.410	0.150
L11	8□28.883'N	4□38.568'E	44.400	485.150	43.840	21.520	0.228
L12	8□28.902'N	4□38.570'E	59.000	516.450	24.700	30.040	0.218
L13	8□28.904'N	4□38.589'E	54.800	516.450	21.610	20.710	0.187
L14	8□28.888'N	4□38.588'E	77.500	406.900	21.000	24.560	0.177
L15	8□28.867'N	4□38.584'E	63.800	422.550	15.440	27.410	0.176
L16	8□28.865'N	4□38.603'E	58.900	547.750	20.380	18.880	0.186
L17	8□28.889'N	4□38.612'E	49.100	626.000	34.580	18.680	0.227
L18	8□28.900'N	4□38.615'E	54.000	485.150	26.550	11.370	0.168
L19	8□28.902'N	4□38.626'E	56.500	735.550	22.850	11.570	0.205
L20	8□28.884'N	4□38.628'E	38.600	766.850	24.700	7.710	0.204
min			13.900	203.450	15.440	1.277	0.150
max			80.700	766.850	60.520	1.038	0.255
mean			47.815	456.196	29.025	0.964	0.206

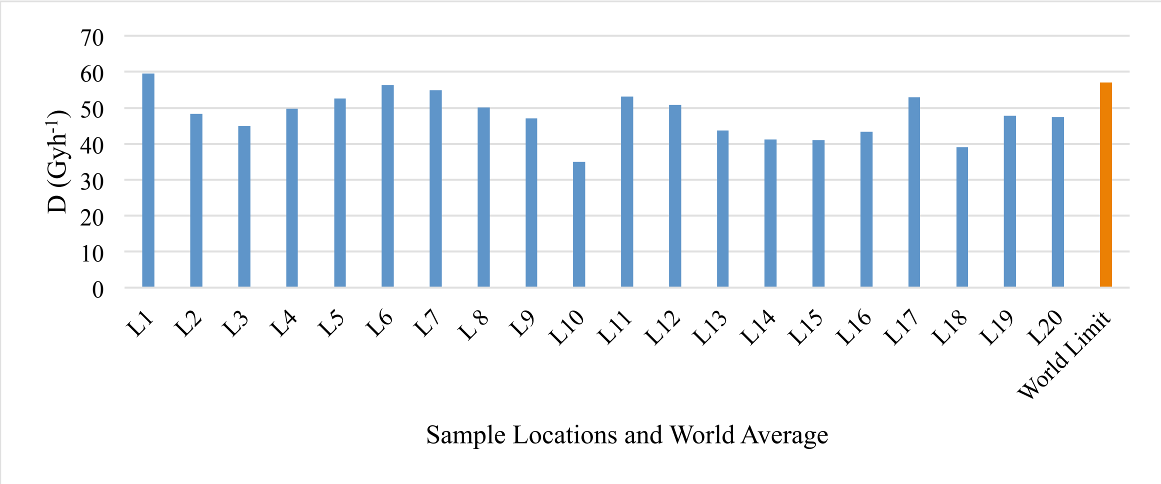

Figure 3. Absorbed Dose rate

4. Conclusion

The use of the fertilizers that contains Potassium in the sampling sites may contribute to the higher values of ^{40}K activity high values of the radionuclide. The values obtained in the study are within the recommended safety limit, implying that the teak plantation does not pose any immediate significant radiation hazard and hence the location of the plantation close to different settlements is considered to be safe for the inhabitants in the neighboring settlements. The probability of developing cancer over a lifetime exist from the ELCR obtained results, using 70 years as an adult life time.

5. Acknowledgement

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