Assessment of Radioactivity and Health Implications of Some Surface Soils in Guma Local Government Area of Benue State, North Central, Nigeria

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ABSTRACT--- ***In this work, the activity concentration of some radionuclides in soil samples collected from 10 locations in Guma local government area of Benue State Nigeria have been determined using Gamma ray spectroscopy. (Model: 3M3/3). The soil activity for urban areas ranged from 38.12–58.10Bq/kg, 3.53–4.41Bq/kg, and3.35 –7.11Bq/kg for ^{40}K, ^{238}U and ^{232}Th respectively for urban areas while in the rural areas the concentrations ranged from 54.06 –76.17Bq/kg, 3.66 – 5.27Bq/kg and 4.74 – 7.18Bq/kg ^{40}K, ^{238}U and ^{232}Th respectively. The absorbed dose and annual effective dose range from 5.89 – 7.70nGy/h and 0.01mSv/y in the urban areas with mean of 6.48nGy/h and 0.01mSv/y while in the rural area, the values ranges from 7.48 – 8.52nGy/h and 0.01 – 0.02mSv/y with mean values of 8.00nGy/h and 0.01mSv/y. All the computed values are much lower than permissible value recommended by the United Nation for Scientific Committee on Effect of Atomic Radiation UNSCEAR but lower than the values reported by (Avwiri and Ononugbo, 2012) and (Ajayi et al; 2013).***

Keywords---- soil, background radiation, evaluation, doses and health implication.

1. INTRODUCTION

The effect of environmental radiation is one of the hazards to living things and this is caused by naturally occurring radioactive materials (NORM) in the soils, water and intake of air, etc. The soil contains different types of heavy metals that emit radiation such as potassium, uranium and Thorium Jibiri *et al;* (2007) revealed that, the food consumed in Nigeria contains traces of radionuclide, Akinloye and Omomo, (2005) also established that vegetation and environmental fields in Nigeria contains traces of radionuclides.

Human beings are repeatedly exposed to environmental radiation, and are also source of radiation. The earth is naturally radioactive and about 90% of human radiation exposure arises from natural sources such as cosmic radiation, exposure to radon gas and terrestrial radionuclides (Lee et al; 2004). Gamma rays are known to be highly penetrating and are part product of the radioactive materials containing radon gas that may be inhaled (ingested) into the human body from the soil (Avwiri and Esi; 2014). Continuous absorption of these radon gas may have imposed high risk of health hazard to man such as, cancer of the lung, hypokalemia, heart disease, mutation, and others hence it becomes very important to investigate the background radiation level in our surface soils.

Avwiri and Ononugbo; (2012) reported naturally occurring radioactive materials (NORMs) from twelve oil fields and their host communities in Niger Delta of Nigeria the activity concentration of ^{226}Ra, ^{232}Th, and ^{40}K ranging from 10.10 to 41.23Bq/kg, 7.42 to 30.31Bq/kg and 92.42 to 482.79Bq/kg respectively. In host communities and the values ranged from 16.27 to 52.19Bq/kg for ^{226}Ra, 9.72 to 34.13Bq/kg for ^{232}Th and 134.50 to 395.15Bq/kg for ^{40}K. The study concluded that the radiation levels exceeded the normal background level of 35.0, 30.0, and 400Bq/kg in only two oil fields. Ajaiya et al; (2013) studied the radioactivity of surface soils from Oyo state, south western, Nigeria and reported that, specific activity concentration of the radionuclides ranged from 1±0.4Bq/kg for ^{137}Cs to 1190±30Bq/kg for ^{40}K. The estimated outdoor absorbed dose rates in air varied from52nGy/h in Egbeda (rural area) to 414nGy/h in Eruwa (also rural area). The annual effective dose for urban areas was 0.1mSv/y while that of rural areas was 0.3mSv/y with a standard deviation of 0.02mSv/y to 0.3mSv/y respectively. The investigation concluded that mean annual effective dose values for urban and rural areas are higher than the world average annual outdoor terrestrial radiation value of 0.07mSv/y reported by the United Nation for Scientific Committee on Effects of Atomic Radiation (UNSCEAR). The objective of this work is to measure/estimate the activity concentration of ^{40}K, ^{238}Uand^{232}Th, to create awareness to the public on the health implication of the radionuclides, to produce a baseline data for future radionuclide monitoring in Guma local government area of Benue State. In the North Central Region of Nigeria have no researcher so far been reported on the radioactivity of the soil in this area

Table 1. Sampling Locations and their Coordinates in Guma Local Government

Serial Number	Location	Latitude /Longitude
1.	Gbajimba	N7˚30’12”/E8˚30’41”
2.	Agasha	N7˚37’23”/E9˚48’3”
3.	Kwagh-ta	N7˚25’57”/E8˚0’37”
4.	Tse-Ikyo	N7˚33’0”/E8˚35’4”
5.	Tse-Nongu	N7˚51’11”/E9˚22’17”
6.	Andyair (NKST)	N7˚29’09”/E9˚3’10”
7.	Tse- Agaku	N7˚8’0”/E8˚34’54”
8.	Abensi	N7˚34’27”/E9˚35’12”
9.	Torkula village	N7˚12’54”/E9^{0}0’22”
10.	Uvi village	N7˚34’13”/E8˚01’54”

Geology:

Guma is a local government area in Benue State of Nigeria with a population of about 191,599 reported by 2006 Nigerian census, and the total land mass of about 28,882km^2. The local government is surrounded with sedimentary rocks and the soil dominantly associated with mineral deposits like lead, salt, barite, feldspar, and brown earth from volcanic eruption. Guma lies between latitude N7 32 and N8 51 and longitude E9 35 and E9 22 with an average high rain fall of about 1198 – 1798mm annually. Relative humidity is between 43 – 86%, temperature ranges from 27^0 and 37^{0}C.

2. MATERIALS AND METHODS

2.1 Experimental method

Natural radioactivity of surface soil sample was collected and measured. The soil samples were collected from the four vertices and the centre of 1 – 2m square land area at a depth of between 0 – 5cm. The soil samples were processed according to the recommended procedure by the International Atomic Energy Agency (IAEA). Samples were collected from 10 (ten) locations see table1in the local government area using geographical positioning system (GPS) to determine (marked) the exact position of the sampling. The soils were packed into labeled plastic containers for analysis purpose. The samples were, sundried to a constant weight, ground and sieved using 2mm mesh to obtain a fine – powder texture that would give an equilibrium level to the detector. About 200g of each sieved sample was poured into the plastic container and sealed for at least 30 days before analysis. This was to allowed time for the daughters to reunite with their parent radionuclides.

The activity concentration of ^{40}K, ^{238}U and ^{232}Th were measured using gamma ray spectroscopy NaI(TI) method (Model NO. 3M3/3). The detector has a resolution of about 8% at 0.662MeV of 137Cs. The detection energy calibrations of the system were carried out using reference standard source (IAEA - 444) prepared from the Radiochemical Centre, Amersham, England. The 1.460MeV photo peak was used for the measurement of ^{40}K while 1.120MeV photo peak from ^{214}Bi and the 0.911MeV photo peak from ^{288}Ac were used for the measurement of ^{238}U and ^{232}Th, respectively. Each of the samples was counted for 25200 seconds. Absorbed dose and annual effective dose rates were calculated from specific activity concentration. Dose rate in air was estimated using equation (1) and Annual effective dose estimated using equation (2) (UNSCEAR, 2008) and with background reduction factor of 12.3, 15.4 and 18.5 for Uranium-238, Thorium-232 and Potassium respectively (Avwiri and Ononugbo., 2012):

$$D_a = 0.470A_u + 0.572A_{Th} + 0.0421A_k \quad (1)$$

$$A_{e(mSv/y)} = nGy/h \times O_f \times 8760 \times C_f \times 10^{-6} \quad (2)$$

Table2. Activity concentrations of radionuclides (Bq/kg) in soil samples of urban areas.

Location	A_k	A_u	A_{Th}
Gbajimba	41.48±0.30	4.05±0.34	5.44±1.28
Agasha	38.12±0.29	4.37±0.50	7.11±1.39
Abensi	58.10±0.38	3.53±0.30	3.54±0.92
Kwaghta	46.41±0.33	4.32±0.35	3.35±0.58
Tseikyo	47.04±0.35	4.41±0.38	5.19±1.02
Range	38.12-58.10	3.53-4.41	3.35-7.11
Mean	46.23±0.33	4.13±0.37	4.92±1.03
S.D	±7.570	±0.350	±1.541
SME	±3.392	±0.156	±0.691

S.D = Standard deviation

SME = Standard mean error

Table3. Activity Concentrations of radionuclides (Bq/kg) in soil samples of rural areas.

Location	A_k	A_u	A_{Th}
Uvi villa	76.17±0.47	4.12±0.33	4.74±1.15
Tse-Nongu	55.21±0.38	4.37±0.35	5.45±1.27
Andyair	67.24±0.43	4.02±0.37	5.14±1.31
Tse-Agaku	54.06±0.36	5.27±0.40	6.17±1.40
Torkula	63.94±0.40	3.66±0.31	7.18±1.62
Range	54.06-76.17	3.66-5.27	4.74-7.18
Mean	63.32±0.40	4.28±0.35	5.73±1.35
S.D	±8.408	±0.605	±0.962
SME	±3.776	±0.271	±0.431

S.D = Standard deviation

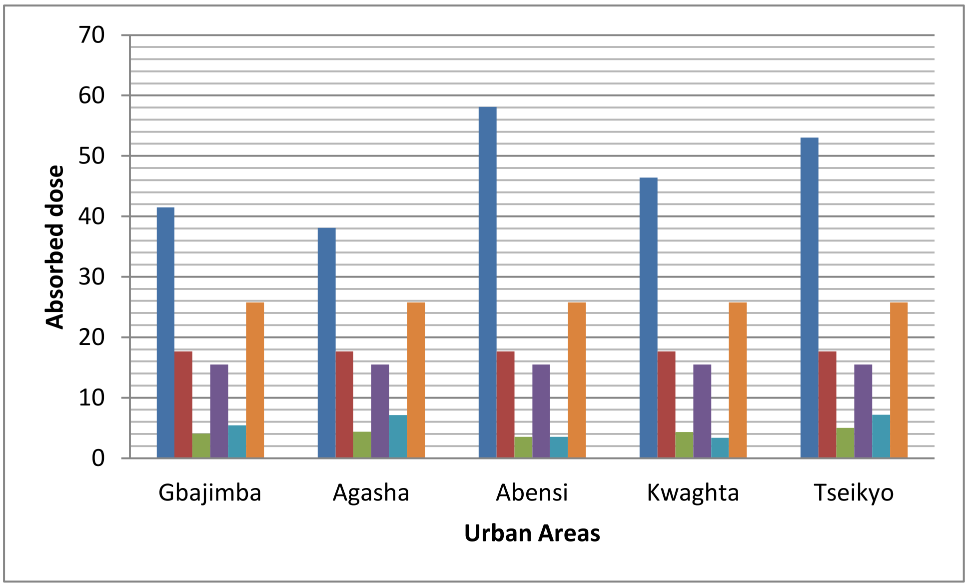
SME = Standard mean error

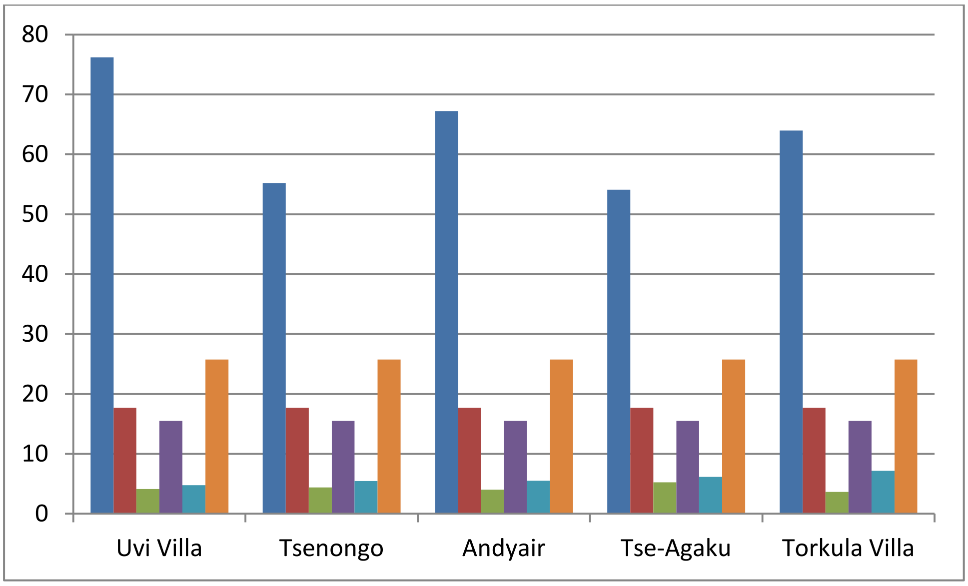
Table4. Absorbed dose rate in air and annual outdoor effective dose rate at different locations in the study area due to terrestrial radiation in urban areas.

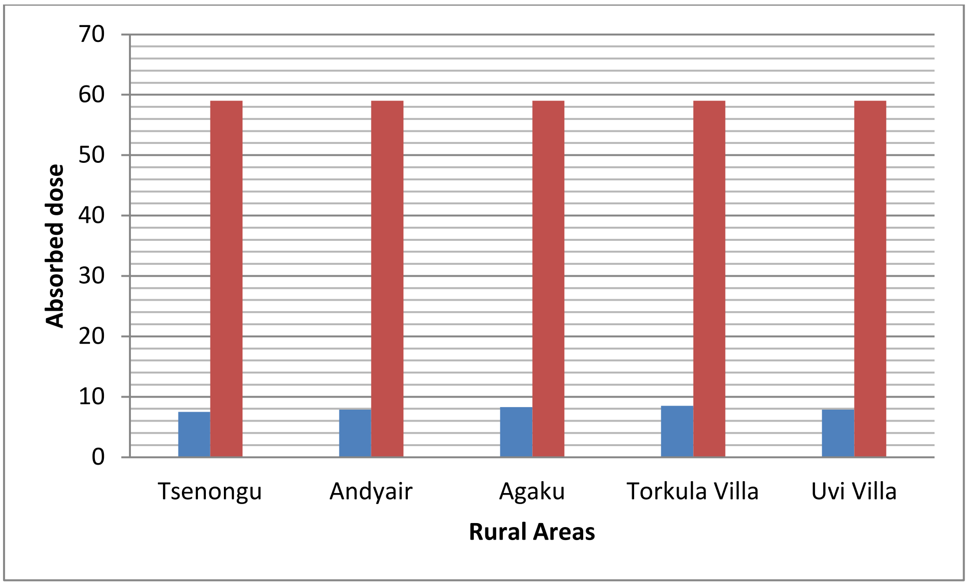
Sites	Absorbed Dose (nGy/h)	Annual Effective Dose (Ae) (mSv/y)
Gbajimba	6.75	0.01
Agasha	7.70	0.01
Abensi	6.11	0.01
Kwaghta	5.89	0.01
Tseikyo	5.97	0.01
Range	5.89–7.70	0.01 – 0.01
Mean	6.48	0.01

Table5. Absorbed dose rate in air and annual outdoor effective dose rate at different locations in the study area due to terrestrial radiation rural areas.

Locations	Absorbed Dose (Da) (nGy/h)	Annual Effective Dose (Ae) (mSv/y)
Tse-Nongu	7.48	0.01
Andyair	7.87	0.01
Agaku	8.28	0.02
Torkula Village	8.52	0.02
Uvi Village	7.86	0.01
Range	7.48–8.52	0.01 – 0.02
Mean	8.00	0.01






70
60
50
40
30
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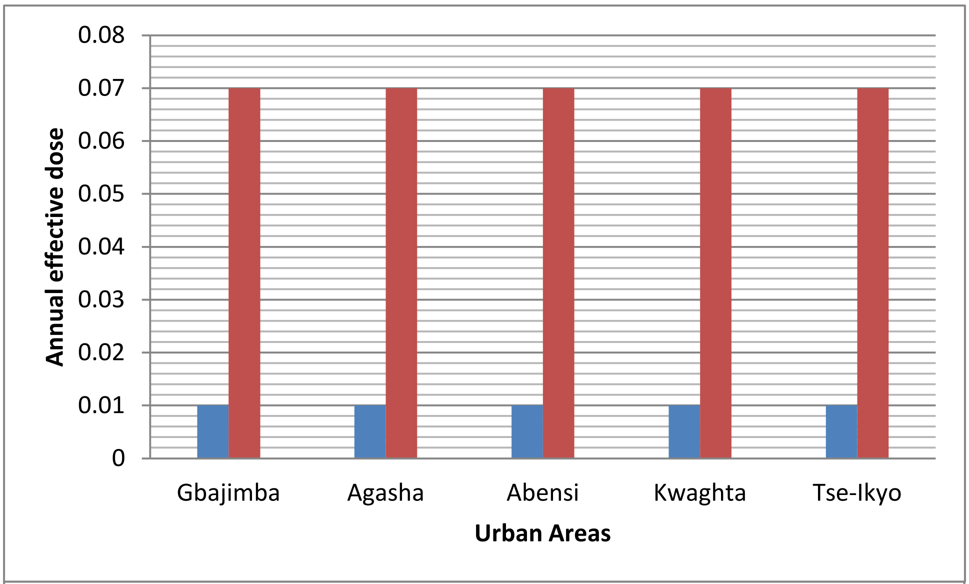
10
0
Absorbed dose
Tsenongu
Andyair
Agaku
Torkula Villa
Uvi Villa
Rural Areas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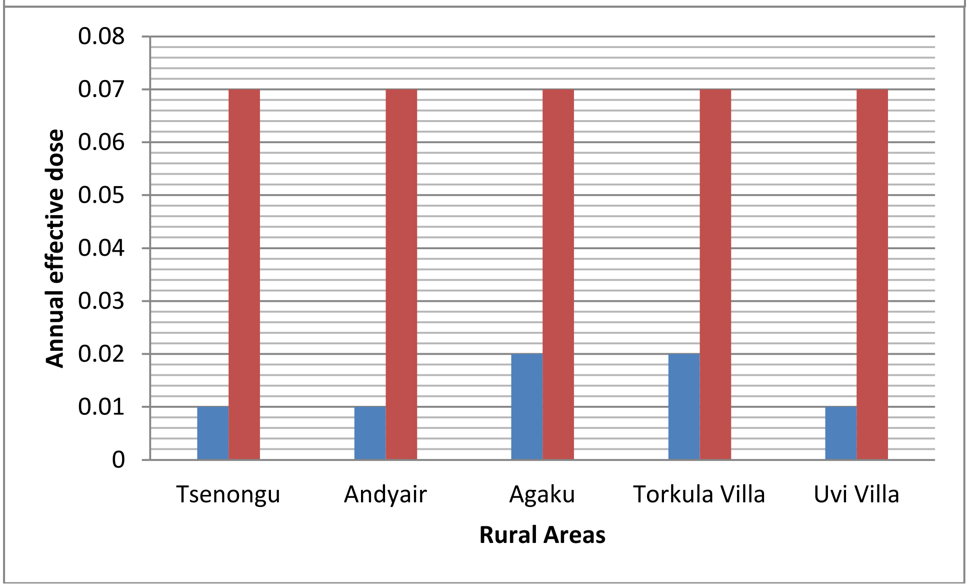
Annual effective dose
Gbajimba
Agasha
Abensi
Kwaghta
Tse-Ikyo
Urban Areas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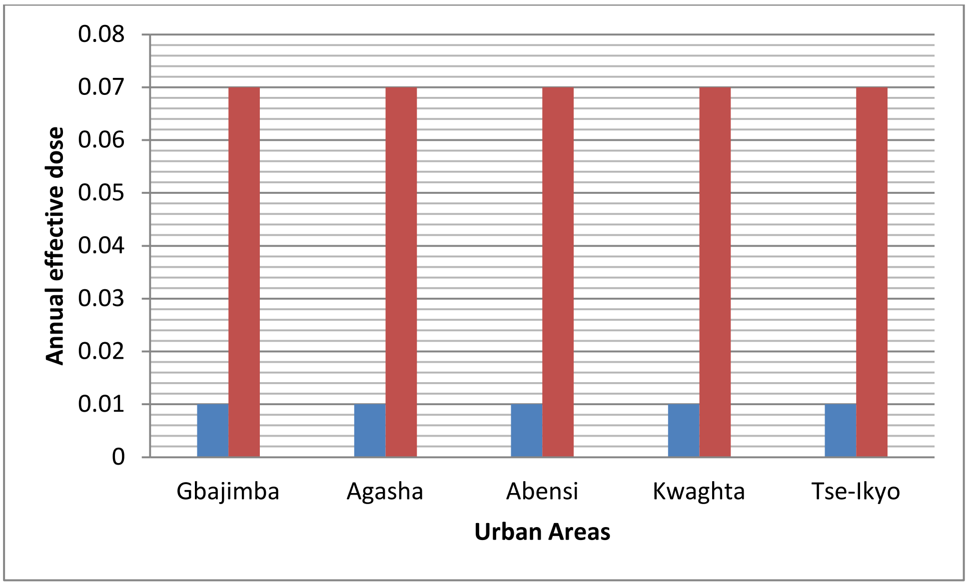
Annual effective dose
Tsenongu
Andyair
Agaku
Torkula Villa
Uvi Villa
Rural Areas



The specific activity concentration of the background ionization radiation of the soils sample measured ranged from 38.12–58.10Bq/kg for ^{40}K, 3.53–4.41Bq/kg for ^{238}U and 3.35–7.11Bq/kg for ^{232}Th in the urban areas see table2 with mean values of 46.23, 413 and 4.92Bq/kg respectively. The values obtained are lower than the world average value of 420, 33, and 45Bq/kg reported by Avwiri and Ononugbo (2012). Table3. shows five sample location sites in the rural area of local government. The ionization background radiation ranges from 54.06–76.17Bq/kg for ^{40}K, 3.66–5.27Bq/kg for ^{238}U and 5.73–1.35Bq/kg for ^{232}Th with mean values of 63.32, 4.28 and 5.73Bq/kg respectively. This is lower than the values obtained and reported by UNSCEAR, (2008); and also lower than the values reported by Ajayi and Ibikunle,(2013); Olubosede *et al;* (2013) for the environs of Niger Delta of Nigeria.

Absorbed dose rate is the measure of the amount of energy (radionuclides) deposited by ionization radiation in the human body for a given period (Avwiri and Ononugbo, 2013). To avoid any radiological health implications. The United Nation for Scientific Committee on Effect of Atomic Radiation (UNSCEAR) set out a permissible limit dose allowed for workers and non – workers as 0.07mSv/y. Table4 shows the absorbed dose rate and annual effective dose in urban areas. The computed absorbed dose values ranged from 5.89–7.70nGy/h with a mean of 6.48nGy/h, this is lower than the absorbed dose of value 59nGy/h set by (UNSCEAR; 2008). The effective dose ranges from 0.01mSv/y with a mean of 0.01, this is lower than 0.07mSv/y set by UNSCEAR but the values are also lower than the values reported by Ajayi and Ibikunle (2013); and Avwiri and Ononugbo (2012). Table5. Shows the absorbed dose and annual effective dose in the rural areas, the absorbed dose ranges from 7.48–8.52nGy/h with a mean of 8.00nGy/h this is much lower than the world allowed dose of 59nGy/h while the annual effective dose values are lower than the permissible dose approved by UNSCEAR. The little values of the background ionizations radiation and absorbed dose rate obtained in the sample areas may be as a result of metamorphic rock underlying the territory, lead mining, use of phosphate fertilizer by farmers in the areas, brown earth volcanic formation of material (salt spring) and other hazardous materials in the areas. Therefore, continuous absorption of the radiation dose may result to health problems such as cancer of the lungs, mutation, heart disease, chronic kidney disease, hypokalemia and antibiotics, erythema, low and high blood pressure etc. This calls for medical investigation of the radiological level of the surface soils in Guma local government area of Benue State, Nigeria.

3. CONCLUSION

The assessment of radioactivity of 10 surface soils sample of Guma local government of Benue State, Nigeria has been carried out using NaI(TI) detector. The specific activity concentration in all the soil samples are much lower than the normal background radiation of 59nGy/h and the computed absorbed dose rate results are also lower than the permissible safe limit recommended by the (UNSCEAR; 2008). The reported values may not indicate immediate health implications but continuous absorption may lead to a long term health problem.

4. RECOMMENDATION

We recommend that;

1. Other alternative should be used by improving the soil fertility than to depend on fertilizer hence it add reasonable amount of heavy metals in the soil.
2. Adequate information should be sought from the environmental scientist before construction of any building in order to assess the level of background ionization radiation.

5. REFERENCES

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