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Assessment of Natural Radioactivity Level in Soil Samples and Radiological Health Hazard in Floriculture Soil, Adami Tullu, Shoa, Ethiopia, Using Gamma-Ray Spectrometry

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Abstract:- The current investigation aims to survey levels of natural radioactivity in soil samples gathered from farming and floriculture area to assess environmental radioactivity and radiological wellbeing risk using sodium iodide NaI(TI) gamma-ray spectrometry in Adami Tullu, Shoa, Ethiopia. The outcomes were contrasted and one another and with worldwide standard soil samples. The mean radionuclide concentrations (^{238}U, ^{232}Th, and ^{40}K) in the farming soil samples were 31.39 ± 0.02, 9.43 ± 0.02, and 49.5 ± 0.06 Bqkg/1, and in the floriculture soil samples were 80.69 ± 0.056, 12.9 ± 0.016, and 28.79 ± 0.078 Bqkg/1. The annual effective dose in the farming and floriculture land was lower than the world's methods approval. The absorbed dose rate noticeable all-around at one meter over the ground was gone between 10.4 to 45.5nGyh-1, with a mean of 21.4nGyh/1 in the farming soil samples while it went from 5.87 to 63.67 nGyh/1 with a mean estimation of 43.69 nGyh/1 in the floriculture soil samples. The estimation of the external and internal hazard index was gone from 0.065 to 0.52, with a mean of 0.22 and 0.036 to 0.725, with a mean of 0.42 individually. This worth is underneath as far as possible. Accordingly, the investigation region is safe for nearby local community health.

Keywords:- *Agricultural Soil, Floriculture Soil, Gamma-Ray Spectrometry, Radioactivity.*

I. INTRODUCTION

The naturally happening radioactive materials show all over on earth's underside and their radioactivity may be concentrated in a certain region as a result of human exercises. The floriculture industry is one of the places in which numerous labor powers are contributed and variables increment the levels of characteristic radiations that are regularly utilized. These businesses had been utilizing overabundance, a few sorts of fertilizers created from sedimentary shake by including sulphuric acidic and nitric acidic [1]. Due to these forms, triple superphosphate (TSP) and Di Ammonium phosphate (DAP) fertilizers can be created. The normal phosphates from sedimentary express to around 85% of fertilizers, which contain characteristic radioactive material [2]. Utilizing phosphate fertilizers over numerous a long time seem inevitably increment the radium and uranium substance of the soil and subsequently increment the radiation measurements which would result within the comparing increment of the dosage and causes illnesses for the human body [3].

Floriculture is the development of bloom and elaborate plants for gardens and the flower business. This industry utilizes an enormous number of fertilizers and synthetic compounds to expand the efficiency of blossoms. Utilizing overabundance of phosphate fertilizers in gardening increment the degree of natural radioactivity [10]. Since these fertilizers contain common radioactive material, the laborers get an opportunity to be influenced by radiation from fertilizers and synthetic substances. A few investigations report that floriculture has social and ecological effects because of synthetics and fertilizers utilized. The profoundly predominant illness side effects were additionally seen in Sebeta floriculture laborers and these indications had been seen on the individuals who didn't have full close to home defensive hardware [4]. A few infections identified with these are Methemoglobinemia, Japanese encephalitis (JE), malignancy, and so on have been noted because of the utilization of synthetics and fertilizers. Until this point, there is no detailed writing on the natural radioactivity level in the floriculture district (particularly the East Shoa zone of Adami Tullu), Ethiopia. Subsequently, this investigation plans is to survey natural radioactivity levels and the possible radiological wellbeing dangers related to floriculture by NaI(TI) detectors close to Adami Tullu town, East Shoa, Ethiopia, from the floriculture territory.

II. MATERIALS AND METHODS

The investigation zone is around Adami Tullu town, situated at 189KM toward the southern part of the capital city of the nation, Addis Ababa. Worldwide it is covering to the Lat.7^0, 51'22.324" N and Longtd. 38^0, 42'28.742"E. The investigation territory comprises of fertilizer soil neighborhood farmers have been utilizing for the creation of cereal crops.

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Fig:1. Geological Map of Adami Tullu Floriculture industry and it's surrounding referring to the sample study areas.

➢ *Sampling and Sample Preparation*

we have gathered nine soil tests from cultivating and gardening soil arbitrarily inside the investigation territory. Test determination depended on the availability of general society and closeness to the floricultural industry. At that point, the soil samples gathered were spread in a plate and permitted to dry at room temperature for about fourteen days and afterward dried in a broiler at a temperature of 105°C for 12 h until the samples were very much dried with a steady weight. The dried samples were squashed and sieved with work having openings every one of a width of 0.2 mm to eliminate natural materials, bits of stones, rock, and protuberances. At that point, the homogenized samples were gauged and a mass of 190g of each sample was pressed in a round and hollow plastic compartment of stature 7cm and 6cm in breadth. The plastic compartments were fixed with sticky tape for 30 days to consider ^{238}U and its brief descendants to arrive at mainstream radioactive harmony [5].

Each sample was estimated by gamma spectrometry with MAESTRO - 32 multichannel analyzers. It is protected in an office of two layers beginning with the inward part tempered steel of 3 mm thick and lead of 45 mm thick to lessen foundation radiations [6]. We fixed the finder in the focal point of the chamber to limit the impact of the dispersed radiation from the protecting materials. At that point, we saved the samples over the finder for 24 hours. The spectra were assessed physically by contrasting and the spectra from references given by IAEA recorded soil-375 and soil-6 for the energies of 238kev of Pb-212 for Th-232 distinguishing proof, 351kev of Pb-214 for U-238 ID, and 1460.9kev gamma line for K-40 action focus [7].

➢ *Radioactivity measurements*

The time each sample tallied was 24hrs and those gamma-beam spectra were examined by the Maestro-32 programming bundle for nuclide recognizable proof, top looking, top assessment, the information obtaining, energy, and efficiency computation. From the range examination, check rates for each identified photopeak and explicit action for each of the distinguished nuclides are determined. The specific activity (in Bq kg/1), A_{Ei}, of a nuclide i and for a peak at energy E, is given by

$$A_{Ei} = \frac{N_{Ei}}{t \times \varepsilon_E \times \gamma_D \times M_s}$$

where N_{Ei} is the Net Peak Area of at energy E, ε_E is the recognition efficiency at energy E, t is the count live time, γ_d is the number of gammas per decaying of this nuclide for progress at energy E, and Ms is the mass in kg of the deliberate sample. We likewise utilized this equation for the estimation of exercises of reference soils and the calculation of testing materials are nearly the equivalent and we filled the readied fine powder of tests similarly. As it is now known, the action of radioactive components in reference soil was at that point known, and we deduct the current movement of sources from the date of giving by IAEA. After we found the current exercises, we utilized a similar method to quantify the action of our samples.

The final equation should be;

$$A_{sEi} = A_{REi} \times \frac{NPA_{(Samples)}}{NPA_{(Re\,ferencesoils)}} \times \frac{M_{(S\tan dards)}}{M_{(Samples)}}$$

Where As_{Ei} is the activity of photopeak from our sample (Michalis Tzortzis et al., 2012; IAEA 1998/1999, Mirions Technologies, 2017).

Advances from rots of brief radionuclides in the ^{238}U, ^{232}Th, and rot chains, for example, ^{214}Pb and ^{214}Bi, were utilized to assess the movement grouping of ^{226}Ra and ^{228}Ac, ^{212}Pb, and ^{208}Tl were likewise used to decide the action convergence of ^{232}Th. Foundation commitments were deducted from the peak zones for the deliberate samples [8, 9].

➢ *Radium equivalent*

The spreading of common radionuclides was not uniform in the samples under investigation, a radiological list, called radium equivalent (Raeq) action, was characterized to assess the radiation hazard, related to these radionuclides. This index was determined, utilizing condition 3 [8]:

$Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0.077A_K$ (3)

Where A_{Ra}, $A_{Th,}$ and A_k are the activities of ^{226}Ra, ^{232}Th, and ^{40}K in the studied samples, respectively.

➢ *Hazard indices*

The discharged gamma beams of the samples were identified with outer and inside risk list, were determined utilizing condition 4 and 5 [8]:

$$Hex = \frac{ARa}{370} + \frac{ATh}{259} + \frac{AK}{4810} \leq 1 \quad (4)$$

$$Hin = \frac{ARa}{185} + \frac{ATh}{259} + \frac{AK}{4810} \leq 1 \quad (5)$$

Dose calculations

The consumed gamma radiation portion can be assessed outside from soil and one meter over the ground [8]:

$D(nGyh/1) = [0.427A_{Ra} + 0.662A_{Th} + 0.0432A_K]$ (6)

Where A_{Ra}, A_{Th}, and A_K are the specific activities of ^{226}Ra, ^{232}Th, and ^{40}K in soil samples, from conditions 4, 5, and 6 individually.

To measure the annual effective dose (AED) in µSv/y utilizing conditions 7 and 8. These conditions as per the UNSCEAR reports utilized the worth 0.7 Sv/Gy as the transformation factor from the retained portion rate noticeable all around to the viable portion rate for the populace in the circumstance outside or inside. Inhabitance variables ought to be considered. Inhabitance factors 0.2 and 0.8 are utilized for open-air and indoor inhabitance individually [9].

AED outdoor (µSv/y)= Dose rate (nGy/h) ×8766 (h/y) × 0.2× 0.7 (Sv/Gy)× 10^{-3} (7)

AED indoor (µSv/y) = Dose rate (nGy/h) ×8766 (h/y) × 0.8× 0.7 (Sv/Gy) × 10^{-3} (8)

III. RESULTS AND DISCUSSION

The activity concentrations of ^{238}U, ^{232}Th, and ^{40}K of the soil samples from cultivating and horticulture land were resolved. From the outcomes got activity concentrations of radionuclides in floriculture soil samples were high. Activity concentrations of ^{238}U were seen in all samples gathered from floriculture soil were high, this might be credited to the fertilizers utilized in the investigation territory because of the horticulture exercises. Similarly, the activity concentrations of the framing land from the outlining land were additionally seen to be high. This might be because of the fertilizers utilized by the farmer for a long time. Contrasting these outcomes and one another, the soil samples from the horticulture, the activity concentrations were seen to be higher, this perception could be credited to the high measure of fertilizers utilized by the floriculture business.

S. C	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)
ADT-1	4.93±0.036	12.56±0.007	33.92±0.02
ADT-2	21.1±0.097	11.28±0.008	11.19±0.05
ADT-3	-	10.66±0.008	119.06±0.004
ADT-4	41.32±0.16	6.31±0.01	32.65±0.02
ADT-5	9.6±0.25	6.6±0.012	50.9±0.024
Average	*31.39±0.314*	*9.48±0.02*	*49.54±0.06*
ADT-6	86.23±0.036	9.06±0.009	33.07±0.02
ADT-7	-	8.9±0.01	8.6±0.07
ADT-8	115.71±0.031	21.35±0.006	22.62±0.029
ADT-9	120.84±0.03	12.3±0.007	50.88±0.002
Average	*80.69±0.056*	*12.9±0.016*	*28.79±0.078*

Table. 1: Farming and floriculture soil samples activity concentration of natural radionuclide .

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S. C	Ra_{eq} (B/kg)	D_R(nGy/h)	AD_R (mSv/y)	H_{in}	H_{ex}
ADT-1	105.5±0.36	45.5±0.016	0.056	0.29	0.52
ADT-2	38.09±0.098	16.5±0.04	0.02	0.104	0.16
ADT-3	24.41±0.011	11.72±0.005	0.014	0.065	0.065
ADT-4	52.85±0.16	22.9±0.0681	0.028	0.14	0.25
ADT-5	22.94±0.25	10.4±0.11	0.013	0.065	0.09
Average	*48.76±0.48*	*21.4±0.14*	*0.026*	*0.13*	*0.22*
ADT-6	101.74±0.04	43.8±0.016	0.054	0.27	0.512
ADT-7	13.39±0.015	5.87±0.007	0.0072	0.036	0.036
AGT-8	147.95±0.03	63.67±0.014	0.078	0.35	0.725
ADT-9	142.35±0.03	61.42±0.014	0.075	0.37	0.39
Average	*101.1±0.64*	*43.69±0.026*	*0.054*	*0.26*	*0.42*

Table.2: Radium equivalent (Ra_{eq}), absorbed doses (D_R), Annual effective dose (AD_R), the external and internal hazard index of soil samples collected from farming land and Floriculture land.

References	Coutry	^{238}U	^{232}Th	^{40}K	Ra_{eq}	D_R	AD_R
Present study	Ethipia	64.73	25.91	39.14	74.93	32.54	0.03 [P.S]
Hailu Geremew 2019	Ethipia	138.06	7.82	179.9	123.4	62.35	0.07 [10]
Ademola & Ademonehin, 2010	Nigeia	13.3	40	240.2	91.9	41.5	0.05 [11]
El Afifi, 2006	Egypt	78	33	337			[12]
Augustine Kolapo Ademola, 2014	Nigeia	55.3	26.4	505.1	132	66.3	0.08 [13]
W.R. Alharbi, 2013	Saudi Araba	64	17	2453			[14]

Table:3. Comparison of the present study with some results obtained from the literature review.

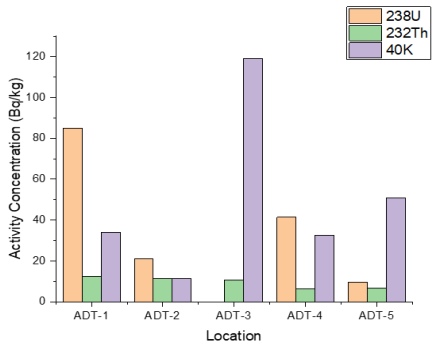

Fig.1: Activity concentration of ^{238}U, ^{232}Th, and ^{40}K in farming soil samples.

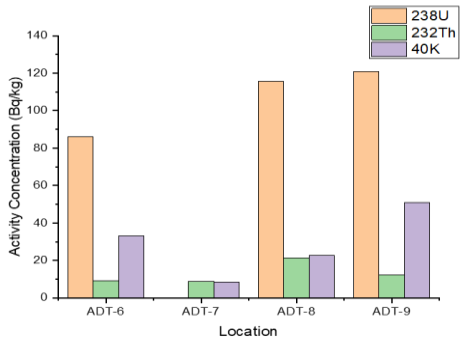

Fig:2. Activity concentrations of ^{238}U, ^{232}Th, and ^{40}K in floriculture soil samples.

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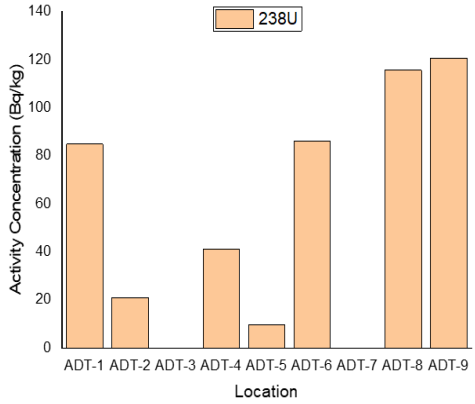

Fig: 3. Histogram showing Activity concentrations of 238U in farming and floriculture soil samples.

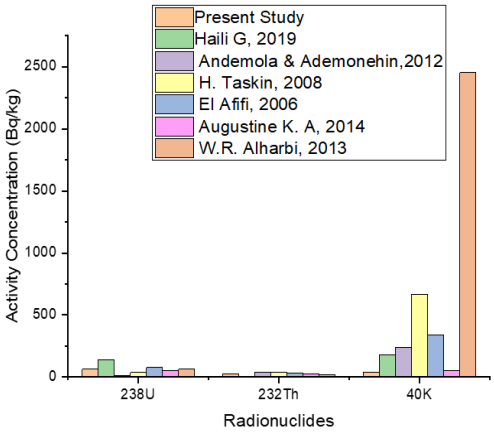

Fig:4. Figure showing the comparison of the present study with some literature.

The acquired value of activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K of each soil sample from the farming and floriculture land appear in Fig. 1 and 2. The most reduced activity concentrations were seen to be (4.93 ± 0.036), (6.31 ± 0.01) and (11.19 ± 0.05) at the farming land and (86.23 ± 0.036), (8.9 ± 0.01) and (8.6 ± 0.07) (Bq/kg) at the floriculture, individually. In another manner, the highest activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K discovered to be (41.32 ± 0.16), (12.56 ± 0.007) and (119.06 ± 0.004) at the farming land and (120.84 ± 0.03), (21.35 ± 0.006) and (50.88 ± 0.002) (Bq/kg) at the floriculture, individually. The highest activity concentrations of ^{238}U were invested in totally estimated radionuclides of soil samples. It can likewise be seen that the activity concentrations of the floriculture soil samples were higher than that of the farming; this variety can be attributed to a lot of fertilizer store in the soil.

The outcomes got in this work in Table 1 contrasts and the world mean qualities introduced by [15]. The got results demonstrated that the activity concentrations of U-238 for the soil samples went from (4.93 ± 0.036) to (41.32 ± 0.16) and (86.23 ± 0.036) to (120.84 ± 0.03), individually. The concentration of ^{238}U at the floriculture soil was discovered to be higher than the overall mean worth. The activity concentrations of ^{232}Th and ^{40}K went from (6.3 ± 0.01) to (12.56 ± 0.007) and (11.19 ± 0.05) to (50.06 ± 0.024) at the farming land, and (8.9 ± 0.01) to (21.35 ± 0.006) and (8.6 ± 0.07) to (50.88 ± 0.002) (Bq/kg) at the floriculture, individually. The mean activity concentrations of ^{232}Th and ^{40}K in farming land and floriculture soil samples are underneath the overall mean worth.

From table 3 absorbed dose rates (nGy/h) of the soil samples went from (10.4 ± 0.11) to (45.5 ± 0.016) with a mean estimation of (21.4 ± 0.14) at the farming land and went from (5.87 ± 0.007) to (63.67 ± 0.014) with a mean estimation of (43.69 ± 0.027) at the floriculture land, individually. As we saw from these outcomes the mean estimation of the absorbed dose rate from all the samples was lower than the overall mean worth.

The effective dose (mSv/y) of the soil samples are changed from (0.013) to (0.056), with the mean estimation of (0.026) at the farming land and went from (0.0072) to (0.078), with a mean estimation of (0.054), which is lower than the worldwide of 0.07mSv/y [16].

Radium equivalent activity went from (22.94 ± 0.25) to (105.5 ± 0.36), with a mean of (48.76 ± 0.48) in the farming land and went from (13.39 ± 0.015) to (147.95 ± 0.015), with a mean of (101.36 ± 0.064) (Bq/kg) in the floricultural land, separately. The estimations of Raeq were lower than the constraint of 370Bq/kg [17], [8], [18]. Henceforth, the

utilization of the farming area and floriculture has no wellbeing risk of radiation.

In table 2 the external and internal hazard index record of the soil samples of farming land went from (0.065) to (0.52) with a mean estimation of (0.22), and (0.065) to (0.29), with the mean estimation of (0.13) at the farming land and (0.036) to (0.37), with the mean estimation of (0.26) and (0.036) to (0.725) with the mean estimations of (0.42), and at the floricultural land, individually. The consequences of the (H_{ex}) and (H_{in}) show that the soil samples are underneath the solidarity and the radiation portion is inside the passable furthest reaches of 1 mSv/y as suggested by [8].

Table. 4 and fig. 4 show the inspection of this investigation with results from the literature. From this inspection activity concentration of ^{238}U was higher than the world mean normal qualities [8]. The outcomes we appeared from Table. 4 and fig. 4 infer that activity concentration of ^{232}Th is lower than that [11, 12], yet it is higher than that acquired by [10, 13, 14]. The estimation of activity concentration of ^{232}Th is lower than the world mean worth [8]. The ^{40}K activity concentration from this investigation was lower than ^{238}U and ^{232}Th. The estimation of the activity concentration of ^{40}K was lower than the world's methods of approval. The annual effective dose in the farming soil sample is 0.026mSvy-1 and in floriculture is likewise 0.054mSv/y. The mean annual effective dose in this investigation is underneath the world normal of cutoff solidarity suggested by [7].

IV. CONCLUSION

In Adami Tullu floriculture and it's encompassing the activity concentration of ^{238}U, ^{232}Th, and ^{40}K have been dictated by the NaI(TI) detector. The activity concentration of ^{238}U, ^{232}Th, and ^{40}K in the soil samples from farming and floriculture land were determined to be 31.39 ± 0.314, 9.48 ± 0.02, and 49.54 ± 0.06 Bqkg-1, while in the floriculture regions was 80.69 ±0.056, 12.9 ± 0.016, and 28.79 ± 0.078 Bqkg-1 individually. The consequences of ^{238}U and ^{232}Th in the farming and floriculture soil samples are higher than the world's normal worth. The normal estimation of effective dose is below the world normal suggested by (UNSCEAR, 2000). The mean activity concentrations of ^{40}K in the farming and floriculture soil samples is lower than the cutoff. The investigation territory shows normal radionuclides levels inside and outside floriculture regions are beneath the overall normal. Consequently, the floriculture business has no negative effect on the laborers and the general population.

REFERENCES

[1]. Cioroianu, T.M., Bunus, F. et al., 2000. “environmental considerations on uranium and radium from phosphate fertilizers”, Research Institute CfflMENERG, Design and Research Institute for Rare and Radioactive Metals, Bucharest, 215-224.
[2]. Mesay Adugna Kassa, 2017. “Review on Environmental Effects of Ethiopian Floriculture Industry”, Asian Research Journal of Agriculture, DOI: 10.9734/ARJA/2017/31884.
[3]. S. Righi, P. Lucialli and L. Bruzzi, “Health and Environmental Impacts of a Fertilizer Plant Part I: Assessment of Radioactive Pollution,” Journal of Environmental Radioactivity, Vol. 82, No. 2, 2005, pp. 167-182. doi:10.1016/j.jenvrad.2004.11.007
[4]. Mulugeta Getu Sisay, 2009. “Ethiopian Floriculture and Its Impact on the Environment: Regulation, Supervision, and Compliance”, 3(2) mizan law review, 240-270.
[5]. Veiga R, Sanches N, Anjos R M, Macario K & Bastos J, Radiat Meas, 4(2006) 89.
[6]. Gulcin Bilgici Cengiz and Asl Caglar, 2017. “Evaluation of Natural Radioactivity Levels and Radiological Hazards in Soil Samples of Sarkam Province, Kars, Turkey”, Radiation Science and Technology., doi: 10.11648/j.rst.20170306.13.
[7]. Faanu, A. Adukpo, O. K. et al., 2016. “Natural radioactivity levels in soils, rocks, and water at a mining concession of Perseus gold mine and surrounding towns in Central Region of Ghana”, A springer journal, DOI 10.1186/s40064-016-1716-5.
[8]. Bunzl K, Trautmannsheimer M. 1999. “Transfer of 238U, 226Ra, and 210Po from slag-contaminated soils to vegetables under field conditions”. Science of the Total Environment 231:91-99.
[9]. Sheppard SC, Evenden WG. 1988. “The assumption of linearity in soil and plant concentration ratio: an experimental evaluation”. The Journal of Environmental Radioactivity 7:221-247.
[10]. Hailu Geremew (2019). “Investigations of natural radioactivity levels and the possible radiation hazards in floriculture soil, holeta, shoa, Ethiopia, using gamma-ray spectrometry”, International Journal of Current Research, 11, (02), 1535-1540
[11]. J.A. Ademola and S. Ademonehin (2010). “Radioactivity concentrations and dose assessment for bitumen and soil samples around a bituminous deposit in Ondo State, Nigeria”. Cambridge University Press: Volume 45, Issue 3, pp. 359-368
[12]. EL AFIFI, (2006). “Evaluation of U, Th, K and emanated radon in some NORM and TENORM samples”. Radiation Measurements, Volume 41, Issue 5, May 2006, Pages 627-633.

[13]. Augustine Kolapo Ademola (2014). "Determination of natural radioactivity and hazard in soil samples in and around the gold mining area in Itagunmodi, south-western, Nigeria". Journal of radiation research and applied science, Vol 7,2014- Issue 3
[14]. W.R. Alharbi, (2013). "Natural Radioactivity and Dose Assessment for Brands of Chemical and Organic Fertilizers Used in Saudi". Journal of Modern Physics Vol.4 No.3(2013).
[15]. Khandaker MU, Jojo PJ, Kassim HA, AminYM, 2012. "Radiometric analysis of construction materials Using HPGe gamma-ray spectrometry". Radiat Prot Dosim. 2012; 152 (1–3): 33- 37.
[16]. Taskin, H., Karavus, M., Topuzogluu, A., Hindiroglu, S. Karahan, G. (2009). "Radionuclide Concentrations in Soil and Lifetime Cancer".
[17]. Ibeanu, I.G.E., 1999. "Assessment of radiological effects of tin mining activities in Jos and its Environs". Ph.D. Thesis (Unpublished) Submitted to the Post Graduate School of Ahmadu Bello University, Zaria, Nigeria.
[18]. EC. (1999). Radiation Protection Principles Concerning the Natural Radioactivity in Building Materials Environmental Nuclear Safety and Civil Protection, Directorate General, European Commission.