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Radiological Assessment of *Vernonia Amygdalina* and Health Risk to the Consumers at Sagamu, Southwest Nigeria

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ABSTRACT

Natural radionuclides are elements that are found in the air, water and soil. They find their ways into the plants through the leaves and roots. Herbal plants are commonly used in Africa for prevention and treatment of diseases. *Vernonia amygdalina* is a herbal plant that is so used in south-western part of Nigeria due to its multifunctional traditional medicinal health uses. With this, there is need to determine the radiological health risk of these natural radionuclides to the consumers of V*ernonia amygdalina* in the study area. The fresh leaves of *Vernonia amygdalina,* a shrub, were plucked from ten (10) locations at Sagamu, Ogun State in Nigeria. The concentrations of ^{40}K, ^{238}U and ^{232}Th in the leaves were determined using gamma spectrometry method, and average annual committed effective dose to the adult consumers was determined. No artificial radionuclide was detected. The highest annual committed effective doses of ^{40}K, ^{238}U and ^{232}Th to the consumers of *Vernonia amygdalina* were 0.00133 $mSvy^{-1}$, 0.00147 $mSvy^{-1}$ and 0.00336 $mSvy^{-1}$ respectively. The average annual committed effective dose of the radionuclides to the consumers was 0.00135 $mSvy^{-1}$. The value was below the limit of 0.3 $mSvy^{-1}$ recommended. The consumers of the medicinal plant do not have significant radiological health risk. Furthermore, the results obtained can serve as reference data for future studies in the study area and its environs.

Keywords*:* Dose, Health risk, Medicinal plant, Natural Radionuclide.

INTRODUCTION

Natural radionuclides are elements that are found in the soil and artificial ones are made by man. They are capable of decaying or disintegrating when they attain their half lives. This results to release of huge amount of energy which can be so destructive if not under control. Radionuclides

can be released into the environment as a result of human activities including energy production and military operations such as nuclear weapons testing or caused by nuclear accidents. Some industrial establishments like the phosphate, mining and agricultural activities can also release technologically enhanced naturally occurring radioactive materials into the environment.

One type of industrial activities which is also a potential of naturally occurring radionuclide release into the environment is during cement manufacture. The environmental problem of the cement industry is the release of cement dust. Cement dust has been identified as consisting significant amount of primordial radionuclides of ^{238}U, ^{232}Th and ^{40}K [1]. Cement dust spreads along large areas through wind, rain and others are accumulated in and on soils, plants and animals, and can affect human health adversely [2, 3].

According to Sowole [4], assessment of our environment radiologically is so important in order to ascertain safety of man from radionuclides. Ingestion and inhalation are the main pathways through which natural radinuclides enter into the human body. According to Tawalbeh et al. [5] ingested radionuclides could be concentrated in certain parts of the body. For example, chemical uranium toxicity primarily affects the kidney, causing damage to the proximal tubule, while this metal has also been identified as a potential reproductive toxicant [6]. ^{232}Th causes effect in lungs, liver and skeleton tissues and ^{40}K in muscles. Depositions of large quantities of these radionuclides in particular organs will affect the health condition of the human such as weakening the immune system, induce various types of diseases, and finally increase in mortality rate [5].

There are several sources contributing to plant contamination which can result in direct deposition of radioactive particles from the atmosphere to the surface of the earth which are absorbed by plants through the root system and by recycling are deposited in to the soil. The presence of radionuclides in plants constitutes a pathway for their transfer to man.

The use of herbal plants in treatment of diseases has been in existence in Nigeria before the era of colonization when western medicine was introduced. According to Ayitey-Smith [7], traditional medicine which involves the use of herbal plants evolved from environmental resources, which the people of a community adapted in desperation for survival from disease. On the African continent, traditional medical practices date as far back as 4000 years. It was the sole

medical system for health care before the advent of orthodox or modern medicine. According to W.H.O. [8], up to 80% of persons living in Africa, use traditional medicines, especially herbal medicine for their primary healthcare needs. Even, in developed countries such as the United States, herbal products have seen an increasing level of use and it is now used by approximately 20% of the population [9]. With this, high level of use of herbal medicines in both developed and developing countries has been noticed. For people in developing countries, high dependence on herbal medicine may be due to the ease of accessibility, affordability, availability and acceptability. With developed countries; however, the drive for the use of herbal medicine may stem from the notion that as plants, herbs are natural hence safer [10, 11]. According to the International Food Safety Authorities Network [12], plants used as food commonly have ^{40}K, ^{232}Th and ^{238}U and their progenies. It is expected that similarities would be found in plants used for medicinal purposes since plants are the primary pathway of natural radionuclides entering into the human body through the food chain.

In a variety of concentrations, Naturally Occurring Radioactive Materials (NORMs) have always been present in every part of the earth and in the tissue of all living beings. Natural radionuclides such as ^{238}U, ^{232}Th and ^{40}K can be found almost everywhere; in soil, public water supplies, oil and atmosphere thereby subjecting human beings to reasonable exposure [13]. The role of NORMs in animal and plant metabolism has long been established, but their effect and influence on administration of medicinal plants had received relatively little attention without due regard to possible side effects because they have been perceived to be in smaller quantities. Meanwhile mankind has continually used traditional herbal medicine from medicinal plants for the treatment of various diseases and ailments [14-17]

*Vernonia amygdalina (*VA) identified as 'bitter leaf' [18] due to the fact that it has bitter taste has been shown to be valuable nutritionally. It contains significant quantities of lipids [19] and proteins with essential amino acids [20]. It also contains carbohydrates [21] and carotenoids, though not in large quantities [22]. Also contained in this plant are essential elements such as calcium, iron, protein, potassium, phosphorus, manganese, copper and cobalt [23]. The widespread use of *Vernonia amygdalina* both as food and medicine in the rural communities call for urgent attention in order to effectively exploit the maximum benefits of the plant and to avoid or ameliorate the adverse side effects that may emanate from indiscriminate use of the plant. The leaves of *Vernonia amygdalina* had been used to treat diabetes locally in Nigerian folk medicine

[24]. The aqueous leaf extract of V*ernonia amygdalina* in combination with *Azadirachta indica* leaf extract is the best cure for Type 2 diabetes in Nigeria [25]. The root extract of *Vernonia amygdalina* boosts immune system [26]. Oboh et al. [27] reported that the plant has antibacterial activity. More so, Oyugi et al. [28] reported the plant as effective in the treatment of breast cancer cells and Howard et al. [29] gave the anti - cancer principles in the aqueous extract of the plant by showing that it inhibited the growth of human cancer cells. About 60% methanolic extract of the leaves of *Vernonia amygdalina* gave antimicrobial activity against *Bacillus subtilis, Klebsiella pneumonia, P.aeruginosa*, *Proteus vulgaris, Shigella dysenteriae and S.aureus* [30]. All parts of the plant were pharmacologically suspected to be useful. Both the roots and leaves are used in the treatment of fever, hiccups, kidney disease and stomach discomfort, among others [31, 32]. The plant was claimed to also exhibit anti-helmitic and anti-malaria properties [33] as well as anti-tumourgenic properties [34].

In Nigeria today, the use of herbal medicines for therapeutic purposes has increased drastically due to the fact that medicinal plants are cheap, readily available and widely distributed. Apart from the high cost of procuring available allopathic medicines for treating even common health disorders, other reasons for this shift are inaccessibility of health institutions in the rural or remote locations in the country and growing awareness of adverse reaction to some allopathic drugs. Besides, Nigeria being in the tropics, has forest that are full of cheap, easily available and sustainable medicinal plants which can be used and have always been used for the treatment of various diseases [35].

Herbal medicine in Nigeria of today has taken new dimension due to the fact that the traditional practitioners now go into partnership with pharmacologists and pharmacists in the aspect of effective dosage and preservation. It is a known fact that the drugs being used in orthodox medicine are produced from extracts from herbal plants. More so, pharmacists and pharmacologists seek the knowledge of herbal plants from traditional practitioners. That shows that the use of herbal plants for treatment of diseases has been so effective.

This research work determines the concentrations of the natural radionuclides present in the leaves of *Vernonia amygdalina* medicinal plant and the average annual committed effective dose to the consumers of the leaves or the extracts from the leaves, being the major part of the plant that is commonly used.

MATERIALS AND METHODS

Samples collection and preparation

The fresh leaves of *Vernonia amygdalina*, a shrub were plucked from ten (10) locations at Sagamu, Ogun State in Nigeria. They were kept in different plastic containers and well labeled for easy identification. The samples were thoroughly washed with spring water and rinsed with distilled water in order to prevent contamination of the samples. The leaves were dried for 5 minutes in an oven at 60 ^{o}C to stop enzyme activity [36]. They were then air dried at room temperature to a constant weight and milled to powder form after which they were packed 65.0 g in plastic containers of base diameter 5.0 cm so as to sit comfortably on the NaI (Tl) detector used in this work. The samples were all sealed and kept for 28 days in order to obtain secular equilibrium between radioactive daughter nuclides and their respective progenies.

Experimental analysis

The method of gamma spectrometry was adopted for the analysis of the samples collected in order to obtain data on ^{40}K, ^{238}U and ^{232}Th. The spectrometer used was a Canberra lead shielded 7.6 cm x 7.6 cm NaI (Tl) detector, model Bicron, Canberra, USA. This was coupled to a multichannel analyzer (MCA) through a preamplifier base. The resolution of the detector is about 10% at 0.662 MeV of ^{137}Cs. For the analyses of ^{40}K, ^{238}U and ^{232}Th, the photo peak regions of ^{40}K (1.46 MeV), ^{214}Bi (1.76 MeV) and ^{208}TI (2.615 MeV) were respectively used. The cylindrical plastic containers holding the samples were put to sit on the high geometry 7.6 cm x 7.6 cm NaI (TI) detector. High level shielding against the environmental background radiation was achieved by counting in a Canberra 10 cm thick lead castle. The counting of each sample was done for 10 hrs because of suspected low activities of the radionuclides in the samples. The areas under the photo-peaks of ^{40}K, ^{238}U and ^{232}Th were computed using the Multichannel Analyzer system. The activity concentrations of the radionuclides were calculated based on the efficiency of the detector and the net count rate under each photopeak over a period of 10 hours using equation 1.0 [37].

$$A = \frac{N(E_\gamma)}{\varepsilon(E_\gamma) I_\gamma M t_c} \quad \text{.....Eqn. (1)}$$

Where: N (E_γ) = Net peak area of the radionuclide of interest, $\varepsilon(E_\gamma)$ = Efficiency of the detector for the γ- energy of interest, I_γ = Intensity per decay for the γ- energy of interest, M = Mass of the sample, t_c = Total counting time in seconds (36000 s).

In addition, the annual committed effective dose (ACED) for ingestion of NORMs in medicinal plants is calculated using the expression [38]:

$$ACED = C\ x\ DCF\ x\ CR \quad \text{.....Eqn. (2)}$$

Where:

C = Concentration of each radionuclide, DCF = Dose conversion factors for ingestion of the radionuclides and CR = Consumption rate of intake of NORMs from the medicinal plants

RESULTS AND DISCUSSION

The leaves of *Vernonia amygdalina* had the highest concentration values of ^{40}K to be 86.02 ± 6.35 Bqkg^{-1} which was obtained from VAS_2 while the lowest was from VAS_3 of value 54.69 ± 4.86 Bqkg^{-1}. ^{238}U had the highest concentration value of 13.02 ± 5.34 Bqkg^{-1}from VAS_9, while the lowest was 5.43 ± 2.66 Bqkg^{-1}from VAS_5. Concerning ^{232}Th, the highest concentration was 5.84 ± 1.76 Bqkg^{-1} from VAS_4 while the lowest was 2.24 ± 1.62 Bqkg^{-1}from VAS_9. The mean values were 66.46 ± 6.28, 8.64 Bqkg^{-1} ± 3.92 Bqkg^{-1} and 3.52 ± 1.78 Bqkg^{-1} for ^{40}K, ^{238}U and ^{232}Th respectively, as shown in table 1. The values obtained were lower than those obtained in Ghana [38] and by Chandrashekara and Somashekarappa [39].

Table 1: Activity concentrations of natural radionuclides in leaves of *Vernonia amygdalina* samples

Sample code	**Activity concentration (Bqkg-1)**		
	^{40}K	^{238}U	^{232}Th
VAS_1	65.84 ± 7.24	5.64 ± 2.41	3.65 ± 1.36
VAS_2	86.02 ± 6.35	8.15 ± 3.76	2.86 ± 1.56
VAS_3	54.69 ± 4.86	6.84 ± 2.95	4.25 ± 2.04
VAS_4	75.05 ± 7.92	10.26 ± 4.27	5.84 ± 1.76
VAS_5	62.47 ± 7.49	5.43 ± 2.66	2.26 ± 1.32
VAS_6	58.31 ± 5.04	11.94 ± 4.82	3.71 ± 2.56
VAS_7	61.52 ± 4.92	7.26 ± 3.54	2.82 ± 1.02
VAS_8	80.44 ± 7.25	8.47 ± 4.63	4.16 ± 2.35
VAS_9	56.37 ± 4.69	13.02 ± 5.34	2.24 ± 1.62
VAS_{10}	63.86 ± 7.05	9.38 ± 4.78	3.44 ± 2.16
Range	**54.69 - 86.02**	**5.43 - 13.02**	**2.24 - 5.84**
Mean	**66.46 ± 6.28**	**8.64 ± 3.92**	**3.52 ± 1.78**

VAS represents *Vernonia amygdalina* sample

No artificial radionuclide was detected in all the samples collected indicating that the mining of limestone activities do not contribute to radiological pollution of the medicinal plant of the study area. The highest ACED as shown in table 2 and figure 1 of ^{40}K, ^{238}U and ^{232}Th to the consumers of *Vernonia amygdalina* were obtained as 0.00133 $mSvy^{-1}$, 0.00147 $mSvy^{-1}$ and 0.00336 $mSvy^{-1}$ respectively. The mean values of ACED for ^{40}K, ^{238}U and ^{232}Th were 66.46 ± 6.28 $mSvy^{-1}$, 8.64 ± 3.92 $mSvy^{-1}$and 3.52 ± 1.78 $mSvy^{-1}$ respectively. Average annual committed effective dose of all the radionuclides (AACED) to the consumers was 0.00135 $mSvy^{-1}$. The values were lower than those obtained by Lordford et al., Chandrashekara and Somashekarappa, and Sowole et al. [38- 40]. Furthermore, the values were below the average recommended limit of 0.3 $mSvy^{-1}$ [41] for ingestion of natural radionuclides.

Table 2: Calculated annual committed effective dose of natural radionuclides from *Vernonia amygdalina* to consumers

Sample code	**^{40}K ACED ($mSvy^{-1}$)**	**^{238}U ACED ($mSvy^{-1}$)**	**^{232}Th ACED ($mSvy^{-1}$)**
VAS_1	0.00102	0.00064	0.00220
VAS_2	0.00133	0.00092	0.00165
VAS_3	0.00085	0.00077	0.00244
VAS_4	0.00116	0.00115	0.00336
VAS_5	0.00097	0.00061	0.00130
VAS_6	0.00090	0.00134	0.00213
VAS_7	0.00095	0.00082	0.00162
VAS_8	0.00125	0.00095	0.00239
VAS_9	0.00087	0.00147	0.00129
VAS_{10}	0.00099	0.00106	0.00198
Mean	**0.00103**	**0.00097**	**0.00204**

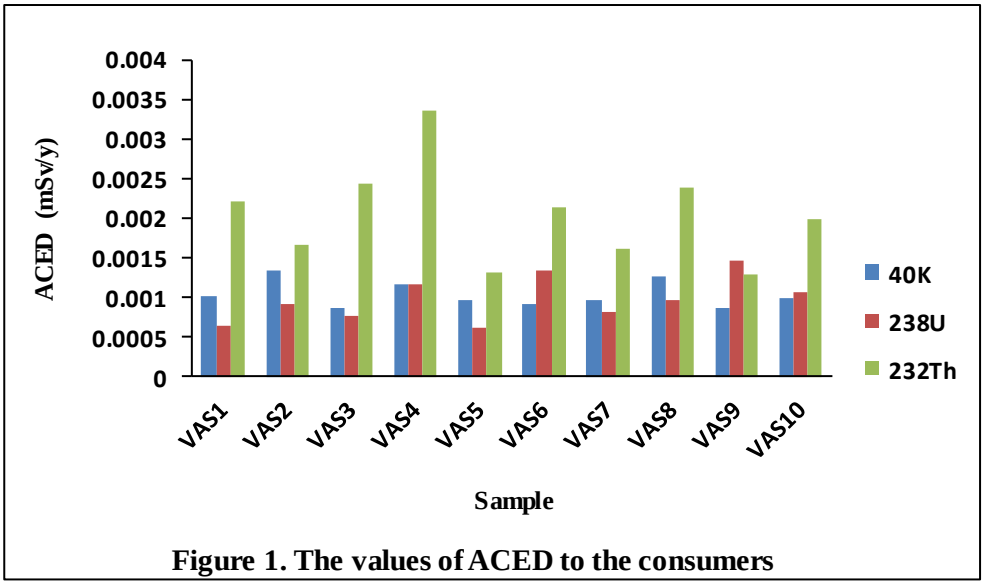

Figure 1. The values of ACED to the consumers

All the values obtained showed that the consumers of the medicinal plant were radiological term safe with reference to the intake of the natural radionuclides through the medicinal plant.

CONCLUSION

This research work has shown the safety of the use of *Vernonia amygdalina* as one of very important and effective herbal plants radiologically to the consumers at Sagamu, southwest, Nigeria. The consumers of the medicinal plant do not have significant radiological health risk [41]. The results obtained can serve as reference data for future studies in the study area and its environs.

REFERENCES

[1] Mujahid, S. A., Rahim, A., Hussain, S. & Farooq, M. (2007). Measurement of radioactivity and radon inhalation rates of different brands of cement used in Pakistan, *Radiation Protection Dosimetry*, 130 (2), 206- 212.

[2] Bayhan, Y. K. & Özbay, O. (2006). Cadmium exposure from the cement dust emissions: a field study in a rural residence, *Chemosphere*, 63, 1546-1552.

[3] Demir, T. A., Isikli, B., Urer, S. M., Berber, A., Akar, T., Canbek, M. & Kalyoncu, C. (2005). Nickel exposure and its effects, *Biometal*, 18, 7-13

[4] Sowole, O. (2014). Assessment of radiological hazard indices from surface soil to individuals from major markets at Sagamu Ogun State, Nigeria**,** *Science World* Journal, 9 (3),1 - 4.

[5] Tawalbeh, A. A., Samat, S. B., Yasir, M. S. & Omar, M. (2012). Radiological impact of drinks intakes of naturally occurring radionuclides on adults of central zone of Malaysia, *Malaysian Journal of Analytical Sciences*, 16 (2), 187 – 193.

[6] Linares, V., Bellés, M., Albina, M. L., Sirvent, J. J., Sánchez, D. J. & Domingo, J. L. (2005). Assessment of the pro-oxidant activity of uranium in kidney and testis of rats, *Toxicology Letters*, 167, 152-161.

[7] Ayitey-Smith, E. (1989). Prospects and scope of plant medicine in health care. Ghana Universities Press, Accra, 1-2.

[8] WHO (World Health Organization). (2002). Traditional medicine strategy 2002 – 2005. WHO/EDM/TRM/2002 1. Geneva.

[9] Bent, S. (2008). Herbal medicine in the United States: Review of efficacy, safety and regulation, *Journal of General Internal. Medicine*, 23, 854-859.

[10] Ernst, E. (1998). Harmless herbs? A review of the recent literature, *American Journal of Medicine*, 104, 170-178.

[11] Tamuno, I. (2011). Traditional medicine for HIV infected patients in anti retroviral therapy in a tertiary hospital in Kano, North West, Nigeria, *Asian Pacific Journal of Tropical Medicine*, 4, 152-155.

[12] INFOSAN (International Food Safety Authorities Network). (2011). Information on nuclear accidents and radioactive contamination of foods. Geneva

[13] Varier, M. K. (2009). Nuclear radiation detection: Measurements and analysis. New Delhi, India: Narosa Publishing House.

[14] Odugbemi, T. (2006). Outlines and pictures of medicinal plants from Nigeria. Akoka, Yaba-Lagos, Nigeria: University of Lagos Press. 158.

[15] Odugbemi, T., & Akinsulire, O. (2008). Medicinal plants species, family names and uses. In T. Odugbemi (Ed.), A textbook of medicinal plants from Akoka, Yaba-Lagos, Nigeria: University of Lagos Press, Nigeria. 541- 608.

[16] Okoli, R. I., Aigbe, O., Ohaju-Obodo, J. O. & Mensah, J. K. (2007). Medicinal herbs used for managing some common ailments among Esan People of Edo State, Nigeria, *Pakistan Journal of Nutrition*, 6(5), 490 - 496.

[17] Oladipo, M. O. A., Njinga, R. L., Baba, A., & Muhammad, H. L. (2012). Evaluation of trace elements in some Northern-Nigeria traditional medicinal plants using INAA technique, *Applied Radiation and Isotopes*,70, 917 -921.

[18] Ekpo A., Eseyin O. A., Ikpeme A. O. & Edoho, E. J. (2007). Studies on some biochemical effects of *Vernonia amygdalina* in rats, *Asian Journal of Biochem*istry, 2, 193-197.

[19] Ejoh, R. A., Nkonga, D. V., Innocent, G. & Moses, M. C. **(**2007). Nutritional components of some non-conventional leafy vegetables consumed in Cameroun, *Pakistan Journal of Nutrition*, 6, 712-714

[20] Igile, G. O., Oleszek, W. I., Jurysta, M. R., Burda, S. I., Farifunso, M. E. & Fansanmade, A. A. **(**1994). Flavonoids from *Vernonia amygdalina* and their antioxidant activities, *Journal of Agricultural and Food Chemistry*, 42, 2445-2448.

[21] Eleyinmi, A. F., Sporns, P. & Bressler, D. C. **(**2008). Nutritional composition of *Gongronem alatifolium* and *Vernonia amygdalina*, *Nutrition and Food Science*, 38, 99-109.

[22] Udensi, E., Ijeh, I. & Ogbonna, U. **(**2002). Effect of traditional processing on the phytochemical and nutrient composition of some local Nigerian leafy vegetables, *Journal of Science and Technology*, 8, 37-40.

[23] Bonsi, M. L., Osuji, P. O., Tuah, A. K. & Umunna, M. N. (1995). *Vernonia amygdalina* as a supplement of teff straw (Eragrostis tef) fed to Ethopian Menz sheep, *Agroforestry Systems*, 31(3), 229-241.

[24] Kar A. Choudhary B. K. & Bandyopadhyay N. G. (2003). Comparative evaluation of hypoglycaemic activity of some Indian medicinal plants in alloxan diabetic rats, *Journal of Ethnopharmacology*, 84, 105 - 108.

[25] Eyong, E. U., Atangwho, I. J., David-Oku, E., Agiang, M. A. & Ebong, P. E. (2011). Haematological and immunological effect of co-administration of extracts of *Vernonia amygdalina* and *Azadirachta indica* on normal and diabetic rats, *African Journal of Biotechnology*, 10 (50), 10258-10262.

[26] Eyo, J. E. , Nwachukwu, L. O., Onah, I. E., Atama, C. I., Ekeh, F. N., Ezenwaji, N. E. & Ivoke, N. (2013). Effects of the Aqueous Root Extract of *Vernonia amygdalina*onthe

haematological profile of *Rattus norvegicus*, *Advances in Life Science and Technology*, 11, 19 – 24

[27] Oboh, G., Raddatz, H. & Henle, T. (2008). Antioxidant properties of polar and non polar extracts of some tropical green leafy vegetables, *Journal of the Science of Food and Agric*ulture, 88 (14), 2486–2492.

[28] Oyugi, D. A., Luo, X., Lee, K. S., Hill, B. & Izevbigie, E. B. (2009). Activity markers of the anti-breast carcinoma cell growth fractions of *Vernonia amygdalina* extracts, *Proceedings of the Society for Experimental Biology and Medicine* Doi: 10.3181/0811-RM-325.

[29] Howard, C. B., Izevbigie, E. B. & Opata, M. M. (2006). Inhibition of paclitaxel- resistant MCF-7 Rag cell growth by *Vernonia amygdalina* extract. 1st AACR *International Conference on Molecular Diagnostics in Cancer Therapeutics Development*. September, 12-15.

[30] Akinpelu, D. A. (1999). Antimicrobial activity of *Vernonia amygdalina* leaves, *Fitoterapia*, 70, 432-434.

[31] Gill, L. S. (1992). Ethnomedical uses of plants in Nigeria. University of Benin press, Benin City, Nigeria.

[32] Hamowia, A. M. & Saffaf, A. M. (1994). Pharmacological studies on *Vernonia amygdalina* (Del) and Tithonia diversifolia (gray), *Veterinary Medicine Journal*, 2, 91- 97.

[33] Abosi, A. O. & Raseroka, B. H. (2003). In vivo antimalarial activity of *Vernonia amygdalina*, *British Journal of Biomedical Science*, 60 (20), 89-91. http://personal.ph.surrey.ac.uk/~phs1pr/msc_dissertations/msc-diss-2008/fuad-ali-msc-diss-NORM-2008.pdf

[34] Izevbigie, E. B., Bryant, J. L. & Walker, A. (2004). A novel natural inhibitor of extra cellular signal related kinases and human breast cancer cell growth, *Experimental Biology Medicine*, 228, 293–298

[35] Oni, O. M., Isola, G. A., Oni, F. G. O. & Sowole, O. (2011). Natural activity concentrations and assessment of radiological dose equivalents in medicinal plants around oil and gas facilities in Ughelli and environs, Nigeria, *Canadian Center of Science and Education*, 1, 201 - 206.

[36] Effraim, K. D., Salami, H. A., & Osewa, T. S. (2000). The effect of aqueous leaf extract of *Ocimum gratissimum* on haematological and biochemical parameters in rabbits, *African Journal of Biomedical Res*earch, 175-179.

[37] IAEA (International Atomic Energy Agency), (1989). Measurements of radionuclides in food and the environment – A Guidebook. STI/DOC/10/295 IAEA Vienna.

[38] Lordford, T., Emmanuel, O. D., Cyril, S. & Alfred, A. A. (2013). Natural radioactivity levels of some medicinal plants commonly used in Ghana, *Springer Plus*, 2, 157

[39] Chandrashekara, K. & Somashekarappa, H. M. (2016). Estimation of radionuclides concentration and average annual committed effective dose due to ingestion for some selected medicinal plants of South India, *Journal of Radiation Research and Applied Sciences*, 9, 68 – 77

[40] Sowole, O. Olaniyi, O. E. & Amodu, F. R. (2020). Evaluation of primordial radionuclides in *Ocimum gratissimum* and health risk to the consumers at Ewekoro Southwest of Nigeria, *Journal of Applied Science and Environmental Management*, 24(2), 367 – 372.

[41] UNSCEAR (United Nations scientific Committee on the Effects of Atomic Radiation), (2000). Sources and effects of ionizing radiation. New York. United Nations.