WWJMRD 2018; 4(7): 55-66
www.wwjmrd.com
International Journal
Peer Reviewed Journal
Refereed Journal
Indexed Journal
Impact Factor MJIF: 4.25
E-ISSN: 2454-6615

T.S Magili
Department of Pure and Applied Chemistry, Adamawa State University, Mubi, Nigeria

I.B Bwatanglang
Department of Pure and Applied Chemistry, Adamawa State University, Mubi, Nigeria

Correspondence:
I.B Bwatanglang
Department of Pure and Applied Chemistry, Adamawa State University, Mubi, Nigeria

Determination of Natural Radioactive and Trace elements in Some Selected Anti-diabetic Medicinal Plants in Adamawa State, Nigeria Using Instrumental Neutron Analysis

T.S Magili, I.B Bwatanglang

Abstract
The accumulations of trace elements and radionuclides in ten (10) anti-diabetic medicinal plants commonly used in Adamawa state, Nigeria were investigated to ascertain their distribution in the leaves, stem bark and roots bark samples respectively using INAA. The results of the analysis indicated the presence of traceable amount of both the non-radioactive elements (Al, As, Ba, Rb, Sc, Sr and V) and the following radioactive element (Eu, La, Lu, Sm, Th, U, and Yb) in the plants species. From the results, the elements with the highest concentration distribution are Al and the least distributed element is as. The highest concentration of Al (14560±146 mg/kg) was found in the root bark sample of *Ageratum conyzoides* with the leave sample of *Anogeissus leiocarpus* containing the highest amount of As (0.500±0.10 mg/kg). Analysis of the radioactive materials though, below the risk impact levels showed La in virtually all the plants species and widely distributed in all the plant tissues, with the highest concentration recorded in the leaves sample of *Daniellia oliveri* (1096±24.0 mg/kg). The results further shows the presence of small amount of U in only few of the plants species with the highest concentration recorded in the stem bark sample of *Balamites aegyptiacae* (0.47±0.0 mg/kg). Base on the outcome of this study, the distribution and accumulation of the trace element and radionuclides in the selected anti-diabetic medicinal plants will provides useful insight to the immediate community that relied on these plants for the treatment and management of diabetes mellitus to make an inform decision in the choice of plant tissue while being mindful of possible toxic related effects of other non-essential element in the medicinal plants.

Keywords: Anti-diabetic**,** Medicinal plants, Natural radionuclide, Trace element, Diabetes mellitus, INNA, Radioactive elements

1. Introduction
Statistically, about 387 million people globally are reported to be diabetic [1]. Based on this record, diabetes mellitus (DM) is projected to take the 7th position in global dead related diseases by 2030 [2]. This projection is feasible considering the leap experienced from 1985 to 2006. In 1985, about 30 million reported cases was filed and by the end of 2006, the values was observed to have grown exponentially to about 230 million, with about 80% of the reported cases emanating from developing economies [3-5]. The scary part is that, out of the world 7 billion population, about 366 million adults are estimated to have DM [6], gulping at least USD 465 billion in total health expenditure [5,7,8]. International diabetes federation (IDF) 2010, reported a prevalence estimate of 3.9% for Nigeria [6], a value not far from the prevalence rate of 4.9% reported by Akinkugbe, [9]. This indicated that, the implementation of the health policy programs has little or insignificant impact towards slowing down the prevalence rate.
These projections have left a scary picture thus, putting pressure towards research and innovations in the treatment and management DM. In addition to the control dieting and physical activities [10], holistic approaches in the treatment and management of diabetes often required regimentary application of both insulin and oral hypoglycemic drugs [11, 12]. However, despite the progress made pharmacologically, a hole is still left open considering

the fact that these conventional drugs in addition to being rarely available are far beyond the reach of an ordinary patient. For that purpose, search for complimentary medicine has shifted emphases into plant-based therapy for DM and its complications.

Nature by it very definition has provided reservoirs of plants species with active anti-diabetic properties [13, 14]. Based on this vast pools of plants species, over 400 species are already identified to possess hypoglycemic properties [15]. The hypoglycemic properties are reported to be actively potentiated by the available micro and macro nutrient in the plants [11, 16]. Several studies reported a direct link between macro and trace elements in the control and management of insulin action on reducing blood glucose level [11, 17], found to be embedded in medicinal herbs use for the treatment of DM [11, 18, 19]. Based on this findings, we report in our previous study, the presence of macro and micro nutrient in some selected plants species widely used in Adamawa state, Nigeria for the treatment and management of DM [20, 21]. The investigation using INAA revealed the presence of macro elements (Ca, K, Mg; Na) and micro elements (Cl, Co, Cr, Fe, Mn, Zn), and as the order of preference revealed, the most potent source of these nutrient with respect to their plant tissues are reported to further highlight the importance of these elements in potentiating insulin metabolic activity.

As interesting as these finding entails, the availability of essential elements in plant tissues also point to the possibility of other trace elements or radionuclide that may or may not have a direct positive impact health wise. Various trace (Al, As, Ba, Rb, Sc, Sr and V,) and radioactive (Eu, La, Lu, Sm, Th, U, and Yb) elements are component of the ecosystem and thus, these element are taking up by plants same way the aforementioned essential nutrients are absorbed [22, 23]. Radioactive materials and their progeny are found in nature in the soil, originated from the earth's crust [23]. Thus, the long-lived naturally occurring radionuclide (NRN) present in the soil may find their way into the plant by absorption and translocation into plant tissues same way as other nutrient elements [24].

Therefore, this present study is intended to provide useful information on the safety and potency of anti-diabetic medicinal plants by investigating the specific activity concentrations of some trace elements such as Al, As, Ba, Rb, Sc, Sr and V, and radionuclide (Eu, La, Lu, Sm, Th, U, and Yb) in the leaves, stem bark and root bark samples of species commonly used in Adamawa state. And relate the outcome to their toxic potential and radiological risk associated with the use of these medicinal plants. The determination of these trace and radioactive elements is necessary as suggested by World Health Organisation to evaluate safety of such medicinal plants as well as their efficacy and potency [25].

2. Materials and Methods

2.1 Sampling and Sample Preparations

Ethno-botanical characteristics of the selected plants often used traditionally in Nigeria as remedy for the treatment and management of DM informed the choice of the respective plants. The leaf, stem back and root bark samples of the selected medicinal plants as presented in Table 1 were collected from Mubi North, Mubi South and Maiha Local Government Areas of Adamawa State, Nigeria. Following the sampling, the respective plants were fully authenticated by Mr. Jarafu U. Mamza, from the Department of Botany, Adamawa State University, Mubi, Nigeria and a voucher specimen samples deposited accordingly. Based on the same protocols described by Magili *et al*, [20], the dried powdered samples of the plants tissues for each plants species were respectively sieved using 2 mm mesh and homogenized prior to the elemental analysis using INAA. For the INAA analysis, about 250 mg to 300 mg of the respective plant samples were heat-sealed and processed following same methods adapted in our previous work [20, 21].

Table 1: List of the Selected Medicinal Plant used in the investigation

S/No.	Botanical name	Family name	Common name	Local name (Hausa)	Parts used.	Abbreviation used
1.	*Terminalia avicennioides*	*Combretaceae*	*Terminaliadictyonum adiels*	*Baushe*	Roots, stem bark and leaves	TA
2.	*Hymenocadia acida*	*Hymenocadiacese*	*Red onion*	*Janyaaro*	Roots, stem bark and leaves	HA
3.	*Leptadenia Hastata*	*Asclepiadaceae*	*Cyandumhastatum*	*Dan barawo*	Roots, stem bark and leaves	LA
4.	*Balamites aegyptiacae*	*Balanitiaceae*	*Soapberry tree*	*Aduwaa*	Roots, stem bark and leaves	BA
5.	*Ageratum conyzoides*	*Asteraceae*	*White weed, Billi-Goat weeds*	*Gwiwan jimina*	Roots, stem bark and leaves	AC
6.	*Sclerocarya birrea*	*Anacaardiaceae*	*Spondias birrea*	*Daniya/Lule/Nunu*	Roots, stem bark and leaves	SB
7.	*Anogeissus leiocarpus*	*Combretaceae*	*African birch*	*Markee*	Roots, stem bark and leaves	AL
8.	*Jatropha gossypiifolia*	*Euphorbiaceae*	*Wild cassada*	*Zugu*	Roots, stem bark and leaves	JG
9.	*Daniellia oliveri*	*Caesalpinioideae*	*Paradaniellia oliveri*	*maje*	Roots, stem bark and leaves	DO
10.	*Sarcocephalus*	*Rubiaceae*	*Nauclea latifolia*	*tafashiya*	Roots, stem bark	SL

	latifolius				and leaves	

2.2 Elemental Analysis of the Anti-diabetic Medicinal Plants using INAA

The elemental analysis was conducted using the Nigerian Research Reactor-1 (NIRR-1) facility at the center for energy research and training ABU Zaria. For the analysis, reference material SRM NIST-1547 (Peach leaves) were used for quality control test and quantitative analyses. And the analytical values obtained were equally compared with the actual values in mg/kg according to the method described in our previous study [21]. The protocols for sample irradiation were performed in two irradiations stages. The first irradiation was designed to capture short half-life radionuclide while, the second irradiation was designed to capture the long half-life radionuclide [26-28]. Following the various irradiation regime, the retrieved irradiated samples were then collected for the identification of various radionuclide concentration using gamma ray spectrum analysis software (WINSPAN 2004) [29], software developed at CIAE, Beijing, China

2.3 Statistical Analysis

The obtained results were presented as mean ± SD (standard deviation). All differences are considered significant at $p<0.05$ using Analyse-it (version 2.3). Significant elemental concentration differences in plants samples were determined by analysis of variance (ANOVA).

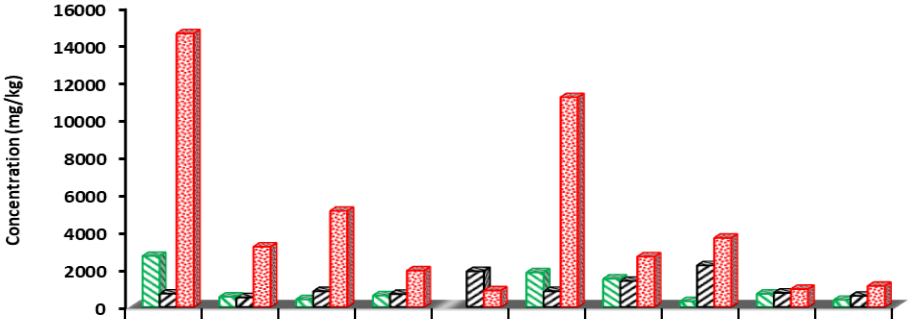
3. Results

3.1Non-essential Elements in Anti-diabetic Medicinal Plant Samples

Based on the results presented in Fig.1, Aluminum (Al) was observed to be present in all the samples analyzed, except in the leave samples of *Hymenocardia acida*. The highest concentration was recorded in the leave samples of *Ageratum conyzoides* (2705±30 mg/kg), with the least concentrations recorded in the leave sample of *Sarcocephalus latifolius* (290±5 mg/kg), with variability coefficient of 81%. The results revealed significant ($P<0.05$) differences between all pairwise concentrations in the leaves samples, except between *Terminalia avicennioides vs Balanites aegytiacae* and *Anogeissus leiocarpus vs Daniellia oliveri*. Further, the concentration of Al in the stem bark samples was highest in *Sarcocephalus latifolius* (2205±22 mg/kg) and least in *Anogeissus leiocarpus* (498±18 mg/kg), with variability coefficient of 55%. The results revealed significant ($P<0.05$) differences between all pairwise concentrations except between *Balanites aegytiacae vs Jathropha gossypiifolia, Ageratum conyzoides vs Sclerocarya birrea* and *Ageratum conyzoides vs Daniellia oliveri*.

The results of the study further shows highest concentration of Al in the root bark sample of *Ageratum conyzoides* (14560±146 mg/kg) and least amount in *Hymenocardia acida* (864±39 mg/kg), with a variability coefficient of 99.6%. The results revealed significant ($P<0.05$) differences between all pairwise concentrations except between *Terminalia avicennioides vs Hymenocardia acida, Terminalia avicennioides vs Sclerocarya birrea* and *Hymenocardia acida vs Sclerocarya birrea.*

On the average, the order of Al concentrations distribution were observed to followg the ranking, root bark>stem bark>leaves. Furthermore, the concentration of Al in all the plants parts showed that *Sarcocephalus latifolius*, contained the least (290.0±5.0 mg/kg) while *Ageratum conyzoides* (14560.0±146 mg/kg) was highest.

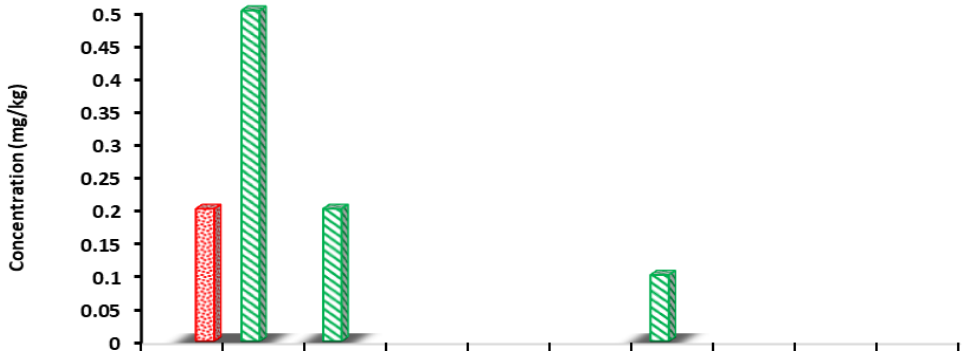


	AC	AL	BA	DO	HA	JG	LH	SL	SB	TA
Leaves	2705	531	398	599.3	BDL	1829	1494	290	691	363
Stem Bark	695	498	825	677	1892	832	1373	2205	744	580
Root Bark	14560	3195	5109	1925	864	11160	2671	3665	941	1107

Fig. 1: Analysis of Tissues Samples of Anti-diabetic Medicinal Plants showing the Concentrations of Aluminum. The results are presented as Mean±SD of three replicate analysis. Where "BDL" signified below detection limit.

Figure 2, shows the distribution of Arsenic (As) in the leave, stem bark and root bark samples of the anti-diabetic medicinal plants. The concentration of As was highest in the leave of *Anogeissus leiocarpus* (0.500±0.10 mg/kg) and least in *Ageratum conyzoides* (0.047±0.014 mg/kg), with variability coefficient of 95%. Arsenic was not detected in the leave samples of *Daniellia oliveri, Hymenocardia acida, Jathropha gossypiifolia, Sarcocephalus latifolius, Sclerocarya birrea* and *Terminalia avicennioides*, but the results revealed significant ($P<0.05$) differences between the pairwise concentrations in four leaves samples except between *Leptadenia hastata vs Balanites aegytiacae, Leptadenia hastata vs Ageratum conyzoides* and *Balanites aegytiacae vs Ageratum conyzoides*. The stem bark concentration of As was detected only in *Sarcocephalus latifolius* (0.0310±0.009 mg/kg). Similarly, the concentration of As was detected only in root bark samples of three species, the *Ageratum conyzoides* (0.1600±0.02 mg/kg), *Sarcocephalus latifolius* (0.0380±0.011 mg/kg) and *Terminalia avicennioides* (0.0200±0.01 mg/kg), with a

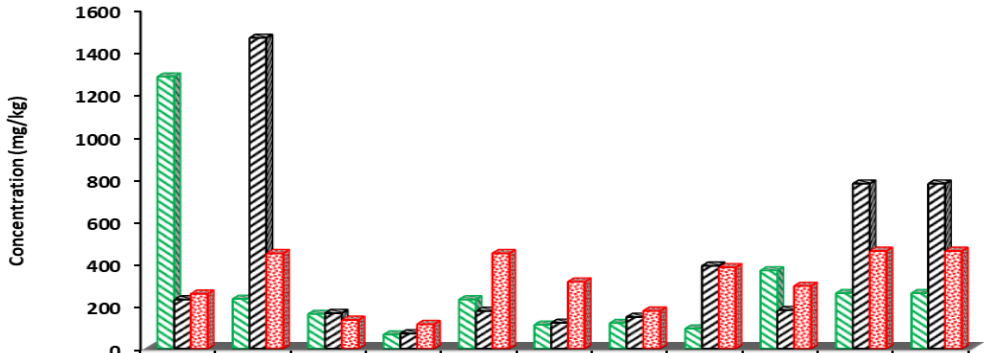
variability coefficient of 92.4%. The results revealed significant (P<0.05) differences between pairwise concentrations in the plants samples except between *Terminalia avicennioides vs Sarcocephalus latifolius.* On the average, the order of As concentrations distribution was observed to follow the pattern, leaves> root bark>stem bark. And further showed that Sclerocarya *birrea* contained the least while, *Anogeissus leiocarpus* (0.5±0.1mg/kg) was highest.



	AC	AL	BA	DO	HA	JG	LH	SL	SB	TA
Leaves	BDL	0.5	0.2	BDL	BDL	BDL	0.1	BDL	BDL	BDL
Stem Bark	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Root Bark	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Fig. 2: Analysis of Tissues Samples of Anti-diabetic Medicinal Plants showing the Concentrations of Arsenic. The results are presented as Mean±SD of three replicate analysis. Where "BDL" signified below detection limit.

The distribution of Barium (Ba) in the leave, stem bark and root bark samples of the anti-diabetic medicinal plants are presented in Figure 3. The results showed that Ba was present in all the samples analyzed. The concentrations in the leave was highest in *Ageratum conyzoides* (1280±12 mg/kg) and least in *Daniellia oliveri* (65.0±17.0 mg/kg), with variability coefficient of 119%. The results revealed significant (P<0.05) differences between the pairwise concentrations in more than 60% of the leaves samples. The concentration of Ba in the stem bark samples was higher in *Anogeissus leiocarpus* (230.0±16.0 mg/kg) and least in *Daniellia oliveri* (70.0±14.0 mg/kg), with variability coefficient of 113%. The results revealed significant (P<0.05) differences between the pairwise concentrations in more than 60% of the stem bark samples. Furthermore, the concentration in the root bark samples was observed to be higher in *Terminalia avicennioides* (459±16 mg/kg) and lowest in *Daniellia oliveri* (114±14 mg/kg), with a variability coefficient of 42.1%. The results revealed significant (P<.05) differences between the pairwise concentrations in more than 70% of the root bark samples. The order of concentrations distribution was observed to follow the ranking, stem bark> root bark>leaves.



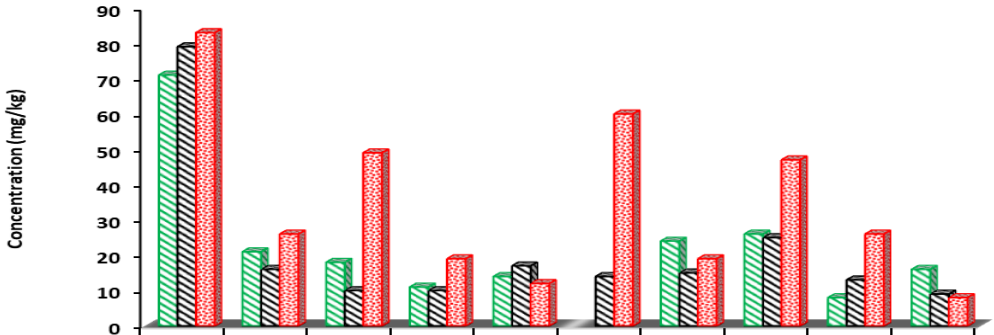
	AC	AL	BA	DO	HA	JG	LH	SL	SB	TA	TA
Leaves	1280	233	162	65	230	111	119	93	367	260	260
Stem Bark	230	1463	166	70	176	120	148	389	180	776	776
Root Bark	257	448	134	114	448	314	177	382	294	459	459

Fig. 3: Analysis of Tissues Samples of Anti-diabetic Medicinal Plants showing the Concentrations of Barium. The results are presented as Mean±SD of three replicate analysis.

The distribution of Rubidium (Rb) in the leave, stem bark and root bark samples of the anti-diabetic medicinal plants investigated are presented in Figure 4. With the exception of the tissues samples of *Jathropha gossypiifolia*, the results showed Rb detected in all the samples analyzed.

The concentration of Rb was highest in the leave of *Ageratum conyzoides* (71.0±3.0 mg/kg) and least in *Daniellia oliveri* (8.0±2.0 mg/kg), with variability coefficient of 78%. The results revealed significant (P<0.05) differences between the pairwise concentrations in more than 60% of the leave samples. The stem bark concentration of Rb was highest in *Ageratum conyzoides* (79.0±3.0 mg/kg) and least in *Terminalia avicennioides* (9.5±1.4 mg/kg), with variability coefficient of 97%. The results revealed significant (P<0.05) differences between pairwise concentrations in only about 45% of the stem bark

samples. Furthermore, the concentration of Rb in the root bark sample was observed to be higher in *Ageratum conyzoides* (83.2±2.8 mg/kg) and lowest in *Terminalia avicennioides* (8.0±1.0 mg/kg), with a variability coefficient of 67%. The results revealed significant (P<0.05) differences between pairwise concentrations in about 80% of root bark samples. On the average, the order of Rb concentrations distribution followed the ranking, root bark>leaves >stem bark.



	AC	AL	BA	DO	HA	JG	LH	SL	SB	TA
Leaves	71	21	18	11	14	BDL	24	26	8	16
Stem Bark	79	16	10	10	17	14	15	25	13	9
Root Bark	83	26	49	19	12	60	19	47	26	8

Fig. 4: Analysis of Tissues Samples of Anti-diabetic Medicinal Plants showing the Concentrations of Rubidium. The results are presented as Mean±SD of three replicate analysis. Where "BDL" signified below detection limit

The distribution of Scandium (Sc) in the leave, stem bark and root bark samples of the anti-diabetic medicinal plants are presented in Figure 5. From the figure, Sc was detected in all the samples analyzed. The concentration of Sc was observed to be higher in the leave sample of *Sarcocephalus latifolius* (457.0±84.0 mg/kg) and least in *Daniellia oliveri* (0.060±0.01 mg/kg), with variability coefficient of 308%. The results revealed significant (P<0.05) differences between pairwise concentrations in only about 30% of the leaves samples. The concentration in the stem bark was equally observed to be higher in *Sarcocephalus latifolius* (0.390±0.01 mg/kg) and least in *Anogeissus leiocarpus* (0.080±0.01 mg/kg), with variability coefficient of 60.4%. The results revealed significant (P<0.05) differences between pairwise concentrations in more than 75% of stem bark samples.

Furthermore, the results shows the highest concentration of Sc in the root bark sample of *Jathropha gossypiifolia* (76.0±2.0 mg/kg) and lowest in *Hymenocardia acida* (0.084±0.012 mg/kg), with a variability coefficient of 198%. The results revealed significant (P<0.05) differences between pairwise concentrations in only about 40% of the root bark samples. On the average, the order of Sc concentrations distribution was observed to follow the ranking, leaves > root bark>stem bark. The concentrations of Sc in plants parts showed that *Anogeissus leiocarpus, Balanites aegytiacae, Terminalia avicennioides,Sclerocarya birrea and Daniellia oliveri* contained the lowest concentration, while *Sarcocephalus latifolius* is the highest.

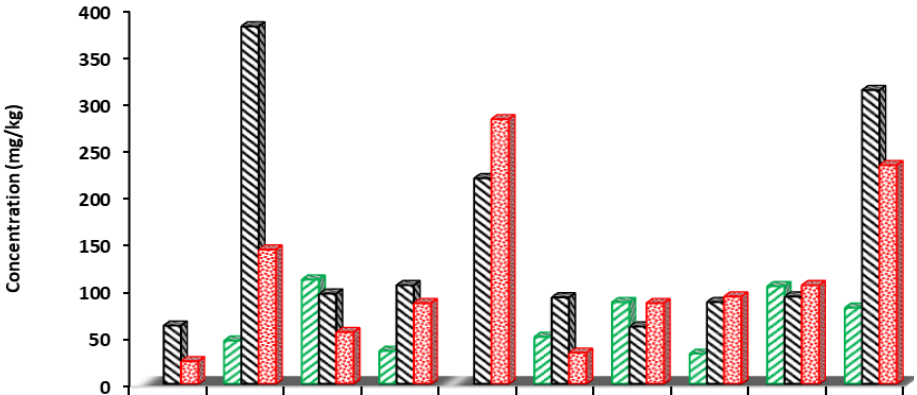
	AC	AL	BA	DO	HA	JG	LH	SL	SB	TA
Leaves	0.4	0.1	0.1	0.1	0.3	0.2	0.2	457	0.1	0.1
Stem Bark	0.2	0.1	0.1	0.1	0.3	0.2	0.2	0.4	0.1	0.1
Root Bark	1.5	0.5	0.7	0.3	0.1	76	0.2	71	0.1	0.2

Fig. 5 Analysis of Tissues Samples of Anti-diabetic Medicinal Plants showing the Concentrations of Scandium. The results are presented as Mean±SD of three replicate analysis.

The results in Fig.6, shows the distribution of Strontium (Sr) in the leave, stem bark and root bark samples of the anti-diabetic medicinal. With the exception of the leave samples of *Ageratum conyzoides* and *Hymenocardia acida*, Sr was detected in all other tissue samples analyzed. The highest concentration was recorded in the leave sample of *Balanites aegytiacae* (111.0±7.0 mg/kg) and least in *Sarcocephalus latifolius* (32.0±6.0 mg/kg), with a variability coefficient of 45%. The results showed significant (P<0.05) differences between pairwise concentrations in more than 70% of leave samples. Likewise, the results showed significant concentration of Sr in the stem bark samples of *Anogeissus leiocarpus* (381.0±10.0 mg/kg) and least in the sample of *Leptadenia*

hastata (61.0±6.0 mg/kg), with variability coefficient of 73%. With significant (P<0.05) differences between pairwise concentrations in about 70% of the stem bark samples.

The concentration in the root bark samples was observed to be higher in *Hymenocardia acida* (282.0±18.0 mg/kg) and lowest in *Ageratum conyzoides* (24.0±8.0 mg/kg), with a variability coefficient of 71%. The results revealed significant (P<0.05) differences between pairwise concentrations in about 80% of root bark samples. On the average, the order of Sr concentrations distribution was observed to follow the ranking, stem bark> root bark>leaves.



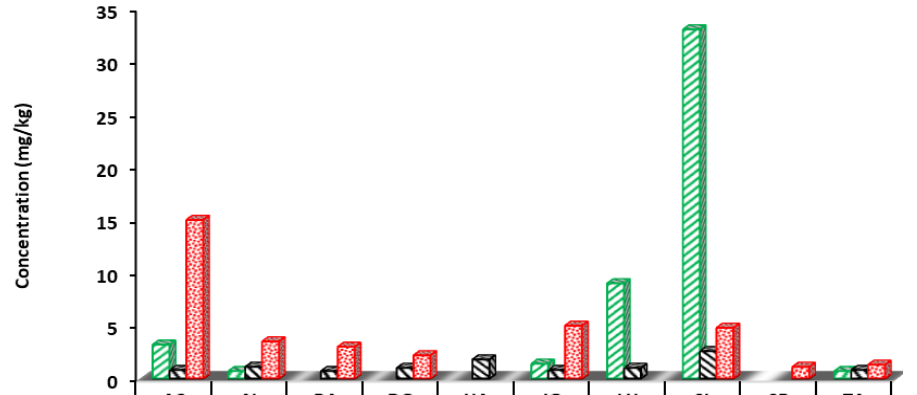
	AC	AL	BA	DO	HA	JG	LH	SL	SB	TA
Leaves	BDL	46	111	35	BDL	50	87	32	104	81
Stem Bark	62	381	96	105	219	92	61	87	93	313
Root Bark	24	143	55	86	282	33	86	93	105	233

Fig. 6: Analysis of Tissues Samples of Anti-diabetic Medicinal Plants showing the Concentrations of Strontium. The results are presented as Mean±SD of three replicate analysis. Where "BDL" signified below detection limit.

The distribution of Vanadium (V) in the leave, stem bark and root bark samples of the anti-diabetic medicinal plants is presented in Fig 7. The concentration was highest in the leave samples of *Sarcocephalus latifolius* (33.0±6.0 mg/kg) and lowest in *Anogeissus leiocarpus* (0.68±0.15 mg/kg), with variability coefficient of 186%. Vanadium was not detected in the leave samples of *Balanites aegytiacae*, *Daniellia oliveri*, *Hymenocardia acida* and *Sclerocaryabirrea*, but the results showed significant (P<0.05) differences only between pairwise concentrations of the leave samples of *Leptadenia hastata vs Sarcocephalus latifolius*, *Terminalia avicennioides vs Sarcocephalus latifolius*, *Ageratum conyzoides vs Sarcocephalus latifolius*,*Anogeissus leiocarpus vs Sarcocephalus latifolius* and *Jathropha gossypiifolia vs Sarcocephalus latifolius*.

The concentration in the stem bark samples was higher in *Sarcocephalus latifolius* (2.60±0.2 mg/kg) and lowest in *Balanites aegytiacae* (0.70±0.2 mg/kg), with variability coefficient of 66%. Vanadium was not detected in stem bark samples of *Sclerocarya birrea*, but the results revealed significant (P<0.05) differences between pairwise concentrations in only about 30% of stem bark samples. The study revealed significant concentration of V in the root bark sample of *Ageratum conyzoides* (15.0±1.0 mg/kg) and lowest in *Sclerocarya birrea* (1.120±0.24 mg/kg), with a variability coefficient of 96%. Vanadium was not detected in the root bark samples of *Hymenocardia acida* and *Leptadenia hastata*, but the results revealed significant (P<0.05) differences between the pairwise concentrations in about 50% of the root bark samples.

On the average, the order of V concentrations distribution was observed to follow the ranking, leaves > root bark>stem bark respectively.



	AC	AL	BA	DO	HA	JG	LH	SL	SB	TA
Leaves	3.2	0.7	BDL	BDL	BDL	1.4	9	33	BDL	0.7
Stem Bark	0.8	1.1	0.7	1	1.8	0.8	1	2.6	BDL	0.8
Root Bark	15	3.5	3	2.2	BDL	5	BDL	4.8	1.1	1.3

Fig. 7: Analysis of Tissues Samples of Anti-diabetic Medicinal Plants showing the Concentrations of Vanadium. The results are presented as Mean±SD of three replicate analysis. Where "BDL" signified below detection limit.

3.2 Radioactive Elements in the Anti-diabetic Medicinal Plant Samples

The activity levels of the radioactive elements in the anti-diabetic plants tissue samples are respectively presented in Table 2.

From the results in the table, the concentrations of Europium (Eu) in the leaves sample was observed to be higher in *Hymenocardia acida* (4.940±0.12mg/kg) and lowest in *Leptadenia hastata* (0.101±0.03 mg/kg), with variability coefficient of 181.4%. The elements was not detected in leave samples of *Ageratum conyzoides, Daniellia oliveri, Jathropha gossypiifolia,Sarcocephalus latifolius* and *Terminalia avicennioides*, but the results showed significant (P<0.05) differences only between pairwise concentrations of the leave samples of *Leptadenia hastata vs Hymenocardia acida, Hymenocardia acida vs Balanites aegytiacae, Hymenocardia acida vs Sclerocarya birrea* and *Hymenocardia acida vs Anogeissus leiocarpus*.

The results further shows the concentration of Eu to be highest in the stem bark samples of *Sclerocarya birrea* (2.60±0.2 mg/kg) and lowest in *Anogeissus leiocarpus* and *Balanites aegytiacae* (0.090±0.02 mg/kg), with variability coefficient of 149.7%. The element was not detected in the stem bark samples of *Daniellia oliveri, Jathropha gossypiifolia* and *Sarcocephalus latifolius*, but the results revealed significant (P<0.05) differences between pairwise concentrations in about 50% of stem bark samples. Furthermore, the root bark sample was observed to contain the highest concentration in *Hymenocardia acida* (0.250±0.05 mg/kg) and lowest in *Sclerocarya birrea* (0.090±0.03 mg/kg), with a variability coefficient of 42%. The element was not detected in root bark samples of *Balanites aegytiacae, Daniellia oliveri, Jathropha gossypiifolia, Leptademia hastata, Sarcocephalus latifolius* and *Terminalia avicennioides*, but the results revealed significant (P<0.05) difference only between pairwise concentrations of *Hymenocardia acida vs Sclerocarya birrea* in root bark samples. On the average, the order of Eu concentrations distribution was observed to follow the ranking, leaves >stem bark> root bark.

The distribution of Lanthanum (La) in the leave, stem bark and root bark samples of the anti-diabetic medicinal plants are presented and discussed herein. The concentration in the leaves was observed to be higher in *Daniellia oliveri* (1096.0±24.0 mg/kg) and lowest in *Balanites aegytiacae* (2.330±0.03 mg/kg) with variability coefficient of 272%. The results revealed significant (P<0.05) differences between pairwise concentrations in only about 50% of the leaves samples. The stem bark concentration was observed to be higher in *Hymenocardia acida* (11.540±0.06 mg/kg) and least in *Daniellia oliveri* (0.860±0.02 mg/kg), with variability coefficient of 83%. The results revealed significant (P<0.05) differences between all pairwise concentrations with the exception of *Terminalia avicennioides vs Sclerocarya birrea*. In the root bark samples, the concentration of La was highest in *Balanites aegytiacae* (21.230±0.09 mg/kg) and lowest in *Jathropha gossypiifolia* (2.280±0.04 mg/kg), with a variability coefficient of 68%.The results revealed significant (P<0.05) differences between all pairwise concentrations in the respective root bark samples. On the average, the order of La concentrations distribution is leave > root bark>stem bark.

The results further show the distribution of Lutetium (Lu) in the leave, stem bark and root bark samples of anti-diabetic medicinal plants. The concentrations in the leave samples was highest in *Hymenocardia acida* (2.750±0.03 mg/kg) and lowest in *Jathropha gossypiifolia* (0.030±0.006 mg/kg), with variability coefficient of 167%. However, it was not detected in leave samples of *Anogeissus leiocarpus, Balanites aegytiacae, Daniellia oliveri, Leptademia hastata,Sarcocephalus latifolius*and *Terminalia avicennioides*, but the results showed significant (P<0.05) differences only between the pairwise concentrations of the leaves samples of *Hymenocardia acida* against all the other three plants samples, *Ageratum conyzoides, Jathropha gossypiifolia* and *Sclerocarya birrea*. Stem bark concentration of Lu was highest in *Sarcocephalus latifolius* (2.60±0.2 mg/kg) and lowest in *Jathropha gossypiifolia* (0.090±0.02 mg/kg), with variability coefficient of 199%. However, it was not detected in stem bark samples of *Ageratum conyzoides, Balanites aegytiacae, Danielliaoliveri, Jathropha gossypiifolia, Sclerocarya birrea* and *Terminalia avicennioides,* but the results revealed significant (P<0.05) differences between the pairwise concentrations in the stem bark samples except between *Leptadenia hastata vs Anogeissus leiocarpus, Leptadenia hastata vs Jathropha gossypiifolia* and *Anogeissus leiocarpus vs Jathropha gossypiifolia.*

Further, the concentrations in the root bark was observed to be higher in *Ageratum conyzoides* (0.210±0.01 mg/kg) and lowest in *Terminalia avicennioides* (0.029±0.006 mg/kg), with a variability coefficient of 63%. The results revealed significant (P<0.05) difference only between pairwise concentrations of about 40% of root bark samples. On the average, the order of Lu concentrations distribution is leave > root bark>stem bark. The concentration of Lu in plants parts showed that *Ageratum conyzoides, Balanites aegytiacae and Sclerocarya birrea* (0.1±0.0 mg/kg) contained the lowest concentration, while *Hymenocardia acida* (2.75±0.00 mg/kg) is highest.

From the results, the highest concentration of Samarium (Sm) was recorded in the leave sample of *Hymenocardia acida* (53.500±0.10 mg/kg) and the lowest concentration recorded in *Balanites aegytiacae* (0.315±0.007 mg/kg), with variability coefficient of 269%. The results showed significant (P<0.05) differences between the pairwise concentrations in about 70% of the leave samples. The result further shows the stem bark concentration of Sm to be highest in *Sclerocarya birrea* (22.100±0.50 mg/kg) and lowest in *Daniellia oliveri* (0.160±0.004 mg/kg), with variability coefficient of 216%. The results showed significant (P<0.05) differences between pairwise concentrations in about 50% of the stem bark samples.

The concentration in the root bark sample was higher in *Sclerocarya birrea* (59.00±1.00 mg/kg) and lowest in *Leptadenia hastata* (0.370±0.010 mg/kg), with a variability coefficient of 245%.

The results revealed significant (P<0.05) difference only between pairwise concentrations of about 50% of root bark samples. On the average, the order of Sm concentrations distribution is root bark>leaves >stem bark.

The results also shows the distribution of Thorium (Th) in the leaves, stem bark and root bark sample of the anti-diabetic medicinal plants investigated. The result revealed that Th was detected in all the samples except in the leave samples of *Daniellia oliveri, Hymenocardia acida* and *Sarcocephalus latifolius.* The concentration of Th in the

leaves was highest in *Jathropha gossypiifolia* (0.670±0.01 mg/kg) and lowest in *Balanites aegytiacae* (0.040±0.01 mg/kg), with variability coefficient of 101%. Results showed significant (P<0.05) differences between all the pairwise concentrations of Th in leave samples, except between *Terminalia avicennioides vs Balanites aegytiacae, Hymenocardia acida vs Daniellia oliveri, Hymenocardia acida vs Sarcocephalus latifolius, Sclerocarya birrea vs Anogeissus leiocarpus* and *Daniellia oliveri vs Sarcocephalus latifolius*.

The results further shows the concentration in the stem bark sample to be higher in *Leptadenia hastata* (0.390±0.1 mg/kg) and lowest in *Jathropha gossypiifolia* (0.070±0.01 mg/kg), with variability coefficient of 65%. The results revealed significant (P<0.05) differences between the pairwise concentrations of about 65% of the stem bark samples. The concentration in the root bark sample was highest in *Balanites aegytiacae* (2.120±0.08 mg/kg) and lowest in *Hymenocardia acida* (0.060±0.01 mg/kg), with a variability coefficient of 94%. The results revealed significant (P<0.05) difference between all pairwise concentrations of the root bark samples, except between *Terminalia avicennioides vs Leptademia Hastata, Terminalia avicennioides vs Sclerocarya birrea, Hymenocardia acida vs Anogeissus leiocarpus, Leptadenia hastata vs Sclerocarya birrea,* and *Jathropha gossypiifolia vs Daniellia oliveri*. On the average, the order of Th concentrations distribution is root bark>stem bark>leaves.

Furthermore, the concentration distribution of Uranium (U) was detected only in the leaves of two plants species, *Hymenocardia acida* (0.070±0.01 mg/kg) and *Ageratum conyzoides* (0.010±0.006 mg/kg). The concentrations in the stem bark was highest in *Balanites aegytiacae* (0.381±0.005 mg/kg) and lowest in *Terminalia avicennioides* (0.0030±0.001 mg/kg), with variability coefficient of 286%. Uranium was not detected in the stem bark samples of *Anogeissus leiocarpus, Ageratum conyzoides, Daniellia oliveri, Jathropha gossypiifolia, Leptademia hastata* and *Sclerocarya birrea*. The results revealed significant (P<0.05) differences between pairwise concentrations of U in stem bark samples except between *Hymenocardia acida vs Terminalia avicennioides, Hymenocardia acida vs Sarcocephalus latifolius* and *Terminalia avicennioides vs Sarcocephalus latifolius*.

The concentration in the root bark sample was higher in *Ageratum conyzoides* (0.041±0.004 mg/kg) and lowest in *Terminalia avicennioides* (0.007±0.002 mg/kg), with a variability coefficient of 61%. The concentration was not detected in root bark samples of *Jathropha gossypiifolia, Leptademia hastata and Sclerocarya birrea*. The results revealed significant (P<0.05) difference between pairwise concentrations of about 60% of root bark samples. On the average, the order of U concentrations distribution is stem bark > root bark > leaves. The concentration of U in plants parts showed that, *Ageratum conyzoide* (0.010 mg/kg) contained the lowest concentration, while *Balanites aegytiacae* (0.381±0.01 mg/kg) is the highest.

The table also presents the distribution of Ytterbium (Yb) in the leaves, stem bark and root bark samples of the anti-diabetic medicinal. The concentration of Yb in the samples was not detected in *Anogeissus leiocarpus, Balanites aegytiacae, Daniellia oliveri, Sarcocephalus latifolius* and *Terminalia avicennioides* but the highest Yb concentration was in *Hymenocardia acida* (43.50±0.40 mg/kg) and lowest in *Jathropha gossypiifolia* (0.28±0.050 mg/kg), with variability coefficient of 196.8%. The results revealed significant (P<0.05) differences only between the pairwise concentrations of Yb in leave samples of *Leptadenia hastata vs Hymenocardia acida, Hymenocardia acida vs Ageratum conyzoides, Hymenocardia acida vs Sclerocarya birrea* and *Hymenocardia acida vs Jathropha gossypiifolia*.

The concentration in stem bark was not detected in samples of *Anogeissus leiocarpus, Ageratum conyzoides, Balanites aegytiacae, Daniellia oliveri, Sclerocarya birrea* and *Terminalia avicennioides.* But Yb concentration was highest in *Hymenocardia acida* (2.000±0.100 mg/kg) and lowest in *Jathropha gossypiifolia* (0.140±0.030 mg/kg), with variability coefficient of 215.6%. The results revealed significant (P<0.05) differences between the pairwise concentrations of Yb in stem bark samples of the plants except between *Leptadenia hastata vs Jathropha gossypiifolia* and *Leptadenia hastata vs Sarcocephalus latifolius.* The concentration of Yb in the root bark was not detected in samples of *Leptadenia hastata* and *Sclerocarya birrea,* but was highest in *Ageratum conyzoides* (2.940±0.170 mg/kg) and lowest in *Anogeissus leiocarpus* (0.034±0.050 mg/kg), with a variability coefficient of 69.7%. The results revealed significant (P<0.05) difference between pairwise concentrations of about 60% of root bark samples of plants. On the average, the order of Yb concentrations distribution is leaves > root bark >stem bark.

Table 2: The Concentration of Radioactive Elements (mg/kg) in the Anti-diabetic Medicinal Plants Distributed by Tissue (mg/kg). Where "BDL" signified Below Detection Limit

Plant Species	Sample	Eu	La	Lu	Sm	Th	U	Yb
Ageratum conyzoides	Leaves	BDL	4.5±0.0	0.1±0.0	0.7±0.0	0.4±0.0	0.01±0.0	0.8±0.1
	Stem Bark	0.1±0.0	2.2±0.0	BDL	0.3±0.0	0.2±0.0	BDL	BDL
	Root Bark	0.2±0.0	13.6±0.1	0.2±0.0	2.4±0.0	1.2±0.0	0.04±0.0	2.9±0.2
Anogeissus leiocarpus	Leaves	0.2±0.0	6.1±0.0	BDL	1.0±0.0	0.1±0.0	BDL	BDL
	Stem Bark	0.1±0.0	2.0±0.0	BDL	0.2±0.0	0.1±0.0	0.03±0.0	BDL
	Root Bark	0.2±0.0	10.2±0.1	0.1±0.0	1.5±0.0	0.1±0.0	BDL	0.3±0.1
Balanites aegytiacae	Leaves	0.1±0.0	2.3±0.0	BDL	0.3±0.0	BDL	BDL	BDL
	Stem Bark	0.1±0.0	3.6±0.0	BDL	2.6±0.0	0.3±0.0	0.4±0.0	BDL
	Root Bark	BDL	21.2±0.1	0.1±0.1	3.1±0.0	2.1±0.1	0.02±0.0	1.0±0.1
Daniellia oliveri	Leaves	BDL	1096.0±24.0	BDL	0.4±0.0	BDL	BDL	BDL
	Stem Bark	BDL	0.9±0.0	BDL	0.2±0.0	0.1±0.0	BDL	BDL
	Root Bark	BDL	5.7±0.0	0.1±0.0	1.1±0.0	0.8±0.0	BDL	0.9±0.1

Hymenocardia acida	Leaves	4.9±0.1	75.2±0.2	2.8±0.0	53.5±0.1	BDL	0.07±0.01	43.5±0.4
	Stem Bark	0.3±0.0	11.5±0.1	0.2±0.0	3.2±0.0	0.2±0.0	0.02±0.0	2.0±0.1
	Root Bark	0.3±0.1	8.2±0.1	0.1±0.0	2.2±0.0	0.1±0.0	0.02±0.0	1.3±0.1
Jathropha gossypiifolia	Leaves	BDL	2.4±0.0	BDL	0.4±0.0	0.7±0.0	BDL	0.3±0.1
	Stem Bark	BDL	1.6±0.0	BDL	0.3±0.0	0.1±0.0	BDL	0.1±0.0
	Root Bark	BDL	2.3±0.0	0.2±0.0	0.4±0.0	0.8±0.0	BDL	1.3±0.1

Continuation of Table 2

Plant Species	Sample	Eu	La	Lu	Sm	Th	U	Yb
Leptadenia hastata	Leaves	0.1±0.0	5.2±0.1	BDL	0.4±0.0	0.2±0.0	BDL	0.3±0.1
	Stem Bark	0.1±0.0	3.7±0.0	BDL	0.5±0.0	0.4±0.0	BDL	0.3±0.1
	Root Bark	BDL	3.2±0.0	BDL	0.4±0.0	0.3±0.1	BDL	BDL
Sarcocephalus latifolius	Leaves	BDL	2.8±0.0	BDL	0.4±0.0	BDL	BDL	BDL
	Stem Bark	BDL	4.8±0.0	0.5±0.0	0.8±0.0	0.3±0.0	0.02±0.0	0.3±0.0
	Root Bark	BDL	7.5±0.0	0.1±0.0	1.2±0.0	0.6±0.0	0.02±0.0	0.8±0.1
Sclerocarya birrea	Leaves	0.2±0.0	15.5±0.1	0.1±0.0	1.9±0.0	0.1±0.0	BDL	0.4±0.1
	Stem Bark	0.9±0.0	2.5±0.0	BDL	22.1±0.5	0.1±0.0	BDL	BDL
	Root Bark	0.1±0.0	4.7±0.0	BDL	59.0±1.0	0.3±0.0	BDL	BDL
Terminalia avicennioides	Leaves	BDL	7.4±0.0	BDL	0.9±0.0	0.1±0.0	BDL	BDL
	Stem Bark	0.1±0.0	2.4±0.0	BDL	0.2±0.0	0.1±0.0	BDL	BDL
	Root Bark	BDL	4.4±0.0	BDL	0.6±0.0	0.3±0.0	0.002±0.0	0.5±0.1

Discussion

Although soil-plant interactions has always been the source of nutrient transport into plant tissues, naturally occurring radionuclides and other trace elements in the same way constitute to the total uptake of element by plants. Though, the former has been tacitly reported as being beneficial, the role of the latter in the plants are seldom investigated, even though the level of concentration may vary widely from place to place, visa a vice from plant to plants.

Recognizing the fact that some macro and micro elements derived from plants exerts some physiochemistry towards insulin actions, this present study report therein, the presence of other trace elements and NRN in the tissues of the anti-diabetic medicinal plants investigated. This fact quite often is not sufficiently taken into consideration and thus, exposes the patient that depends on such plants extracts for the treatment and management of DM at a great risk of toxic-elements induced effects.

In the categories of non-radiative trace elements (Al, As, Ba, Rb, Sc, Sr and V) investigated, only V were reported to have a direct link with insulin related chemistry. Vanadium was found in almost all the plants samples except in the leave samples of *Balamites aegyptiacae, Daniellia oliveri, Hymenocadia acida* and the root samples of *Hymenocadia acida* and *Leptadenia Hastata.* And based on its role in potentiating insulin action, V will thus, be classified in the categories of essential trace elements. The potential use of vanadium in the treatment of diabetic complications including cardiomyopathy has been assessed and indeed its hypoglycemic effect along with reversal of functional abnormalities has been clearly demonstrated in several studies [30]. Vanadium in the forms of vandyl sulfate (100 mg/day) and sodium metavanadate (125 mg/kg) has been used as a supplement for diabetic patients [31].

The other trace elements (Al, As, Ba, Rb, Sc, and Sr) investigated though, with no available information on their role in potentiating insulin metabolism, are also reported to exert no specific physiochemistry in mimicking other diseases except Ba which behaves as a two edged sword. At low concentration could act as a muscle stimulant and induces nervous breakdown and cardiac imbalance at higher concentrations [32]. In this group, As is considered a major risk factor health wise. Though, found in only few of the plant species at a very low consideration, its presence in the medicinal plants could impair several metabolism. The highest concentrations was recorded in the leave samples of *Anogeissus leiocarpus* (0.50± 0.1mg/kg). High concentration of Arsenic (III) compounds are implicated in inducing metabolic disorder, dermatitis, irritation of upper respiratory passage and perforation of nasal septum, lung cancer, cardiovascular and neurological effects [33,34]. Therefore, monitoring the content of these elements in medicinal plants and their extract is of particular importance for health.

The radioactive elements (Eu, La, Lu, Sm, Tb, U, and Tb.) distributed in the various anti-diabetic medicinal plants investigated in this study are shown in Table 2. Although, these elements are chemically less toxic than other inorganic constituents such as arsenic, selenium, lead, cadmium or mercury compounds, questions have always been raised concerning possible risk associated with radiation. The concentrations of these radioactive elements as observed and recorded in this present study are below levels of human concern [35]. The concentrations of uranium in the medicinal plants are below the current standards of 20 parts per billion (ppb). These elements are below levels of human health risks [35]. It was observed that these plants contain appreciably amount of these radioactive elements such as U and Th which are also considered non-essential for organisms. It is the most poisonous of all metals when injected intravenously or subcutaneously and this can lead to kidney failure. Lanthanum is important in delaying blood

clothing which may also leads to hemorrhage and liver injury. Other radioactive element such as Sm and Yb has a moderate degree of toxicity to animals and are known to depress blood coagulation leading to hemorrhage. Similarly, no known toxicity related effects of Lu and Eu on plants, animals or man available. However, it is suggested that continuous use of medicinal plants containing radionuclides can be toxic, owed to their radioactivity [35].

The uptake of radionuclides by plants serves as one of the portal for the migration of natural radionuclides into human. Leukemia and cancer related diseases are fallback of the accumulation of radionuclides in medicinal plants used for herbal preparations. Study showed that, approximately 10-15% of ^{210}Pb and ^{214}Pb ions, 99% of ^{226}Ra and ^{228}Ra, ^{214}Bi and the soluble form of ^{210}Po readily find their way into the blood and/or the lung fluid stream, and interfered with the normal metabolic activity in the skeletal tissues by displacing/or substituting physiological calcium [36-38]. The affinity of ^{238}U to bind readily to electron donor makes the cells lining of bones and other body tissues susceptible to its attack. Thus contributing to the onset of cancer related chemistry [23, 38]

Many factors are attributed to the availability of NRN in the soil or plant uptake. It was observed that continues application of plant growth enhancement products such as phosphate fertilizer may elevate heavy metal, radionuclide contents and fluorine concentrations in soil profiles. And thus, may increase the soil to plant transfer of alpha activity [24, 39]. Notable radionuclides such as radium, thorium and their decays products are easily sway into plant tissues. A cited example was reported in a study by Kumar and Chauhan, [24], in the study, the track density of radionuclides was found to be higher for plants treated with phosphate fertilizer as compared to plants treated with organic and urea. Phosphate rock which are also reported to be the chief starting materials for phosphate fertilizers are reported by many research to contain high content of radium and thorium [40,41] and may have influenced their bioavailability in medicinal plants. Other study also revealed a direct relationship between the content of P_2O_5 and uranium as both forms of uranium $[U(SO_4)_2]$ or $[UO_2(SO_4)]$ in fertilizers are observed to be readily soluble in water [42]. Thus and increase in fertilizer contents directly influence phosphorus content in soil [41, 43, 44] and hence the availability of uranium into the soil and plant [Kumar and Chauhan, 2014]. Thus, the determination of the concentration of this radionuclide in the selected anti-diabetic medicinal plants in this study will further reinforce awareness of possible side effect to the end user [24].

Conclusion

It's a well-established fact that some macro and micro elements in medicinal plants played an important role in potentiating insulin metabolism, considering the fact that their deficiencies invariable contribute to DM and related complications. Though, their bioavailability in the plants may have contributed to their therapeutic efficiency against the scourge of DM, same plants was observed to house some other non-essential element and NRN that may in a more practical sense leads to the onset of toxic induce metabolism to the end user. This study therefore, revealed the presence of these non-essential element and NRN in the selected anti-diabetic medicinal plants. However, the behavior of V detected in the medicinal plants redefined its position from being non-essential as initially classified to essential element. Vanadium was found in almost all the plants samples except in the leave samples of *Balamites aegyptiacae, Daniellia oliveri Hymenocadia acida* and the root samples of *Hymenocadia acida Leptadenia Hastata*. Vanadium was reported to have a direct link with insulin related chemistry. From the results, the elements with the highest concentration distribution are Al and the least distributed element is As. The highest concentration of Al was found in the root bark sample of *Ageratum conyzoides* with the leave sample of *Anogeissus leiocarpus* containing the highest amount of As. Analysis of the radioactive materials though, below the risk impact levels showed La in virtually all the plants species and widely distributed in all the plant tissues, with the highest concentration recorded in the leaves sample of *Daniellia oliveri*. The results further shows the presence of small amount of U in only few of the plants species with the highest concentration recorded in the stem bark sample of *Balamites aegyptiacae*. It will suffice to say that, the presence of these non-essential elements and NRN as described in this study further bring into light the salient factor related to potential toxicity of the selected anti-diabetic plants. An important factor to consider before considering plant extract for medicinal application

Reference

1. Kanungo S, Mahapatra T, Bhowmik K., Mahapatra, SJ, Pal D, Sarkar K. Diabetes scenario in a backward rural district population of India and need for restructuring of health care delivery services. Epidemiol, 2016; 6(2): 1-10.
2. Kasali FM, Wendo FM, Muyisa SK, Ntokamunda KJ. Comparative hypoglycemic activity of flavonoids and tannins fractions of *Stachytarphetaindica* (L.) Vahl leaves extracts in Guinea-Pig and Rabbits. International Journal of Pharmacy and Pharmaceutical Research (Ijppr), 2016;5(2): 48-57
3. Roglic G, Unwin N, Bennett PH, Mathers C, Tuomilehto J, et al. The burden of mortality attributable to diabetes: realistic estimates for the year 2000. Diabetes Care, 2005; 28: 2130-2135.
4. King H, Gruber W, Lander T. Implementing national diabetes programmes- Report of a WHO meeting. Geneva: World Health Organization. International Diabetes Federation (IDF), 1995; (5th edn) Diabetes Atlas.
5. Oguejiofor O, Odenigbo C, Onwukwe C. Diabetes in Nigeria: Impact, Challenges, Future Directions. Endocrinol Metab Synd, 2014; 3 (2):100-130.
6. International Diabetes Federation (IDF). Diabetes Atlas. 2010; (4th edn), IDF, Brussels, Belgium
7. Mbanya JC, Mbanya D. Diabetes cost in sub-Saharan Africa. J Cardiovasc Risk, 2003; 10: 191-193.
8. Kirigia JM, Sambo HB, Sambo LG, Barry SP. Economic burden of diabetes mellitus in the WHO African region. BMC Int Health Hum Rights, 2009; 9: 6.
9. Akinkugbe OO. Non-Communicable Diseases in Nigeria: National Survey (Final Report) on Hypertension, Coronary Heart Disease, Diabetes Mellitus, Haemoglobinopathies, G6PD Deficiency and Anaemia. National Expert Committee on Non-Communicable Diseases, Federal Ministry of Health and Social Services, Lagos. 1997

10. Guilbert JJ. The world health report 2002 - reducing risks, promoting healthy life. Educ Health (Abingdon). 2003; 16: 230.
11. Arika WM, Ogola PE, Nyamai DW, Mawia AM, Wambua FK, Kiboi NG, et al. Mineral elements content of selected Kenyan antidiabetic medicinal plants. Advanced Techniques in Biology & Medicine, 2016; 4(1): 2-5.
12. Ngugi MP, Njagi JM, Kibiti CM, Miriti PM. Pharmacological Management of Diabetes Mellitus. Asian Journal of Biochemical and Pharaceutical Research, 2012; 2: 375-381
13. Devi S, Kumar D, Kumar M. Ethnobotanical values of antidiabetic plants of M.P. region, India. Journal of Medicinal Plants Studies, 2016; 4(3):26-28.
14. Magili ST and Bwatanglang IB. Toxicity Study of Aqueous Leaves Extract of *Jatropha gossypiifolia* from Nigerian in Albino Rats: Serum Biochemistry and Histopathological Evaluation. International Journal of Biochemistry Research & Review**,** 2018a; 21(3): 1-12.
15. Patel DK, Prasad SK, Kumar R. An overview on antidiabetic medicinal plants having insulin mimics property. Asian Pacific Journal of Tropical Biomedicine, 2012; 2(4): 320-330
16. Ngugi P, Njagi J, Kibiti C, Maina D, Ngeranwa J, et al. Trace elements content of selected Kenyan anti-diabetic medicinal plants. Int J Curr Pharm Res, 2012; 4: 39-42.
17. Al-Awadi FM, Anim JT, Srikumar TS. Possible role of trace elements in the hypoglycemic effect of plants extract in diabetic rats. The Journal of Trace Elements in Experimental Medicine, 2004; 1731–1744.
18. Biswajit S and Bhabesh CG. Study on element content of some Antidiabetic medicinal plants grown in North East India by Atomic Absorption Spectroscopy (AAS) and Flame Photometry. International Journal of ChemTech Research, 2017; 10(6): 644-652
19. Srinivasu CC, Babu NG, Raju TP, Narayana PVL, Ram SS, Sudershan M, Das NL. Concentration of trace elements in selected Indian antidiabetic medicinal plants by using Edxrf technique. International Journal of Recent Scientific Research, 2016; 7(2): 9104-9108
20. Magili ST, Maina HM, Barminas JT, Maitera ON, Onen AI. Study of some trace and macro elements in selected antidiabetic medicinal plants used in Adamawa State, Nigeria by neutron activation analysis (NAA). Peak Journal of Medical plant research, 2014; 2(2): 13-22
21. Magili TS and Bwatanglang IB. Determination of Macro and Micro Elements in Some
    Selected Anti-diabetic Medicinal Plants in Adamawa State, Nigeria Using Instrumental Neutron Analysis. WWJMRD, 2018b; 4(6): 181-190
22. INFOSAN. Information on nuclear accidents and radioactive contamination of foods. International Food Safety Authorities Network. World Health Organization (WHO), Geneva, 2011.
23. Tettey-Larbi, Darko EO, Schandorf C, Appiah AM. Natural radioactivity levels of some medicinal plants commonly used in Ghana. SpringerPlus, 2013; 2:157
24. Kumar A and Chauhan RP. Measurement of alpha activity from leaves and roots of radish plant enhanced by fertilizers. Journal of radiation Research and Applied Sciences, 2014; 7: 4 5 4 -4 5 8
25. FAO/WHO. Contaminants in Codex Alimentarius, Vol xvii, edition 1. FAO/WHO, Codex Alimentarius Commission, Rome, 1984
26. Jonah SA, Balogun GI, Umar MI, Mayaki MC. Neutron spectrum parameters in irradiation channels of the Nigeria Research Reactor-1 (NIRR-1) for k0-NAA standardization. Journal of Radioanalytical and Nuclear Chemistry, 2005; 266 (1):83-88.
27. Debrah SK, Ayivor JE, D,enutsui D, Buah – Kwofie A, Forson A, Nuviadenu C. Elemental evaluation of some herbal plants used in Ghana using INAA. Der Pharma Chemica, 2011; 3 (5):202-207
28. Oladipo MOA, Njingab RL, Achid SS, Ogunleyea PO, Alfab B, Ibrahim AA. Analysis of Savannah and Rainforest Soils of Nigeria using Thermal Neutron Activation Analysis Technique International. Journal of Science and Technology, 2012; 2(8):584-586
29. Liyu WA. Multi-Purpose Gamma-Ray Spectrum Analysis Software. WINSPAN (2004), CIAE, Beijing, China
30. Heyliger CE, Tahiliani AG and McNeill JH.Effect of vanadate on elevated blood glucose and depressed cardiac performance of diabetic rats, Science, 1985; 227:1474-1477
31. Boden G, Chen X, Ruiz J, Rossum GD, Tanco S. (1996). Effect of Vanadyl sulphate on carbohydrate and lipid metabolism in Patients with non-insulin dependent diabetes mellitus. Metabolism, 1996; 45:1130 – 1135
32. Birhanu WT, Chaueby AK, Teklemariam TT, Dewud BBM, Funtuae II. Application of Instrumental Neutron Activation Analysis (INAA) in the Analysis of Essential Elements in Six Endemic Ethiopian Medicinal Plants. International Journal of Sciences: Basic and Applied Research (IJSBAR), 2015; 19(1):213-227
33. Bwatanglang IB, Ogugbuaja VO, Garba SH, Jacks TW, Ibrahim LD. *In vivo* Toxicity Evaluation of Nigerian Bituminous Coal Fly Ash Following Repeated Administration to Albino rats. Journal of Chemical and Pharmaceutical Research**,** 2017; 9(10):275-285
34. Bwatanglang IB, Garba SH, Lynna DI, Shinggu DY, Magili TS and Musa Y. Systemic Effects of Nigerian Bituminous Coal Fly Ash in Albino Rats: Serum Biochemistry and Histopathological Evaluation. International Journal of Biochemistry Research & Review, 2017; 20(2): 1-10
35. Tadmore J. Radioactivity from coal-fired power plants: A review. Journal of Environmental Radioactivity, 1986; (4):177-204
36. UNSCEAR. Sources and effects of ionizing radiation United Nations Scientific Committee on the Effects of Atomic Radiation. United Nations, New York, 1988
37. UNSCEAR. Sources and effects of ionising radiation United Nations Scientific Committee on the Effects of Atomic Radiation. United Nations, New York, 2000
38. Cember H, Johnson TE. Introduction to health physics. 2009, Fourth edition. McGraw-Hill Companies, Inc., USA.
39. Garba H, Shinggu DY, Bwatanglang IB and Magili TS. The Role of 2, 2-Dichlorovinyl Dimethyl Phosphate and the Dynamics of Heavy Metals Absorption/Translocation in Plants: Emphasis on Sorrel and Spinach. Int. J. Curr. Res. Biosci. Plant Biol, 2018; 5(6):1-10

40. Ahmed NK and El-Arabi AGM. Natural radioactivity in farm soil and phosphate fertilizer and its environmental implications in Qena governorate, Upper Egypt. Journal of Environmental Radioactivity, 2005; 84:51-64.
41. Chauhan P, Chauhan RP, Gupta M. Estimation of naturally occurring radionuclides in fertilizers using gamma spectrometry and elemental analysis by XRF and XRD techniques. Microchemical Journal, 2013; 106:73-78.
42. Khater AEM, and AL-Sewaidan HA. Radiation exposure due to agricultural uses of phosphate fertilizers. Radiation Measurements, 2008; 43:1402-1407
43. Al-Mohammadi F, and Al-Zubi, Y. Soil chemical properties and yield of tomato as influenced by different levels of irrigation water and fertilizer. Journal of Agriculture Science and Technology, 2011; 13:289-299.
44. Qian P, Schoenau JJ, Mooleki P. (2004). Phosphorus amount and distribution in a Saskatchewan soil after five years of swine and cattle manure application. Canadian Journal of Soil Science, 2004; 84:275-281