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Application of Instrumental Neutron Activation Analysis (INAA) in the Analysis of Essential Elements in Six Endemic Ethiopian Medicinal Plants

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Abstract

The main objective of this study was to examine the elemental compositions of six medicinal plants known as Artemisia abyssinica, Lippia Adolensis, Celematics Longicanda, Echinops Kebericho, Thymus schimperi and Millettia ferruginea which are commonly used in Ethiopia as traditional system of medicine for curing various ailments using Instrumental Neutron Activation Analysis (INAA). After the samples were collected, dried, gridded, and homogenized they were irradiated using the Nigerian Research Reactor-1 (NIRR-1). The induced activities of the samples were counted by a gamma -ray spectrometer equipped with HPGe detector, multi-channel analyzer and gamma acquisition software packages Winspan 2004.

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The concentrations of 20 elements were analyzed in six of the medicinal plants. Mg, K, Ca, Cl, Al and Fe were observed as major in high concentrations while Na and Mn were found as minor in appreciable concentration with Ba, Br, Eu, La, Sc, Sm, Nd, Rb, Tb, V, Zn and Yb measured in traces. The possible links between the medicinal role of most elements and their concentration contents were discussed by comparing with the reported values in literature. The results showed that the medicinal plants are very rich with essential elements and could be used for the treatment of different diseases.

Keywords: Medicinal plant, macro- and micro-nutrients, neutron activation analysis, Standard reference materials

1. Introduction

Nowadays 70-80 % of the world population use medicinal plants as a traditional system of medicine for primary health care, curing diseases and food supplements [1,2]. Thus taking into consideration the importance of medicinal plants, nowadays scientific research interests on medicinal plants have been growing up to study the essential and/or toxic elements in medicinal plants. Some findings, for instance; report that medicinal plants are enriched with trace elements, minerals, carbohydrates, proteins, fats and vitamins that are very important for the plants themselves and ultimately for animals and humans that feed upon them [3,4].

However, unless otherwise the medicinal plants are administered and taken wisely, consuming any assumed medicinal plants might have adverse effects on human and animals health so that care should be taken [5]. As worth mentioned by [6] medicinal plants can be contaminated by heavy metals during their growth via roots uptake and by the deposition of pollutants from the atmosphere on their leaves. Heavy metals like As, Cd and Pb can be toxic if their concentration amounts in plants are more than 1.0, 0.3 and 10 ppm respectively [7, 8]. Aside from heavy metal toxicities, the excess or deficiency of essential nutrients in medicinal plants can cause various complications and metabolic disorders in human body.

About 80 % of the Ethiopian population use traditional medicine plants for immediate relief of illness, health care, spices of food and as a food supplement [9] Studies report that although the availability, spatial distribution and in general the biodiversities of the medicinal plants in Ethiopia were studied well but their elemental compositions have not been assessed satisfactorily so far using analytical techniques like Neutron Activation Analysis (NAA), X-ray Fluorescence (XRF), Laser Induced Breakdown Spectroscopy (LIBS). Belayneh et al., (2012)[10], for instance, reported that some of the medicinal plants in Ethiopia have not been studied well but still awaits scientific studies. Similarly, Endeshaw [11] also reported that the modern research made on Ethiopian medicinal plants has been focused on inventories and checklists although some of them have been touched.

The aim of the present study was to examine the elemental compositions of Ethiopian endemic medicinal plants known as Thymus Schimperi, Echinops Kebericho, Artemisia Abyssinical, Lippia Adolensis, Celematics Longicanda and Millettia ferruginea for the very reason that these medicinal plants are widely used as traditional medicine to cure various ailments. The method used for this work was Instrumental Neutron Activation analysis

(INAA). INAA has been proved to be a sensitive and widely employed non-destructive nuclear technique to analyze and determine elements present in plants, food items and other allied materials [12]. The scientific names, the vernacular (or local) name and traditional uses of the six medicinal plants considered in the study are listed in Table 1.

Table 1: Classification of medicinal plants and their medicinal values

Sample code	Scientific name	Local name	Parts used	Medicinal use
SMP1	Artemissia Abyssinisia	Chikugn	Leave	Intestinal problems, infection disease, anti-leishmanial, cold.
SMP2	Lippia Adoensis	Kesse	Leave	Stomach ache, for flavor of butter, and for washing wooden and ceramic utensils to make fresh and clean smell
SMP3	Celematics Longicanda	Nech Yeazeo harge	Steam	Treatment of ear and antimicrobial activities on bacterial and fungal strains
SMP4	Echinopis Kebericho	Kebericho	Root	Head ache, typhus, malaria fever and cold, repellent of mosquitoes and snakes, chewed for alleviate stomach ache, diarrhea and expelling tape worm
SMP5	Thymus Schimper	Tossigne	Leave	Head ache, cough, diabetics and control of Gonorrhea; dried leaves uses for flavor of tea, coffee, meat, vegetables and some people some it as a cigarette.
SMP6	Millettia ferruginea	Birbra	Pod	For fish poisons and inducing abortion

In INAA, there are three methods of activation analysis namely: absolute method, relative method and k_0 method. In this work, however, the method chosen for the calculation of elemental concentrations of unknown elements in the medicinal plants was the relative method of INAA. In relative method, since the sample and standard were irradiated and counted under the same conditions and geometries, nuclear parameters such as cross section, neutron flux, decaying scheme and detector efficiency are eliminated in both the sample and standard. Thus, the only measured parameters that are considered in the calculations are the activity rates, masses of the sample and standard, irradiating time, cooling time and counting time as shown in equation (1). The concentrations of the elements in a sample were determined in comparison with the known masses and concentrations of elements in standard reference material using equation (1):

$$C_a = C_{std} \frac{A_a}{A_{std}} \frac{(e^{-\lambda t_d})_{std}}{(e^{-\lambda t_d})_a} \quad (1)$$

where, C_a and C_{std} are concentrations of unknown analyte (or element) in sample and standard; A_a and A_{std} the activity rates of unknown analyte in the sample and standard t_d is the decay time of the unknown element in the sample and in the standard, $(e^{-\lambda t_d})_a$ and $(e^{-\lambda t_d})_{std}$ are the decaying factors for the analyte and the standard respectively.

2. Experimental

2.1 Sample Collection and Preparation

Six different medicinal plant samples were obtained from Gondar city and Taragedam areas near Addis Zemen in Northwest, Ethiopia. According to Geographical Position System (GPS), the Taragedam area is located at latitude of 12^0 08' 38.48" N and longitude of $37^0$44'42.77'E. Similarly, Gondar city where the sample of Millettia ferruginea were taken is located at latitude of 12^0 36'29.04"N and longitude of 37^0 28' 9.96" E. The samples were washed off, dried in an open air and girded by agate mortar into powder formation. The powder form of the samples was then passed through a 100-mesh sieve to get a fine powder in a homogeneous state. To avoid any moisture content the powder form of the samples were dried again at 45^0c in an oven for 24 hrs and then put them in a desiccators again for 24 hrs.

Finally a small representative mass in the range of 0.250-0.300 g was weighed from each sample using a four-digit Meter model weighing balance and heat sealed in a polyethylene sheet for irradiation. Similarly, for the purpose of quality assurance, a standard reference material of biological origin, known as appeal leaves (NIST 1515) whose mass equivalent to the mass of the medicinal plant was also prepared for irradiation. Both samples and Standard Reference Materials (SRMs) were then packed together in polyethylene vial for irradiation.

2.2 Irradiation and Counting

The samples and standards were irradiated simultaneously using the Nigerian Research Reactor-1 (NIRR-1) swimming pool -type reactor operating at 31.5 kw via the Pneumatic Rabbit System that operates at a pressure of 0.5 MPa. According to Yamusa et al., (2013) [12], the NIRR-1 uses high enriched uranium as a fuel and light water as moderator and coolant. Short and long irradiation schemes were designed to determine the concentration of elements according to the varying half lives of radionuclides.

During short irradiation, the samples were irradiated for 5 minute at a neutron fluxes $2.5x10^{11}$, $n.m^{-2}.s^{-1}$ in the outer irradiation channel B4 of the reactor and then cooled outside the reactor for about 2-15 minutes before the first round of counting was performed for 10 minutes (1S) at the position height of 2 cm just above the surface of the HPGe detector as shown in table 2. After 3-4 hrs waiting periods for cooling, a second round counting for 10 minutes (2S) was done for the same batch of samples. In the case of long irradiation scheme about 6-7 samples including the standards were irradiated in the same nuclear facility for 6 hrs at neutron fluxes $5x10^{11}$ $n.m^{-2}.s^{-1}$ in the inner core channel B1. After 3-4 days waiting time for cooling, the first round of count for the long irradiation was performed for 30 minutes (1L) to determine radionuclides with half-lives in the order of hours or few days. The second round of counting for the long irradiation was done for 1 hr (2L) after 9-11 days waiting periods for cooling to determine again radionuclides with half-lives in the order of days and years.

However, before starting counting the activities of irradiated samples, efficiency calibration and standardization of the HPGe detector were carried out using radioactive sources ^{37}Cs, ^{22}Na, ^{60}Co, ^{242}Am and ^{152}Eu at a positions of 2 cm and 15 cm above the detector. Similarly, energy calibration of the detector system was set at Full Width Half at Maximum (FWHM) = 1.3 keV at 1332 keV resolution using ^{60}Co and Maestro software.

The concentrations of the elements in the activated samples as displayed in table 5 were calculated quantitatively using the gamma-ray spectrum analysis softwares packages known Winspan 2004. Similarly, the types of elements available in the samples could also be identified qualitatively by Winspan 2004 in way similar to typical gamma spectra as shown in figure 1, for the medicinal plant Echinops Kebericho.

3. Results and Discussions

The accuracy and precision of the relative method of INAA was evaluated by analyzing the standard reference material (SRM) known as appeal Leaves (NIST 1515) which was irradiated along with the samples. From results obtained it was observed that the measured concentrations of elements in the activated apple leaves in this work were in good agreement with the certified values of the same apple leaves as shown in table 3.

In our short irradiation and counting schemes (1S and 2S) nuclides with short half-lives such as Mg, Al, Ca, Cl, Na, K, Mn and V were determined whereas in long irradiation and counting schemes (1L, 2L) nuclides with long half-lives such as Br, La, Sm, Sc, Fe, Zn, Rb, Ba, Eu, Nd, Tb and Yb were obtained as tabulated in table 2. In table 4, the prevailing concentrations of these 20 elements in the medicinal plants considered in this work were determined quantitatively using instrumental neutron activation analysis (INAA). The elemental compositions of the medicinal plants were found varied due to the preferential absorption of the plants for specific elements, mineral composition of the soils in which the plants were grown and due to climatic conditions [13, 14, 15].

Among the 20 elements shown in table 4 Mg, K, Ca, Cl, Al and Fe were found as major (or macro) nutrients in along all samples whereas Mn and Na were obtained as minor (or micro) nutrients with all other elements measured in traces. Macro-nutrients in human body are required to maintain the health of bones, teeth and blood, for supporting processes such as protein synthesis, cell growth, energy production, and for proper functioning of the heart and nervous systems.

Magnesium content in this work was observed the highest 917160 ±132 ppm in Artemisia abyssinica and lowest 1186 ±164 ppm in Celematics Longicanda. This concentration range was found in agreeable with the range of previous findings on other medicinal plants [15, 18, 19] except that the concentration of Mg in Artemisia abyssinica in this study was noticed the highest one. The minimum safe dietary concentration of Mg in plants for animal health is 2000 ppm [20]. With regard to pharmacological importance Mg is used for treatment of asthma, headache and stress. It is also responsible for the activation of enzymes and for proper function of muscular and nerve systems. Low magnesium levels in human body are likely to cause hypertension, cardiovascular disease, and diabetes in human body. The necessary daily intake of Mg is 350 mg/day for men and 300 mg/day for women as to maintain a healthy body.

Table 2 Classification of radionuclide based on (n,γ) reaction, irradiation time ($t_{\_irr}$), cooling time ($t_{\_irr}$), counting time (t_c), irradiation, counting scheme, and product radionuclide including half life time ($\tau_{1/2}$) and energy (in kev).

$t_{\_irr}$	$t_{\_d}$	$t_{\_c}$	**Counting scheme**	**Product radionuclide (with half time and energy) [**Ref 16, 17**]**
5 min	3-15 min	10min	1st short (1S)	^{27}**Mg** (9.46 min, 1014.4kev), ^{28}**A**l (2.24 min, 1779.0 kev), ^{38}**Cl** (37.2 min, 2167.7kev), ^{49}**Ca** (8.72 min, 3084.5 kev) & ^{52}**V** (3.75min, 1434.1kev)
	3-4 hrs	10 min	2nd short (2s)	^{24}**Na** (15.0 hrs, 2754.0 kev), ^{42}**K** (12.4 hrs, 1524.5 kev) & ^{56}**Mn** (2.58 hrs, 1810.7 kev)
6hrs	3-4 days	30 min	1st Long (1L)	^{140}**La** (,40.3 hrs, 1596), ^{80} **Sm** (46.3 hrs , 103.2 kev) & ^{82}**Br** (35.3 hrs, 776.5 kev)
	9-11 days	1hr	2nd Long (2L)	^{46}**Sc** (83.8 days, 889.3 kev) , ^{59}**Fe** (44.5 days, 1291.6 kev), ^{65} **Zn** (244 days, 1115.6), ^{86}**Rb** (18.7 days, 1076.6 kev), ^{131}**Ba** (11.8 days, 496.3 kev), ^{152} **Eu** (13.3 yrs, 1408.0 kev), ^{147}**Nd** (11 day, 91.1 kev), ^{160}**Tb** (72.3 days, 879.34 kev) & ^{175}**Yb** (4.19 days, 396.3 kev)

High content of Ca is required for mineralization and enhancement of the qualities of bones and teeth [21]. Calcium like Mg is important for blood clotting, relief of stress, proper functioning of the heart and nervous systems as well as for normal function of muscle system. Ca concentration in the present study was found in the range from 16910±641 ppm in Millettia ferruginea to 2679±193 ppm in Celematics Longicanda. This concentration range of Ca was found agreeable with the previous finding on medicinal plants [15, 22, 23, 24].

K, Cl and Na as electrolytes are important for the normal distribution of fluid balance in the intracellular and extracellular cells of human body. These elements are also involved actively for the proper balance of acid- base in the body. A high content of K was observed at macronutrient level in this study with concentration range varied between 2370±90 ppm in Celematics Longicanda to 18850±245 ppm in Lippia Adoensis. This concentration range was found agreeable with previous work on other medicinal plants [15, 24]. Potassium plays a vital role as electrolyte in the blood and for the smooth flow of communication signals from cell to cell but low level of K in human body cause diseases like heart stroke, diabetes and hypertension [25].

Chlorine (Cl) like K is an essential nutrient. It acts as an anion in the extracellular fluid in plasma, lymph, connective tissue and bone of human body [13]. But high doses of chlorine intake result in malfunction of nervous system and organs on such as liver and lungs [26]. The concentration of chlorine was found between 8058±64 ppm in Lippia Adoensis and 1362±30) ppm in Echinops Kebericho. This range of concentration was found agreeable with the previous work on other medicinal plants [15, 22]. Although aluminum (Al) is the third most abundant metal on Earth's crust, it has no known physiological importance in the human body [27]. Most studies related to Al indicate that excess intake of Al causes diseases like neurological dementia (or kidney dialysis), Parkinson and Alzheimer. The daily average intake of Al by adult is in about 7 to 10 mg/day [28].

Table 3: NAA results of NIST 1515 (Apple leaves)

Element	This work (in ppm)	Certified value (in ppm)
Mg	0.271±0.015	0.2710±0.008
K	1.61±0.02	1.61±0.02
Ca	1.5260±0.043	1.5260±0016
Al	286±5	286±9
Cl	579±20	579±23
V	0.26±0.08	0.26±0.03
Br	1.8±0.03	(1.8)
Na	24.4±0.5	24.4±1.2
Ba	49±11	49±2
Mn	54±1	54±3
La	20.00±0.08	(20)
Sm	3.00±0.01	(3.00)
Sc	0.030±0.007	(0.030)
Fe	83±26	83±5
Zn	12.5±1.7	12.5±0.3
Rb	10.2±0.3	10.2±1.5
Nd	17±1	17±1
Eu	0.20±0.05	(0.20)
Tb	0.40±0.05	(0.40)
Yb	0.30±0.06	(0.30)

BDL = Below Detection Limit, ppm = parts per million, Values in parentheses ( ) are information values

Al concentration in this work was observed significantly high in Artemisia abyssinica 49500±346 ppm which is 191 times higher that of 259±8ppm in Millettia ferruginea. The possible cause for the high concentration of Al in this study could be due to high absorption of Al by the plants from the soil. On a similar manner, the leaf of

Artemisia abyssinica accumulated high content of iron 4593±275ppm. Iron concentration in this study was between 323±28ppm in Millettia ferruginea and 54930±275 in Artemisia abyssinica. Biologically, Iron is required for the proper growth of plants and is also responsible for the oxidation process of carbohydrates, protein and fat, and for the formation of hemoglobin in red blood cells and transporting oxygen in human body. According to (FAO)/WHO (1984), the permissible limit of iron for edible plants is 20 ppm [29]. Low Fe content in human body causes gastrointestinal infection and nose bleeding [30].

Table 4: Elemental concentrations of medicinal plants used in this work (in ppm)

Element	Artemisia Abyssinica	Lippia Adoensis	Celematics Longicanda	Echinops Kebericho	Thymus Schimperi	Millettia Ferruginea
Mg, x10^4	1.716±0.113	0.636±0.004	0.117±0.016	0.202±0.022	0.488±0.035	0.469±0.025
K x10^4	0.527±0.020	1.885±0.025	0.237±0.009	0.482±0.015	0.799±0.018	0.439±0.010
Ca x10^4	1.418±0.081	1.599±0.054	0.268 ±0.019	0.346±0.026	1.617±0.063	1.691±0.054
Cl	4205±62	8058±64	652±20	1362±30	2407±41	2584±39
Al	49500±346	889.4±19.6	417±7	3069±36	6273±345	259±8
V	256±4	3.793±0.041	2.24±0.14	14.33±0.53	15.04±0.99	0.91±0.17
Na	1969±4	75±1	23.4±0.6	113±1	136±1	25.9±0.5
Br	728.5±0.2	14.0±0.1	1.6±0.4	24.69±0.15	27.8±0.16	28.74±0.14
Mn	566±11	53.77±0.27	41.24±0.25	135.4±0.4	223.66±0.67	50.24±0.25
La	9.30±0.08	0.35±0.02	0.27±0.01	1.22±0.03	2.93±0.04	0.11±0.01
Sm	3.65±0.02	0.08±0.01	0.059±0.004	0.45±0.01	0.517±0.007	0.029±0.004
Sc	29.2 ±0.01	0.03±0.01	0.21±0.01	1.26±0.02	1.78±0.03	0.10±0.01
Fe	45930±275	522±34	382±35	2353±64	3580±75	323±28
Zn	BDL	38±3	11±2	BDL	37±3	38±3
Rb	22± 4	14.5±2	BDL	769±1.49	BDL	BDL
Ba	315±3	BDL	BDL	BDL	190±15	BDL
Eu	0.86±0.05	BDL	BDL	0.52±0.02	14±3	BDL
Nd	9.23±2.10	BDL	BDL	BDL	BDL	BDL
Tb	1.20±0.17	BDL	BDL	BDL	BDL	BDL
Yb	3.15±0.26	BDL	BDl	BDL	0.38±0.09	BDL

BDL = Below Detection Limit, ppm = parts per million

Sodium and manganese in this study was found in the category of micronutrient as shown in figure 2. The main function of Na is to control the volume of fluid and to maintain the acid-base equilibrium in human body [14]. Surprisingly high or low level of Na in human body can cause seizures, coma and death. The concentration of Na in this work ranged from 23.4±0.6 to 1969 ± ppm and the leaf of Artemisia abyssinica accumulated high Na content as shown in figure 2. This concentration range was found almost in agreeable with other works on other medicinal plants [15]. Thus, consuming Artemisia abyssinica as medicinal plant might cause seizer and comma

The permissible limit of Mn in edible plants as set by FAO/WHO (1984) is 2 ppm [29, 32]. Although Mn concentration in this study was found above the permissible limit, it was found in agreeable with the range of previous works on other medicinal plants [3, 23].

Zinc and vanadium are actually essential chemical elements. Zinc, for instance, is very important for the metabolic function, bone formation wound healing and normal insulin secretion in human body [33]. The dietary limit of Zn is 100 ppm [34]. In pharmacological aspect, Zn is used for the prevention and treatment of diabetes Mellituses and malaria. According to FAO/WHO (1984), the permissible limit of Zn for edible plants is 27.4 ppm [18]. In present study, Zn concentration was obtained 83 ± 3 ppm high in both Lippia Adoensis and Millettia ferruginea and 11±2 ppm lowest in Celematics Longicand. Similarly, vanadium is also a trace element useful for prevention and treatment of diabetes Mellitus 2 [26].

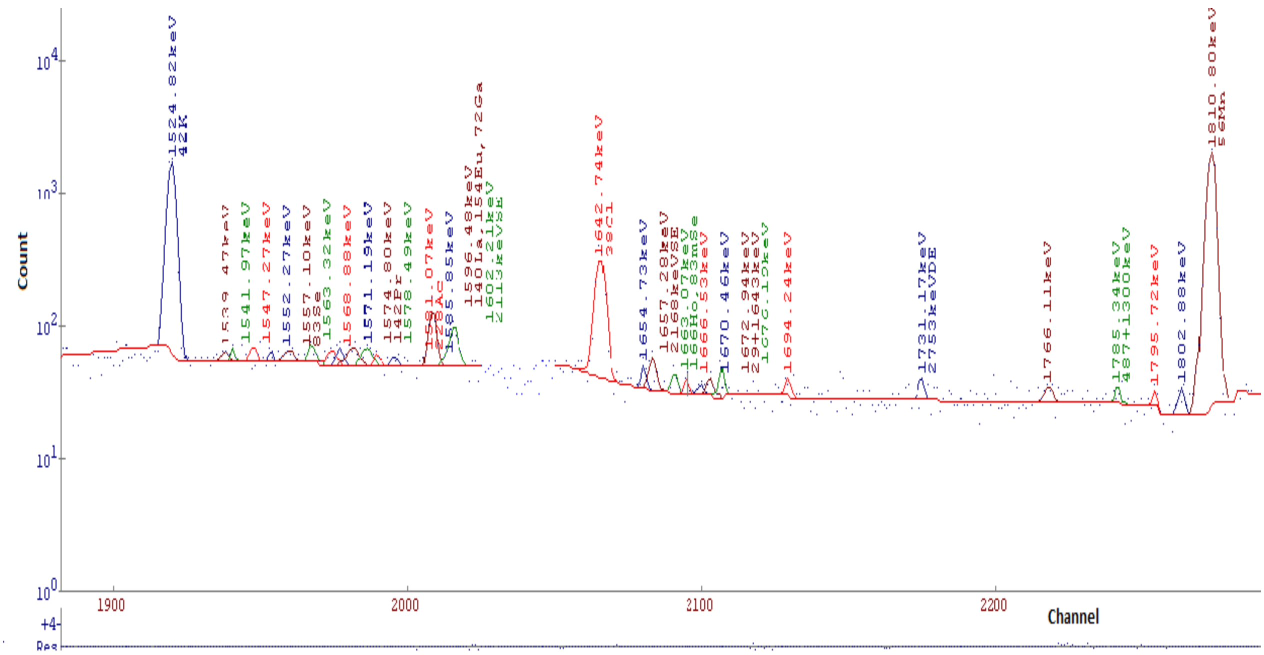

Figure 1 A typical gamma ray spectrum of Echinops Kebericho at t_{irr} = 5min, t_d = 6min and t_c = 10min.

Similarly, manganese like Na is an essential micronutrient which is used for the normal bone structure, reproduction and normal functioning of the central nervous system, for eliminating tiredness, fatigue and nervous irritability [31]. Results of Mn obtained in this study showed that the leaf of Artemisia abyssinica was dominate in Mn accumulation (556±11ppm) and the lowest was noticed in Celematics Longicanda (11±2 pm).

Vanadium works the activities of insulin to produce reduced glucose levels in blood. Vanadium concentration was obtained high 256±4 ppm in Millettia ferruginea and the lowest 92.24±0.14 pm in Celematics Longicanda. Barium concentration in Artemisia abyssinica and Thymus Schimperi samples was measured 315±3 ppm and 90±15 ppm respectively but in the other samples it was noticed below detection limit. As studies suggest Ba ions at low concentration act as a muscle stimulant but at higher concentration, it affects the nervous system, causing cardiac irregularities, tremors, weakness, anxiety and paralysis.

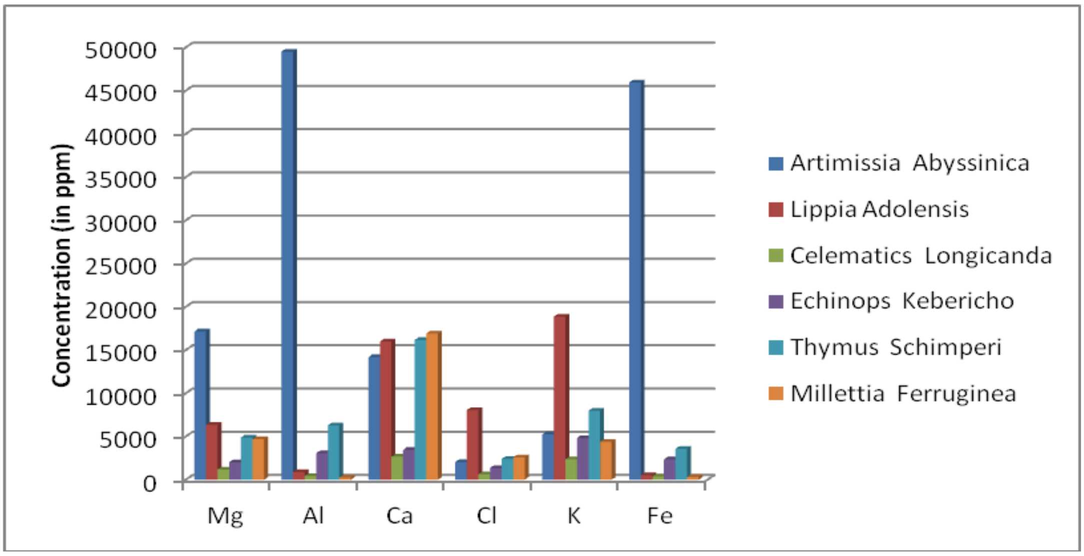

Fig. 2: Macronutrients in six medicinal plants

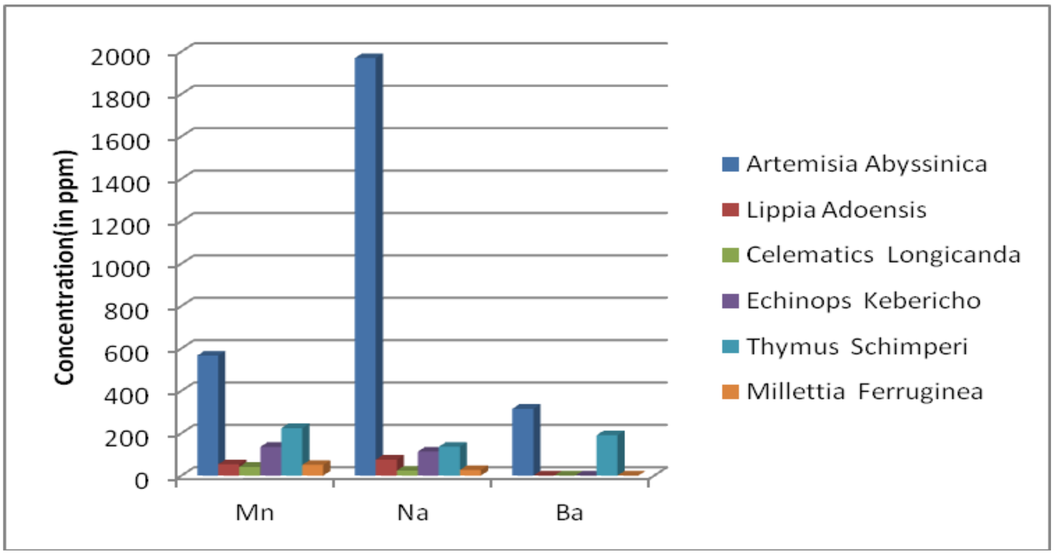

Fig. 3: Micronutrients in six medicinal plants

Aside from essential elements, some elements such as Br, La, Sm, Sc, Rb, Nd, Eu, Tb and Yb were also measured in traces in some of the samples. But the functional roles of these elements have not been known so far. For instance, Br, La and Sm were measured at trace level in all samples but these elements have no known essential role in human body [24, 26]. Similarly elements like Sc, Rb, Nd, Eu, Tb and Yb were found in Artemisia Abyssinia rather than the other sample. The concentrations ranges of these elements were obtained in the range of 0.52±0.02 ppm with Eu in Echinops Kebericho and 14±3 ppm in Thymus Schimperi.

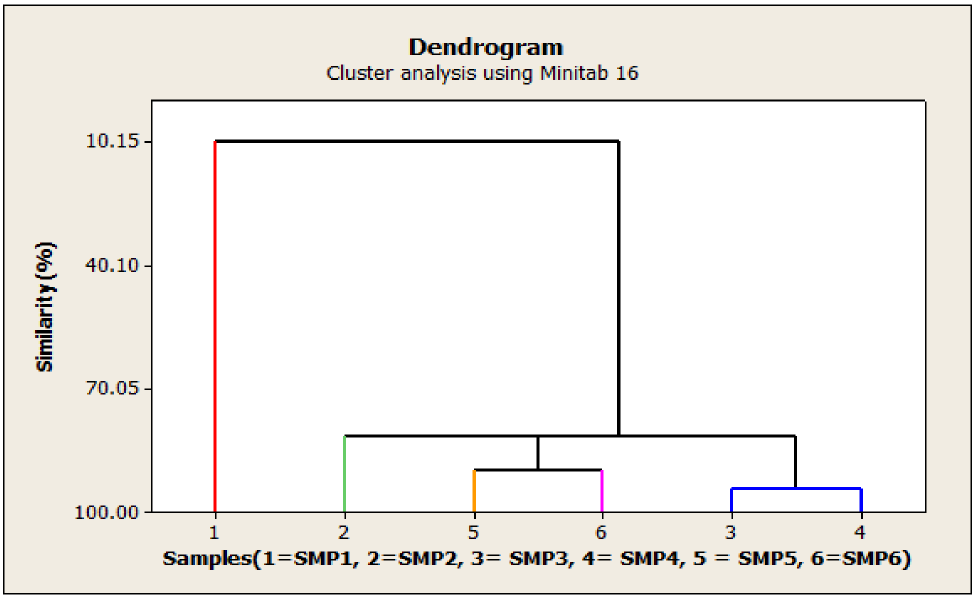

Fig.4: Cluster Analysis of six medicinal plants

The data sets as shown in table 4 was also subjected to cluster analysis to evaluate the similarities among the medicinal samples based on their elemental concentrations using the cluster package in Mintab 16 windows. The clustering is displayed in a two dimensional tree diagram known as dendrogram as shown in figure 4. Dendrogram is a kind of multivariate diagram that can able to cluster different samples having similar contents of elements in a two dimensions. In figure 5, the highest clustering of the medicinal plants was observed between Celematics longicanada and Echinops Kebericho with the similarity level of 94.31% followed by Thymus Schimperi and Millettia ferruginea with the similarity level 89.78% ; Lippia Adoensis and Thymus Schimperi with the similarity level of 81.861%, Lippia Adoensis and Celemetics Longicanda with the similarity level of 81.751 % and the lowest clustering was seen between Artemisia Abyssinica and Lippa Adoensis with the similarity level of 10.15 %. The cluster analysis showed that on one hand Celematics longicanada and Echinops Kebericho have similar elements with equivalent concentration amounts and thus these plants could have similar curative properties. This is also true for Thymus Schimperi and Millettia ferruginea. On the other hand, the similarity between elements in Artemisia Abyssinica and Lippa Adoensis were found strongly weak.

4. Conclusion

In this work, a total of 20 elements in six medicinal plants was determined quantitatively using instrumental neutron activation analysis. According to the experimental results obtained K, Mg, Al, Ca, Cl and Fe were found in high concentrations at macro-nutrient level in all samples. Ba, Mn and Na were found under the category of micro-nutrient with elements such as Ba, Br, Eu, La, Sc, Sm, Nd, Rb, Tb, V and Yb were measured in traces. The concentrations of the elements were varied in wide ranges from the lowest concentration of Eu in root of Echinops Kebericho (0.50±0.02 ppm) to the highest concentration of Na in leave of Artemisia abyssinica (54930±275 ppm). It was observed the leaf of Artemisia abyssinica accumulated 19 elements with significantly highest concentrations. However, although the leaf of Artemisia abyssinica is well enriched in essential chemical elements, the excessive amounts of Al and Fe in the plant may cause diseases such as neurological dementia, Parkison and Alzhemir rather than its medicinal benefit.

In general, the data obtained in this study indicate that the six medicinal plants are well enriched with essential elements which are required for the metabolic process, proper growth and development of human body, prevention and healing of various diseases and for the synthesis of new drugs which can be used for the control and cure of various diseases as stated in table 1. In particular, the elemental and concentration contents of Celematics longicanada and Echinops Kebericho plants were found almost similar in elemental concentration so that these plants could have similar curative properties. Similarly, the same is also true for Thymus Schimperi and Millettia ferruginea.

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