International Journal of Biomedical Science and Engineering
2015; 3(3): 34-43
Published online April 27, 2015 (http://www.sciencepublishinggroup.com/j/ijbse)
doi: 10.11648/j.ijbse.20150303.11
ISSN: 2376-7227 (Print); ISSN: 2376-7235 (Online)

Measurement of Elemental Compositions of Selected Tropical Wood Species – a Case Study of Pra Anum Forest, Ghana

S. Aggrey-Smith[1], K. Preko[2], F. Wilson[3], J. Gbadago[4]

[1]Institute of Distance Learning, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[2]Department of Physics, College of Science, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[3]Council for Scientific and Industrial Research, Forestry Research Institute of Ghana, Fumesua, Kumasi, Ghana
[4]National Nuclear Research Institute, Ghana Atomic Energy Commission, Kwabenya, Accra, Ghana

Email address:

saggreysmith@yahoo.com (S. Aggrey-Smith), saggreysmith7@gmail.com (S. Aggrey-Smith), kpreko@yahoo.com (K. Preko), fwowusu3@yahoo.com (F. Wilson), jgbada@yahoo.com (J. Gbadago)

To cite this article:

S. Aggrey-Smith, K. Preko, F. Wilson, J. Gbadago. Measurement of Elemental Compositions of Selected Tropical Wood Species – a Case Study of Pra Anum Forest, Ghana. *International Journal of Biomedical Science and Engineering.* Vol. 3, No. 3, 2015, pp. 34-43.
doi: 10.11648/j.ijbse.20150303.11

Abstract: The elemental compositions and concentration of major and minor trace elements of twenty (20) tropical hardwoods from the environmental site of Pra Anum forest (longitudes 1^o $12^{'}$ and 1^o $15^{'}$ W; latitude 6^o $14^{'}$ and 6^o $20^{'}$ N) were determined using Instrumental Neutron Activation Analysis (INAA). The investigation covered samples from the immediate vicinity of the soil in which the woods were grown, the root, stem and the leaf segments of the wood species. A total of seven major trace elements (Al, Mg, Ca, K, Na, Cl, Na) and two minor trace elements (Br, La) were identified. The concentrations of all the elements were found to be generally highest in the leaves (> 10,000 ppm) of all the wood species. Ca and K were found in highest concentration levels in the stem (> 500 ppm) of the wood species, *Albizia zygia*, *Morinda lucida* and *Stromboria glaucescens*. In the root, Ca and K were found comparatively high (> 500 ppm) in *Daniellia ogeafaro, Albizia zygia*, *Morinda lucida* and *Stromboria glaucescens*. There were anomalous cases of certain wood species having greater concentrations of trace elements in their parts than that measured in the soils. The concentrations of Ca in *Albizia zygia* and *Morinda lucida* were found to be on the average, constant for the roots, stems and leaves.

Keywords: Hardwood, Instrumental Neutron Activation Analysis (INAA), Trace Elements

1. Introduction

The elemental composition of wood cannot be defined precisely for a given tree species or even for a given tree (Pettersen, 1984). Elemental compositions vary with tree part (root, stem, or branch), type of wood (i.e., normal, tension, or compression) geographic location, climate, and soil conditions. Analytical data accumulated from many years of work and from many different laboratories have helped to define average expected values for the elemental composition of wood. Ordinary chemical analysis can distinguish between hardwoods (angiosperms) and softwoods (gymnosperrns). Unfortunately, such techniques cannot be used to identify individual tree species because of the variation within each species and the similarities among many species. There are two major chemical components in wood: lignin (18– 35%) and carbohydrate (65–75%) both of which are complex, polymeric materials. Minor amounts of extraneous materials, mostly in the form of organic extractives and inorganic minerals (ash), are also present in wood (usually 4– 10%). Overall, wood has an elemental composition of about 50% carbon, 6% hydrogen, 44% oxygen, and trace amounts of several metal ions (Pettersen, 1984).

The major factor for the structure of the forest tree communities is the distribution characteristics of mineral elements in both trees and soils (Walter, 1995). In promoting the survival of an ecosystem there is the need to provide specific mineral elements in appropriate quantities for the rapid growth and reproduction of plant and soil nutrients.

The African continent is richly endowed with a vast species of medicinal plants which are utilized for the treatment of different types of ailments. It is generally estimated that over 6000 plants in Africa are in use in traditional folk and herbal medicine, representing about 75% of the medicinal needs of the third world countries (Veerachari and Bopaiah, 2011). According to Okoli *et al.,* (2007), the traditional African society has always used herbs to promote healing. A large body of evidence has accumulated to demonstrate the promising potentials of medicinal plants used in various traditional, complementary and alternate systems of treatments of human diseases (Alam, 2009). Many medicinal plants are traditionally used for the treatment of different types of diseases like skin infections, diarrhea, diabetes, malaria, respiratory problems, fungal and bacterial infections (Sofowora, 2008). Different plants are being employed as a source of medication against various ailments due to their bio-diversity and perhaps for their rich complement of photochemicals and secondary metabolites (Zafar et al., 2010; Ncube et al., 2008).

Medicinal plants contain both organic and inorganic constituents (Moss, 1981). A lot of research has been done on the organic constituents of the medicinal plants while little attention has been on the inorganic elements in the medicinal use of these plants (Singh and Garg, 1997).In addition to the identity of organic compounds, knowledge of the elemental content in medicinal plants is also very important. Many trace elements play a significant role in the formation of active constituents which are responsible for their curative properties (Yamashita et al., 2005; Balaji et al., 2000).They serve a variety of catalytic, structural and regulatory functions, in which they interact with macromolecules such as enzymes, pro-hormones, pre-secretary granules and biological membranes (Zargar et al., 1998).

Many of the plants consumed by the rural inhabitants of the developing nations which are believed to have medicinal and nutritive value may contain toxic substances that are detrimental to the health of the consumers (Vashishta *et al.*, 2007). Moreover, deficiencies or excesses of minerals especially trace elements lead to various complications and metabolic disorders in human beings. This paper therefore identifies and determines the composition and concentration of the major and minor trace elements which might be responsible for the medicinal properties of some tropical wood species in Ghana.

2. Materials and Methods

2.1. Description of Study Site

The study site the Pra-Anum forest reserve (located by longitudes $1^{o}\ 12^{'}$ and $1^{o}\ 15^{'}$ W and latitude $6^{o}\ 14^{'}$ and $6^{o}\ 20^{'}$ N)is about 200 km^2 in extent and lies between Asante Ofoase in the Ashanti Region and Akyem Ofoase in the Eastern Region of Ghana.The site has an equatorial type of climate with mainly woodland vegetation with thicket intermingled with tall hardwood speciesof about 50 m in a mixture of deciduous and evergreen species of varying proportions (Hall and Swaine, 1981). The average temperature is 22 $^{\circ}$C with an annual rainfall of 15.5 mm.

The Pra-Anum forest reserve is underlain by three geological formations which are Lower Birim Rocks, Tarkwain System and Cape Coast Granite rocks. The prevalent soil series at the Pra-Anum Reserve is ferric acrisol. This soil is red, well drained, and sedentary in nature and found on the summit and upper slopes with gradient ranging between 3% and 12%. The soil profile consists of 15 cm to 45 cm of dark brown or dusky red, humus, porous, silty clay loam topsoil which grades below into 60 cm to 150 cm of reddish brown or red, silty clay loam subsoil containing frequent quartz gravels and stones and ironstone concretions. Soils of Pra-Anum are derived from thoroughly weathered parent materials and are primarily classified as forest oxysol-ochrosol inter-grades (Brammer, 1962)

2.2. Sample Collection and Preparation

Each sample was air dried and ground to smooth powder using commercial 8011ES model HGB2WTS3. A mass of 200mg each of the species and the soils were each weighed (4 replicate samples each) and wrapped in transparent polyethelene films to preserve them. The samples were further encapsulated into irradiation capsules and heat sealed for neutron activation analysis.

2.3. Laboratory Measurements

2.3.1. Sample Irradiation and Counting

The prepared samples and certified reference materials (for both calibrations and validations) wereirradiated in the Ghana Research Reactor-1 (GHARR-1) at the National Nuclear Research Center (NNRC), Ghana Atomic Energy Commission.

GHARR-1 was operated at a half full power of 15KW and generated a thermal flux of $5x10^{11}W/cm^2$.Two separate irradiations were performed based on element of interest and the half life of the radionuclide; two minutes and 1 hour irradiation time were chosen for short lived and relatively medium lived radionuclide(s) respectively. The activated samples (short irradiation) were delayed within a period of 2-5 minutes and counted for 10 minutes in order to identify the short lived radionuclide (elements). In order to identify the medium lived radionuclide(s), the activated samples were delayed within 24 hours and counted for 10 minutes.Radioactivity measurement of induced radionuclide was performed by a PC-based γ-ray spectrometry set-up which consisted of an N-type HpGe detector (coaxial type) coupled to a computer based multi-channel analyzer (MCA) via electronic modules. The relative efficiency of the detector is 40%.Its energy resolution was 1.8keV at a γ-ray energy of 1332keV of ^{60}Co. The data acquisition and identification of the radionuclide productwas done using their γ-ray energy through ORTEC MAESTRO-32, the nuclear application software used for data acquisition. Quantitative analysis was done via relative comparator method. The peak area determinations, processing and concentration calculations were done by multipurpose γ-ray spectrum analysis software; winSPAN-2010 version 2.10.

2.3.2. TheWinSPAN Calibration

Application of the relative comparator method requires Standard Reference Materials (SRM's) or Certified Reference Materials (CRM's) for element(s) of interest. National Institute of Standards and Technology (NIST) standard reference material, 1547 (peach leaves) and Northern Balance and Scale (NBS) standard reference materials, 1572 (citrus leaves) were used alternatively for calibration and validations where appropriate. The purpose of these alternate calibrations and validations were to ensure that, only high photo peaks (well defined peaks and of good statistics) were used for calibrations in order to obtain good results.

However, because of low concentration content of As, Cd and Hg, the sensitivity method was used for quantification. This required a separate standard solution of As, Cd and Hg. The net counts under the full energy peak of both samples and standards were integrated manually from the Ortec Maestro software. The principle for elemental quantification was based on the sensitivity method. The sensitivity is defined as the ratio of the net counts under the full peak of the standard (Y) to the mass [g] of the irradiated pure standard element (X). The element of interest (EOI) is the ratio of the net counts of EOI under the full peak of the sample (Z) to the sensitivity; and the concentration is represented by the ratio of EOI to the mass [g] of the irradiated sample.

3. Results and Discussion

A total of nine elements (Al, Mg,Ca, K, Na, Cl, Br, La and Mn) were identified from the soils, roots, stems and leaves of thestudied wood species. Al, Mg, Ca, K, Na, Cl and Mg with concentration greater than 100 ppm are classified as macro nutrients or major trace elements (Kern, 2005) and Br and La with concentration less than 100 ppm are classified as minor trace elements (Kern, 2005).The results of the elemental compositions showing variations in their concentrations are presented in figures 1 to 4.

The concentrations of all the elements were found to be generally highest in the leaves of all the wood species. This might be due to the high translocation of the elements from the soils to the leaves and the influence of wet and dry airborne deposition of these elements upon foliage of the wood species (Nicola, 2003). The high presence of these elements in the leaves is likely to be due to the release of these elements and their compounds into the environment as a result of the mining activities around the area. These elements are essential to life and must be supplemented as micro and macro nutrients in the diets of humans and animals. Trace elements (major and minor) play a significant modulatory role in various diseases (Prasad, 1998; Patel, 1996; Chakraborty et al., 2000). Alteration of trace (major or minor) elemental homeostasis in an organism has direct correlation with different pathological conditions (Oluwole et al., 1990).Ca is crucial in growing new bone and maintaining bone strength. Calcium supplements are standard for treating and preventing osteoporosis; weak and easily broken bones and its precursor, osteopenia. It is an ingredient in many antacids. Medical doctors also use Ca to control high levels of Mg, P and K in the blood. There is good evidence that Ca can help prevent or control high blood pressure. It also may reduce premenstrual symptoms as well as play a role in preventing certain cancers (Keifer, 2014). Mn plays a role in reproduction and bone growth. It is sometimes called the 'brain' mineral, as it is important to mental function. Excessively high levels pose a risk of toxicity. Manganese overdose can cause impotency and nervous system disorders similar to Parkinson's disease.It can also lead to "manganese madness", characterized by irritability, iron. Manganese toxicity can also occur in people with chronic liver disease, as the liver is the means by which the body excretes excess manganese.

High concentration of Mg plays an important role in insulin action, protect against diabetes and serve as cofactor or components for enzyme systems involved in glucose metabolism and increase sensitivity (Durlach and Altura, 1983). The availability of Mg in medicinal plants may be correlated with the use of the medicinal plants in wound healing, malaria treatment and coughs and chest pains as reported by Rude and Shils (2006). This explains the use of Daniellia ogeafaro in treating dysentery.Chloride is essential for the proper distribution of carbon dioxide and the maintenance of osmotic pressure in the tissues. It is necessary for the manufacture of glandular hormone secretions. It prevents the building of excessive fat and autointoxication. Chloride regulates the alkali-acid balance in the blood (Sacek, 2009).This electrolyte mineral works with the other electrolytes potassium and sodium to maintain the proper balance of body fluids, as well as their pH balance.Chloride is also an essential component of digestive juices, as it is needed with hydrogen to form stomach hydrochloric acid, a key component of gastric juice secreted by the stomach that is vital for maintaining the normal acidic environment needed by pepsin, and aids digestion and absorption of many nutrients including iron and vitamin B12. (Sacek, 2009)

Bromine is corrosive to human tissue in a liquid state and its vapors irritate eyes and throat. Bromine vapors are very toxic with inhalation. Humans can absorb organic bromines through the skin, with food and during breathing. Organic bromines are widely used as sprays to kill insects and other unwanted pests. But they are not only poisonous to the animals that they are used against, but also to larger animals. In many cases they are poisonous to humans, too. The most important health effects that can be caused by bromine-containing organic contaminants are malfunctioning of the nervous system and disturbances in genetic materials. But organic bromines can also cause damage to organs such as liver, kidneys, lungs and milt and they can cause stomach and gastrointestinal malfunctioning. Some forms of organic bromines, such as ethylene bromine, can even cause cancer. Inorganic bromines are found in nature, but whereas they occur naturally humans have added too much through the years. Through food and drinking water humans absorb high doses of inorganic bromines. These bromines can damage the nervous system and the thyroid gland. Lanthanum is used to reduce blood levels of phosphate in patients with kidney disease. High levels of phosphate in the blood can cause bone problems. Lanthanum is in a class of medications called phosphate binders. It works by preventing absorption of phosphate from food in the stomach. Excess lanthanum is reported to cause side effects such as reduction in blood calcium, and increase in blood glucose level (Lenntech, 2015).

Ca and K were found in highest concentration levels in the stem of the wood species, OK, KO and AF (Fig 2).In OK concentration of Ca and K were found to be 56665 ppm and 3999 ppm respectively. In KO and AF the concentrations were 72340 ppm, 29999 ppm and 26540 ppm, 500 ppmfor Ca and K respectively. The reason for the accumulation of these elements in the stem might be that the chemical reactions involving elements in this category directly or indirectly impede the ion transport of these elements in the stem therefore regulating uptake and increase in the distribution of these elements in the stem.The increase in the accumulation of these elements in the stem could be the translocation of these elements and others from old leaves to growing leaves through stems of the wood species. These trace macro nutrients play important role in health, disease and wellbeing. K and Ca regulate the fluid balance of the body and thereby influence the cardiac output and changes in their level result in hypertension (Karppanem, 1991; Sacks *et al.,* 1995). These mineral elements, most of which are present in medicinal plants have been known to have health benefits, and their deficiency and toxicity could cause some health hazards (U.S. Food and Drug Administration, 1999).High concentration of K in the wood species is needed for many essential processes, though. These include enzyme activation, photosynthesis, water use efficiency, starch formation and protein synthesis. Potassium participates actively in the maintenance of the cardiac rhythm (Martin et al., 1985). The presence of K in *Daniellia ogeafaro,* for example may explain its use in treating snake bite (Abbiw, 1990), powdered gum water for treating cough and Asthma (Mshana et al., 2000) and water decoction of the root and bark is used for gonorrhea treatment.

In the root, Ca and K were found comparatively high in OK, HY, KO and AF (Fig 3).In OK and HY the concentrations of Ca and K were found to be 56664 ppm and 4001 ppm, 3260 ppm and 12100 ppm respectively. For KO and AF their concentrations were found to be 26450 ppm and 501 ppm for Ca and K respectively. The elemental concentration profiles across roots of tropical and non tropical wood species show that the epidermis could be an efficient selective barrier to the entrance of elements. These elements were likely retained at higher concentration levels in the epidermis and subsequently increased in the inner root. There might also be a higher level of ion concentration and metabolic activity necessitating a higher level of elemental concentration in the roots of the wood species. Excessive levels of calcium in the blood can cause nausea, dry mouth, abdominal pain, irregular heartbeat, and even death Keifer, 2014).

There are elements which abound in the parts of the wood species with higher concentration levels than in the soils. For example in the leaves, Mg, Br, Ca, La, Cl abound more in the leaves than in the soils. In the stem, Br, Mn, Cl, Na, K and Ca are in higher concentration levels than in the soils. Again in the root, Cl possesses higher concentration in the root than in the soils. This could have been the result of industrial pollution, as trace elements could have been easily absorbed from air in this case, and translocated to the leaves, stems or the roots. But, it could have been also a result of using the leaves as fertilizer for plant growth. The excessive mining activities at the community might enhance the release of these minerals into the various parts of wood species. High K can cause paralysis and heart problems. If your K levels are too high, your heartbeat can become irregular. If left untreated, high K levels can even cause your heart to stop (Wint, 2012). High levels of K in the soil can be minimized by planting the species which contain high concentrations of K so that the mineral could be extracted from the soil. The concentrations of Ca in OK and KO were found to be on the average constant from the roots to the leaves (Figs 1-3). This is because Ca is an essential part of plant cell structure and provides for normal transport and retention of other elements as well as strength in the plant. In the soils, Ca (50436 ppm) in KO was highest and on the average Al (10,000 ppm) was next highest (Fig 4).

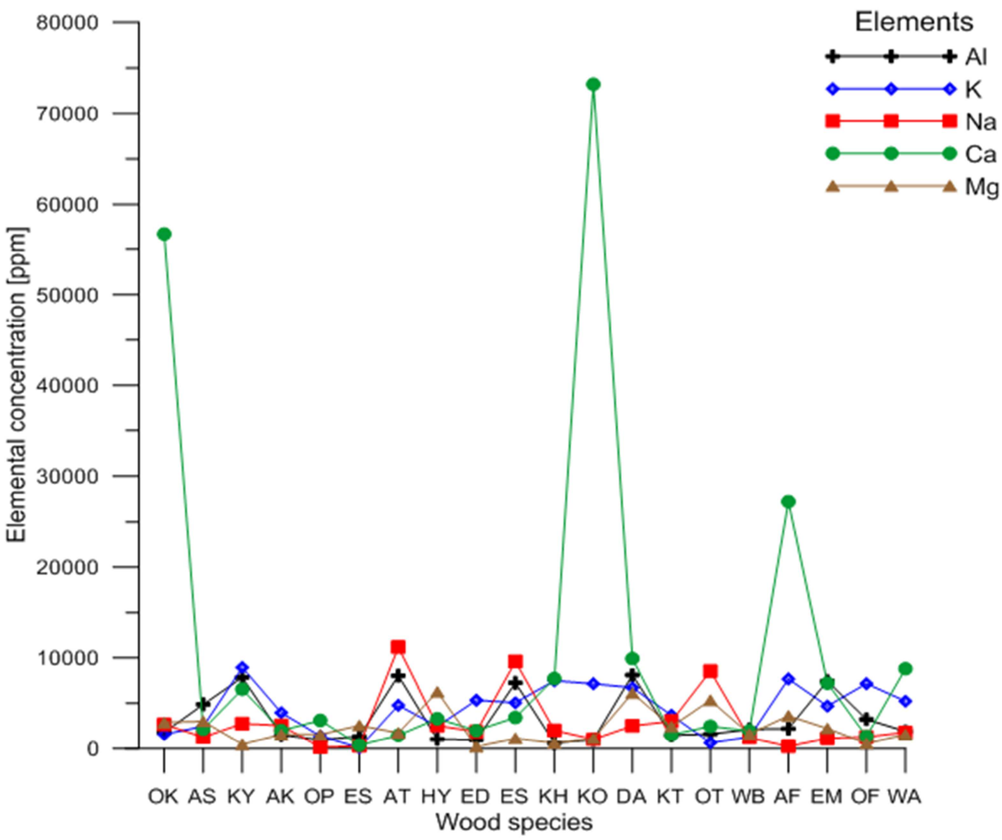

Figure 1i. *Elemental composition of wood species in the leaves.*

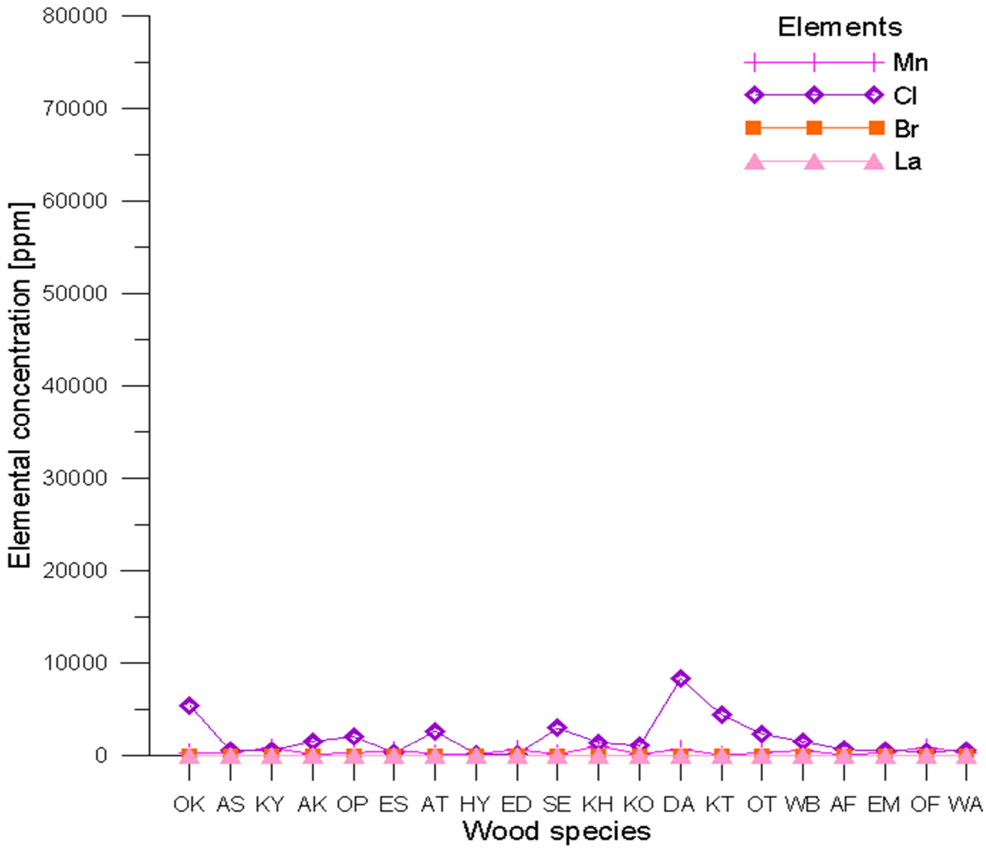

Figure 1ii. *Elemental composition of wood species in the leaves.*

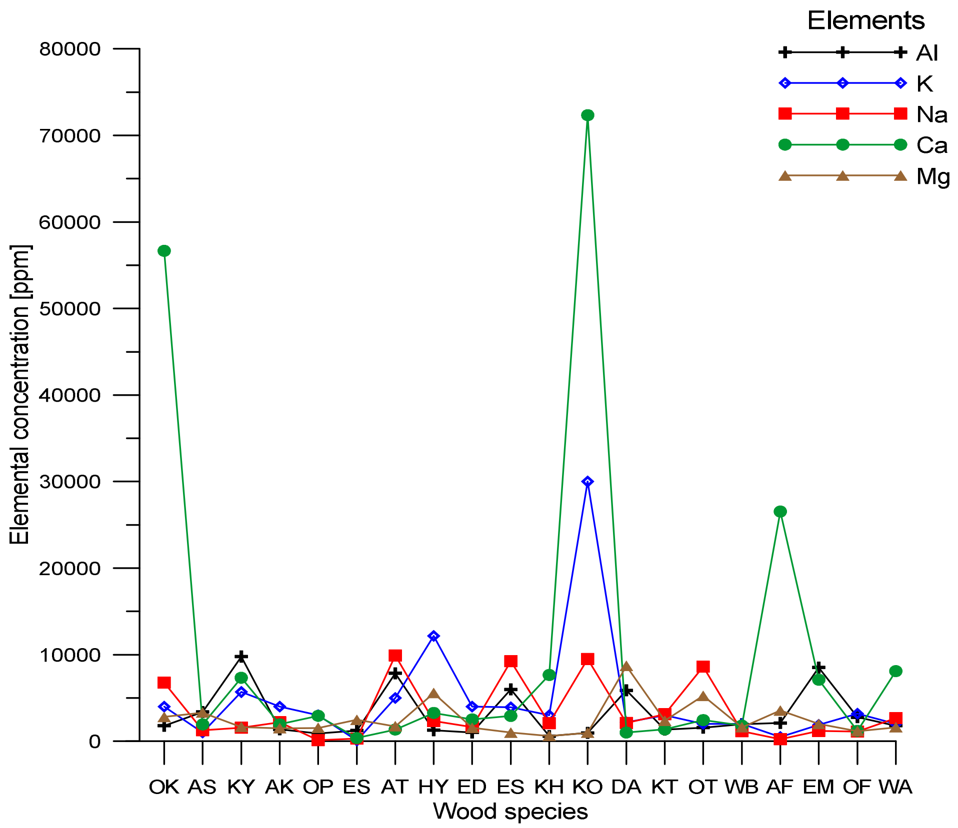

Figure 2i. *Elemental composition of wood species in the stem.*

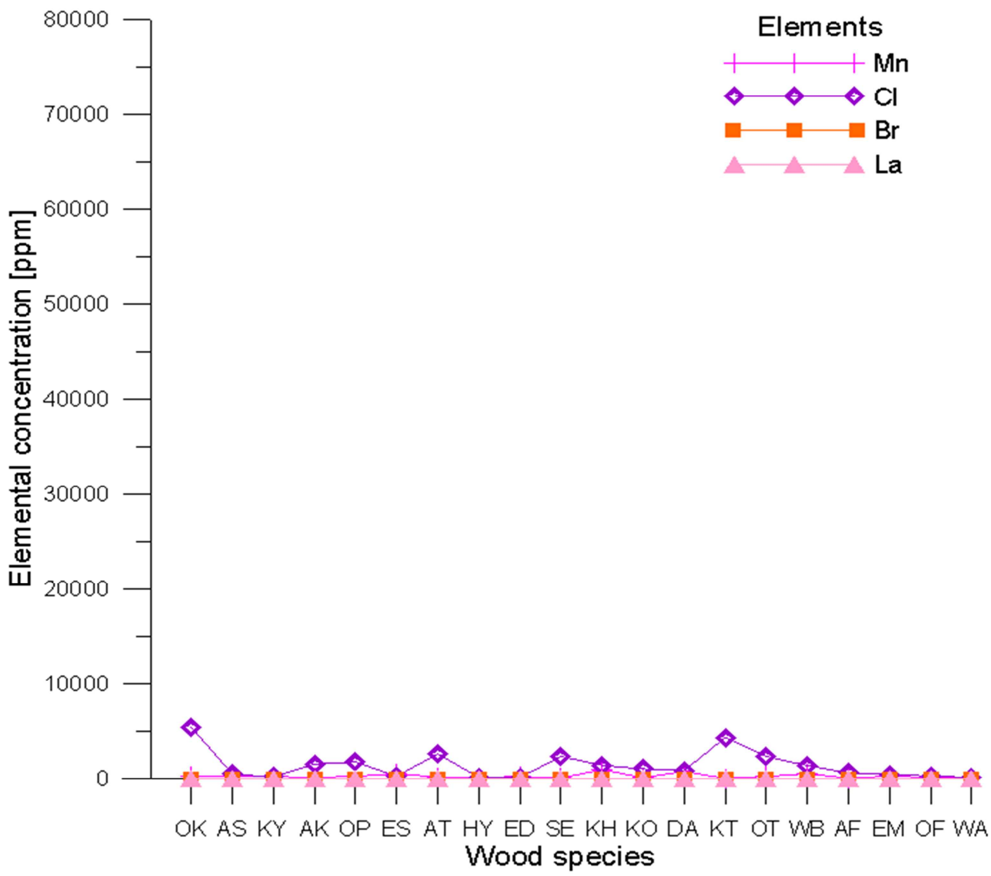

Figure 2ii. *Elemental composition of wood species in the stem.*

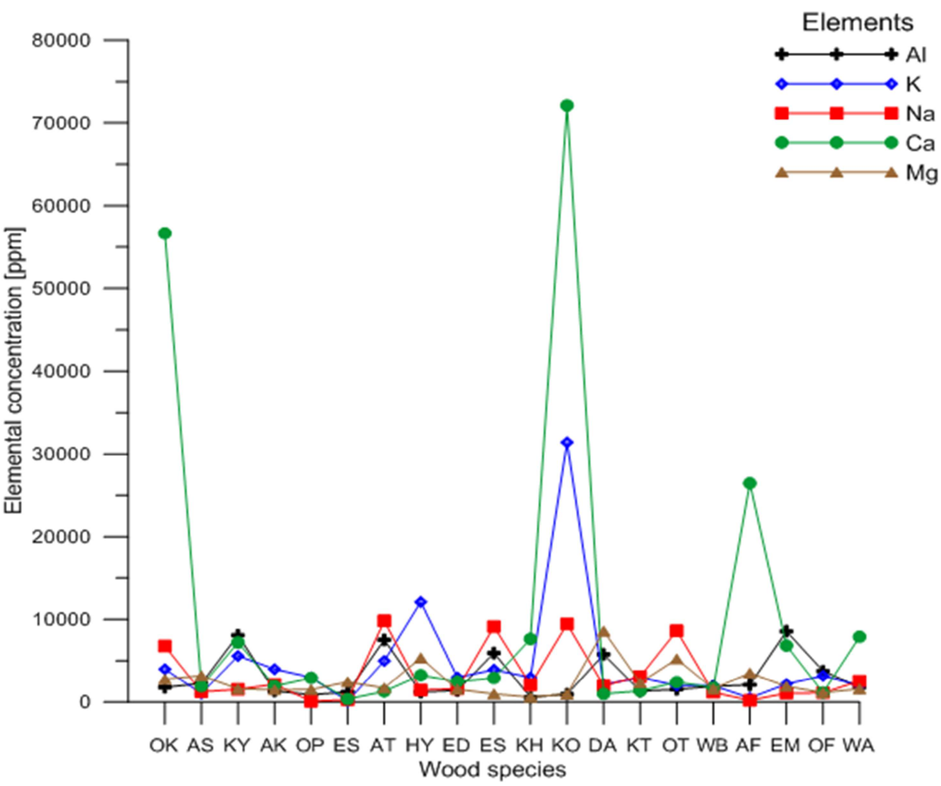

Figure 3i. *Elemental composition of wood species in the root.*

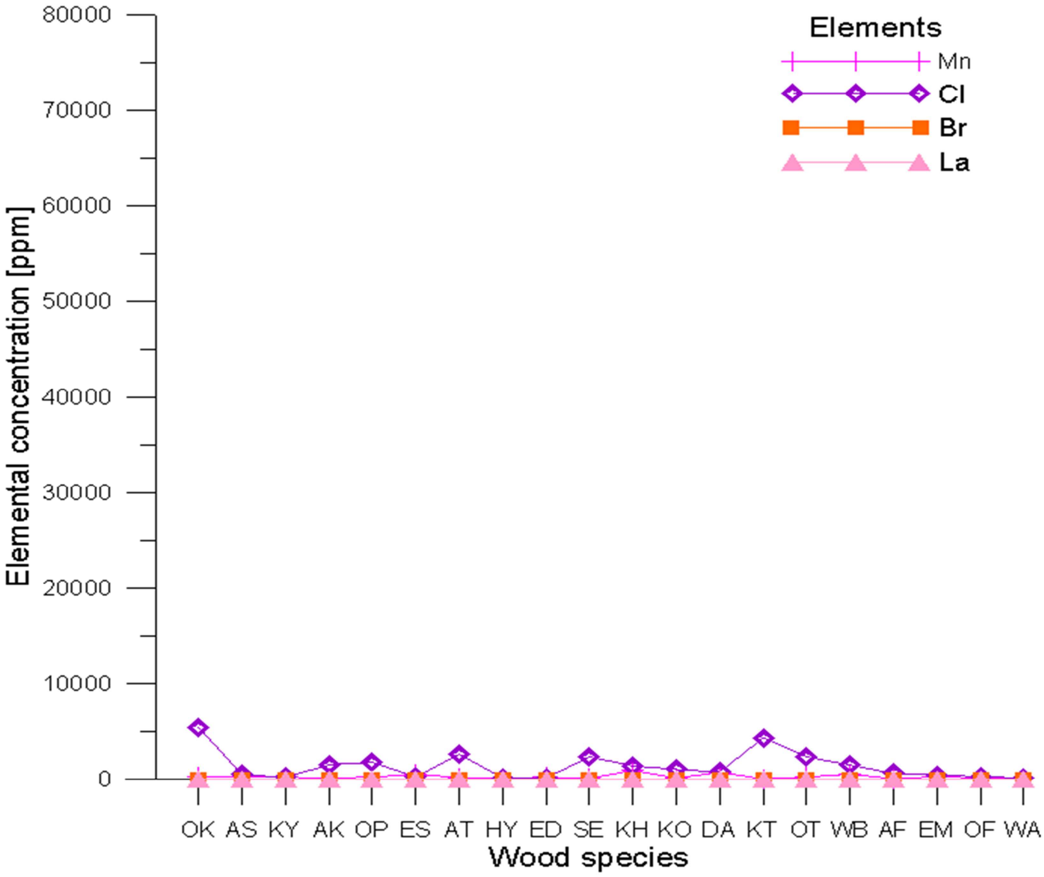

Figure 3ii. *Elemental composition of wood species in the root.*

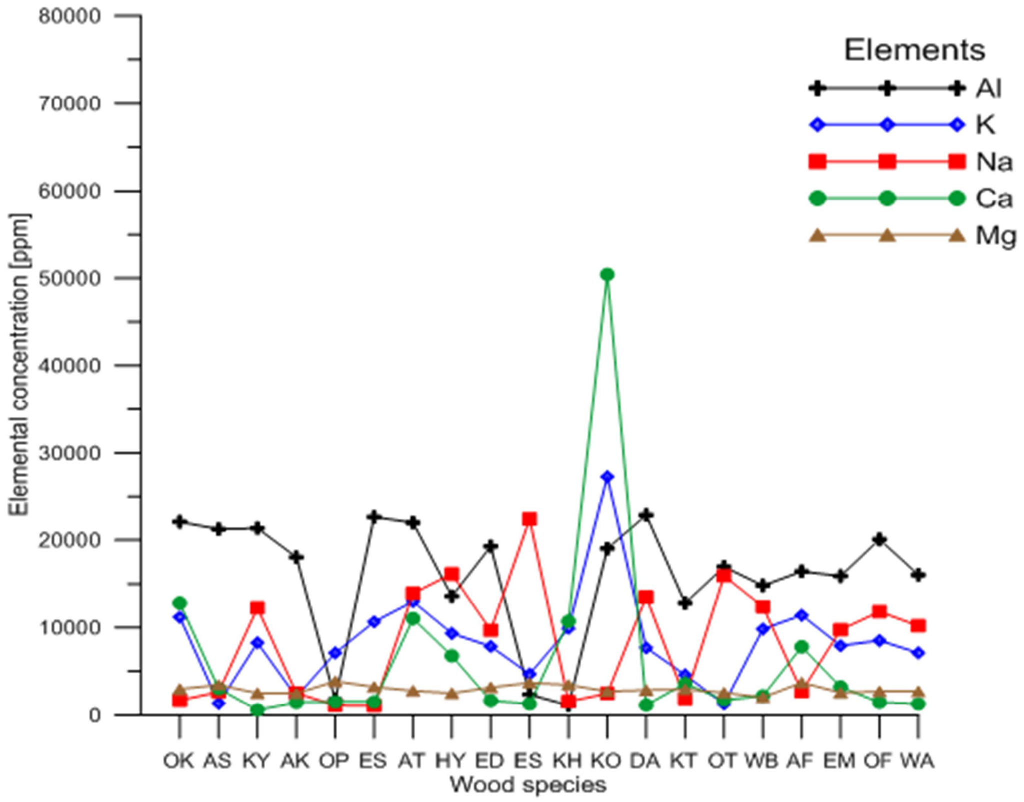

Figure 4i. *Elemental composition of wood species in the soil.*

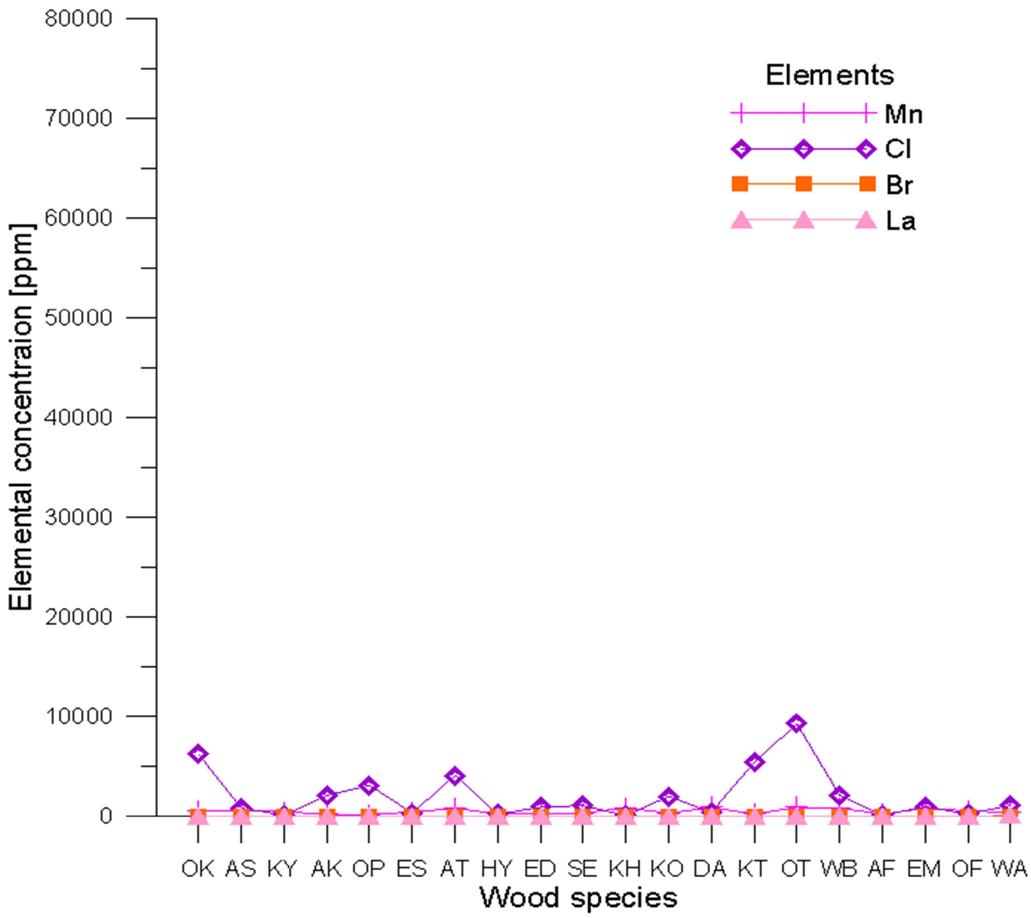

Figure 4ii. *Elemental composition of wood species in the soil.*

4. Conclusion

The elemental presence and concentration of the twenty (20) tropical wood species have been analysed using Instrumental Neutron Activation Analysis(INAA). The concentrations of Al, Mg, Ca, K, Na, Cl, Mn, La and Br which are made up of major and minor trace elements of those wood samples have been measured.

The concentrations of Ca, Mn, Cl, Mg, Mn, Br, La, Na and K were found to be generally highest in the leaves of all the wood species. This might be due to the high translocation of the elements from the soils to the leaves.

The leaves showed the highest accumulation of Ca (73211 ppm) in *Morinda lucida* while the root produced the lowest concentration of La (0.08 ppm) in *Antiaris africana*. The high accumulation of Ca in the leaves could be due to high translocation of Ca from root to the leaves of the species and the evaporation of water containing high amount of Ca in the leaf tissue. The low concentration of La in the roots might be due to a lower level of ion concentration and metabolic activity.

Based on the results from this paper, it can be deduced that the significant presence of K, Na, Mg, Ca, Al, Mn and Cl in the roots, stem and leaves of the wood species couldhelp in the treatment of different kinds of disease. Therefore, in order to develop a stronger basis for appreciating the curative effects of medicinal plants, there is a need for more investigations to be conducted to identify the role of essential elements in the medicinal values of plants and carry out toxicity studies to improve human health.

Acknowledgement

The authors are indebted to Forestry Research Institute of Ghana (FORIG) of the Council for Scientific and Industrial Research (CSIR) and the Logs and Lumber Limited (LLL), wood processing Company, Kumasi, Ghana for the provision of their Pra-Anum forest concessions to obtain the wood species. We are profoundly grateful to the Physics Department of Kwame Nkrumah University of Science and Technology, Kumasi for provision of laboratory facilities to process wood species for the results. Again, our sincere gratitude goes to Mr. Dwamena Akenteng and Mr. Isaac Larbi (WASCAL FUT-Minna) for providing invaluable technical assistance. The facility provided by Physics Department, KNUST, and Kumasi, to store the samples for further research is gratefully acknowledged.

Nomenclature

Species	Notation
Albizia zygia	OK
Aningeria altissima	AS
Antiaris africana	KY
Blighia sopida	AK
Bridelia micranthia	OP
Celtis mildraedii	ES
Chrysophylum perpalchrum	AT
Daniellia ogeafaro	HY
Entandrophragma angolense	ED
Holorrhena floribunda	SE
Khaya ivorensis	KH
Morinda lucida	KO
Nesogordonia papaverifera	DA
Pterygota macrocarpa	KT
Pycnanthus angolensis	OT
Sterculia rhinopetalia	WB
Stromboria glaucescens	AF
Terminalia ivorensis	EM
Triplochiton scleroxylon	WA

References

[1] Abbiw, D.K. (1990). Useful plants in Ghana: West African Uses of Wild and cultivated plant. Intermediate Technology Publication. The Royal Botanic Garden, Kew, Richmond, UK.

[2] Alam, S. (2009). Antimicrobial activity of natural products from medicinal plants. *GomalJournal of Medical Sciences* 7(1):72-78.

[3] Balaji T., Acharya R.N., Nair A.G.C., Reddy A.V.R., RaoK.S, Naidu G.R.K, Manohar S.B. (2000). In:Rabia N, Mir AK, Kiran YK, Mushtaq A, Barkat A, Paras M, Mazhar M, Hussain A (2012). Element Content of Some Ethno medicinal Ziziphus Linn. Species Using Atomic Absorption Spectroscopy Technique. J. Appl. Pharm. Sci. 02(03):96-100.

[4] Brammer, H. (1962). Soils. In J. B. Wills (Ed.), Agriculture and land use in Ghana, Ministry of Agriculture, Accra, Ghana (pp. 84-114). London: Oxford University Press.

[5] Burkil, H. M, (1985). Useful plants of West Africa. Vol. 2 (E-I). Royal Botanic Garden, Kew, Richmond, UK.

[6] Durlach J, Altura BM (1983). Magnesium, diabetes and carbohydrate metabolism. Magnesium (2):173-336.

[7] DRI, 2001. (Dietary Reference Intakes) for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. National Academy Press Washington, D.C.

[8] Gill, L.S., (1992). Ethnomedicinal Uses of plants in Nigeria. Uniben Press, Benin City, Nigeria.

[9] Gbolahan, D. (2001). Lesson Notes on medical importance of trace elements. Center for Natural Health Studies.

[10] Hall, J. B., & Swaine, M. D. (1981). Distribution and ecology of vas-cular plants in a tropical rain forest vegetation of Ghana (383p). Geobotany Series 1, The Hague: Dr. W. Junk Publishers.

[11] Kern, M (2005). CRC desk reference on sports nutrition. CRC Press. pp. 117–. ISBN 978-0-8493-2273-0. Wikipedia, Retrieved March, 2015

[12] Martin Jr, D. W., Mayers, P. A., Rodwell, V. W., Granner, D. K. 1985. Harper's Review of Biochemistry, 20th ed., Lange Medical Publications, California, pp. 651-660

[13] Moss, NS (1981). Ayurvedic Flora Medica, John Lindley, New Delhi.

[14] Mshana, R. N. et al (2000). Traditional medicine and pharmacopoeia: contribution to the revision of enthnobotanical and floristic studies in Ghana. OAU/STRC Publishers.

[15] Ncube N.S, Afolayan A. J, Okoh AI (2008). Assessment Techniques of Antimicrobial Properties of Natural Compounds of Plant Origin: Current Methods and Future Trends. Afri. J. Biotechnol. 7(1 – 2):1797 – 1806

[16] Okoli, R.I., Agbe, O., Ohaju-Obodo, J.O. and Mensah, J.K. 2007. Medicinal plants used for managing some common ailments among Esan people of Edo State, Nigeria. Pakistan Journal of Nutrition 6(5):490-496.

[17] Pettersen, R.C. (1984).The Chemical Composition of WoodU.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, WI 53705. Pg58

[18] Sakina, M. Y.,Alia, E. A. R.,Gihan, O.M. E., andAbdelhafeez, M.A. M., (2013). Elemental Analysis of Ten Sudanese Medicinal Plants Using X-ray Fluorescence. Journal of Applied and Industrial Sciences, April 2013, 1(1):49-53.

[19] Singh V and Garg AN (1997). Availability of essential trace elements in Ayurvedic Indian medicinal herbs using instrumental neutron activation analysis. *J. Appl. RadiationIsotops,* 48: 97-101.

[20] Sofowora, A.(2008). Medicinal plants and Traditional Medicine in Africa. Polygraphics Ventures Ltd. Ibadan. 3rdEd: pp. 253-258.

[21] Sonon, L. (2010). Plants nutrients, aesl.ces.uga.edu

[22] Taylor, C. J. (1960). Synecology and siviculture in Ghana. Thos. Nelson and son Ltd

[23] Vashishtha, V.M., Kumar, A., John, J. and Nayak, N.C. (2007), “Cassia occidentalispoisoning cause’s fatal coma in children in Western Uttar Padesh”, Indian Pediatrics44(17): 522-525.

[24] Veerachari, U. and Bopaiah, A.K. 2011. Preliminary phytochemical evaluation of the leaf extract of five *Cassia* species. Journalof Chemical and Pharmaceutical Research 3(5): 574-583.

[25] Walter, L. (1995). Physiological Plant Ecology: Ecophysiology and Stress Physiology of Functional Groups, 3rd edn. Springer-Verlag, New York. pp. 167–211.

[26] Yamashita C.I, Saiki M, Vasconcellos, M. B. A, Sertic, J. A. A (2005). Characterization of trace elements in Casearia Medicinal Plant by Neutron Activation Analysis. Appl. Radiat. Isot. 633:841-846

[27] Zafar, A.M, Mohammad S, Saad Bin Z. M, Mahwish A. K. (2010) Herbal Treatment for Cardiovascular Disease. The Evidence Based Therapy Pak. J. Pharm. Sci., 23(1):119-124

[28] Zargar, A. H, Shah, N. A, Masoodi, S. R, Laway, B. A, Dar, F. A, Khan, A.R, Sofi, F.A, Wani, A. I (1998). Copper, zinc, and magnesium levels in non-insulin dependent *Diabetes mellitus*. Postgrad. Med. J. (74):665-668.