Study on Mineral content of Some Ayurvedic Indian Medicinal Plants

S. Moscow, K.Jothivenkatachalam*
Department of Chemistry, Anna university of Technology Tiruchirappalli,
Tiruchirappalli.(TN), India.
jothivenkat@yahoo.com

ABSTRACT

Essential and non-essential heavy metals like Mn, Zn,Fe, Ni, Cu, Cr, Pb, Cd,As and Hg were quantified in selected medicinal plants including Acalypha indica Linn., Enicostemma littorale Blume. Nelumbo nucifera Gaertn, Sphaeranthus indicus Linn., and Withania somnifera., by using atomic absorption spectrometry. The main purpose of this study was to document evidence of essential and non-essential heavy metals in these herbs, which are extensively used in the preparation of herbal products and standardized extracts.

High iron contents were observed in W. somnifera 191.37 ppm, Acalypha indica Linn 156.59 ppm, Enicostemma littorale Blume, 95.37 ppm, Nelumbo nucifera Gaertn 171.38 ppm, Sphaeranthus indicus Linn. 169.41 ppm. The concentration of other heavy metals particularly Cr, Pb, Cd, As, Hg was found on the lower side in the selected herbs

Key words: Zn, Fe, Cu, Cr, plant species, heavy metals.

INTRODUCTION

The contribution of medicinal plants in the traditional system of medicine for curing diseases has been documented. Nowadays increased scientific interest and consumer demand have promoted the development of herbal products as dietary supplements. In view of renewed interest, oriental herbal medicines have a prominent role to play in the pharmaceutical and health markets of the 21st century[1]. It has been reported that whatever is taken as food could cause metabolic disturbance subject to the allowed upper and lower limits of trace metals[2]. Both the deficiency and excess of essential micronutrients and trace of toxic metals may cause serious effects on human health [3-4].

The use of medicinal plants in therapeutics or as dietary supplements goes back beyond recorded history,but has increased substantially in the last decades[5-6]. How-ever, the safety of their use has recently been questioned due to the reports of illness and fatalities[7-8]. WHO recommends that medicinal plants which form the raw materials for the finished products may be checked for the presence of heavy metals, further it regulates maximum permissible limits of toxic metals like arsenic, cadmium and lead, which amount to 1.0, 0.3 and 10 ppm, respectively[9]. Medicinal herbs are easily contaminated during growth, development and processing. After collection and transformation into dosage form the heavy metals confined in plants finally enter the human body and may disturb the normal functions of central nervous system, liver, lungs, heart, kidney and brain, leading to hypertension, abdominal pain, skin eruptions, intestinal ulcer and different types of cancers.

MATERIAL AND METHODS

Collection and Pre- Treatment of Plant Material

Medicinal plants were selected based on extensive use by the population and their phytotherapeutic properties. Plants were collected from natural habitat and Plant parts, were washed in fresh running water to eliminate dust, dirt and possible parasites and then treated with de-ionized water and were dried in shade at 25-30 ^{o}C. During this sample processing, necessary measures were taken in order to avoid any loss or contamination of metals.

Atomic Absorption Spectrometer (AAS) Measurement

The samples in the powdered form were accurately weighed and digested in (5:1) mixture of nitric acid and perchloric acid[10] . After digestion few drops of concentrated HCl was added. The solution was heated gently and then filtered. The residue was again subjected to digestion and filtrate was collected. The entire filtrate was diluted suitably with distilled deionized water. The dilute filtrate solution was used for analysis of elements of interest by AAS (Perkin Elmer 3100 model) using suitable hollow cathode lamps. The elements were analyzed by AAS technique by measuring the absorbance of the species at its resonance wavelength. The concentration of various elements was determined by relative method using A.R. grade solutions of elements of interest. For mercury analysis, the digested solution was analyzed by cold vapor AAS after reduction with $NaBH_4$.

RESULTS AND DISCUSSION

Concentration of essential and non-essential heavy metals in medicinal plants beyond permissible limit is a matter of great concern to public safety all over the world. The problem is rather more serious in populated countries, because medicinal plants which form the raw materials for the finished products are neither controlled nor properly regulated by quality assurance parameters.

An examination of the data from Table 2 shows that different medicinal plant contain elements like Fe, Zn, Cu, Cr, Cd, Ni, Pb, As and Hg in various proportions. The variation in elemental concentration is mainly attributed to the differences in botanical structure, as well as in the mineral composition of the soil in which the plants are cultivated. Other factors responsible for a variation in elemental content are preferential absorbability of the plant, use of fertilizers, irrigation water and climatological conditions[11]

Table-1 summarizes pharmacognostic features of the selected medicinal herbs used as herbal remedy. As evident from table, Acalypha indica Linn is repiratory diseases, bleeding piles, irritations, stabbing pain, wheezing[12], whereas Enicostemma littorale Blume have Antidiabetic, and antimalarial properties[13.] Similarly, Nelumbo nucifera Gaertn is recommended for oral Anti-diabetic, Hepatoprotective, anti-hypoglycemic[14]. On the other hand Sphaeranthus indicus Linn is mental illness, hemicrania, jaundice, hepatopathy, diabetes, leprosy, fever, pectoralgia, cough, gastropathy, hernia, hemorrhoids, helminthiasis, dyspepsia and skin diseases[15-16], whereas W. somnifera is associated with Diuretic, Sedative, Antiseptic, Astringent, Abortifacient, Deobstruent, Arthritis.[17]

The concentration of Fe, Zn, Ni, Cu, Cr, Pb, As, Hg and Cd in selected medicinal plants are appended in Table-2. As evident from this table, maximum concentration of iron contents were observed in W. somnifera 191.37 ppm, Acalypha indica Linn 156.59 ppm, Enicostemma littorale Blume, 95.37 ppm, Nelumbo nucifera Gaertn 171.38 ppm, Sphaeranthus indicus Linn. 169.41 ppm. The concentration of other heavy metals particularly Cr, Pb, Cd, As, Hg was found on the lower side in the selected herbs. Iron concentration is high in all plants, however it is within normal background level for the element in plants under the critical concentration of 300-500 ppm.

Iron

Iron is an essential element for human beings and animals and is an essential component of hemoglobin. It facilitates the oxidation of carbohydrates, protein and fat to control body weight, which is very important factor in diabetes. Results in table-2 reveal that maximum concentration of Fe was found in *W.somnifera* 191.37 ppm, followed by *Nelumbo nucifera* Gaertn 171.38 ppm, *Sphaeranthus indicus* Linn. 169.41 ppm, Acalypha indica Linn 156.59 ppm and Enicostemma littorale Blume, 95.37 ppm.

The results suggest that high amount of Fe in plants may also be due to the soil nature. The dietary limit of Fe in the food is 10-60 mg/day[18]. Low Fe content causes gastrointestinal infection, nose bleeding and myocardial infarction[19]. The role of iron in the body is clearly associated with hemoglobin and the transfer of oxygen from lungs to the tissue cells[20.] Iron deficiency is the most prevalent nutritional deficiency in humans[21] and is commonly caused by insufficient dietary intake, excessive menstrual flow or multiple births. In this case, it results especially an anemia.

Zinc

As evident from Table-2, high concentration of Zn was found in Acalypha indica Linn 47.18 ppm followed by Nelumbo nucifera Gaertn 45.00 ppm, W.somnifera 43.01 ppm, *Sphaeranthus indicus* Linn. 38.14

ppm, Enicostemma littorale Blume,32.87 ppm,. Zinc is an essential trace element for plant growth and also plays an important role in various cell processes including normal growth, brain development, behavioural response, bone formation and wound healing. Zinc deficient diabetics fail to improve their power of perception and also causes loss of sense of touch and smell[19]. The dietary limit of Zn is 100 ppm[22].

Zinc deficiency is characterized by recurrent infections, lack of immunity and poor growth. Growth retardation, male hypogonadism, skin changes, poor appetite and mental lethargy are some of the manifestations of chronically zinc-deficient human subjects[23]. Zinc is necessary for the growth and multiplication of cells (enzymes responsible for DNA and RNA synthesis), for skin integrity, bone metabolism and functioning of taste and eyesight[24] .

Copper

Copper is an essential enzymatic element for normal plant growth and development but can be toxic at excessive levels. Phytotoxicity can occur if its concentration in plants is higher than 20- 100 ppm DW (dry weight). As can be seen from the data (Table-2) The concentration of Copper was found in Acalypha indica Linn 9.65 ppm, W. somnifera 8.67 ppm, Nelumbo nucifera Gaertn 8.43 ppm, *Sphaeranthus indicus* Linn. 7.71 ppm, and Enicostemma littorale Blume, 5.08 ppm.. High levels Cu may cause metal fumes fever with flue like symptoms, hair and skin decoloration, dermatitis, irritation of the upper respiratory tract, metallic taste in the mouth and nausea[25]. WHO[26] has recommended the lower limit of the acceptable range of Copper as 20 µg/mg body weight per day[27-28]. Copper deficiency results in anemia and congenital inability to excrete copper resulting in Wilson's disease[29].

Nickel

In case of Nickel the concentration in different plants was in the order of; Acalypha indica Linn 4.35 ppm, *Nelumbo nucifera* Gaertn 4.16 ppm, *Sphaeranthus indicus* Linn. 3.18 ppm, W. somnifera 2.64 ppm, and Enicostemma littorale Blume, 0.94 ppm. The higher concentration of Nickel in plants may be due to anthropogenic activities. The most common ailment arising from Nickel is an allergic dermatitis known as nickel itch, which usually occurs when skin is moist, further more Nickel has been identified as a suspected carcinogen and adversely affects lungs and nasal cavities. Although Nickel is required in minute quantity for body as it is mostly present in the pancreas and hence plays an important role in the production of insulin. Its deficiency results in the disorder of liver[30]. EPA has recommended daily intake of Ni should be less than 1 mg beyond which is toxic[31.]

Chromium

Chromium is essential in carbohydrate metabolism. It also functions in protein and cholesterol synthesis. It plays an important role diabetes treatment. It is an important element required for the maintenance of normal glucose metabolism. The function of chromium is directly related to the function of insulin, which plays a very important role in diabetes. Chromium is found in the pancreas, which produces insulin.[32]

The concentration of Cr found in different plants was in the tune of Acalypha indica Linn, 4.65 ppm, *Sphaeranthus indicus* Linn.1.45 ppm, *W. somnifera*, 0.40 ppm and *Nelumbo nucifera* Gaertn 0.27 ppm (Table-2). The higher concentration of Cr in Enicostemma littorale Blume, 5.30 ppm, it could be a probable cause for yields reduction. With the exception of fall out of atmospheric pollutants through rain and accumulation in plant, it is probable that the metal was translocated through air dust blowing from nearby. The toxic effects of Cr intake is skin rash, nose irritations, bleeds, upset stomach, kidney and liver damage, nasal itch and lungs cancer, chromium deficiency is characterized by disturbance in glucose lipids and protein metabolism[31]. The daily intake of Cr 50-200 µg has been recommended for adults by US National Academy of Sciences[28] .

Cadmium

In case of Cd the concentration in different plants was in the order of; *Sphaeranthus indicus* Linn. 0.074 ppm, W. somnifera 0.0632 ppm Acalypha indica Linn 0.0625 ppm, Enicostemma littorale Blume, 0.047 ppm and *Nelumbo nucifera* Gaertn 0.022 ppm.

Cadmium is a nonessential trace element with uncertain direct functions in both plants and humans[33] and responsible for several cases of poisoning through food. Small quantities of cadmium cause adverse changes in the arteries of human kidney. It replaces zinc biochemically and causes high blood pressures, kidney damage and etc.

It interferes with enzymes and causes a painful disease called Itai-itai[34] and renal dysfunction would be expected in sensitive population groups at cadmium exposure[35] and Cadmium accumulates in human body and damages mainly the kidneys and liver [36].

Lead

As evident from Table-2, high concentration of Pb was found in Acalypha indica Linn 0.8233 ppm, *Nelumbo nucifera* Gaertn 0.728 ppm, *Sphaeranthus indicus* Linn. 0.866 ppm, W. somnifera 0.9125 ppm, and Enicostemma littorale Blume, 1.147 ppm.

Lead is a non-essential element that can be introduced into the human organism by inhalation, ingestion or cutaneous absorption. It is an undesirable trace metal less abundantly found in found in soil, vegetation, animals and food. Although its concentration can be relatively high in the liver and kidney, lead is mainly deposited in the bones. The deleterious properties of lead are particularly signiicant in the central nervous system, kidneys and liver[37].

It is a serious cumulative body poison. Lead inhibits several key enzymes involved in the overall process of haemo-synthesis whereby metabolic intermediate accumulates[38]. WHO[26] prescribed limit for Pb contents in herbal medicine is 10 ppm while the dietary intake limit for Pb is 3 mg/week.

Arsenic

It is a toxic non-essential element and occurs commonly in insecticides, fungicides and herbicides. Among its components, Monitoring of heavy metal concentration Arsenic(III) is most toxic. The concentration of As (Table-2) found in different plants was in the tune of Acalypha indica Linn, 0.095 ppm, *Sphaeranthus indicus* Linn. 0.033 ppm, *W. somnifera*, 0.116 ppm and *Nelumbo nucifera* Gaertn 0.178 ppm an Enicostemma littorale Blume, 0.088 ppm. In all samples the concentrations of as, do not exceed the limits of 1 mg/kg recommended for medicinal plants[39].

High concentration of Arsenic(III) compounds causes metabolic disorder. It also causes dermatitis and the irritation of upper respiratory passage, ulceration and perforation of nasal septum, lung cancer, cardiovascular and neurological effects[40].

Mercury

In case of Hg the concentration in different plants Acalypha indica Linn 0.0035 ppm, Nelumbo nucifera Gaertn 0.065 ppm, *Sphaeranthus indicus* Linn. 0.062 ppm, W. somnifera 0.061ppm, and Enicostemma littorale Blume, 0.025 ppm.

Mercury can cause adverse effects on the renal and nervous systems and can cross the placental barrier, with potential toxic effects on the fetus[41-42]. No tested sample contains high levels of mercury. Mercury the limit of 0.5 µg Hg/g recommended in drugs, including from plants[43].

Mercury exposure for the general population occurs mainly from consumption of fish, as methyl mercury[44] and possibly from dental amalgam fillings and it is unlikely that the exposure through medicinal herbs will affect human health.

CONCLUSIONS

Based on these observations, the data are discussed in the light of current literature and the following conclusions are drawn. The concentration variations of Cadmium, Chromium, Mercury and Lead have been identified to impart more or less uniform growth retardation resulting in similar morphology and tolerance by plants cultivated in nutrient medium artificially contaminated with known quantities of these metals.

The selected medicinal plants have been recommended as remedies for myriad of conditions in the traditional system of medicine. In the field of phytotherapy, tremendous progress has been documented regarding scientific evaluation of medicinal plants across the globe. The practical repercussion of the changing situation may be witnessed in the WHO monographs, National Pharmacopoeias and herbs processing industries. The concentration of heavy metals determined in selected medicinal plants is well below the critical limit.

Non essential heavy metals such as cadmium, chromium, mercury and lead are highly reactive and interfere the normal metabolism and become toxic to plants generating morphological and physiological alterations and modifications. Medicinal plants form the raw materials for Ayurvedic medicines. Most of the medicinal plants are herbs which are cultivated or naturally growing in soil, contaminated with heavy metals by natural and anthropogenic activities and the plants accumulate considerable quantities of toxic heavy metals. The metals confined in medicinal plants finally reach food chain leading to health hazard in human and animals and get recycled. The implication of findings may be taken into consideration whilst using the herbs for human

consumption. The results suggest that medicinal plants used for human consumption or for preparation of herbal products and standardized extracts should be collected from an unpolluted natural habitat.

ACKNOWLEDGEMENT
The authors acknowledge the Anna University of Technology Tiruchirappalli, Tiruchirappalli.

REFERENCES

[1] Kleinschmidt, H.E. and R.W. Johnson. Weeds of Queensland, Queensland Department of Primary Ind., Australia, 1977, P.147.
[2] Prasad, A.S.. Trace elements in human health and diseases vols. 1 and 2, Academic Press, New York, USA, 1976.
[3] Underwood, E.J.. Trace element in human and animals nutrition. 4th edition, Academic Press Inc. New York, 1997.
[4] Reilly, C. Metal Contamination of Food, 1st Ed. Chapter 5 and 6. Applied Science Publishers London. 1980.
[5] Woods, P.W., Herbal healing. Essence, 1999.30, 42–46
[6] Khan, I.A., Allgood, J., Walker, L.A., Abourashed, E.A., Schelenk,D., Benson, W.H., , Determination of heavy metals and pesticides in ginseng products. Journal of AOAC International 2001,84, 936–939.
[7] Stewart, M.J., Moar, J.J., Steenkamp, P., Kokot, M., 1999. Findings in fatal cases of poisoning attributed to traditional remedies in South Africa. Forensic Science International 101, 177–183
[8] Ernst, E.,. Toxic heavy metals and undeclared drugs in Asian herbal medicines. Pharmacological Sciences, 2002,23, 136–139
[9] World Health Organization, Quality Control Methods for Medicinal Plant Materials, WHO Geneva Switzerland. 1998.
[10] Herber, R.F.M. and Stoeppler, M. Eds. Trace Element Analysis in Biological Specimens, Elsevier, New York. 1994.
[11] Rajurkar, N.S. and Pardeshi, B.M. Analysis of some herbal plants from India used in the control of dia-betes mellitus by NAA and AAS techniques. Appl. Ra-diat. Isot., 1997,48, pp. 1059
[12] Kirtikar KR and Basu BD . In: Indian Medicinal Plant, vol. III, International Book Distributors, Dehradun, India, 1999, pp.2262-2263
[13] Maroo J, Vasu VT, Aalinkeel R, Gupta S. Glucose lowering effect of aqueous extract of Enicostemma littorale Blume in diabetes: a possible mechanism of action J Ethnopharmacol. 2002 Aug; 81(3):317-20
[14] Sohn DH, Kim YC, Oh SH, Park EJ, Li X, Lee BH. Hepatoprotective and free radical scavenging effects of Nelumbo nucifera, Phytomedicine. 2003 Mar; 10(2-3):165-9.
[15] Gupta NS. The Ayurvedic system of medicine. Vol. II. New Delhi: Logas Press; 1984
[16] Varsha J. Galani, B. G. Patel, and D. G. Rana, Sphaeranthus indicus Linn.: A phytopharmacological review, Int J Ayurveda Res. 2010 Oct-Dec; 1(4): 247–253
[17] G. Singh*, P. K. Sharma, R. Dudhe and S. Singh, Biological activities of Withania somnifera, Annals of Biological Research, 2010, 1 (3) : 56-63
[18] Kaplan, L.A., A.J. Pesce and S.C. Kazmierczak.. Theory,Analysis, Correlation, In: Clinical Chemistry 4th Ed., Published by Mosby, 1993,707p.
[19] Hunt, J.R.. Bioavailability of Fe, Zn and other Trace Minerals for Vegetarian Diets. Am. J. Clin. Nutr. 1994,78: 633-39.
[20] Sigel H. Metals in Biological Systems. Marcel Dekker, New York, 1978.
[21] Reddy MB, Chidambaram MV, Bates GW. Iron Transport in Microbes, Plants and Animals. VCH, New York, 1987.
[22] Jones, J.W.. Determination of Trace Elements in Food by Inductively Coupled Plasma Atomic Emission Spectrometry,Elements in Health and Disease, 1987.
[23] Prasad AS. Clinical, Biochemical and Nutritional Aspects of Trace Elements. Alan R. Liss, Inc, New York, 1982.
[24] Thunus L, Lejeune R. Handbook on Metals in Clinical and Analytical Chemistry. Marcel Dekker, New York, 1994.
[25] Kaplan, L.A., A.J. Pesce and S.C. Kazmierczak. Theory,Analysis, Correlation, In: Clinical Chemistry 4th Ed., Published by Mosby, 1993,707
[26] World Health Organization,. Quality Control Methods for Medicinal Plant Materials, 1998,WHO Geneva Switzerland.
[27] FDA. Quality standard for foods and with no identity standards;bottle water. Food and drug administration code of Fe,1993. Reg.58, 41612.
[28] Waston, D.. Safety of chemicals in food, chemical contaminants, Published by Ellis, New York, 1993 109.
[29] Gupta, U. Copper in the environment *In* J.O. Nariagu (ed.), John Wiley and Sons, New York, 1975.pp. 255.
[30] Pendias A.K. and H. Pendias.. Trace Elements in Soils and Plants. 2nd ed. Boca Raton F1: CRC Press, 1992, pp. 365.
[31] McGrath, S.P and S.Smith.. Chromium and Nickel in heavy metals in soils. *In* B.J. Alloway (ed.), Blackie, Glasgow, 1990, pp.125
[32] Ano AO, Ubochi CI. Nutrient composition of climbing and prostrate vegetable cowpea accessions. Afr J Biotechnol, 2008;7:3795-6
[33] Zetic VG, Tomas VS, Grba S, Lutilsky L, Kozlek D. Chromium uptake by Saccharomycescerevisiae and isolation of glucose tolerance factor from yeast biomass. J. Biosci. 2001; 26(2):217-23.
[34] Mohan, R.N. Chopra and G.C. Choudhary. Heavy metals in the groundwater of non-industrial area. Poll. Res., 1998,17(2), 167-168.
[35] Nordberg, G., Excursions of intake above ADI: case study on cadmium. Regulatory. Toxicology and Pharmacology, 1999,30, S57–S62
[36] Neil, P.O. Minor Element and Environmental Problems, Environmental Chemistry, 2nd Ed. 1993, 96.
[37] Klaassen CD. Casarett and Doull's Toxicology, 6th edn. McGraw–Hill: New York; 2001, 827–834,.
[38] Wedepohl ,K.H. Hand book of Geochemistry Ex-Editor, Springer Verteg Berlies Herdelberg. New York, 1978, 11-15.
[39] WHO, 1999 Monographs on Selected Medicinal Plants, vol. 1World Health Organization, Geneva 1999.
[40] W.H. Zhang, Y. Cai, C. Tu, L.Q. Ma, Arsenic speciation and distribution in an arsenic hyperaccumulating plant, Science of the Total Environment, 2002, 300: 167–177.
[41] Tong S., Von Schirnding Y.E., Prapamontol T. Environmental lead exposure: a public problem of global dimension. *Bulletin of the World Health Organization*, 2000, 78 : 1068-1077.
[42] WHO. Elemental Mercury and Inorganic Mercury Compounds:Human Health Aspects. *Concise International Chemical Assessment Document 50*. 2003, World Health Organization, Geneva.
[43] Chow P.Y.T., Chua T.H., Tang K.F. Dilute acid digestion procedure for the determination of lead. Copper and mercury in traditional Chinese medicines by atomic absorption spectrometry. *Analyst*, 1995, 120 : 1221-1223.

[44] Baht, R.V., Moy, G.G., Monitoring and assessment of dietary exposure to chemical contaminants. Rapport Trimestriel de Statistiques Sanitaires Mondiales, 1997,50, 132–148.