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INVESTIGATION OF MAJOR AND TRACE ELEMENTS IN SOME MEDICINAL PLANTS USING PIXE

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ABSTRACT

The use of the medicinal herbs for curing disease has been documented in history of all civilizations. With introduction of scientific procedures, researchers isolated active constituents of the medicinal herbs and after testing, some were found to be therapeutically active. Trace elements are important constituents of active principles of medicinal plants which affect the human body. The aim of this study was to determine qualitatively and quantitatively trace elements in these plants and their medicinal roles in the human body. Analysis of medicinal plants of various biological activities, commonly used in Northern India, was carried out using PIXE technique. Plant samples were collected from Chandigarh (India), which is located at the foothills of the Shivalik ranges, which form a part of the fragile Himalayan ecosystem. PIXE measurements were carried out using 2.4 MeV collimated protons from the 3 MV Tandetron (accelerator) of NCCCM, Hyderabad, India. Various elements namely S, Cl, K, Ca, Ti, V, Mn, Fe, Ni, Cu, Zn, Se etc. were detected with different concentrations. Many of these elements play significant roles in human metabolism and are very important with regards to life processes in man.

Keywords: Medicinal; plants; PIXE.

1. Introduction

For many years the role and metabolic functions of trace elements in human body have been investigated. Medicinal plants contain both the organic and inorganic constituents. It is important to measure the trace element content of medicinal plants as they are essential for the function of human body.[1] Both deficiencies and excesses of these elements may result in a number of disorders. Abundant research work has been carried out on the organic constituents of the medicinal plants while little attention has been paid on the role of inorganic elements in the medicinal use of these plants.[2–6] A literature survey revealed that trace elements play a significant role in curing various diseases.[7–12] It has been found that alteration of trace elemental homeostasis in an organism has direct correlation with different pathological conditions.[13] The present investigation is an attempt to gain an insight into the trace elemental composition of some commonly and widely used plants of the North region of India. For this study, we employed Proton Induced X-ray Emission (PIXE), which is a fast, nondestructive multielemental analysis technique.[14] The PIXE technique has several advantages when a rapid and accurate elemental analysis of samples is needed. In fact, it allows a multielemental analysis of practically all elements heavier than Na with a reasonable acquisition time.

2. Experimental

2.1. *Sample preparation*

Fresh samples of the different medicinal plants were collected from various areas of Chandigarh, a northern state of India. The samples were thoroughly washed with distilled water, dried in an oven at 40ºC and subsequently ground into fine powder by using an agate mortar. The powdered samples were thoroughly mixed with high purity graphite powder in the ratio 1:1 by weight.[15] The samples thus obtained were subsequently pressed into pellet of 13 mm diameter and 2 mm thickness. The thick targets of Certified Reference Materials Rye flour (IAEA-V-8) and Hay Powder (IAEA-V-10) were also prepared in a similar way and irradiated for quantification and verification of the results.

2.2. *Experimental system and data analysis*

PIXE measurements were performed at Surface and Profile Measurement Laboratory at National Centre for Compositional Characterization of Materials (NCCCM), BARC, Hyderabad using the 3 MV tandetron accelerator. In PIXE experiments, a well collimated 2.4 MeV proton beam of diameter 5 mm and current 5–7 nA was incident normally on targets placed inside a scattering chamber. The X-rays were detected by a planar high purity germanium (HPGe) detector (Eurisys Measures type EGX100-01, Be window thickness 40 μm, FWHM of 150 eV at 5.9 keV) placed at 45º to the beam axis. To reduce high count rate, a mylar (40 μm) has been used as absorber. An electron suppressor with −900 V was placed in front of the samples. The data were recorded on a PC-based MCA. The obtained PIXE spectra corresponding to different medicinal plants were analyzed using GUPIX software package.[16] Using this software package, concentrations of different elements present in each of the medicinal plants were calculated.

3. Results and Discussion

The obtained results along with the certified values for IAEA-V-10 are furnished in Table 1. PIXE spectrum of one of the plants is shown in Fig. 1.

Table 1. PIXE measurements of IAEA standard “Hay Powder” [IAEA-V-10].

Element	Experimental value (ppm)	Certified value (ppm)
K	20965 ± 52	21000
Ca	21692 ± 54	21600
Fe	184 ± 5	186
Mn	46.1 ± 2.3	47
Sr	43 ± 3	40
Cu	28.5 ± 2.0	27.4
Zn	24 ± 3	18
Cr	5.3 ± 0.7	6.5
Co	0.09	0.13

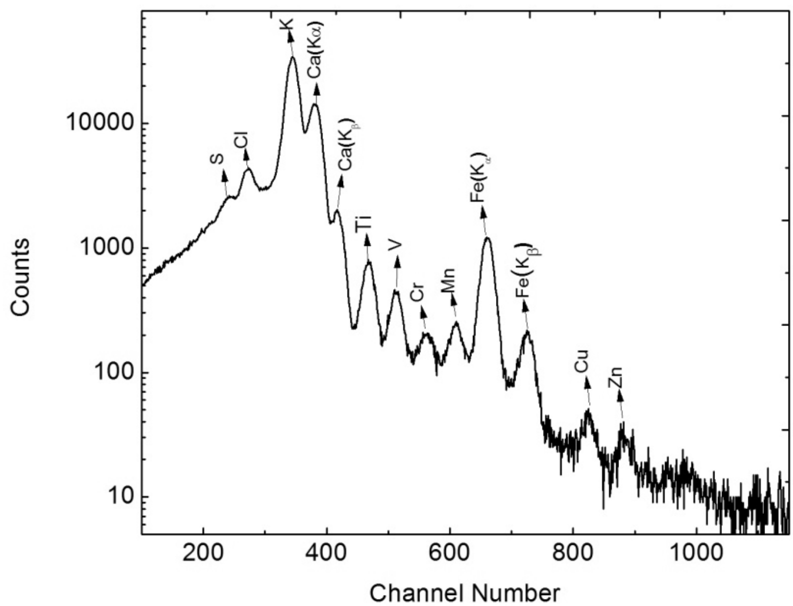

Fig. 1. PIXE spectrum of a medicinal plant (M4: *Eclipta alba* (flowers)).

The average concentrations of the elements and corresponding statistical errors in different samples of each medicinal plant were estimated and the concentrations thus obtained are shown in Table 2.

Thirteen different elements namely S, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Cu, Zn and Se were detected at different concentrations. The concentrations of potassium and calcium are relatively high and are major elements in these plants. The minor elements include sulfur, chlorine and iron. The trace elements include scandium, titanium, vanadium, chromium, manganese, copper, zinc and selenium.

Table 2. Elemental concentrations (in ppm) of the medicinal plants under study.

Element	M1	M2	M3	M4	M5	M6	M7	M8
S	2727 ± 46	3620 ± 54	3345 ± 50	2315 ± 30	1331 ± 37	3022 ± 45	902 ± 3	3775 ± 49
Cl	3226 ± 32	4504 ± 36	2522 ± 25	5454 ± 33	3180 ± 32	5136 ± 30	4089 ± 32	3741 ± 45
K	64530 ± 64	40553 ± 81	58330 ± 87	56452 ± 84	25860 ± 51	31190 ± 62	10865 ± 32	9210 ± 36
Ca	15760 ± 31	18351 ± 37	7474 ± 30	16950 ± 42	61305 ± 25	68070 ± 68	14613 ± 36	56753 ± 79
Sc	136 ± 4	292 ± 6	46 ± 2	148 ± 4	72 ± 3	1030 ± 12	201 ± 5	747 ± 10
Ti	53 ± 2	54 ± 2	153 ±4	1108 ± 11	55 ± 2	–	383.3 ± 6	98 ± 3
V	61 ± 3	252 ± 6	226 ± 6	479 ± 8	32 ± 2	19 ± 1	84 ± 3	102 ± 4
Cr	70 ±3	43 ± 3	68 ± 3	100 ± 4	29 ± 2	41 ± 3	49 ± 3	90 ± 4
Mn	91 ± 4	432 ± 21	90 ± 4	386 ± 8	49 ± 3	118 ± 6	40 ± 4	119 ± 5
Fe	982 ± 14	1122 ± 17	1939 ± 20	4050 ± 31	637 ± 13	705 ± 13	1349 ± 13	1567 ± 20
Cu	82 ± 6	60 ± 5	82 ± 6	178 ± 9	57 ± 5	64 ± 5	41 ± 4	50 ± 5
Zn	61 ± 6	105 ± 8	127 ± 9	147 ± 10	84 ± 7	67 ± 6	14 ± 2	62 ± 6
Se	–	–	–	–	–	–	33 ± 4	–

Plant Codes: M1: *Withania somnifera* (leaves); M2: *Eclipta alba* (leaves); M3: *Withania somnifera* (flowers); M4: *Eclipta alba* (flowers); M5: *Adhatoda vasica* (flowers); M6: *Adhatoda vasica* (leaves); M7: *Boerhavia repanda* (roots); M8: *Aloe vera* (leaves).

Concentration of sulfur in the studied medicinal plants varies between 902 ppm and 3775 ppm. It is maximum in *Aloe vera* (leaves) and minimum in *Boerhavia repanda* (roots). Sulfur helps in protecting the cells in the body from environmental hazards like air pollution and radiation.[17] The concentration of chlorine in the plants varies from 2522 ppm to 5500 ppm. It is found to be maximum in the flowers of *Eclipta alba* and minimum in the flowers of *Withania somnifera.* Chlorine helps man to digest his food properly and to absorb other important elements that he needs to survive. Potassium is a major element in all the medicinal plants and its concentrations vary between 9210 ppm and 64530 ppm. Its maximum concentration is in the leaves of *Withania somnifera* and minimum in the leaves of *Aloe vera*. Potassium is extremely important to cells, and without it, we could not survive. Calcium has great importance in human body and all the medicinal plants have significant concentrations of calcium which vary between 7474 ppm and 68070 ppm. It is maximum in the leaves of *Adhatoda vasica* (68070 ppm) and minimum in the flowers of *Withania somnifera* (7474 ppm). Calcium is needed for the formation and maintenance of bones, development of teeth and healthy gums.

Vanadium is believed to be involved in energy production and a cofactor of enzymes to accelerate chemical reactions in the body. It helps in fat metabolism and in building healthy bones and teeth. Its concentration varies between 19 ppm (*Adhatoda vasica* (leaves)) and 479 ppm (*Eclipta alba* (flowers)). Chromium is an essential nutrient required for normal sugar and fat metabolism. The maximum concentration of Cr was found to be 100 ppm in the flowers of *Eclipta alba* and minimum concentration was found to be 28.9 ppm in the flowers of *Adhatoda vasica*. Manganese is present at minor levels in all the medicinal plants with concentrations that vary between 39 ppm to 432 ppm. *Boerhavia repanda* (roots) have maximum concentration and *Eclipta alba* (leaves) have minimum concentration of Mn. Manganese is essential for bone development, reproduction and the normal functioning of the central nervous system.[18]

Iron is present at minor levels in all the medicinal plants with concentrations which vary from 637 ppm to 4050 ppm. It is found to be maximum in the flowers of *Eclipta alba* and minimum in flowers of *Adhatoda vasica.* Iron has important role in the formation of hemoglobin and certain enzymes.[19] Iron deficiency can lead to anemia when the iron stores in the body become depleted and hemoglobin synthesis is inhibited. Copper is present in all the medicinal plants at trace levels with concentration that varies between 41 ppm to 178 ppm. Its concentration is maximum in *Eclipta alba* (flowers) and minimum in the roots of *Boerhavia repanda.* It is a major component of the oxygen carrying part of blood cells. Concentration of Zn ranges from 14.4 ppm (*Boerhavia repanda roots*) to 147.4 ppm (*Eclipta alba* flowers). This unique element is essential for the creation, release and use of hormones in the body. It helps developing fetuses grow correctly and our brains to work right. Selenium is used in the synthesis of ascorbic acid[20] and helps to revive patients. It is the most important element used in the treatment of cancer. Only one of the sample plants had Se element with concentration 32.7 ppm.

Comparison of elemental concentrations in some medicinal plants common to this study and other similar studies is shown in Table 3. On comparing our results with those of other studies on similar medicinal plants, it is noticed that there are considerable differences in the concentration values. From this table, it is observed that chlorine, potassium, calcium and scandium contents are higher in our study when compared to other studies (Garg *et al.*, 2007; Maharia *et al.*, 2010; Singh and Garg, 1997; Shirin *et al.*, 2009; K.N.Devi *et al.*, 2010). These measurements have been made using the different techniques and this may be one of the reasons for the variation in the elemental composition of same plants in different studies. The other reasons can be attributed to several factors like differences between sites from where the plant samples were collected, preferential absorbability of the plant, use of fertilizers and irrigation water.

4. Conclusions

PIXE technique was employed for the determination of the elemental compositions of some medicinal plants that are commonly used in North India. A total of 13 elements have been determined in these medicinal plants. The results show that these plants contain elements of vital importance in man's metabolism and that are needed for growth and development, prevention and healing of diseases. The variation in elemental concentration is mainly attributed to the differences in botanical structure, secondary metabolism, as well as in the mineral composition of the soil in which the plants are cultivated. The data obtained in the present work, apart from revealing the curative potency of some well known herbs, will also be helpful in the working out of dosage to be administered to patients considering the elemental contents and concentrations. Our preliminary study having baseline information about mineral constituents of medicinal plants of North India will be helpful to develop an approach towards direct link between elemental content and its curative probability, having coherence with traditional use.

Table 3. Comparison of elemental concentrations in some medicinal plants common to this study and other similar studies.

	M1: *Withania somnifera* (leaves)			M2: *Eclipta alba* (leaves)		M3: *Withania somnifera* (flowers)		M6: *Adhatoda vasica* (leaves)		
Elements	This study	Garg *et al.*[5] (2007) (*NAA*)	Maharia *et al.*[21] (2010)	This study	Singh & Garg[2] (1997) (NAA)	This study	Shirin *et al.*[22] (2009) (*AAS*)	This study	K.N. Devi[23] (2010) (PIXE)	Maharia *et al.* (2010) (*NAA & AAS*)*
S	2727 ± 46	–	–	3620 ± 54	–	3345 ± 50	–	3022 ± 45	–	–
Cl	3226 ± 32	1300	–	4504 ± 36	2580	2522 ± 25	–	5136 ± 30	–	–
K	64530 ± 64	14100	–	40553 ± 81	13800	58330 ± 87	–	31190 ± 62	20600	–
Ca	15760 ± 51	14900	–	18351 ± 37	–	7474 ± 30	–	68070 ± 68	13200	–
Sc	136 ± 4	0.04	–	292 ± 6	0.3	46± 2	–	1030 ± 12	–	–
Ti	53 ± 2	–	–	54 ± 2	–	153 ± 4	–	–	–	–
V	61 ± 3	–	–	252 ± 6	–	226 ± 6	–	19 ± 1	–	–
Cr	70 ± 3	2	4	43 ± 3	21	68 ± 3	6	41 ± 3	–	0.3
Mn	91 ± 4	17	69	432 ± 21	69	90 ± 4	421	118 ± 6	54	39
Fe	982 ± 14	221	499	1122 ± 17	3180	1939 ± 20	2380	705 ± 13	42	192
Cu	82 ± 6	10	15	60 ± 5	47	82 ± 6	262	64 ± 5	7	7
Zn	61 ± 6	44	45	105 ± 8	135	127 ± 9	879	67 ± 6	68	35

*NAA: Neutron Activation Analysis.
AAS: Atomic Absorption Spectrophotometer.

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