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Proton induced X-ray emission (PIXE) and proton induced γ-ray emission (PIGE) studies of some medicinal plants of north east India

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Abstract Proton induced X-ray emission (PIXE) and proton induced γ -ray emission (PIGE) techniques were employed for the elemental analysis of twelve different plants traditionally used for medicinal purposes in north east India PIXE is a well established ion beam analysis technique for the sensitive and non destructive determination of various elements having atomic number greater then eleven present in biological samples while PIGE offers a complementary method for the determination of light elements where the sensitivity of PIXE analysis is not quite adequate When combined together these analytical techniques provide concentrations of almost all elements present in the medicinal plants in quantities above ppm Validity of the techniques was assured by analyzing certified plant reference materials (CRMs) A large number of trace elements like Mn, Fe Cu, Zn, Rb, Sr, Na and Al are found to be present in the studied plants with variable proportions K, Ca, Mg and P are quantified in percentage level while other elements are found to be present in parts per million levels The results show that many of these plants contain elements of vital importance for human metabolism and prevention and healing of diseases

Keywords PIXE, PIGE, Medicinal plants, Trace element

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1. Introduction

Proton induced X-ray emission (PIXE) and proton induced γ-ray emission (PIGE) are accelerator based ion beam analysis techniques, capable of simultaneous multi-elemental and non-destructive characterization of various complex matrices [1-4]. Medicinal plants are a unique type of natural product requiring special considerations due to their potential

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impact on peoples' health The chemical constituents present in them are a part of the physiological function of living flora and hence they are believed to have better compatibility with the human body. In addition, medicinal plants contain essential and trace elements which qualify them to be used as non-prescription drugs [5] Though it is well known that certain trace elements are essential for the healthy growth of plants, the uptake of some non-essential elements by these plants can also enhance the medicinal property in specific case [6] So the quantitative estimation of various minor and trace element concentration are important for determining effectiveness of medicinal plants Further, as certain elements at elevated levels are toxic, such an assessment would also be helpful in regulating their use

Manipur, a north-eastern state of India, abounds with rich vegetation, some of which are unique and endemic The people of this region have a rich heritage of using plants in traditional medicines in the treatment of jaundice, hypertension, asthma and various other diseases [7-8]. However, little is known about the trace element distribution in these plants In the present work, we determine the major, minor and trace element content of twelve medicinal plants commonly used in north-east India by using PIXE and PIGE techniques

2. Experimental

2 1 Sample preparation

Fresh samples of different medicinal plants were collected from various areas of Manipur The samples were thoroughly washed with distilled water, dried in an oven at 40^0C and subsequently ground into fine powder The powdered samples were thoroughly mixed with high purity graphite powder in the ratio 4:1 by weight. The samples thus obtained were further mixed with 200ml of 2-wt % polyvinyl alcohol, a binder, dried under an IR-lamp and subsequently pressed into pellet of 18mm diameter and 2mm thickness The thick targets of Certified Reference Materials (CRMs) of cabbage (GBW 08504, China), wheat flour (NIST-8436) and bovine liver (NIST-1577b) were also prepared in a similar way and irradiated for quantification and verification of the results [1]

2.2. Experimental system and data collection :

PIXE and PIGE measurements were performed at Surface and Profile Measurement Laboratory at CCCM, BARC, Hyderabad using the 3MV Tandetron accelerator. In PIXE experiments, a well collimated 2 4 MeV proton beams of diameter 5mm and current 5-7nA was incident normally on targets placed inside a scattering chamber. The X-rays were detected by a planar high purity germanium (HPGe) detector (Eurisys Mesures type EGX100-01, Be window thickness 40μm, FWHM of 150 keV at 5.9 keV) placed at 45° to the beam axis. A 25μm mylar foil served as the X-ray exit window In PIGE measurements, the targets were bombarded with 3 MeV proton beam in the same scattering chamber

and the resulting γ-rays were measured with a HPGe detector (Eurisys) of 40 % efficiency The vacuum in scattering chamber, pumped by a turbomolecular pump, was about 2 × 10^{-6} torr. An electron suppressor with – 900 V was placed in front of the samples The data were recorded on a PC based MCA

2.3. *Data Analysis :*

The PIXE spectral data were analysed by GUPIX [9] software package which provides non-linear fitting of the spectra and converts raw spectral data into elemental concentrations For the quantitative PIGE analysis the unknown concentration $C_{samp\,a}$ for a specific element *a* in the analyzed sample is calculated by using the following equation [10]

$$C_{samp\,a} = C_{ref\,a} \frac{Y_{sam}(E_0) S_{samp}\left(E_{1/2}\right)}{Y_{ref}(E_0) S_{ref}\left(E_{1/2}\right)} \tag{1}$$

where *Y* is the yield of the measured γ-ray at proton energy E_0 and S is the stopping power calculated for the sample and the reference material respectively, at proton energy $E_{1/2}$ This energy corresponds to the proton energy for which the thick target excitation yield has obtained half of its value at the incident energy, namely $Y(E_0) = 2Y(E_{1/2})$ Although the stopping power correction in eq (1) should be performed at the mean energy E_m^{act} [11], the difference in the stopping power evaluation using this value and the corresponding one at energy $E_{1/2}$ has been found to be very small [12]

3. Results and discussion

Figure 1(a) and 1(b) presents the PIXE and PIGE spectra obtained from the *Polygonum posumba* Bach sample. PIXE spectrum indicates the presence of essential trace elements

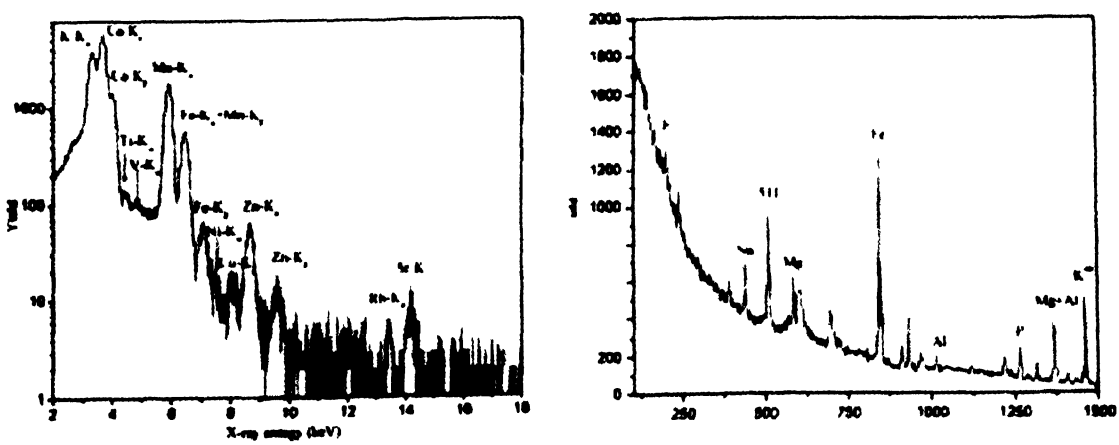

Figure 1. (a) PIXE spectrum (b) PIGE spectrum of *Polygonum posumba* Bach

Table 1. Elemental Concentrations of the medicinal plants under study

Plant Samples	Elements analysed by PIXE								Elements analysed by PIGE			
	K (%)	Ca (%)	Mn	Fe	Cu	Zn	Rb	Sr	Na	Mg (%)	Al	P (%)
Zanthoxylem acanthopodium	1 98	0 98	50 32	41 2	4 73	26 4		54 48	301	0 65	36	0 59
Curcuma domestica	4 84	0 29	24 05	141 75	8 08	45 9	5 28		338	0 41	734	0 77
Oscimum sanctum	3 38	1 76	25 44	384 12	21 99	49 56	31 96	109 46	6030	4 37	8249	0 68
Hedychium marginatum C B Clarke	2 6	0 57	450 87	295 29	1 93	155 7	11 61	59 24	313	0 30	348	0 11
Acacia farnesiana	3 07	0 25	18 14	190 15	17 65	43 389	19 96		159	0 09	242	0 98
Celtis timorensis	0 15	0 14	61 1	51 93	1 81	6 02		45 93	319	0 13	379	0 35
Meriandra benghalensis	1 67	0 51	127 9	170 07	9 78	46 47		46 05	292	0 42	134	0 59
Polygonum posumba Bach	1 3	0 86	722 9	112 5	6 23	66 21	9		243	0 46	1191	0 43
Cissus javana DC	2 14	1 05	167	265 3	5	193 01	6 5	61 08	300	1 38	640	0 34
Zingiber officinale	0 77	0 17	313 42	216 64	4 47	72 53	12 85		266	0 92	60	0 17
Xylosum longifolia	0 99	1 44	185 06	75 56	4 15	67 77	5 28	106 77	88	0 05	108	0 66
Elaeocarpus floribundus Blume	0 24	0 69	65 87	169 79	2 597	13 124			677	0 44	374	0 19

Concentrations are in ppm otherwise mentioned

like Mn, Fe, Cu and Zn and the non-essential elements Rb and Sr along with the major elements K and Ca While PIGE spectrum indicates the presence of Na, Mg, Al and P The concentration of different trace elements along with K Ca, Mg and P obtained from the analysis of the plant samples are provided in Table 1 In all the samples analyzed by PIXE and PIGE the elements Na, Mg, Al, P, K, Ca, Mn, Fe, Cu and Zn are present in varying concentrations (ppm level and above)

Table 1 shows that the trace elements present in the different medicinal plants show a significant variation in their concentration Some of these plants are found to be rich in one or more individual elements, which pertain their therapeutic value for treatment of different disease delicately, either singly or in combination Among the studied plants, *Oscimum sanctum* with numerous medicinal properties [13,14] is found to contain the highest amount of Ca, Fe, Cu, Rb, Sr, Na, Mg and Al *Polygonum posumba* Bach which is used for controlling high blood pressure contains high amount of Mn (722 9 ppm) Mn is an antioxidant

nutrient and is important in the breakdown of fats and cholesterol and also helps in the nourishment of the nerves and the brain [15] The high content of Mn, Fe and Zn in this plant may again support its effective use in the traditional system of medicine by the local people of Manipur. The deficiency or excess of a particular trace element can influence changes in the functioning, forms, activities of some organs or concentrations of such element in the body tissue and fluids can rise above the permissible limit In addition to identifying the active secondary metabolites of these medicinal plants, the knowledge of their elemental composition is very important in determining their toxicity/safety for use

4. Conclusion

PIXE and PIGE techniques have been used in order to determine minor and trace elements present in twelve medicinal plant samples The elements Na, Al, Mg, P, K, Ca, Mn, Fe, Cu, Zn, Rb and Sr are found to be present in all the twelve medicinal plants in varying concentrations. The accuracy and precision of the technique were assured by analyzing the Standard Reference materials This preliminary report establishes PIXE and PIGE as effective techniques for the multi elemental analysis of plant samples and attempts are under progress for future investigation using these techniques.

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