

Quantitative elemental analysis of *Cyperus rotundus* medicinal plant by PIXE and ICP-MS techniques

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Received 3 July 2019

Particle induced x-ray emission (PIXE) and inductively coupled plasma mass spectroscopy (ICP-MS) techniques have been employed in this work to determine the elements present in the root of *Cyperus rotundus* medicinal plant used in the treatment of rheumatoid arthritis. The elements V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Rb and Sr were commonly identified and quantified by both PIXE and ICP-MS, whereas, the elements Li, Be, Al, As, Se, Ag, Cd, Ba, Tl, Pb and U were determined by ICP-MS and Cl, K, Ca, Ti and Br were determined by PIXE. The regional variation of elemental content has also been studied by analyzing the same plant collected from different geographical locations. Information on elemental content of the medicinal plant would be helpful in correlating its ability in the treatment of rheumatoid arthritis and also in deciding the dosage of this herbal medicine from metal toxicity point of view.

Keywords: Trace elements, PIXE, ICP-MS, Medicinal plants

1 Introduction

Since time immemorial, in every culture throughout the world herbal drugs constituting medicinal plant (MP) preparations have been used for curing a wide spectrum of diseases. Plants of medicinal importance constitute compounds of both inorganic and organic nature. Ample analysis has been done on their organic compounds like alkaloids, vitamins, glycosides and essential oils, and other active compounds and their pharmacological impacts, while little consideration has been given to the therapeutic utilization of these plants in terms of their inorganic constituents. The part played by inorganic compounds in metabolism of plants and animals has been proved; however, research on the impacts and effects of these compounds on application of MP has yet to be done on an extensive scale. MP is affluent in numerous major, minor and trace elements and it is implied that this is an imperative factor in the therapeutic use of these plants¹⁻³. Trace elements assume a critical part in the composition of active chemical compounds existing in the MP and are in this manner in charge of their therapeutic and additionally toxic properties⁴.

In recent years, more attention has been paid towards usage of plant based drugs in the treatment of all kinds of diseases when compared to factory-made

synthetic drugs^{5,6}. The escalated usage of these herbal drugs warrants critical evaluation from all perspectives (like quality, safety, and efficacy). Moreover, influence of environmental conditions in a particular geographical region on the elemental concentrations of plant materials cannot be ignored^{7,8}. With this reason, root samples of *Cyperus rotundus* medicinal plant widely used in the treatment of rheumatoid arthritis (RA) collected from different geographical locations are analyzed for their elemental content using PIXE and ICP-MS techniques.

PIXE is a well-recognized nondestructive method for analyzing samples for their elemental content^{9,10}. Due to its high sensitivity, multi-elemental analysis capability, non-destructive nature, ability to analyze tiny samples and suitability for a wide range of samples, this technique has served as an important tool for elemental analysis. ICP-MS, a destructive analytical technique, was also employed as a complementary method to PIXE in this work to identify and determine low Z elemental concentrations in the same MP. ICP-MS is a sensitive and most capable method for determining wide range of metals and many non-metals at different concentration levels^{11,12}.

2 Materials and Methods

Root samples of *Cyperus rotundus* medicinal plant were collected from four different regions: Paarammakonda (R1) in Vizianagaram District,

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Lambasingi (R2) in Visakhapatnam District, Kondapalli (R3) in Krishna District and Bhimadole (R4) in West Godavari District of the state of Andhra Pradesh, India.

These samples were further processed as per the requirement of the two analytical techniques, the details of which can be found in our earlier paper¹. PIXE experiments were carried out at Institute of Physics, Bhubaneswar using 3 MeV protons from 3 MV Tandem Pelletron accelerators whereas ICP-MS experiments were performed at centre for studies on Bay of Bengal, Andhra University, Visakhapatnam. Our earlier work¹⁻³ elaborates the experimental details, data analyses, accuracy and validation of these two techniques.

3 Results and Discussion

The typical X-ray spectrum obtained using PIXE technique Fig. 1 shows the presence of elements Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Br, Rb and Sr in the medicinal plant, whereas, elements Li, Be, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Ag, Cd, Ba, Tl, Pb and U were identified by ICP-MS method. The concentrations of these elements and their regional variations are shown as histograms in Fig. 2. Observed alterations in elemental concentrations from one region to the other might be attributed to environmental conditions in which the medicinal plant has grown.

PIXE analysis reveals the existence of Ca, K and Cl in major concentrations in the studied MP followed by Fe, which is observed in highest concentrations as compared to the levels of other trace elements. The elements V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Rb

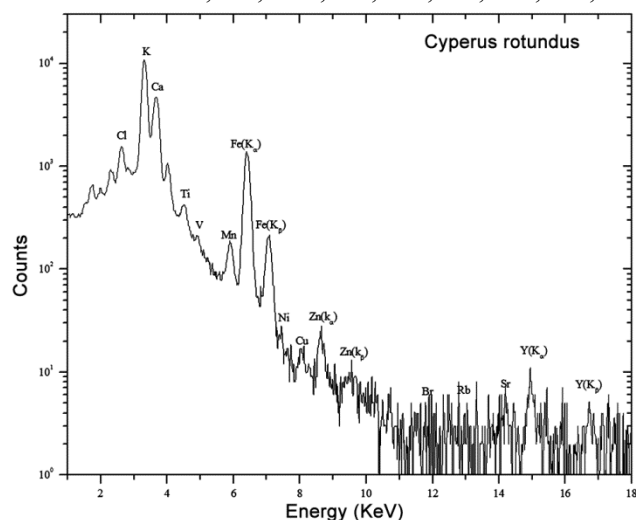


Fig. 1 – PIXE spectrum of *Cyperus rotundus* medicinal plant.

and Sr were commonly identified and quantified by both PIXE and ICP-MS techniques. Both the techniques show similar trend in the regional variation of elemental concentration.

In this work an attempt is made to ascertain whether the dosage of this medicinal plant prescribed by the local herbal practitioner is within the safe limits and does not lead to complications of metal toxicity. This is done by calculating the quantity of each element being supplemented as per the dosage and then comparing it with the RDA/DRI values. It is well established that Cu is an essential dietary nutrient for human beings. However, severe pathological consequences are linked with inadequate and excess levels of Cu^{12,13}. From the both the techniques, the concentration of Cu in the studied medicinal plant was found to range 8.77 $\mu\text{g/g}$ (R 4) to 22.21 $\mu\text{g/g}$ (R 3). The dosage prescribed by the local ayurvedic practitioner is 1350 mg/day of *Cyperus rotundus* powder. This dose contains maximum 0.029 mg of Cu. When compared to the RDA value for Cu, which is 0.9 mg/day, the amount of Cu that gets supplemented via the consumption of 1350 mg of *Cyperus rotundus* powder per day is much less. Similar, calculations for all the other identified elements revealed that almost all are within the safe limits when compared to the respective RDA/DRI values shown in the Table 1.

Depressed levels of trace elements can be corrected by means of nutritional dose supplementation with adequate micronutrients. Administration of Cu may reduce the bone mass loss, particularly in elderly patients with marginal Cu status¹⁴. Supplementation of Zn and Se increases the hormonal and immune response in variety of diseased patients¹⁵⁻¹⁷. Several findings revealed anemia to be a common co-morbidity in individuals with RA. Most of the joint diseases are associated with RA patients who have anemia. Treatment response of RA is likely to be good when anemia is successfully treated first. Supplementation of Fe via this MP might help in enhancing serum iron levels thereby proving to be useful in the treatment of RA¹⁸.

Studies related to nutritional status of patients with active RA frequently demonstrate the deficiencies of metallic elements¹⁹. Supplementation of identified elements through the studied MP apart from the regular diet might be useful in the treatment of RA since, many of them are co-factors in metabolic processes involving collagen and bone formation and in immune system function²⁰.

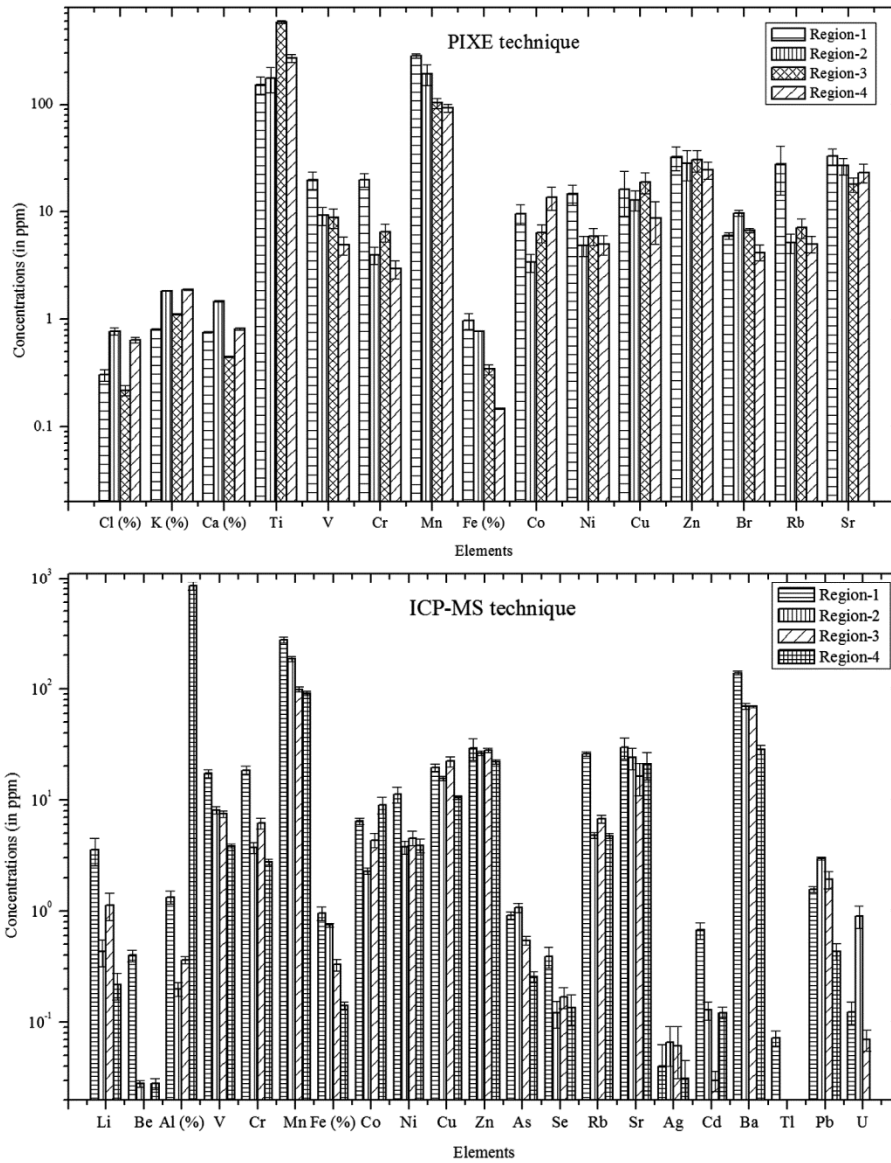


Fig. 2 – Variation of elemental concentrations ($\mu\text{g/g}$) in *Cyperus rotundus* medicinal plant from four regions by PIXE and ICP-MS techniques.

Table 1 – RDA/DRI Values of elements, their concentration in *Cyperus rotundus* powder and there dose supplemented per day.

S.No.	Elements	RDA / DRI* values	Concentration range	Dose supplemented per day
		Women - Men	PIXE / ICP-MS (ppm)	through 1350 mg of MP
1	Li	0.2-0.6 mg/day*	0.217 (R4)-3.54 (R1)	0.003-0.005 mg/day
2	Al	2-10 mg/day*	1990 (R2)-13306 (R1)	2.686-17.963 mg/day
3	Cl	2300 mg/day	2177 (R3)-7697 (R2)	2.939-10.39 mg/day
4	K	4700 mg/day	8038 (R1)-18794 (R4)	10.85-25.37 mg/day
5	Ca	1000-1200 mg/day	4467 (R3)-14728 (R2)	6.030-19.883 mg/day
6	Ti	0.1-1 mg/day*	152 (R1)-585 (R3)	0.205-0.790 mg/day
7	V	1.8 mg/day*	3.85 (R4)-19.80 (R1)	0.005-0.027 mg/day

(Contd.)

Table 1 – RDA/DRI Values of elements, their concentration in *Cyperus rotundus* powder and there dose supplemented per day.

S.No.	Elements	RDA / DRI* values	Concentration range PIXE / ICP-MS (ppm)	Dose supplemented per day through 1350 mg of MP
		Women - Men	Lower - Higher	
8	Cr	25-35 µg/day	2.75 (R4)-19.90 (R1)	3.712-26.865 µg/day
9	Mn	1.8-2.3 mg/day	91 (R4)-283 (R1)	0.123-0.382 mg/day
10	Fe	8-18 mg/day	1410 (R4)-9720 (R1)	1.903-13.122 mg/day
11	Co	0.006 µg/day	2.29 (R2)-13.70 (R4)	3.09-18.49 µg/day
12	Ni	0.4-0.6 mg/day	3.75 (R2)-14.70 (R1)	0.005-0.020 mg/day
13	Cu	900 µg/day	8.77 (R4)-22.21 (R3)	11.84-29.98 µg/day
14	Zn	8-11 mg/day	22.08 (R4)-32.30 (R1)	0.030-0.044 mg/day
15	As	2µg/day/kg body weight *	0.255 (R4)-1.07 (R2)	0.344-1.44 µg/day
16	Se	60-75 µg/day	0.122 (R2)-0.391 (R1)	0.165-0.528 µg/day
17	Br	0-1 mg/kg body weight*	4.20 (R4)-9.76 (R2)	0.006-0.013 mg-day
18	Rb	1.5 mg/day*	4.75 (R4)-27.80 (R1)	0.006-0.037 mg/day
19	Sr	2 mg/kg/day*	16.21 (R3)-33.10 (R1)	0.022-0.045 mg/day
20	Ag	70-88 µg/day*	0.031 (R4)-0.066 (R2)	0.041-0.089 µg/day
21	Cd	0.3 µg/g/day*	0.030 (R3)-0.673 (R1)	0.040-0.908 µg/day
22	Ba	0.2 mg/kg/day*	28.40 (R4)-139 (R1)	0.038-0.188 mg/day
23	Pb	10 µg/g*	0.434 (R4)-2.97 (R2)	0.586-4.01 µg/day
24	U	0.9-1.5 µg/day*	0.006 (R4)-0.904 (R2)	0.08-1.22 g/day

[Values are from FAO/WHO RDA 2010 draft available www.nap.edu]

4 Conclusions

It is concluded that the roots of *Cyperus rotundus* medicinal plant used for the treatment of rheumatoid arthritis as per the present dosage is safe from metal toxicity point of view. The quantitative results of this work demonstrate that the studied MP can be used as source of the necessary elements needed for treating disease.

Acknowledgement

Authors acknowledge Institute of Physics, Bhubaneswar for providing 3 MV accelerator facility to carry out PIXE experiments and UGC for providing financial support to carrying this work.

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