Available online at **www.joac.info**

ISSN: 2278-1862

Journal of Applicable Chemistry

2019, 8 (1): 253-258

(International Peer Reviewed Journal)

Significance of Major and Trace Element Contents in Leaves of Tall Trees and Seasonal Plants

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Accepted on 30th December, 2018

ABSTRACT

Role and function of major and trace elements are now primarily dealt in several fields of environment, bioinorganic, biochemistry etc. In plants, rich literature is available in these aspects. We have chosen leaves as our samples for multielement analysis as it is dynamic and functional in nature contribute to the morphology of the plants. Our analysis is classified as major and trace level elements as water extract and the insoluble part converted to ash in the subsequently analyzed for 11 elements by state of the art MPAES. The unique part of our work is that we have compared two categories of plants as tall trees and seasonal plants. Trends could be identified between the ratio of water soluble and insoluble bound form and some pattern of quantitative nature could be traced out. Correlation study also indicates that some elements like Fe, Zn, Cu, Ca and Mg are more critical. All these results have impact in the overall morphology of plants.

Keywords: Major and trace elements, Tall trees, Seasonal plants, Correlation studies.

INTRODUCTION

Trace elements are now well established to perform vital function in all forms of life. This is equally supported by the major elements which are alkali and alkaline elements. The current literature is mostly on single or multielement analysis in one particular species or other species. In this work we have done multielement analysis of leaves of two categories of plant species. We have chosen leaf for this investigation as it is most dynamic and functional part of the plant. The water extract of plant leaves was separately analyzed and remaining insoluble part is converted to ash which is further analyzed for trace and major elements by Microwave Plasma Atomic Emission Spectrophotometer (MPAES) which has Nitrogen based plasma instead of argon based plasma in ICPAES. Results are presented in two categories of tall trees and seasonal plants. Further correlation analysis also done by well documented statistical formula and software. Useful conclusions have been drowned on this investigation which leads to identify the role of these critical elements for both plant categories and the overall morphology of these plant species. Earlier work has been done of some major and trace elements in plant species. Liu Ying *et a*l., analyzed ordinary and trace elements in desert woody plants and compared with other desert woody plants as they have special biological character [**1**]. Rohana *et al.*, were analyzed major and trace elements in leaves, bark and roots of some endemic plants and soil [**2**]. The determination of Cu, Ni, Zn, Cd, Pd and Hg were analyzed in plant samples of Poland by Retka *et al* [**3**]. Jose *et al*., investigated the trace metals in the plant sample by ICPMS [**4**]. Somnath *et* *al*., Carried out elemental analysis of some ethnomedicinaly importance hydrophytes and marsh plants used in the traditional medicine [5]. Analysis of metal ions in rice samples by ICPOES were carried out by Andrea *et al* [6]. Albert *et al.*, were analyzed the arsenic accumulation in algae and fresh water plant of an extreme arid region [7]. Cesium accumulation of some native trees of Brazilian cerrado was done by Elvis *et al* [8]. The correlation of water extract and the metal content of medicinal plant were analyzed by Sasa *et al* [9]. The interaction of zinc with other elements in plants was analyzed by sayed *et al* [10]. The role of transition metal in control of gene expression was determined by O'Halloran *et al* [11]. Zinc and copper distribution and accumulation in the tissue of nine crops were analyzes by Sekara *et al* [12].

MATERIALS AND METHODS

All leaf samples were collected from Jodhpur region Rajasthan state by noting the location of the species. Only matured leaves were taken so that stable distribution could be obtained. Leaf samples were cleaned, dried, and powdered in mortar and pestle. The leaf powder was extracted with 50 mL milli-Q water including 2 mL ultrapure nitric acid in each sample. The insoluble part was placed in muffle furnace at 800°C for 1h. This ash is dissolved in 2 mL ultrapure nitric acid and volume made upto 50 mL for multielement analysis. For some major elements like Ca, K, Mg and Na, the samples were further diluted by 20 times. All standards solutions were prepared by Standard Method of Analysis, American Public Health Association, Washington DC. Ultrapure Nitric acid (Merck) was used all through the experiment. Milli-Q water was used for all samples and standard solution.

The instrument used is MPAES from Agilent company USA model number 4210 has nitrogen based plasma using nitrogen generator which separate pure nitrogen form surrounding air. The temperature of nitrogen plasma goes upto 5000 K. Calibration error with 5% and flow rate of each sample was different in L min^{-1} as Zn(0.45), Fe(0.65), Cu(0.70), Co(0.75), Ni(0.7.), Mo(0.85), Mn(0.90). All data are presented in tabular form.

RESULTS AND DISCUSSION

Iron in all species of two categories has unique feature in the sense that amount of bound iron is much more than freely mobile form ranging from five to twenty one times (Table 1 to 4), this indicates that iron is widespread and very basic to the vital role which is coordinated in siderophore, enzymes and proteins. According to bioinorganic literature Copper is involved in O_2 transport, storage and electron transport reaction being part of good no. of enzymes. In seasonal plants the rate of oxygen requirement seems to be more than the tall trees as ratio bound to freely mobile Copper is more in seasonal plants which correspond to the faster growth of seasonal plant (Table 1 to 4). Nickel is involved mainly in hydrogenase and urease enzymes which limits its specific function. There is

Table 1. Water extract content in leaves of tall trees with element concentration (ug g^{-1}) d.wt. and wave length (nm)

Elements	Wavelength (nm)	*Ficusbengalensis* (Bargad)	*Ficus religiosa* (Peepal)	*Mangifera india* (Mango)	*Azadirachta indica* (Neem)
Zn	213.857	14.080	11.010	3.730	8.590
Fe	371.993	4.410	14.210	6.410	10.920
Cu	324.754	8.070	8.920	4.190	2.710
Ni	352.454	0.820	0.450	0.690	0.910
Mo	379.825	2.820	1.450	0.000	0.000
Mn	403.825	1.810	8.110	16.710	16.580
Ca	393.366	820.500	549.600	185.200	878.800
K	766.491	1007.400	1895.700	862.700	1877.800
Mg	285.213	374.900	117.800	162.800	309.600
Na	588.995	29.100	9.800	27.500	10.400

Table 2. Analysis of ash in water insoluble part of leaves in tall trees with element concentration (ug g^{-1}) d.wt. and wave length (nm)

Elements	Wavelength (nm)	*Ficusbengalensis* (Bargad)	*Ficus religiosa* (Peepal)	*Mangifera india* (Mango)	*Azadirachta indica* (Neem)
Zn	213.857	14.550	7.120	5.420	9.880
Fe	371.993	94.950	82.090	98.950	109.860
Cu	324.754	3.860	1.850	6.720	2.280
Ni	352.454	0.410	0.250	0.130	0.330
Mo	379.825	1.060	0.790	1.150	0.910
Mn	403.825	21.090	19.660	26.780	12.020
Ca	393.366	19985.200	16353.600	24000.000	10071.800
K	766.491	342.800	46.200	0.000	0.000
Mg	285.213	1530.600	745.800	872.200	1038.800
Na	588.995	588.000	163.000	47.400	57.400

Table 3. Correlation coefficient of element in bound form in leaves of tall trees

Elements	Zn	Fe	Cu	Ni	Mo	Mn	Ca	K	Mg	Na
Zn	**1**									
Fe	0.157	**1**								
Cu	-0.291	0.196	**1**							
Ni	**0.951**	0.129	-0.567	**1**						
Mo	0.070	0.382	**0.926**	-0.226	**1**					
Mn	-0.337	-0.415	**0.811**	-0.580	0.640	**1**				
Ca	-0.197	-0.347	**0.836**	-0.467	0.722	**0.987**	**1**			
K	**0.871**	-0.208	-0.020	0.730	0.248	0.133	0.259	**1**		
Mg	**0.940**	0.258	0.052	**0.792**	0.406	-0.078	0.077	**0.891**	**1**	
Na	**0.863**	-0.268	-0.075	0.737	0.183	0.117	0.236	**0.997**	**0.862**	**1**

balanced ratio of two to three times in tall trees in favour of freely mobile form whereas in seasonal plant the ratio is five to six times. Hence Nickel is more or less has similar function in both the categories (Table 1 to 4). Magnesium being central in chlorophyll is responsible for the photosynthetic activity. Bound Magnesium is more in trees as compared to seasonal plants which suggest that according to the established literature Magnesium plays a structural role which is more prominent in tall trees. There is both positive and negative trend of bound magnesium in both categories by which we suppose that photosynthetic activity has variable intensities (Table 2 and 4).

Table 4. Water extract content in leaves of seasonal plants with element concentration (ug g^{-1}) d.wt. and wave length (nm)

Elements	Wavelength (nm)	*Abelmoschus esculentus* (Ladyfinger)	*Solanum melongena* (Brinjal)	*Cymopsis tetragonoloba* (Gwar bean)	*Capsicum annuum* (Mirch)
Zn	213.857	10.940	7.720	8.740	44.820
Fe	371.993	16.930	14.110	6.040	7.390
Cu	324.754	2.410	5.540	1.190	2.920
Ni	352.454	0.580	4.670	6.120	5.070
Mo	379.825	0.001	0.001	0.001	0.001
Mn	403.825	57.460	13.860	25.200	15.900
Ca	393.366	1200.000	132.100	14000.000	489.600
K	766.491	1492.900	2485.800	15630.400	32385.800
Mg	285.213	532.700	357.800	7046.400	6723.000
Na	588.995	11.800	13.800	193.200	388.400

According to literature zinc is well established for vital function as it is bound to several enzyme and proteins. The Zn in tall trees is more or less similar in both water extract and bound form pertaining to the fact that extremely large no. of leaves are present in tall trees which perhaps make the Zn balanced in both fractions and it reflect the steady growth in tall trees (Table 1and 2). Whereas in the seasonal plants input of Zinc is more than required, ratio of ash to water extract is less than one (Table 3 and 4). In all species of seasonal plants, Molybdenum is completely present in the bound state which shows the essential activity of nitrogen fixation is prominent in this category (Table 4). Manganese known for its role in structure is high content in bound form in tall tress which corresponds to the high strength of tall trees (Table 2). Calcium with very high ratio in favor of bound form in all species of two categories indicates that calcium has basic function in structure, charge carrier and trigger mechanism (Table 1 to 4).

According to the table 5 and 6 we have considered only high value of positive correlation coefficient above 0.80 from table 3 and table 6 which reflects high correlation between selected elements. In tall trees-Zinc and Magnesium has four correlations with (Ni, K, Mg, Na) and (Zn, Ni, K, Na) respectively. Copper, Potassium and Sodium have three correlation with (Mo, Mn, Ca), (Zn, Mn, Na) and (Zn, K, Mg) respectively. Nickel, Manganese, and Calcium have two correlations with (Zn, Mg), (Cu, Ca), and (Cu, Mn) respectively. Molybdenum has only one correlation with Cu. In seasonal

Table 5. Analysis of ash in water insoluble part of leaves in seasonal plants with element concentration (ug g^{-1}) d.wt. and wave length (nm)

Elements	Wavelength (nm)	*Abelmoschus esculentus* (Ladyfinger)	*Solanum melongena* (Brinjal)	*Cymopsis tetragonoloba* (Gwar bean)	*Capsicum annuum* (Mirch)
Zn	213.857	6.060	4.980	2.370	12.340
Fe	371.993	136.710	219.900	31.750	76.510
Cu	324.754	4.760	4.210	2.160	6.490
Ni	352.454	0.130	0.190	1.180	1.280
Mo	379.825	0.520	0.630	0.970	0.750
Mn	403.825	22.810	20.570	2.310	4.460
Ca	393.366	24000.000	24000.000	3412.000	15434.000
K	766.491	0.001	21.400	0.001	762.000
Mg	285.213	807.600	1488.800	602.000	915.600
Na	588.995	37.400	33.400	213.800	220.800

Table 6. Correlation coefficient of element in bound form in leaves of seasonal plants

Elements	Zn	Fe	Cu	Ni	Mo	Mn	Ca	K	Mg	Na
Zn	**1**									
Fe	-0.887	**1**								
Cu	**0.995**	-0.928	**1**							
Ni	**0.983**	-0.789	**0.961**	**1**						
Mo	**0.805**	-0.441	0.744	**0.900**	**1**					
Mn	-0.969	0.746	-0.941	-0.998	-0.926	**1**				
Ca	-0.991	**0.816**	-0.973	-0.999	-0.878	**0.994**	**1**			
K	**0.987**	-0.802	**0.967**	**1.000**	**0.890**	-0.996	-1.000	**1**		
Mg	-0.490	**0.837**	-0.572	-0.323	0.123	0.260	0.367	-0.344	**1**	
Na	**0.993**	-0.827	**0.977**	**0.998**	**0.869**	-0.991	-1.000	**0.999**	-0.384	**1**

plants -Zinc, Nickel, Potassium and Sodium have five correlations with (Cu, Ni, Mo, K, Na), (Zn, Cu, Mo, K, Na), (Zn, Cu, Ni, Mo, K) and (Zn, Cu, Ni, Mo, K) respectively. Copper and Molybdenum have four correlations with (Zn, Ni, K, Na) and (Zn, Ni, K, Na) respectively. Iron and Calcium have two correlations with (Ca, Mg) and (Fe, Mn) respectively. Manganese and Magnesium have only one correlation with Ca and Fe respectively. Zinc has four to five correlations in both categories which correspond to its well established function as a part of enzymes and proteins. Magnesium has four correlations in trees and only one correlation in seasonal plants supports to the fact that magnesium is involved in structure function. Potassium and Sodium have five correlations in seasonal plants and only three correlations in tall trees reflects that charge carriers functions is more prominent in seasonal plants which correspond to its higher rate of growth. Iron in trees with no correlations suggests that iron is working independently in tall trees. In seasonal plants Iron is involved with two correlations with Ca and Mg should support the structure function. Calcium in both categories is correlated with manganese hence has similar role in both the categories. Molybdenum has four correlations in seasonal plants whereas only one in trees is supports to the fact that seasonal plants have high rate of growth as .compared to tall trees.

APPLICATION

This study has helped to understand that role and function of major and trace elements in plants in better manner. The pattern obtained by the study helps to classify certain plant species in one category hence this study reveals to understand the phenomena of biodiversity which has wide applications.

CONCLUSION

According to bioinorganic literature Calcium, Magnesium, Zinc and Manganese are known to play a role in structural aspects. In tall trees high correlation in (Ca, Mg, Zn and Mn) as compared to seasonal plants supports the fact that trees have strong and long lasting structure. Distribution and content of major and trace elements in leaves have a pattern corresponding to its size, shape and geographical location. The distribution of each element between water extract and bound form makes that bound form can give information about its overall impact of the size and shape of the plant. By correlation studies we can infer that some elements are involved positively with other elements. Ultimately these elements work at the very basic level. This should help in understanding the widespread phenomena of the biodiversity.

ACKNOWLEDGEMENTS

The author Chandra Shekhar Jeengar gratefully acknowledges JRF granted by UGC. Award Number - F117.1/201617/RGNF 201517 SCRAJ 13827/ (SAIII/Website).

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