Asian Journal of Chemistry Vol. 18, No. 2 (2006), 991–996

Comparative Studies on Plants as Bioindicator for Cu, Co, Ni, Pb, Zn, Cr, Fe, Mn, F and K_2O in Lead-Zinc-Fluorite Mine Area of Chandidongri, Distt. Rajnandgaon (C.G.), India

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Present studies were carried out on twelve tree species, *viz.*, *Azadirachta indica* Adr. Juss., *Buchanania lanzan* Spreng, *Cassia fistula* L., *Chloroxylon swietenia* D.C., *Ficus glomerata* Roxb., *Ficus retusa* L., *Holdenia cordifolia* (Roxb.) Ridsd., *Lagerstroemia parviflora* Roxb., *Madhuca indica* J. Gmelin., *Pterocarpus marsupium* Roxb., *Semecarpus anacardium* L. and *Stereospermum sauveolens* D.C. in lead-zinc-fluorite mining area in Chandidongri district, Rajnandgaon. The concentration of the elements, *viz.*, Cu, Co, Ni, Pb, Zn, Cr, Fe, Mn, F and K_2O, were estimated from washed plant leaves and young twig samples which were collected from mineralized and nonmineralized areas. Chemical analysis of plants showed higher elemental concentrations for Cu, Co, Ni, Zn, Cr, Fe, Mn, F and K_2O in comparison with the nonmineralized area plants and elemental composition of uncontaminated angiospermic plant tissues. The growth, distribution and toxic effects of plants of the mine area may be influenced by subsurface geology, reflecting the accumulation and toxic level of these elements.

Key Words: Plant indicator, Heavy metals, Chandidongri District, Rajnandgaon.

INTRODUCTION

Since ancient times man has been well familiar with the importance of plant cover as an indicator of ecological or hydrological or mineral purposes. Varahamihira (505–587 A.D.), the great Indian astrologer, astronomer and mathematician, has described in 125 slokas (verses) several features of vegetation, termite mounds, soil and rocks that may help in locating in ground water sources and mineral deposits[1, 2]. The distribution of species over the earth's surface has some correlation with the elemental contents present hidden beneath the earth's crust. The biological method for prospecting minerals which involves visual survey of the vegetation to detect the presence of minerals by observing plant distribution, the presence of indicator plants and morphological or mutational changes caused by the presence or excess quantity of certain elements in the substrate[3, 4].

Biogeochemical sampling is certainly better than geochemical sampling. An analysis of samples from a single tree may provide information not available even from a hundred soil samples from the same area. Plants are the best for sampling, are ubiquitous, have a deep root system and show fairly constant correlation between plant composition and the supporting medium. Certain elements, which because of some particular properties provide anomalies or halos are more readily usable than the element sought for which they are associated as pathfinder elements. The use of iron and manganese are used in vegetation is a pathfinder for other elements[5]. Arsenic in vegetation is a pathfinder for gold in the soil with good positive results[6]. Zinc usually occurs in soils associated with lead and cadmium which is in soil and in plant nutrition as well as toxicants are sometimes found in plants growing in soils of mine area. Similarly, cadmium can be used as a pathfinder for zinc in biogeochemistry, as its higher concentration in soils as well as in plants is found only over zinc anomalies and it provides a better contrast between areas of commercial zinc mineralization and the general background[7]. During the present studies, to evaluate the pathfinder value of some elements, twelve tree species were selected for chemical analysis from mineralized fluorite mine area of Chandidongri and same species., from the adjoining nonmineralized area of district Rajnandgaon.

EXPERIMENTAL

After visual observation from the study area twelve tree species were selected for selective analysis. The leaves and young twigs were washed thoroughly under running water to remove adhering particles. These plant samples, dried in a hot air oven, were powdered and kept in polythene bags for further analysis.

Chemical analysis of plant samples

0.10 g dry powder of plant sample in a platinum crucible was mixed with 0.5 g sodium carbonate (AR grade) and 0.1 g zinc oxide and fused at 900°C for 30 min in a muffle furnace. The ashes were cooled and pretreatment of samples was done with conc. HNO_3. It was digested with a mixture of 10 mL of HNO_3, 3 mL of perchloric acid and 10 mL of HF acid and finally added 10 mL conc. HCl. This was then transferred to a 100 mL volumetric flask and made up to volume with distilled water. The solution was then shaken well before aspiration into the AAS[8, 9]. Fluoride was estimated with the help of ORINON ion selective electron model No. 3.5, using fluoride electrode. Potassium was estimated with the help of flame photometer, Microprocessor Based/Chemita-102 model at 766.5 nm, for potassium.

RESULTS AND DISCUSSION

Table-1 and Fig. 1–4 show the chemical analysis of the leafy twigs of twelve tree sps. by which concentrations of ten elements were estimated. Concentration of potassium as K_2O was higher, hence was expressed in percentage while other elements having lesser concentration were expressed in ppm. Plants were collected from the mineralized area (MA) of Chandidogri and nonmineralized area (NA) within the district Rajnandgaon. On the basis of the biogeochemical analysis it has been established that the concentrations of the toxicants are in direct proportion in the soil and in the plant sps. In other words, the growth and distribution of a particular plant in a given area is known to be influenced by subsurface geology. It is in comparison to the elements found in uncontaminated

TABLE-1
CHEMICAL ANALYSIS OF THE LEAFY TWIGS OF 12 TREES FROM MINERALIZED (MA) AND NONMINERALIZED (NM) AREAS FOR SOME ELEMENTS (EXCEPT FOR K_2O, ALL OTHER VALUES ARE IN ppm)

Plants		Cu	Co	Ni	Pb	Zn	Cr	Fe	Mn	F	K_2O (%)
A. indica	MA	6.00	1.00	4.00	1.00	24.00	13.00	107.00	31.00	40.00	1.66
Adr. Juss.	NM	5.00	7.00	4.00	2.00	18.00	30.00	84.00	30.00	0.00	2.13
B. lanzan	MA	5.00	6.00	19.00	1.00	67.00	11.00	98.00	32.00	2.00	2.51
Spreng.	NM	1.00	3.00	7.00	1.00	26.00	7.00	36.00	25.00	1.00	1.07
C. fistula L.	MA	1.00	2.00	13.00	3.00	19.00	6.00	107.00	99.00	1.00	0.71
	NM	0.00	6.00	15.00	3.00	18.00	13.00	78.00	98.00	0.00	0.74
C. swietenia	MA	10.00	4.00	4.00	1.00	64.00	2.00	51.00	231.00	1.00	1.50
D.C.	NM	4.00	2.00	3.00	3.00	24.00	32.00	24.00	133.00	0.00	0.62
F. glometara	MA	2.00	3.00	14.00	1.00	61.00	163.00	130.00	163.00	20.00	0.87
Roxb.	NM	13.00	3.00	16.00	2.00	30.00	15.00	58.00	55.00	0.00	2.26
F. retusa L.	MA	4.00	4.00	8.00	1.00	30.00	8.00	108.00	126.00	1.00	0.60
	NM	3.00	2.00	7.00	1.00	12.00	9.00	56.00	42.00	0.00	1.04
H. cordifolia	MA	5.00	2.00	5.00	1.00	33.00	2.00	145.00	32.00	1.00	1.67
(Roxb.) Ridsd.	NM	3.00	4.00	7.00	1.00	12.00	4.00	78.00	18.00	0.00	1.05
L. parviflora	MA	16.00	8.00	19.00	1.00	97.00	11.00	13.00	32.00	10.00	2.18
Roxb.	NM	7.00	2.00	10.00	1.00	18.00	20.00	47.00	96.00	0.00	1.33
M. indica, J.	MA	5.00	1.00	12.00	3.00	9.00	10.00	253.00	114.00	1.00	9.56
Gmelin.	NM	7.00	2.00	8.00	1.00	10.00	23.00	168.00	198.00	0.00	0.69
P. marsupium	MA	6.00	1.00	5.00	1.00	38.00	8.00	160.00	88.00	75.00	9.76
Roxb.	NM	3.00	1.00	2.00	1.00	12.00	18.00	98.00	65.00	1.00	2.78
S. anacardium	MA	1.00	5.00	26.00	1.00	163.00	70.00	110.00	608.00	2.00	1.58
L.	NM	2.00	6.00	22.00	1.00	67.00	24.00	59.00	215.00	1.00	1.05
S. sauveolens,	MA	3.00	2.00	19.00	1.00	46.00	70.00	183.00	228.00	1.00	2.78
D.C.	NM	1.00	4.00	16.00	0.00	17.00	32.00	86.00	115.00	0.00	1.38

angiospermic plant tissues observed[10]. However, concentration of copper in the plants of mineralized area ranged from 1.0–16 ppm; the maximum 16.0 ppm. was recorded for *Lagerstroemia parviflora*. Cobalt, detected to be present in all the plants analyzed presently from the mineralized area ranged in its concentrations from 1.0–8.0 ppm; maximum was recorded for *Lagerstroemia parviflora*. Nickel, in the plants from mineralized area, was found to range from 1.0–26.0 ppm where the maximum concentration was recorded for *Semecarpus anacardium*. The main toxic symptoms of nickel appear to be a combination of induced iron deficiency chlorosis, foliar necrosis and unusual spotting of leaves and stems[11]. Lead concentration in mineralized area ranged between 1.0–3.0 ppm and the maximum was 3.0 ppm recorded in two tree sps., namely, *Cassia fistula* and *Madhuca indica*.

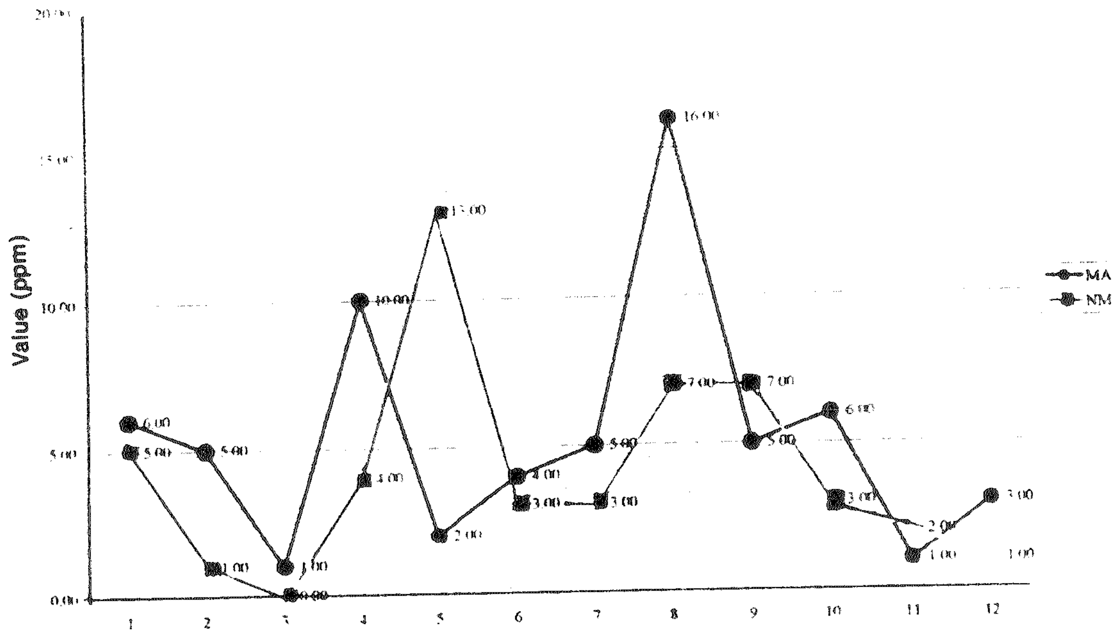

Fig. 1. Chemical analysis of the leafy twigs of 12 trees from mineralized (MA) and non-mineralized (NM) areas, for copper values in ppm

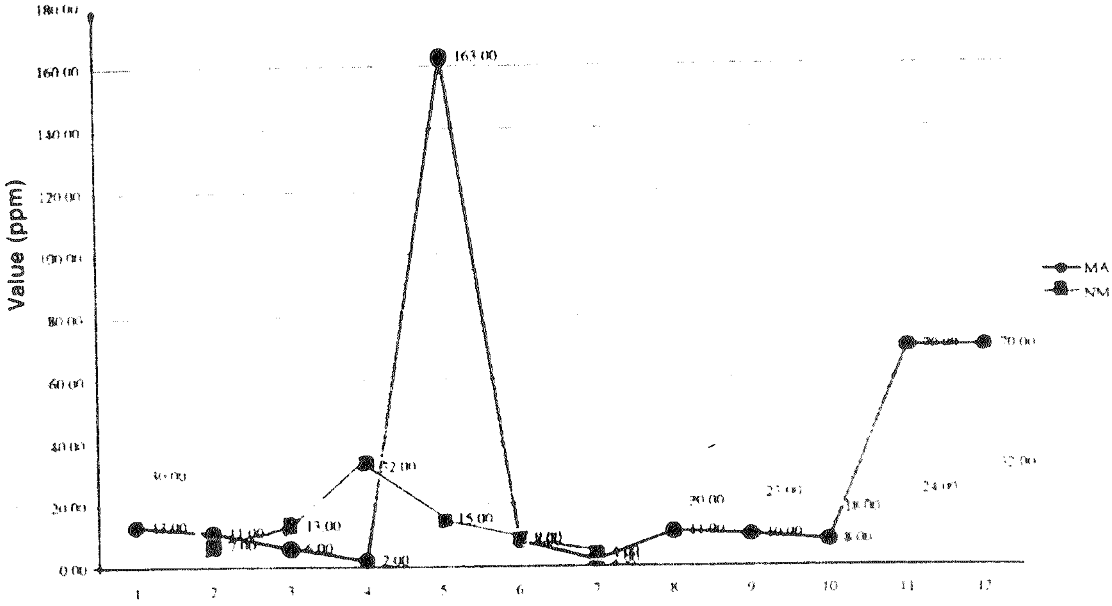

Fig. 2. Chemical analysis of the leafy twigs of 12 trees from mineralized (MA) and non-mineralized (NM) areas, for chromium values in ppm

Concentration of zinc ranged from 9.0–163 ppm and maximum 163 ppm zinc was recorded for *Semecarpus anacardium*. The values from mineralized area ranged from 2.0–163.0 ppm; maximum 163.0 ppm was recorded for *Ficus glomerata*. Concentration of iron ranged from 13.0–253.0 ppm highest concentration of 253 ppm for *Madhuca indica*. The trend of average values of manganese in the plants from mineralized area ranged from 31–608 ppm; the highest concentration 608 ppm was recorded for *Semecarpus anacardium*. Concentration of fluoride in the plants from mineralized area was lower as compared to the concentration of iron and manganese, having concentration 1.0–75 ppm; the

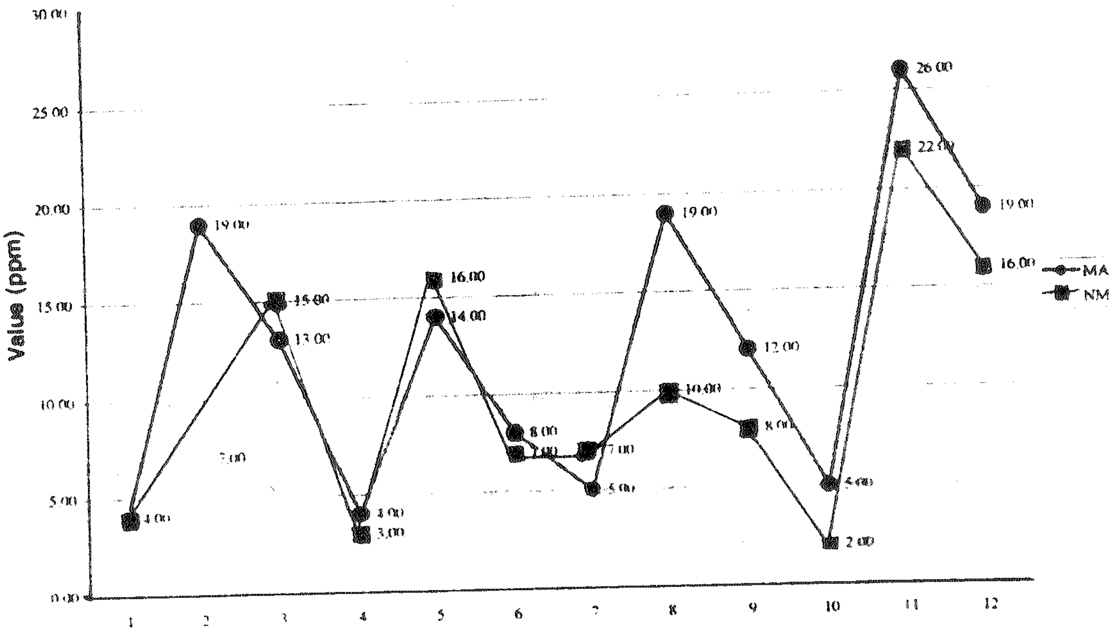

Fig. 3. Chemical analysis of the leafy twigs of 12 trees from mineralized (MA) and non-mineralized (NM) areas, for nickel values in ppm

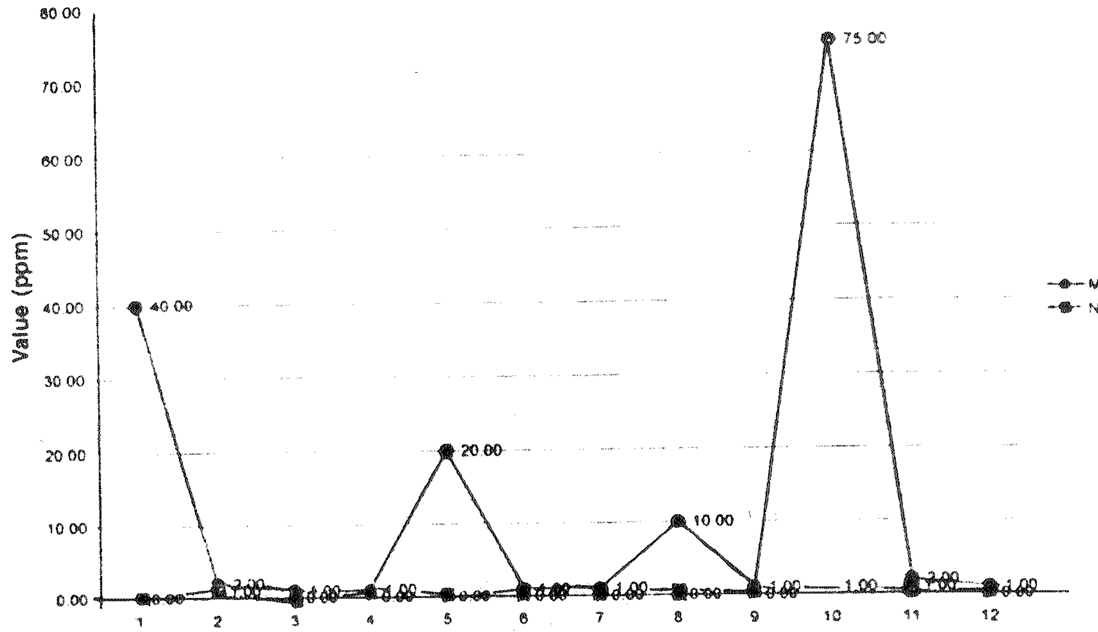

Fig. 4. Chemical analysis of the leafy twigs of 12 trees from mineralized (MA) and non-mineralized (NM) areas, for fluoride values in ppm

highest concentration 75 ppm was recorded for *Pterocarpus marsupium*. The presence of fluoride decreases the process of photosynthesis by breaking down chlorophyll in plants[12]. Potassium, estimated as K_2O, was detected in all the plants, both from mineralized and nonmineralized areas. In mineralized area K_2O ranged from 0.60–9.76% and highest concentration of K_2O was recorded in *Pteocarpus marsupium*. As per visual survey among these trees, chlorosis, dwarfism, necrosis of leaves, brown spot and leaf tip burn were observed in mineralized area. In spite of abundant iron in soil, chlorosis was observed in leaves of mineralized area; it may be a result of the reduction of iron uptake caused by antagonistic effects of other elements present in the soil in high amounts. The chemotoxic effects cannot be attributed to only one element but it can be a combined effect of other elements present in the soil. On the basis of chemical analysis it was shown that higher concentration of elements in comparison to nonmineralized area and elemental composition of uncontaminated plant tissue[10] revealed that the plants *Azadirachta indica, Ficus glomerata, Lagerstroemia parviflora, Madhuca indica, Pterocarpus marsupium* and *Semecarpus anacardium* could be considered as mild accumulators of the elements in mine area.

ACKNOWLEDGEMENT

The author is highly grateful to the Director, Geology and Mining Department, Raipur (C.G.) and Bioscience Department, Pt. Ravishanka University, Raipur (C.G.) for providing necessary laboratory facilities and helpful suggestions during this work.

REFERENCES

1. S. Dwivedi, in: Bhattopal (Ed.), The 'Brihat Samhita' by Varhamihira, with a Commentary, E.J. Lazarus & Co., Banaras (1897).
2. E.A.V. Prasad, *Ground Water News*, **1–2**, 36 (1986).
3. R.R. Brooks, Geobotany and Biogeochemistry in Mineral Exploration, Harper & Row, New York (1972).
4. ———, Biological Methods of Prospecting for Minerals, John Wiley & Sons (1983).
5. H.V. Warren, R.E. Delavault and J. Barakso, *Econ. Geology*, **59**, 1381 (1964).
6. R.M. Talipov, K. Aripova, K.K. Karabaev, S. Khatamov and N. Akhundkhodzhaeva, *Uzbek. Zhur.*, **12**, 43 (1968).
7. Y.D. Tiagi and N.C. Aery, Plant indicators of heavy metals, in: Biological Monitoring of the State of the Environment: Bioindicators, INSA, New Delhi, pp. 207–222 (1985).
8. M. Pinta, Detection and Determination of Trace Elements, Wiley, Chichester (1974).
9. W.J. Price, Spectrochemical Analysis by Atomic Absorption, 2nd Edn., Heyden, London (1979).
10. H.J.M. Bowen, Trace Elements in Biogeochemistry, Academic Press, New York, p. 241 (1966).
11. D. Mishra and M. Kar, *Bot. Rev.*, **40**, 395 (1974).
12. D. Paterson and J.B. Kenworthy, An investigation of the effects of fluoride on related moss species, Department of Botany, University of Aberdeen, Scotland (1984).

(*Received*: 19 March 2005; *Accepted*: 12 December 2005) AJC-4520