A preliminary study of indicator plants of copper and manganese occurring in the ore rich areas of Balaghat District, Madhya Pradesh, India

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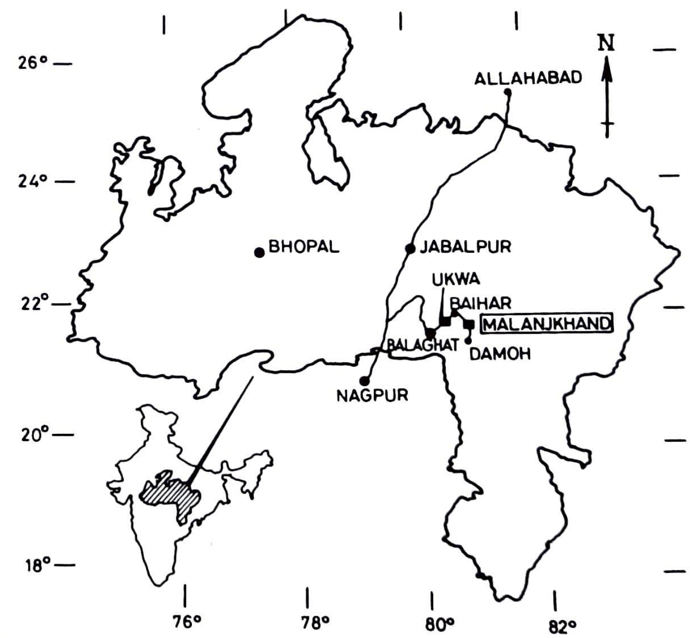
In the present communication an attempt has been made to identify indicator plants of copper and manganese bearing rocks occurring in the Balaghat District of Madhya Pradesh, Central India. The preliminary studies based on geobotanical and biogeochemical methods suggest that *Borreria pusilla* (Wall.) DC., *Hyptis suaveolens* Poit. and *Cassia tora* Linn. can be considered as "local" indicators of copper and manganese respectively, in the Central India.

Key-words - Geobotany, Biogeochemistry, Indicator Plants, Copper and Manganese, Central India.

INTRODUCTION

THE use of vegetation as a guide to mineralisation is a subject which primarily combines the use of Geobotany and Biogeochemistry. In brief the former involves identification of indicator plants by visual observation, aerial photography or satellite imagery of the vegetation cover whereas the latter deals with gathering evidence of mineralisation through chemical analysis of the plant cover and its underlying soil (Brooks 1983).

The use of indicator plants or plant communities in search of water or minerals has been known since long. Chinese recognised the relationship between plants and ore deposits as early as in eighth century (Cannon 1960). Zinc floras was known to central Europeans and particularly in Belgium and Rhine region and the early miners were led to ore deposits by such plants as *Viola calaminaria*. Medieval miners of Scandinavia were familiar with "Kis-plant" or copper plant (*Viscaria alpina*) which grow on copper ores. This aspect of plants has been exploited in various parts of the world particularly in the former U.S.S.R., Australia, New Zealand, Scandinavian countries, Canada, U.S.A and Central Africa. Geobotanist was included in all major Russian geological expedition since 1945 (Cannon 1960; Thaler 1962). In ancient times Indian sages had fairly good idea about the plant cover as an indicator of water or minerals (Tiagi 1990). *Aphanamixis polystachya* (Wall.) Parker (syn. *Amoora rohituka* W. & A.) has been considered as indicator of presence of ground water (Aiyer 1956). However, the subject has never been pursued vigorously in India. There are only stray reports of work on Geobotany in India. (Gandhi &



Map-1: Showing locations of Ukwa (manganese) and Malanjkhand (copper) mines in Madhya Pradesh.

Aswathanarayana 1975; Farooqui *et al.* 1992; Gyan Chand & Venu 1994; Mehta *et al.* 1964; Pocock & Vasanthy 1986; Poddar 1965; Ravikiran & Bedi 1984; Roy 1974; Sahu & Pandian 1993; Sriramdas & Raju 1994; Vasanthy & Pocock 1981; Venkatesh 1964, 1966 a, b). Tiagi and his associates by their valuable contribution provided necessary impetus to Geobotany in India (Aery 1977, Aery & Tiagi, 1985, 1986, 1987, 1988; Tiagi 1990; Tiagi & Aery 1981, 1982, 1985, 1986 a,b, 1987, Venu & Gyan Chand 1996). In his presidential address at the 77th Indian Science Congress, Tiagi (1990) has drawn attention to this neglected aspect of plant use in India and recommended that study on Geobotany and biogeochemical analysis of plants may be promoted for the exploration of mineral deposits. Geobotany can only be considered as additional or accessory method of mineral prospecting through botanical means. It necessarily may not give the complete picture of mineralisation in a given area but the technique is of great value in completing the picture and in some cases decisively represent the differences in success or failure of an exploration (Brooks 1972). In view of the above facts the present work was undertaken.

In this paper results of geobotanical survey of Malanjkhand copper mine and Ukwa manganese mine together with chemical analysis of the plant and soil samples and their geobotanical implications have been discussed.

STUDY AREA AND PROCEDURES ADOPTED

The Balaghat area of Madhya Pradesh in Central India was selected for the present study for two reasons. Firstly the area has never been explored geobotanically as is evident from the above resumé of the work done so far in India. Secondly two different ore rich areas, namely, Malanjkhand copper mine and Ukwa manganese mine are closely situated in the area (Map 1).

The Malanjkhand copper mine is situated about 90 km north-east of Balaghat (Lat. 22° 00′ 05″: Long. 80° 42′ 33″). The total estimated ore reserves are 237 million tonnes and the mining is done by mechanised open-cast method. The plant and soil samples were collected from an undisturbed hillock situated close to the northern end of the mine pit boundary and copper leaching complex. Similarly Ukwa manganese mine is about 44 km north-east (Lat. 21° 59′ : Long. 80° 21′) of Balaghat and is easily reachable. The *in situ* ore reserves are about 11 million tonnes and the mining is carried out by underground method. The plant and the soil samples were collected from Samanapur section of the mine. The two mines are situated in hilly terrain ranging in height from 625 to 650 m above mean sea level. The formation of the orebody and the country rocks in both the mine areas belong to the Archean age. The vegetational analysis was done by line transect method. Chemical analysis of different organs of plants and underlying soil samples were carried out on dry weight basis for six elements by Varian Techron AAS. Plant and soil samples were powdered and dried at 80°C for 48 hours. One gram of the dried material was digested with ternary acid (10:4:1 namely HNO_3, $HClO_3$ and H_2SO_4) and made up to suitable volume (1000 ml) and analyzed by AAS (Tiagi & Aery 1981). The iron, manganese, zinc, copper, lead and cadmium concentration (ppm) in some of the plant species and the underlying soil are shown in Table I and Table II.

DISCUSSION

A botanical survey of the Malanjkhand area has revealed the occurrence of a number of trees, shrubs and herbs. The dominant trees encountered

TABLE -I. Analysis of Ukwa manganese mine plants

Name of plant	Sample No.	Fe (%)	Mn(%)	Zn (ppm)	Cu (ppm)	Pb (ppm)	Cd (ppm)
Cassia tora Linn.	1(R)	0.08	0.14	26	9.0	1.0	NT
	2(St)	0.09	0.18	27	14.0	4.0	NT
	3(L)	2.77	8.37	42	32.0	21.0	1.0
	5(So)	6.60	22.88	128	108.0	73.0	5.0
Borreria articularis (L.f.) F.N. Will.	33(L)	0.31	1.06	73	12.0	2.0	0.25
	34 (Se)	0.18	0.50	41	10.0	1.5	NT
	35 (So)	7.60	31.81	80	108.0	72.5	7.50
Pogostemon benghalensis Kuntze	83(L)	0.10	0.11	22	14.0	7.75	0.50
	85(So)	5.44	36.59	65	78.0	72.50	7.50

Abbreviations: NT-non-traceable; R-root; St-stem; L-leaf; Se- seed; So-soil

TABLE- II. Analysis of Malanjkhand copper mine plants

Name of Plant	Sample No.	Fe (%)	Mn (%)	Zn (ppm)	Cu (ppm)	Pb (ppm)	Cd (ppm)
Hyptis suaveolens Poit	111(R)	0.25	0.26	9	74.0	1.50	0.25
	111(B)	0.11	0.0097	16	69.0	6.00	0.25
	112(St)	0.07	0.09	12	24.0	4.00	0.25
	112(B)	0.01	0.0188	25	19.0	NT	NT
	113(L)	1.59	0.02	29	240.0	9.50	0.75
	113(B)	0.09	0.0106	88	119.0	10.00	0.75
	115(So)	7.03	0.0278	30	1463.0	48.00	2.50
	115 (B)	5.35	0.1223	95	1223.0	70.00	5.00
Tephrosia senticosa Pers.	232(St)	0.02	0.02	33	20.0	8.00	0.25
	233(L)	0.04	0.03	43	30.0	2.25	0.50
	234 (FL/Se)	0.05	0.01	26	19.0	2.25	0.50
	235(So)	8.56	0.06	28	1412.0	37.50	2.50
Borreria pusilla (Wall.) DC.	131(B)	0.2925	0.0050	20	18.0	14.00	NT
	132(St)	0.18	0.04	23	42	4.75	0.50
	132(B)	0.1480	0.0034	38	13.0	9.00	NT
	133(L)	3.14	0.05	34	460.0	15.00	1.25
	133(B)	2.14	0.0352	40	51.0	11.00	NT
	134(Fl/Fr)	0.82	3.17	60	40.0	13.50	0.75
	134(B)	1.44	0.0172	36	30.0	11.00	NT
	135(SO)	8.44	0.08	35	1392.0	47.50	2.50
	135(B)	12.25	0.2055	142	295.0	68.00	NT

Abbreviations: NT-non-traceable; R-root; St-stem; L-leaf; Se-seed; Fl/Fr/-flower/fruit; So-soil; B-background.

in the area are: *Anogeissus latifolia* Wall., *Buchanania lanzan* Spreng., *Butea frondosa* Roxb., *Holarrhena anti-dysenterica* Wall., *Diospyros exculpta* Buch. - Ham. Other commonly occurring trees are *Gardenia latifolia* Ait., *Syzygium cumini* (L.) Skeels, *Garuga pinnata* Roxb., *Boswellia serrata* Roxb., *Erythrina suberosa* Roxb., *Lagerstroemia parviflora* Roxb., *Bridelia stipularis* Bl., *Mitragyna parvifolia* Korth., *Tectona grandis* Linn. f. The shrubby flora consists of *Lantana camara* Linn., *Ziziphus* sp., *Diospyros montana* Roxb., *Chloroxylon swietenia* DC., *Urena lobata* Linn. The dominant herbaceous plants found in the area comprise of *Borreria pusilla* (Wall.) DC., *Hyptis suaveolens* Poit., *Cassia absus* Linn., *Justicia simplex* D.Don, *Triumfetta rhomboidea* Jacq., *Volulopsis nummularis* (Linn.) Roberty, *Evolvulus alsinoides* Linn. The other herbs are: *Cassia pumila* Lamk., *Mollugo pentaphylla* Linn., *Tephrosia senticosa* Pers., *Crotalaria prostrata* Rottle., *Zornia diphylla* Pers., *Cassia tora* Linn., *Triumfetta neglecta* W. & B., *Indigofera linifolia* Retz., *I. enneaphylla* Linn., *Bidens biternata* Linn., *Canscora decussata* Roem. & Schult., *Cyanotis cristata* Schult., *Phyllanthus simplex* Retz., *P. debilis* Klein ex Willd., *P. urinaria* Linn.

The vegetation of Ukwa area consists of trees of *Firmiana colorata* (Roxb.) R. Br., *Buchanania lanzan* Spreng., *Lagerstroemia parviflora* Roxb., *Anogeissus latifolia* Wall., *Pongamia pinnata* (Linn.) Pierr., *Limonia acidissima* Linn., *Pithecellobium dulce* Benth. and shrubs of *Lantana camara* Linn., *Ziziphus oenoplia* Lamk., *Urena lobata* Linn. and *Jatropha curcas* Linn. The herbaceous vegetation is dominated by *Cassia tora* Linn., *Ageratum conyzoides* Linn., *Canscora decussata* Roem. & Schult., *Cyanotis cristata* Schult., *Desmodium triflorum* DC., *Zornia diphylla* Pers. besides the common occurrence of *Blumea membranacea* DC., *Adiantum* sp., *Crotalaria prostata* Rottl., *Crepis japonica* Benth., *Desmodium gangeticum* DC., *Oldenlandia corymbosa* Linn., *Rungia pectinata* Cl., *Phyllanthus simplex* Retz., *Borreria articularis* (L.f.) F.N. Will., *Indigofera linifolia* Retz. and *Alysicarpus monilifer* DC.

Amongst the dominant herbaceous plants, *Borreria pusilla* (Wall.) DC. and the aromatic *Hyptis suaveolens* Poit. of the family Rubiaceae and

Lamiaceae (Labiatae), respectively were found growing in profuse abundance at the Malanjkhand mineralised site. They were further characterized by their stunted growth. The former ranging from 3 cm to 6 cm and the latter 25 cm to 30 cm compared to their large sized background samples. In the nonmineralised area *Hyptis suaveolens* Poit., was found upto 2 m tall and *Borreria pusilla* (Wall.) DC., upto 35 cm tall. Obviously, the two plants visually indicate some kind of abnormality leading to suspicion that their stunted growth may be due to high concentration of mineral (copper) in the copper mineralised soil. Moreover, their numerical abundance at the site indicate that they have the capacity to tolerate excess mineral (or minerals) content of the soil. Such type of plants have been classified as "local indicators" (Malyuga, 1964).

Chemical analysis of the plant samples*, *viz.*, *Borreria pusilla* (Wall.) DC., *Hyptis suaveolens* Poit. and *Tephrosia senticosa* Pers. was done. The first two are the dominant species and the latter a normally occurring plant at Malanjkhand site. The results of mineral analysis (Table-I) revealed that *Borreria pusilla* (Wall.) DC. samples show maximum concentration of copper (460 ppm) in its leaves, almost 1/3rd of the quantity found in the underlying soil samples (1392 ppm); followed by *Hyptis suaveolens* Poit. (240 ppm), about 1/6th of the quantity found in the soil samples. *Tephrosia senticosa* Pers. a normal occurring plant did not show any noticeable quantity of copper (maximum 30 ppm). Thus the biogeochemical results are in accordance with the geobotanical observations. Hence, *Borreria pusilla* (Wall.) DC. and *Hyptis suaveolens* Poit. can be considered as "local indicators" of copper.

Geobotanical studies at Ukwa manganese mine showed that *Cassia tora* Linn. though found in great abundance, yet its growth was stunted. *Pogostemon benghalensis* Kuntze had normal growth. Unlike Majanjkhand copper mine, *Borreria* was not found in abundance in Ukwa mine. Moreover, it was replaced by a different species, namely *Borreria articularis* (L.f.) F.N. Will. The abundance of *Cassia tora* Linn. and its stunted growth (about 30 cm) at the Ukwa site compared to large sized background plants (about 90 cm) gave a clue about the possible relationship with mineral concentration in the underlying soil. To confirm this the three plant samples and the soil samples were subjected to chemical analysis. The result of analysis (Table-II) shows that *Pogostemon benghalensis* Kuntze hardly indicated any worthwhile concentraion of manganese in its tissues, *Borreria* does show some increase but not significant. The highest concentration was seen in *Cassia tora* (8.37%). Evidently *Cassia tora* Linn. shows positive correlation with manganese concentrations in the soil thereby confirming the inference drawn independently on the basis of field observations of the plants. Hence *Cassia tora* Linn. can be considered as a "local indicator" of manganese.

Thus on the basis of preliminary studies it is concluded that the numerical abundance coupled with stunted growth of *Borreria pusilla* (Wall.) DC., and *Hyptis suaveolens* Poit. together indicate a copper rich substratum. Likewise the abundance and stunted growth of *Cassia tora* Linn. also gives clue about the manganese rich area.

*The samples were chemically analysed at the Trace Element Laboratory of the Malanjkhand copper mine, Malanjkhand, Balaghat District, M.P.

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REFERENCES

Aery, N.C. 1977. Studies on the Geobotany of Zawar mines. *Geobios* 4: 225-228.

Aery, N.C. & Tiagi, Y.D. 1985. Biogeochemical studies of the Zn deposit areas in the environs of Udaipur: On cadmium the pathfinder for Zinc. *J. Indian bot. Soc.* 64: 148-155.

Aery, N.C. & Tiagi, Y.D. 1986. Bioindicators and accumulators in geobotanical and biogeochemical prospecting of metals. *Acta biol. Hung.* 37 : 67-78.

Aery, N.C. & Tiagi, Y.D. 1987. Observation on the biogeochemistry of lead at Zawar Mines, Udaipur, India. *Sci. Dev, Environ.* : 117-129.

Aery, N.C. & Tiagi, Y.D. 1988. Accumulation of cadmium by plants of Zawar mines, Rajasthan, India. *Acta biol. Hung.* 39: 87-98.

Aiyer, A.K.Y.N. 1956. *The Antiquity of Some Field and Forest Flora of India.* The Bangalore Printing and Publishing Co., Ltd.

Brooks, R.R. 1972. *Geobotany and the Biogeochemistry in Mineral Exploration.* Harper & Row, Publishers, New York.

Brooks, R.R. 1983. *Biological Methods of Prospecting for Minerals*. New York.

Cannon, H.L. 1960. Botanical prospecting of ore deposits. *Science* **132**: 591-598.

Farooqui, A., Srivastava, K. & Farooqui, S.A. 1992. A vegetational survey of some mineral exploration areas in Lalitpur, Uttar Pradesh, India. *Geophytology* **21**: 113-118.

Gandhi, S.M. & Aswathanarayana, U. 1975. A possible base metal indicator plant from Mamandur, South India. *J. Geochem. Explor.* **4**: 247-250.

Gyan Chand & Venu, P. 1994. A study on the plant communities in relation to copper mineralisation around Rakha mines, Singhbhum Copper belt, Bihar. *J.geol. Soc. India* **44**(6): 663-670.

Malyuga, D.P. 1964. *Biogeochemical Methods of Prospecting*. Consultant Bureau, New York.

Mehta, B.V., Reddy, G.R., Nair, G.K., Gandhi, S.C., Neelkantan, V. & Reddy, K.G. 1964. Micronutrient sudies on Gujarat soils and plants. *J. Indian Soc. Soil Sci.* **72**: 329-342.

Nayar, M.P. & Venu, P. 1990. Problems and prospects of botanical methods of mineral exploration with reference to India - An appraisal. *Bull. Bot. Surv. India* **32** (1-4) : 28-42.

Pocock S.A. J. & Vasanthy, G. 1986. EDS analysis of pollen wall surface of *Vernonia monosis* Cl. (Asteraceae) and pollen soil concentration of elements. *Geophytology* **16**(1): 37-53.

Poddar, B.C. 1965. A probable plant indicator for zinc mineralisation in the Zawar Pb-Zn belt, Udaipur District, Rajasthan. *Curr. Sci.* **34**: 48-49.

Ravikiran, M & Bedi, S.J. 1984. *Cometes surattensis* Burm. var. *ambajiensis* Bedi and Madala as an indicator of copper-lead-zinc mineralisation. *J. Geochem. Explor.* **20**: 47-53.

Roy, S. 1974. Geobotany in the exploration for nickel in the Ultra mafics of the Sukinda Valley, Orissa. *Geol. Min. metall. Soc. India.* (Golden Jubilee Vol.): 251-256.

Sahu, S.K. & Pandian, M.S. 1993. Dwarf date (*Phoenix acaulis*): A possible botanical indicator of Bauxite in Panchpatmali Plateau. *Indian Miner.* **47**(3): 249-252.

Sriramdas, A & Raju, V.P. 1964. Structural lithological and geobotanical guide to Manganese ores of Nellimarla, Vishagapatnum, Andhra Pradesh.

Thaler, L. 1962. Botanical prospecting as an auxilliary to chemical prospecting for mineral deposits (in French). *Nature* **3325**: 208-214.

Tiagi, Y.D. 1990. Geobotany and Biogeochemistry in mineral prospecting. *Proc. 77th Indian Sci. Congr.*, Calcutta, Part II (Presidential address. Botany Sction): 1-26.

Tiagi, YD. & Aery, N.C. 1981. Biogeochemical studies in Zinc deposit areas of Zawar mines, Rajasthan, India. *Proc. Indian Sci. Acad.* **47B** (6): 867-887.

Tiagi, Y.D. & Aery, N.C. 1982. Geobotanical studies on Zinc deposit areas of Zawar mines, Udaipur. *Vegetatio* **5**: 65-71.

Tiagi, Y.D. & Aery, N.C. 1985. Plant indicators of Heavy metals. In *Symp. Vol. "Biomonitoring and State of Environment"*., New Delhi: 207-222.

Tiagi, Y.D. & Aery, N.C. 1986a. Biogeochemical studies on Khetri copper deposits of Rajasthan, India. *Proc. 73rd Indian Sci. Congr.* Part IV: 49-50.

Tiagi, Y.D. & Aery, N.C. 1986b. Biogeochemical studies on Khetri copper deposis. *J. Geochem. Explor.* **26**: 267-274.

Tiagi, Y.D. & Aery, N.C. 1987. The biogeochemistry of cadmium. *J.trop. For.* **3**: 1-36.

Vasanthy, G. & Pocock, S.A.J. 1981. A compartive study of anomalous and normal pollen of *Rapanea*: morphlogy, elemental analysis, sterility and fungal parasitism. *Pollen Spores* **23** (3-4): 349-379.

Venkatesh, V. 1964. Geobotanical methods of mineral prospecting in India. *Indian Miner.* **18**: 101.

Venkatesh, V. 1966a. Geobotany in mineral exploration. *Steel Mines Rev.* **6**: 3-5.

Venkatesh, V., 1966b. Use of the geobotanical method in geological and hydrogeological investigations (in Russian). *Izv. Akad. Nauk SSR.*, 997, Moscow.

Venu, P. & Gyan Chand. 1996. Biogeochemical studies in some copper rich areas of Singhbhum Copper belt, Bihar, India. *J. geol. Soc. India* **48**(4): 439-448.