Environmental Impact of Barytes Deposit: A Case Study from Mangampeta Area, Cuddapah Basin, Andhra Pradesh, India

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Abstract
This paper presents, the results of a study of accumulation of elements in plants developed on mine dumps. The Mangampeta baryte deposit is one of the World's largest known deposits having a distinct volcanic origin. Barytes is mined from the opencast mine and waste overburden is removed and dumped in the nearby areas. These areas are mainly inhabited by the plant species, which include Dodonea viscosa, Lantana camera, Azadirachta indica, Calotropis gigantea, Prosopis juliflora, Acacia leucophloea etc. In the present study accumulation of trace elements viz., Ba, Sr, Mn, B, Zn, Pb, Ni, Co and Cr in different plant species and their associated soils has been studied. Further, this study has given greater emphasis on the plant-soil relationship in the mining area to study the accumulation of elements and their significance in environmental studies.

Introduction

The Mangampeta baryte deposit (Lat. 14° 01' N ; Long. 79° 19' E) is located in the Kodur Mandal of Cuddapah District, Andhra Pradesh. It is included in the Survey of India toposheet No. 57 N/8. It consists of quartzites, shales and dolomites and it is the single largest deposit of its kind in the world. The deposit occurs as two separate lensoid bodies within the upper carbonaceous tuff zone of Pullampet formation of the middle Proterozoic Cuddapah Supergroup. Of these two lensoid deposits, the northern one is relatively bigger compared to the southern. The mine waste from these two opencast mines chiefly comprises various varieties of tuff material. This overburden is being dumped indiscriminately in an area of about 6 km^2.

Four types of barite namely granular, lapilli, vein, and replacement, occur in this area. The granular barite beds overlain by a zone of lapilli barite and constitute the economically significant deposit with an estimated reserve of over 74 million tons. The ore deposit at some places is associated with copper mineralization primarily consisting of pyrite, chalcopyrite, azurite and malachite. The approximate thickness of the over burden is 5.85 mts, which includes top soil (0.5-2.5m) followed by carbonaceous tuff. Earlier workers studied mineralogical (Kurien et al.1977), geochemical (Neelakantam, 1987; Basu, 1997), petrological (Viswanath and Sastry 1983) aspects of this mineralized area and confirmed that the deposit of volcanic origin.

Man has unknowingly increased the trace element content of his environment in exploiting the reserves of minerals. Lands altered as a result of indiscriminate mining activities must be rehabilitated. In such areas, mine dumps or tailings cause a major problem, since they contain a high concentration of heavy metals, which are toxic to plants. On the freshly excavated dumps, which serve as a new substrate for plants comprise of various mixtures of topsoil and substrate rock. The fresh unweathered rocks that are brought to the surface, may release elements to the soil in greater concentrations, than existed in original soil and therefore may affect the growth of plants (Ebens and Shacklett, 1982). Generally, mining activity is a major cause of pollution in its surrounding environment (Salomons 1995).

In Mangampeta mining operations have been going on since 1976. Barytes is mined from the opencast mine and waste overburden is removed and dumped in the nearby areas up to a distance of 6 km on either side of the road. The dumps are invariably associated with pockets of soil/carbonaceous tuff overburden or waste rock incorporated into the tailings. From the present investigation, we are reporting the accumulation potentials of certain plant species viz., Dodonea viscosa, Lantana camera, Azadirachta indica, Calotropis gigantea, Prosopis juliflora, Acacia leucophloea etc., which are occurring profusely on mine dumps. The aim of the present investigation is to study the accumulation of mineral elements in all these plant species growing on tailings and also how they can be used for maintaining and stabilizing these tailings.

Materials and Methods

Composite samples of leaves and twigs of five plants of each species were collected. After thorough washing and elimination of moisture, the leaves and twigs of plant samples were ashed at 450°C in a muffle furnace. Soils were air dried, ashed at 450°C and sieved through 100-mesh nylon sieve. Both the soil and plant samples were digested according to the method referred to by Brooks et al., (1995). These samples were analyzed for Ba, Sr, Mn, B, Zn, Pb, Ni, Co and Cr by atomic absorption spectrometry and the values are shown in Table 1 on ash weight basis.

Results and Discussion

The results of the present study, clearly indicate that leaves and twigs of plant species showed variation in concentration of elements. The elemental accumulation for different elements is as follows.

From Table 1, it is clear that the elements Sr, B, Cu, Zn, Pb and Co have concentrated in small amounts in soil than in plant ash and converse is true in the case of Ba, Ni, and Cr. Further the elements viz., Ba, B, Mn, Zn, Pb, Ni, and Cr have accumulated in large concentrations in leaves than in twigs. Converse is true in the case of Sr, Cu and Co. Huge amount of Ba with mean value of 2422 is accumulated in the soil. Though the concentration of Ba in soils is accumulated in large amounts, but its concentration in plant parts is considerably less. Norrish (1975) pointed out that barite is insoluble, enough to be taken up by plants growing on barium rich soils. Further, strontium is accumulated in large quantities than barium in all plant species. Highest concentration with an average value of 417 ppm of Sr is noticed in the twigs of Lantana camera. Raju et al. (1999) have showed that Pterocarpus santalinus is capable of accumulating large amounts of Sr, Zn and Cu. Further, Azadirachta indica has also been proved as an accumulator of Sr (Nagaraju and Prasad, 2000).

In the present study, leaf concentrations of boron are consistently higher than stem concentrations in different plant species. Highest concentration with a mean value of about 1010 ppm of B is observed in the leaf of Calotropis gigantea. This element is relatively immobile in plants and frequently the B content increase from the lower to the upper plant parts (Oertli and Richardson, 1970). It is also reported that the concentration of boron in the leaves of certain plants from Nellore mica belt (Nagaraju and Prasad, 1995). Amongst the six plant species studied have shown that, the average concentration of Cu ranged from 221 ppm to 396 ppm and Zn varied from 218 - 540 ppm. Lombini et al. (1998) have reported such a behaviour in certain plants of armarian species in Italy. Further, Do van et al. (1972)

have also noticed the accumulation of B, Cu, Mn, Ni, Ba and Sr in plants and soils of Ust-Urt plateau.

All the plant species under study showed a large amount of Mn ranging with a mean value of 106 ppm to 855 ppm. Lounama (1956) has quoted on the manganese content of leaves and stems of several conifers and deciduous trees and shrubs growing on different rocks. He found generally that the leaves contained more Mn than the stems.

From Table 1, it is clear that the average concentration of Pb varied from 79 to 170 ppm in all the plant species. Earlier workers have also noticed that the concentrations of Pb in plants were not significantly high due to the relatively low soil Pb contents and low availability Pb to plants (Jung and Thornton, 1996). The average nickel content of plant material is about 60 to 240 ppm in different plant species. Twigs contained less nickel than did leaves. Accordingly Cataldo et al. (1978) found that, following its absorption by the root, nickel transported within in the xylem as organic complexes, was highly mobile in plants, with leaves being the major sink in shoots during vegetative growth. In the present study, in all plant species, the average concentration of cobalt varied from 12 to 68 ppm and it is concentrated more amounts in twigs than in leaves.

The average concentration of Cr in soils ranged 179-215 ppm and in the plants it is 32-58 ppm. The metal uptake is strongly controlled by the amount of metal available in soil solution for uptake by plants. Cr has a low mobility in soil suggesting that the metal uptake might be dependent of the amount of metal available in the soil but depends on the metabolism of each species having selective absorption of the metals (Lombini et al., 1998).

The existence of plants on the mine wastes and metal contaminated soil led to the belief that metal tolerant species grow by natural selection. Many waste materials are relatively infertile and may be toxic. They do not have a single, clear-cut substrate factor responsible for reducing growth. The most successful populations at each site were those with highest tolerance to the metals occurring on the waste, provided the species was appropriately adapted to the other soil conditions. Brooks (1983) states that plants vary greatly in their ability to accumulate elements from the soil. The variation in the composition of soils and plants in this baryte mining area can be attributed to the bioavailability of these elements and genesis of the ore body and its associated rock types.

Further, mining activity degrades the environment both directly and indirectly. The piles of these wastes or overburden or tailings are toxic to the biological organisms and are one of the inhibitory ecological factors affecting plant growth (Salomons, 1995). The physiological function of each element is different, and in many cases the purpose for which the element enters the plant, is also unique. Because different elements have different functions within the plant and the content of the nutrients varies from organ to organ (Brooks, 1998; Siegel, 2002). The activities of plants solubilize and mobilize nutrients, making them potentially more susceptible to the agencies of erosion. It can be concluded that the strategies adapted by plants to avoid, restrict or alleviate, make it unlikely that a unifying adaptive principle lies behind the development of tolerance throughout the plant kingdom.

Satisfying the society's concern for the fertile and aesthetic value of land, an increasing available area for wild life habitat and livestock use, while reducing erosion, are major goals for reclamation scientists.

Therefore, in order to restore these adversely affected mining areas for amenity, the plant species which have an ability to successfully germinate, grow and reproduce under adversely affected environments have to be identified and utilised for reclamation and revegetation programs.

Hence, it is envisaged that these plant species can be used for reclaiming the tailings in barite mining area of Mangampeta for the purpose of stabilizing the area. The most successful populations at each site, were those with highest tolerance to the metals occurring on the waste, provided, the species was appropriately adapted to the other soil conditions. In higher plants, the ability to accumulate the elements and survive on mine soils and mine relics containing toxic quantities of various heavy metals occurs sporadically throughout different genera (Peterson,1971). So these plant species must have developed a tolerance mechanism, which enables them to survive on the toxic soils.

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Table 1: Concentrations of trace elements in certain plant species and their soils

Element (ppm)	Dodonea viscosa			Lantana camera			Azadirachta indica			Calotropis gigantea			Prosopis juliflora			Acacia leucophloea		
	Leaf	Twig	Soil	Leaf	Twig	Soil	Leaf	Twig	Soil	Leaf	Twig	Soil	Leaf	Twig	Soil	Leaf	Twig	soil
Ba	233 ± 9.79	129 ± 3.56	2130 ± 18.78	365 ± 8.51	290 ± 5.00	1865 ± 12.94	220 ± 3.99	178 ± 3.51	2422 ± 23.29	394 ± 3.33	147 ± 3.21	2310 ± 14.75	326 ± 2.47	185 ± 4.79	1945 ± 12.15	357 ± 3.11	156 ± 2.63	1890 ± 31.26
Sr	258 ± 10.90	365 ± 7.24	30 ± 1.06	232 ± 3.30	417 ± 2.21	28 ± 1.41	252 ± 5.47	280 ± 5.70	32 ± 1.41	312 ± 4.46	375 ± 5.70	31 ± 0.71	270 ± 8.80	392 ± 5.65	34 ± 1.52	360 ± 9.10	395 ± 5.28	39 ± 2.21
Mn	398 ± 8.42	258 ± 9.59	260 ± 8.06	855 ± 22.30	679 ± 6.64	220 ± 3.53	240 ± 6.12	236 ± 6.36	168 ± 4.27	300 ± 3.54	180 ± 5.00	140 ± 3.54	236 ± 5.40	106 ± 3.21	83 ± 4.79	280 ± 3.33	120 ± 2.63	126 ± 2.24
B	713 ± 6.63	340 ± 7.91	12 ± 0.71	540 ± 11.07	365 ± 6.12	11 ± 0.45	416 ± 7.02	215 ± 4.79	13 ± 0.71	845 ± 6.12	330 ± 1061	11 ± 0.71	986 ± 7.94	540 ± 6.52	12 ± 0.32	1010 ± 9.35	430 ± 11.88	12 ± 0.55
Cu	258 ± 3.45	360 ± 6.12	79 ± 2.51	286 ± 4.18	384 ± 3.56	32 ± 1.14	254 ± 2.07	396 ± 3.89	33 ± 1.14	221 ± 3.21	335 ± 11.72	18 ± 0.84	233 ± 2.63	367 ± 4.35	25 ± 0.95	250 ± 4.32	334 ± 5.79	26 ± 1.00
Zn	416 ± 7.15	330 ± 4.74	52 ± 1.51	540 ± 3.88	336 ± 5.21	51 ± 1.41	280 ± 3.54	245 ± 6.12	43 ± 1.52	512 ± 6.40	314 ± 1.76	46 ± 1.52	397 ± 4.89	218 ± 2.21	32 ± 1.41	337 ± 7.37	248 ± 4.79	22 ± 1.00
Pb	110 ± 7.69	85 ± 6.42	12 ± 1.00	165 ± 4.79	79 ± 3.16	14 ± 1.00	114 ± 5.19	88 ± 1.92	12 ± 1.14	170 ± 4.84	113 ± 1.64	13 ± 1.14	149 ± 6.69	83 ± 5.43	14 ± 0.71	157 ± 3.16	79 ± 4.66	11 ± 0.71
Ni	100 ± 4.21	85 ± 3.45	240 ± 8.80	130 ± 5.63	95 ± 4.46	232 ± 12.76	13 ± 4.89	63 ± 3.74	231 ± 4.13	130 ± 5.09	72 ± 3.73	202 ± 6.78	18 ± 4.18	60 ± 5.09	225 ± 6.15	108 ± 4.03	72 ± 4.49	209 ± 3.30
Co	21 ± 1.14	68 ± 4.21	18 ± 1.14	15 ± 1.14	31 ± 1.64	13 ± 0.71	16 ± 1.48	27 ± 1.15	11 ± 0.95	17 ± 1.22	29 ± 2.12	9 ± 0.55	12 ± 0.71	26 ± 2.12	10 ± 0.71	13 ± 1.52	29 ± 1.87	11 ± 0.71
Cr	50 ± 2.59	36 ± 2.70	215 ± 6.16	48 ± 2.30	39 ± 1.41	179 ± 4.76	47 ± 2.83	32 ± 1.52	187 ± 3.16	58 ± 2.05	39 ± 2.92	187 ± 4.51	57 ± 3.21	34 ± 3.02	193 ± 8.44	51 ± 4.69	32 ± 1.52	192 ± 9.35

Concentrations are values of average of five samples ±S.E