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STUDY



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 $\operatorname{ABSTRACT}$: Mining activities generate huge amount of wastes with extremely high concentrations of heavy metal that have adverse effects on ecosystems and human health. Metal contamination extended several kilometers away from the mine sites probably by wind and water. Native vegetation was directly affected by the pollution. Hence, understanding the dynamic of metals in soil and plants is essential for ecosystem management and risk assessment. The present study was designed to assess the toxic metals viz., lead (Pb), cadmium (Cd), nickel (Ni) and chromium (Cr) present in the soil and plant samples of 18 plant species collected from nearby areas Sukinda chromite mining zone. Samples of soil and plants were collected from six different sites and were analyzed for pH, EC, Cr, Cd, Pb and Ni by pH meter, conductivity meter and atomic absorption spectrophotometer, respectively. Soil pH was slightly acidic in nature and varied from 5.5 to 6.4. Total heavy metal concentrations in soils were in the order of Cr>Ni>Pb>Cd. Cr and Ni exceed the critical limit value of WHO specified standard. Accumulation of metals in the plant species and in their organs varies, e.g. accumulation of heavy metal was higher in stem as compared to leaf. Ailanthus excelea Roxb. has highest capability for accumulating Cr in the shoot part as compared to other collected plants. The plants can ideally be used as the possible application in agricultural reconnaissance surveys, reclamation and revegetation of adversely affected mining environment.

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Environmental disturbances resulting from human activities, such as deforestation, land clearing or mining deeply modify the dynamics and functioning of ecosystems (Vitousek *et al.*, 1997). The cessation of such disturbances generally leads to the long-term natural reconstitution of the ecosystem (Holl, 2002). Mining activities generated spoils, effluents and dust with outstandingly large concentrations of heavy metal (Cr, Pb, Cd, Ni, Zn) or metalloids (As) which have adverse effects on biological receptors and ecosystems (Wiegleb and Felinks, 2001). The spatial distribution and

degree of contamination is mainly governed by the ways of dissemination of metal pollutants from the source into the environment. In general, mining causes a large amount of destruction of the environment in the form of alteration of the landscape, deterioration of vast land areas, extinction of wildlife, etc. (Ezeaku and Davidson, 2008). In open cast mining large amount of excavated overburdens is dumped on the surface (mine spoils), that may contain various trace metals. Most of these trace metals are toxic in nature and affect the surface and subsurface environment when its concentration exceeds the permissible limit. Weathering of mine spoils, dumped on the surface produces leachate which on interaction with the parent rocks assimilates heavy metals during its subsurface journey. Surface runoff and wind erosion cause increase in concentration of the heavy metals in local biota and have significant effect on the ecosystem that may lead to geoaccumulation and subsequent bio-accumulation and biomagnifications in the food chain. These heavy metals get accumulated through time in soils and plants and have a negative influence on physiological activities of plants (e.g. photosynthesis, gaseous exchange and nutrient absorption) causing the reductions in plant growth, dry matter accumulation and yield (Suciu et al., 2008). The decontamination of highly metal-contaminated soils by physical or chemical methods is very difficult and costly (Cunningham and Berti, 2000).

Phytoremediation is one of the promising methods for reclamation of these soils by using hyper accumulator plants (Baker et al., 2000; Ghosh and Singh, 2005; Lazaro et al., 2006). For this, detailed studies of the soils and vegetation of such strongly metal contaminated sites and their peripheries are essential for an accurate assessment of the metal toxicity of soils and aerial plant parts with regard to the possible toxic impacts on herbivorous consumers and human health. Such studies are also necessary to provide valuable information for reasoning strategies of land reclamation in metalliferous sites. Only a restricted number of plants from the local flora are able to grow in metalliferous soils. The plant species which have the ability to successfully germinate, grow and reproduce under the adverse affected environments have to be useful for reclamation and revegetation. The

reclamation of metal contaminated sites by plants native to toxic areas aims to stabilize the soil, immobilizing trace elements in the rhizosphere and thereby reducing the risks of the dissemination of metalliferous dust by wind, water erosion or by downward water percolation from the root zone.

Hence, an attempt was made to assess the heavy metal accumulation capacity of indigenous plant species in the Sukinda, chromite mine zone of Odisha. It is expected that the results generated from this study will be useful for the complete understanding of the restoration potential of these plants in the phytostabilization of mining areas.

EXPERIMENTAL METHODOLOGY

Site description :

Sukinda lies between latitude 21° 1' to 21° 4' N and longitude 85° 45' to 85° 48' E and is a part of Sukinda valley, Jajpur district, Odisha. Sukinda, ultramafic belt of Odisha forms an E-W trending V-shaped valley bounded by the Daitari and Mahagiri hill ranges of Precambrian quartzites and banded iron formation as shown in Fig. A. Sukinda valley contains about 98 per cent of chromium reserve and it has been exploited mostly by open-cast mining process since 1950. Most of the mines are located in the central part of the valley and are leased to various companies. The ultramafic rocks carry large reserves of chromite ores in the form of thick seams, lenses and pods are extensively altered and laterized (oxidized). As many as ten chromite seams, each several metals in thickness are known in the area and the mineral is being extensively exploited by open-cast mining. Several such



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chromite quarries are being operated by different agencies in these regions. The giant mining companies are Orissa Mines Corporation (OMC), Indian Metals and Ferro Alloy, TISCO, etc. (Dhakate, 2008). Activities of mining, roasting and smelting of elements has caused disastrous effects on the vegetation and overall environment (Amiro and Courtin, 1981; Gratton *et al.*, 2000; Nkongolo *et al.*, 2008; Vandeligt *et al.*, 2011 and Narendrula *et al.*, 2012 and 2013). Assessment of the levels of metal bioavailability and bioaccessibility is critical in understanding the possible effect on soil biota (Ettler *et al.*, 2012 and Juhasz *et al.*, 2011).

Sampling :

Soil samples were collected from six different zones (unreclaimed overburden dumps and native soil) of open cast mines where local vegetation is already established. The overburden mine spoils are collected by random grid method of 10 m \times 10 m grid. In case of the native soil, the samples were collected from 5–15 cm depth ('A' horizon) of the top soil, which is usually contaminated by the mine spoil and also affected by air pollution and anthropogenic sources of pollutants. GPS (Garmin) instrument was used to correctly find out the sampling locations in the field. The map of the study site shown in Fig. A. The samples were collected in self-locking polythene bags. To avoid the metal contamination, plastic spatula was used.

Soil analysis :

The soil samples were oven dried for two days at 60 °C at the laboratory, crushed and pulverized to pass through 2-mm sieve. For each soil sample, various physico-chemical parameters such as pH, EC, texture, CEC were analyzed. Heavy metals *viz.*, Pb, Cd, Fe, Ni and Cr were also estimated. Soil sample measuring 1 g and 2 g of plant sample was digested in a mixture of concentrated HNO₃, H₂SO₄ and H₂O₂ (2:6:6) as prescribed by Saison *et al.* (2004) for 30 minutes using Microwave Accelerated Reaction System (MARS, CEM®). Towards the end of the digestion, the flasks were brought to near dryness. The solutions were made with 20 ml each in measuring cylinder with double distilled water and examined for heavy metals by AAS at CSIR-

Table A : Brief descriptions of different site of the study area										
Location site	Site-1	Site-2	Site-3	Site-4	Site-5	Site-6				
Latitude	21 °03'49"N	20 °59'18"N	24 °47'49"N	22 °13'49"N	23°03'49''N	25 °73'49"N				
Longitude	85 ° 47'32"E	82°19'89"E	83°47'21"E	86°68'29"E	85°47'32"E	81°25'56"E				

Table B : List of plant species and family sampled								
Species No.	Scientific name	Family						
1.	Cassia alata (L.) Roxb.	Caesalpinioideae						
2.	Thephrosia purpurea (L.) Pers.	Fabaceae						
3.	Alstonia schloraris (L.)R.Br.	Apocynaceae						
4.	Ailanthus excelsa Roxb.	Simaroubaceae						
5.	Oroxylum indicum (L.) Vent.	Bignoniaceae						
6.	Catharanthus roseus (L.)G.Don	Apocynaceae						
7.	Eupatorium odoratum L.	Asteraceae						
8.	Urena lobata L.	Malvaceae						
9.	Sida cordifolia (Burm.f.)Borssum	Malvaceae						
10.	Cassia tora L.	Leguminosae						
11.	Grewia tiliifolia Vahl.	Malvaceae						
12.	Schleichera oleosa (Lour.) Oken	Sapindaceae						
13.	Blumea lacera (Burm.f.) D.C	Asteraceae						
14.	Phyllanthus amarus Schum and Thonn.	Phyllanthaceae						
15.	Cleistanthus collinus (Roxb.)Benth.ex.Hook.f.	Phyllanthaceae						
16.	Acacia auriculiformis A.Cunn.ex.Benth	Fabaceae						
17.	Saccharum sp.	Poaceae						
18.	Pteris sp.	Pteridaceae						

IMMT. Mean values of triplicate of each sample of the soil and plant samples were calculated and considered. Soil pH was determined using a portable pH meter (Hanna instrument model 209) in a 1:5 soil–water suspension. Soil electrical conductivity (EC) was measured using a conductivity meter (Hanna instrument model 209).

Plant analysis :

Dominant plant samples (divided into leaf and shoot) from each site were collected. Leaves and stems were collected separately at various points around the circumference of the tree and these are made into a composite sample. Care was exercised to collect matured plant materials that have gone through the main process of mineral accumulation. All plant samples were sealed with polythene bags in the field and transported into the laboratory for further analysis. A total of 18 plant species such as Cassia alata Linn., Thephrosia purpuria (Linn.) Pers., Alstonia schloris. L.R. Br., Ailanthus excelsa Roxb., Oroxylum indicum (L.) Benth. ex Kurz, Catharanthus roseus (L.) G. Don, Eupatorium odoratum L., Urena labata Linn., Sida cordifolia L., Cassia tora L., Grewia tiliaefolia Vahl., Schleichera oleosa (Lour.) Oken., Blumea lacera (Burm.f.) D.C., Phyllanthus amarus Schum. & Thonn., Cleistanthus collinus (Roxb.) Benth.ex Hook.f., Acacia auricuformis A. Cunn. ex Benth, Saccharum sp., Pteris sp., was collected in the month of December, 2013. Before analysis, each plant part (stems and leaves) were carefully removed and washed (for 2-3 minutes approximately) with tap water and with deionized water to remove any soil and surface dust. Plant samples were dried in oven at 80 °C temperature for two weeks pulverized and passed through 2 mm stainless steel sieve. The list of plants collected and their families was represented in the Table B.

EXPERIMENTAL FINDINGS AND DISCUSSION

Soil pH was in the range of 5.5 to 6.3 which slightly acidic in nature. Electrical conductivity varies from 101

to 131 μ S⁻¹ as shown in Table 1. Heavy metal concentration in the soil was in the range of 0.2817 to 10.267 (Cr), 0.2792 to 10.9041 (Ni), 0.0200 to 6.6755 (Pb) and 0.0068 to 0. 0087 mg/kg (Cd). In the present study, Cr and Ni content in soil was higher as compared to other heavy metals. It might it due the mining operation. The concentration of Cr and Ni was higher as compared to other heavy metals, it may be due the chromite mining operations. The result showed that the concentration of Ni and Cr was beyond the permissible limit (WHO). The heavy metal concentration in soil, shoot and root was shown in Table 2. The distribution of elemental concentrations and the metal uptake in different organs of plant varies widely due to the complex process of metabolism. Each plant species has its own requirements and tolerance to elemental uptake and retention. Generally the plants take up metals to varying degrees from the substrates in which they are rooted and developed and the level of tolerance developed can often be related to the amount of metal in the soil. Plants growing on contaminated soils respond differently on their ability to take in or exclude a variety of metals (Bech et al., 2002). The uptake of metals, specially chromium in relation to



ig. 1: Concentration of Cr in rhizospheric soil and aerial parts of plants

Table 1 : Soil pH and EC																		
Site	Site 1			Site 2 Site 3		Site 4		Site 5		Site 6								
Sample No.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
pH	6.5	6.2	5.9	6.2	6.3	5.9	6.8	6.2	5.5	5.9	5.8	6.1	5.9	6.0	5.7	6.1	5.5	6.0
EC	102	124	116	105	101	108	111	115	120	131	119	120	124	127	123	109	107	103



Sr. No. Plant species Concentration of havey methy Concentration of havey methy 1. Cassia alota (L) Roxb. RS 4.9301 0.0308 9.0178 0.0004 1. Cassia alota (L) Roxb. RS 4.9301 0.00178 0.0064 2. Thephrosic purpurer (L.) Pers. RS 6.869 18.293 8.1412 0.0007 3. Aloonia solitoraris (L.) RBr. RS 4.3327 2.1726 6.7090 0.0037 4. Aloonia solitoraris (L.) RBr. RS 4.3327 2.1726 6.7090 0.0007 5. Oronyme indicum (L.) Vent. RS 5.359 4.3031 0.0004 0.0037 5. Oronyme indicum (L.) Vent. RS 0.3910 6.6755 2.0000 0.0015 6. Catharanthus roseus (L.) G.Don RS 2.3740 0.0101 0.0141 7. Expatorium odoratum L. RS 2.301 1.0494 0.3434 0.0041 7. Expatorium odoratum L. RS 2.301 1.0494 <th colspan="12">Table 2 : Distribution of heavy metals (in ppm) in leaf, stem and soil</th>	Table 2 : Distribution of heavy metals (in ppm) in leaf, stem and soil											
International and the second	Sr. No.	Plant species	Parts -	Co	eavy metal in mg/l	kg						
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6. Catharanthus roseus (L.) G.Don RS 2.5563 0.4442 1.3903 0.0041 7. Eupatorium odoratum L. Stem 1.2092 0.3333 0.7617 0.0181 7. Eupatorium odoratum L. RS 2.3740 0.4010 1.4108 0.0066 8. Urena lobata L. RS 2.3740 0.4010 1.4108 0.0039 8. Urena lobata L. RS 2.3691 1.0949 0.7084 0.0039 9. Sida cordata (Burm.f.)Borsum RS 3.2380 3.5907 1.2007 0.0057 9. Sida cordata (Burm.f.)Borsum RS 8.1469 1.050 3.3849 0.0052 10. Cassia tora L. RS 8.1469 1.050 3.3849 0.0067 11. Pteris sp. RS 9.1432 2.0050 2.1355 0.0077 12. Grewia tilijola Vahl. RS 10.2671 3.0849 0.0051 13. Schleichera oleosa (Lour.) Oken RS 1.2668			Leaf	1.0234	0.0400	0.1035	0.0112					
Stem 1.2092 0.3393 0.7617 0.0181 7. Eupatorium odoratum L. RS 2.1740 0.0101 1.4108 0.0066 Stem 2.1211 0.3208 0.5092 0.0142 8. Urena lobata L. RS 2.3740 0.4049 0.3062 0.0122 8. Urena lobata L. RS 2.3691 1.0949 0.7084 0.0039 9. Sida cordata (Burm.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 9. Sida cordata (Burm.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 10. Cassia tora L. RS 8.1469 1.0530 3.3849 0.0052 11. Pteris sp. RS 9.1432 2.0050 2.1355 0.0077 12. Grewia rillifolia Vahl. RS 1.02671 3.0964 5.1764 Nd* 13. Schleichera aleosa (Lour.) Oken RS 10.2668 1.0100 0.8265 0.0013 1	6.	Catharanthus roseus (L.) G.Don	RS	2.5563	0.4442	1.3903	0.0041					
Lear 17389 0.0350 0.0333 0.0141 7. Eupatorium odoratum L. RS 2.3740 0.4010 1.4108 0.0066 Stem 2.1211 0.3208 0.5092 0.0146 Leaf 1.1324 0.0649 0.3062 0.0122 8. Urena lobata L. RS 2.3691 1.0949 0.7084 0.0039 9. Sida cordata (Burm.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 9. Sida cordata (Burm.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 10. Cassia tora L. RS 8.1469 1.033 0.3449 0.0052 11. Pteris sp. RS 9.1432 2.0050 0.3153 0.0067 12. Grewia tilifolia Vahl. RS 10.2671 3.964 5.1796 0.0081 13. Schleichera aleacera (Burm.f.) D.C RS 3.0881 0.9150 1.5937 0.0041 Stem 0.2671 3.096			Stem	1.2092	0.3393	0.7617	0.0181					
7. Expatorium odoratum L. RS 2.3740 0.4010 1.4108 0.0066 Stem 2.1211 0.3208 0.5092 0.0146 Stem 2.1211 0.0499 0.3062 0.0122 8. Urena lobata L. RS 2.3691 1.0949 0.7084 0.0039 9. Sida cordata (Burn.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 9. Sida cordata (Burn.f.)Borssum RS 3.2380 3.5907 1.2307 0.0059 10. Cassia tora L. RS 8.1469 1.033 0.2046 0.0069 11. Pteris sp. RS 9.1452 2.0050 2.1335 0.0077 11. Pteris sp. RS 9.1452 2.0050 2.1355 0.0077 12. Grewia tillifolia Vahl. RS 9.1422 2.0050 2.1355 0.0071 13. Schleichera oleosa (Lour.) Oken RS 1.02671 3.0846 0.0081 14. Blamea lacera (Burm.f.) D.C RS 3.0881 0.9150 1.5937 0.0041 </td <td></td> <td></td> <td>Leaf</td> <td>1.7389</td> <td>0.0350</td> <td>0.0333</td> <td>0.0141</td>			Leaf	1.7389	0.0350	0.0333	0.0141					
Stem 2.1211 0.3208 0.5092 0.0146 Leaf 1.1324 0.0649 0.3062 0.0122 8. Urena lobata L. RS 2.3691 1.0949 0.7084 0.0039 9. Sida cordata (Burm.f.)Borssum RS 3.2380 3.5907 1.2377 0.0057 9. Sida cordata (Burm.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 9. Sida cordata (Burm.f.)Borssum RS 8.1499 1.0350 3.3849 0.0052 9. Cassia tora L. RS 8.1499 1.0350 3.3849 0.0066 10. Cassia tora L. RS 8.1499 1.0350 3.3849 0.00657 11. Pteris sp. RS S.1499 0.5121 1.0254 0.00675 12. Grewia tilifolia Vahl. RS 10.2671 3.0964 5.1796 0.0081 13. Schleichera oleosa (Lour.) Oken RS 1.2668 1.0100 0.8265 0.0013	7.	Eupatorium odoratum L.	RS	2.3740	0.4010	1.4108	0.0066					
Leaf 1.1324 0.0649 0.3062 0.0122 8. Urena lobata L. RS 2.3691 1.0949 0.7084 0.0039 9. Sida cordata (Burn.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 9. Sida cordata (Burn.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 9. Sida cordata (Burn.f.)Borssum RS 3.2380 3.5907 1.2307 0.0059 10. Cassia tora L. RS 8.1469 1.0351 3.3849 0.0052 11. Pteris sp. RS 9.1432 2.0505 2.1355 0.0077 11. Pteris sp. RS 9.1432 2.0505 2.1355 0.0077 12. Grewia tiliifolia Vahl. RS 10.2675 0.9678 1.5734 0.0081 13. Schleichera oleosa (Lour.) Oken RS 10.2675 0.1533 0.0774 0.0865 14. Blumea lacera (Burn.f.) D.C RS 3.0881 0.1526 <t< td=""><td></td><td></td><td>Stem</td><td>2.1211</td><td>0.3208</td><td>0.5092</td><td>0.0146</td></t<>			Stem	2.1211	0.3208	0.5092	0.0146					
8. Urena lobata L. RS 2.3691 1.0949 0.7084 0.0039 Stem 1.252 0.2221 0.4498 0.0058 9. Sida cordata (Burm.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 9. Sida cordata (Burm.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 9. Stem 0.3547 0.4010 0.6482 0.0181 0.0 Cassia tora L. RS 8.1469 1.0353 0.3849 0.0052 10. Cassia tora L. RS 8.1469 1.0353 0.0065 11. Pteris sp. RS 9.1432 2.0050 2.1355 0.0077 11. Pteris sp. RS 9.1432 2.0050 2.1355 0.0077 12. Grewia tiliifolia Vahl. RS 10.2671 3.0964 5.1796 0.0081 13. Schleichera oleosa (Lour.) Oken RS 1.2686 1.0100 0.8265 0.0013 14. Blumea lacera (Burm.f.) D.C RS 3.0899 0.1863 0.0725 0.0931<			Leaf	1.1324	0.0649	0.3062	0.0122					
Stem 1.2532 0.2221 0.4498 0.0058 9. Sida cordata (Burm.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 10. Cassia tora L. RS 8.1469 1.0350 3.849 0.0069 10. Cassia tora L. RS 8.1469 1.0530 3.3849 0.0052 11. Pteris sp. RS 8.1469 1.05121 1.0254 0.0066 11. Pteris sp. RS 9.1432 2.0050 2.1355 0.0075 12. Grewia tilijolia Vahl. RS NB 0.2711 3.0964 5.1766 0.0081 13. Schleichera oleosa (Lour.) Oken RS 1.6749 Nd* 14. Blumea lacera (Burm.f.) D.C RS 3.0881 0.0153 0.0081 15. Phyllanthus amarus Schum and Thonn. RS 1.2665 0.1010 0.8265 0.0123 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.0265 0.1234 0.00063	8.	Urena lobata L.	RS	2.3691	1.0949	0.7084	0.0039					
Jean Leaf 1.1033 0.2036 Nd* 0.0120 9. Sida cordata (Burm.f.)Borssum RS 3.2380 3.5907 1.2307 0.0057 10. Cassia tora L. Leaf 1.4159 0.0699 0.0678 0.0069 10. Cassia tora L. RS 8.1469 1.0350 3.3849 0.0052 11. Pteris sp. RS 9.1432 2.0050 2.1355 0.0077 11. Pteris sp. RS 9.1432 2.0050 2.1355 0.0077 12. Grewia tiliifolia Vahl. RS 10.2671 3.0964 5.1796 0.0081 13. Schleichera oleosa (Lour.) Oken RS 1.2668 1.0100 0.8265 0.0013 14. Blumea lacera (Burm.f.) D.C RS 3.0881 0.9150 1.5937 0.0041 15. Phyllanthus amarus Schum and Thonn. RS 4.0172 0.8643 0.0105 14. Blumea lacera (Burm.f.) D.C RS 3.0877 0.1526			Stem	1.2532	0.2221	0.4498	0.0058					
9. Sida cordata (Burm.f.)Borssum RS Stem 3.2380 3.5907 1.2307 0.0057 Stem 0.3547 0.4010 0.6482 0.0181 Leaf 1.4159 0.0699 0.0678 0.0069 10. Cassia tora L. RS 8.1469 1.0350 3.3849 0.0052 Stem 4.0891 0.5121 1.0254 0.0066 11. Pteris sp. RS 9.1432 2.0050 2.1355 0.0077 Stem 7.8965 0.9678 1.8743 0.0089 12. Grewia tiliifolia Vahl. RS 10.2671 3.0964 5.1796 0.0081 Stem 8.9012 0.3987 1.6749 Nd* 13. Schleichera oleosa (Lour.) Oken RS 1.2668 1.0100 0.8265 0.0013 14. Blumea lacera (Burm.f.) D.C RS 3.0881 0.9150 1.5937 0.0041 15. Phyllanthus amarus Schum and Thonn. RS 4.0172 0.8649 1.0915			Leaf	1.1033	0.2036	Nd*	0.0120					
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	9.	Sida cordata (Burm.f.)Borssum	RS	3.2380	3.5907	1.2307	0.0057					
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$			Stem	0.3547	0.4010	0.6482	0.0181					
10. Cassia tora L. RS 8.1469 1.0350 3.3849 0.0052 Stem A0891 0.5121 1.0254 0.0066 Leaf 2.8976 0.1851 0.3153 0.0045 11. Pteris sp. RS 9.1432 2.0050 2.1355 0.0077 Stem 7.8965 0.66754 1.8743 0.0089 Leaf 6.8950 0.66754 0.0979 0.0075 12. Grewia tillifolia Vahl. RS 10.2671 3.064 5.1796 0.0081 13. Schleichera oleosa (Lour.) Oken RS 1.2668 1.0100 0.8265 0.0013 14. Blumea lacera (Burm.f.) D.C RS 1.2668 0.1563 0.0846 0.0105 14. Blumea lacera (Burm.f.) D.C RS 4.0172 0.1833 0.0041 0.0081 15. Phyllanthus anarus Schum and Thonn. RS 4.0172 0.8649 1.0915 0.0042 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1383 0.0000 0.00863 17.			Leaf	1.4159	0.0699	0.0678	0.0069					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	10.	Cassia tora L.	RS	8.1469	1.0350	3.3849	0.0052					
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $			Stem	4.0891	0.5121	1.0254	0.0066					
11. Pteris sp. RS 9.1432 2.0050 2.1355 0.0077 Stem 7.8965 0.9678 1.8743 0.0089 Leaf 6.8950 0.6754 0.0979 0.0075 12. Grewia tiliifolia Vahl. RS 10.2671 3.0964 5.1796 0.0081 12. Grewia tiliifolia Vahl. RS 10.2671 3.0964 5.1796 0.0081 13. Schleichera oleosa (Lour.) Oken RS 1.2668 1.0100 0.8265 0.0013 14. Blumea lacera (Burm.f.) D.C RS 3.0881 0.9150 1.5937 0.0041 15. Phyllanthus amarus Schum and Thonn. RS 4.0172 0.8649 1.0915 0.0059 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0100 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 17. Acacia auriculiformis A.Cunn.ex.Benth RS<			Leaf	2.8976	0.1851	0.3153	0.0045					
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	11.	Pteris sp.	RS	9.1432	2.0050	2.1355	0.0077					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $			Stem	7.8965	0.9678	1.8743	0.0089					
12. Grewia tiliifolia Vahl. RS 10.2671 3.0964 5.1796 0.0081 Stem 8.9012 0.3987 1.6749 Nd* 13. Schleichera oleosa (Lour.) Oken RS 1.2668 1.0100 0.8265 0.0013 13. Schleichera oleosa (Lour.) Oken RS 1.2668 1.0100 0.8265 0.0013 14. Blumea lacera (Burm.f.) D.C RS 3.0881 0.9150 1.5937 0.0041 15. Phyllanthus amarus Schum and Thonn. RS 4.0172 0.8649 1.0915 0.0063 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 <t< td=""><td></td><td></td><td>Leaf</td><td>6.8950</td><td>0.6754</td><td>0.0979</td><td>0.0075</td></t<>			Leaf	6.8950	0.6754	0.0979	0.0075					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	12.	Grewia tiliifolia Vahl.	RS	10.2671	3.0964	5.1796	0.0081					
Leaf 7.9182 0.3208 0.8951 Nd* 13. Schleichera oleosa (Lour.) Oken RS 1.2668 1.0100 0.8265 0.0013 Stem 0.2720 0.1833 0.0704 0.0086 Leaf 0.3976 0.1563 0.0846 0.0105 14. Blumea lacera (Burm.f.) D.C RS 3.0881 0.9150 1.5937 0.0041 15. Phyllanthus amarus Schum and Thonn. RS 4.0172 0.8649 1.0915 0.0042 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.2647 0.0200 0.2792 0.0048 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 <t< td=""><td></td><td></td><td>Stem</td><td>8.9012</td><td>0.3987</td><td>1.6749</td><td>Nd*</td></t<>			Stem	8.9012	0.3987	1.6749	Nd*					
13. Schleichera oleosa (Lour.) Oken RS 1.2668 1.0100 0.8265 0.0013 Stem 0.2720 0.1833 0.0704 0.0086 Leaf 0.3976 0.1563 0.0846 0.0105 14. Blumea lacera (Burm.f.) D.C RS 3.0881 0.9150 1.5937 0.0041 Stem 0.2685 0.1294 0.1526 0.0123 Leaf 0.3399 0.1186 0.2011 0.0081 15. Phyllanthus amarus Schum and Thonn. RS 4.0172 0.8649 1.0915 0.0063 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 Stem			Leaf	7.9182	0.3208	0.8951	Nd*					
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	13.	Schleichera oleosa (Lour.) Oken	RS	1.2668	1.0100	0.8265	0.0013					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $			Stem	0.2720	0.1833	0.0704	0.0086					
14. Blumea lacera (Burm.f.) D.C RS 3.0881 0.9150 1.5937 0.0041 Stem 0.2685 0.1294 0.1526 0.0123 Leaf 0.3399 0.1186 0.2011 0.0081 15. Phyllanthus amarus Schum and Thonn. RS 4.0172 0.8649 1.0915 0.0042 Stem 1.3607 0.1725 0.1939 0.0063 Leaf 1.4114 0.1132 0.2842 0.0105 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 Stem 0.1981 Nd* Nd* Nd* Nd* Nd*			Leaf	0.3976	0.1563	0.0846	0.0105					
Stem 0.2685 0.1294 0.1526 0.0123 15. Phyllanthus amarus Schum and Thom. RS 4.0172 0.8649 1.0915 0.0042 15. Phyllanthus amarus Schum and Thom. RS 4.0172 0.8649 1.0915 0.0042 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 Stem 0.1981 Nd* Nd* Nd* Nd* Nd* Nd*	14.	<i>Blumea lacera</i> (Burm.f.) D.C	RS	3.0881	0.9150	1.5937	0.0041					
Leaf 0.3399 0.1186 0.2011 0.0081 15. Phyllanthus amarus Schum and Thonn. RS 4.0172 0.8649 1.0915 0.0042 Stem 1.3607 0.1725 0.1939 0.0063 Leaf 1.4114 0.1132 0.2842 0.0105 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 18. Saccharum sp. RS 0.1981 Nd* 0.0897 Nd* RS.*-Rhizosphere soil; Nd*- Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel; Pb-L ead			Stem	0.2685	0.1294	0.1526	0.0123					
15. Phyllanthus amarus Schum and Thonn. RS 4.0172 0.8649 1.0915 0.0042 Stem 1.3607 0.1725 0.1939 0.0063 Leaf 1.4114 0.1132 0.2842 0.0105 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1665 0.1348 0.0846 0.0100 Leaf 0.1482 0.0863 0.0902 0.0088 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 Stem 0.0945 Nd* 0.5193 0.0100 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 Stem 0.1981 Nd* 0.0897 Nd* RS.*-Rhizosphere soil; Nd*-Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel; Pb-L ead			Leaf	0.3399	0.1186	0.2011	0.0081					
Stem 1.3607 0.1725 0.1939 0.0063 Leaf 1.4114 0.1132 0.2842 0.0105 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 Stem 0.1665 0.1348 0.0846 0.0100 Leaf 0.1482 0.0863 0.0902 0.0088 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 Stem 0.0945 Nd* 0.5193 0.0100 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 Stem 0.1981 Nd* 0.0897 Nd* RS.*-Rhizosphere soil; Nd*- Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel; Pb-Lead	15.	<i>Phyllanthus amarus</i> Schum and Thonn.	RS	4.0172	0.8649	1.0915	0.0042					
16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.f. RS 0.1712 0.1200 1.3224 0.0059 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 18. Saccharum sp. RS 0.1981 Nd* 0.0897 Nd* RS.*-Rhizosphere soil; Nd*- Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel; Pb-Lead			Stem	1.3607	0.1725	0.1939	0.0063					
16. Cleistanthus collinus (Roxb.)Benth.ex.Hook.I. RS 0.1712 0.1200 1.3224 0.0059 Stem 0.1665 0.1348 0.0846 0.0100 Leaf 0.1482 0.0863 0.0902 0.0088 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 Stem 0.0945 Nd* 0.5193 0.0100 Leaf 0.1059 Nd* Nd* 0.0107 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 Stem 0.1981 Nd* 0.0897 Nd* RS.*-Rhizosphere soil; Nd*- Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel; Pb-Lead	16		Leaf	1.4114	0.1132	0.2842	0.0105					
Stem 0.1665 0.1348 0.0846 0.0100 Leaf 0.1482 0.0863 0.0902 0.0088 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 Stem 0.0945 Nd* 0.5193 0.0100 Leaf 0.1059 Nd* Nd* 0.0107 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 Stem 0.1981 Nd* 0.0897 Nd* RS.*-Rhizosphere soil; Nd*- Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel; Pb-Lead	16.	Cleistanthus collinus (Roxb.)Benth.ex.Hook.f.	RS	0.1712	0.1200	1.3224	0.0059					
17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 17. Acacia auriculiformis A.Cunn.ex.Benth RS 0.8359 0.0970 0.6364 0.0074 Stem 0.0945 Nd* 0.5193 0.0100 Leaf 0.1059 Nd* Nd* 0.0107 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 Stem 0.1981 Nd* 0.0897 Nd* RS.*-Rhizosphere soil; Nd*- Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel; Pb-Lead			Stem	0.1665	0.1348	0.0846	0.0100					
17. Acacia auricaliformis A.Cum.ex.Benti KS 0.8359 0.0970 0.8564 0.0074 Stem 0.0945 Nd* 0.5193 0.0100 Leaf 0.1059 Nd* Nd* 0.0107 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 Stem 0.1981 Nd* 0.0897 Nd* RS.*-Rhizosphere soil; Nd*- Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel; Pb-Lead	17	Accord anniculiformia A Cump on Bonth	Lear	0.1482	0.0863	0.0902	0.0088					
Stem 0.0945 Nd* 0.5193 0.0100 Leaf 0.1059 Nd* Nd* 0.0107 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 Stem 0.1981 Nd* 0.0897 Nd* Leaf Nd* Nd* Nd* RS.*-Rhizosphere soil; Nd*-Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel; Pb-Lead	1/.	Acacia auricuijormis A.Cunn.ex.Benth	KS	0.0045	0.0970 N-4*	0.0304	0.0074					
Itean 0.1059 Nd* Nd* 0.0107 18. Saccharum sp. RS 0.2647 0.0200 0.2792 0.0048 Stem 0.1981 Nd* 0.0897 Nd* Leaf Nd* Nd* Nd* RS.*-Rhizosphere soil; Nd*-Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel; Pb-Lead			Stem	0.1050	INU"" NJA*	U.3193 NA*	0.0100					
RS. RS 0.2047 0.0200 0.2792 0.0048 Stem 0.1981 Nd* 0.0897 Nd* Leaf Nd* Nd* Nd* Nd* RS.*-Rhizosphere soil; Nd*-Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel; Pb-Lead	18	Saccharum sp	Leal	0.1039	1NU* 0.0200	1NU	0.0107					
Stem 0.1981 Nd* 0.0897 Nd* Leaf Nd* Nd* Nd* Nd* RS.*-Rhizosphere soil; Nd*- Not detectable; Cr-Chromium; Cd-Cadmium; Ni-Nickel: Pb-Lead	10.	<i>Succharum</i> sp.	Kð	0.2047	0.0200 NA*	0.2792	0.0048 NJ4*					
RS.*-Rhizosphere soil; Nd*- Not detectable; Cr-Chromium: Cd-Cadmium: Ni-Nickel: Ph-Lead			Stem Loof	0.1981 NA*	NU" NA*	0.0897 NA*	Nd*					
	RS.*-Rhizos	phere soil; Nd*- Not detectable:	Cr-Chromium:	Cd-C:	admium:	Ni-Nickel:	Pb-Lead					

Fable	2:	Distribution	of heavy	z metals ((in n	nm)	in leaf	. stem	and soil
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the soil was shown in Fig. 1. The resulted it was concluded that *Ailanthus excelsa* Roxb. has highest.

Conclusion

The present paper aims to evaluate plant and soil contamination with metals in and around largest mine waste area located in Sukinda of Jajpur district, Odisha. From the result, it can conclude that the indigenous plants can tolerate the mental stress and able to flourish. Hence, they can be ideally used for reclamation. Accumulation of metals varied greatly among plant species and uptake of an element by a plant is primarily dependent on the plant species, its inherent controls and the soil quality (Chunilall et al., 2005). The different plant organs show wide variations in respect of accumulation of different elements. The high concentration of an element in one particular organ does not imply that this is the best part of the plant to sample for biogeochemical prospecting. The structure of the sediment has also been considered very important that affect the extent of the metals taken up by the plants. Furthermore, studies are needed to determine the growth performance, biomass production and phytoextraction of metals of these species in metal contaminated soils for their better management, conservation and value addition. From this study, it may be concluded that the Ailanthus exile has a special ability to accumulate higher amounts of Cr but there is needs for further studies get extra information on its optimum ability to accumulate the Cr content.

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REFERENCES

Amiro, B.D. and Courtin, G.M. (1981). Patterns of vegetation in the vicinity of an industrially disturbed ecosystem, Sudbury, Ontario. *Canadian J. Botany*, **59**(9):1623-1639. DOI: 10.1139/ b81-221. **Baker, A.J.M., McGrath, S.P., Reeves, R.D. and Smith, J.A.C.** (2000). Metal hyperaccumulator plants: A review of the ecology and physiology of a biological resource for phytoremediation of metal-polluted soils. In: Phytoremediation of contaminated soil and water (Eds: N. Terry and G. Banuelos). Boca Raton, Lewis. 85-108pp.

Bech, J., Poschenrieder, C., Barcelo, J. and Lansac, A. (2002). Plants from mine spoils in the south American area as potential sources of germplasm for phytoremediation technologies. *Acta Biotech.*, **22**(1-2): 5–11.

Begum, A., Ramaiah, M., Irfanulla, K. and Veena, K. (2009). Analysis of heavy metal concentrations in soil and litchens from various localities of Hosur Road, Bangalore, India. CODEN ECJHAO, *E-J. Chem.*, **6**(1): 13-22.

Bleeker, P.M., Assunc^ao, A.G.L., Teiga, P.M., Koe, T.D. and Verkleij, J.A.C. (2002). Revegetation of the acidic, As contaminated Jales mine spoil tips using a combination of spoil amendments and tolerant grasses. *Sci. Total Environ.*, **300**(1-3): 1–13.

Businelli, D., Massaccesi L. and Onofri, L. (2009b). Evaluation of Pb and Ni mobility of groundwater in calcareous urban soils of Ancona, Italy. *Water Air Soil Pollu.*, **201** (1-4) : 185-193. DOI: 10.1007/s11270-008-9936-0 Businelli *et al.*, 2009a; 2009b;

Chunilall, V., Kindness, A. and Jonnalagadda, S.B. (2005). Heavy metal uptake by two edible Amaranthus herbs grown on soils contaminated with Lead, Mercury, Cadmium and Nickel. *J. Environ. Sci. & Health*, **40** (2): 375-384.

Cunningham, S.D. and Ow, D.W. (1996). Promises and prospects of phytoremediation. *Plant Physiol.*, **110** (3): 715-719.

De Matos, A.T., Fontes, M.P.F., da Costa, L.M. and Martinez, M.A. (2001). Mobility of heavy metals as related to soil chemical and mineralogical characteristics of brazilian soils. *Environ. Pollut.*, **111** (3) : 429-435. DOI: 10.1016/S0269-7491(00)00088-9.

Ettler, V., Kribek, B., Majer, V., Knesl, I. and Mihaljevic, M. (2012). Differences in the bioaccessibility of metals/metalloids in soils from mining and smelting areas (Copperbelt, Zambia). *J. Geochem. Explor.*, **113**:68-75. DOI: 10.1016/j.gexplo.2011.08. 001.

Ezeaku, P.I. and Davidson, A. (2008). Analytical situations of land degradation and sustainable management strategies in Africa. *J. Agric. & Social Sci.*, **4** : 42-52.

Ghosh, M. and Singh, S.P. (2005). A comparative study of cadmium phytoextraction by accumulator and weed species. *Environ Poll.*, **133** (2): 365-371.

81

Gratton, W.S., Nkongolo, K.K. and Spiers, G.A. (2000). Heavy metal accumulation in soil and jack pine (Pinus banksiana) needles in Sudbury, Ontario, *Canada. Bull. Environ. Contaminat. Toxicol.*, **64** (4) : 550-557. DOI: 10.1007/s001280000038.

Holl, K.D. (2002). Effect of shrubs on tree seedling establishment in an abandoned tropical pasture. *J. Ecol.*, **90** (1):179-187.

Juhasz, A.L., Weber, J. and Smith, E. (2011). Impact of soil particle size and bioaccessibility on children and adult lead exposure in peri-urban contaminated soils. *J. Hazard. Mater.*, **186** (2-3): 1870-1879. DOI: 10.1016/j.jhazmat.2010.12.095.

Kouame, I.K., Dibi, B., Koffi, K., Savane, I. and Sandu, I. (2010). Statistical approach of assessing horizontal mobility of heavy metals in the soil of Akouedo Landfill Nearby Ebrie Lagoon (Abidjan-Cote D'Ivoire). *Internat. J. Conserva. Sci.*, **1** (3) : 149-160.

Lazaro, J.D., Kidd, P.S. and Martinez, C.M. (2006). A phytogeochemical study of the Tra's-os-Montes region (NE Portugal): Possible species for plant - based soil remediation technologies. *Sci. the Total Environ.*, **354** (2-3) : 265-277.

Narendrula, R., Nkongolo, K. and Beckett, P. (2012). Comparative soil metal analyses in Sudbury (Ontario, Canada) and Lubumbashi (Katanga, DRCongo). *Bull. Environ. Contaminat. Toxicol.*, **88** (2): 187-192.

Narendrula, R., Nkongolo, K.K., Beckett, P. and Spiers, G. (2013). Total and bioavailable metals in two contrasting mining regions (Sudbury in Canada and Lubumbashi in DR-Congo): Relation to genetic variation in plant populations. *Chem. Ecol.*, 29 (2): 111-127. DOI: 10.1080/02757540.2012.696617.

Nkongolo, K.K., Vaillancourt, A., Dobrzeniecka, S., Mehes, M. and Beckett, P. (2008). Metal content in soil and black spruce (*Picea mariana*) trees in the Sudbury region (Ontario, Canada): Low concentration of arsenic, cadmium and nickel detected near smelter sources. *Bull. Environ. Contaminat.* *Toxicol.*, **80** (2): 107-111. DOI: 10.1007/s00128-007-9325-1.

Rao, A.V. and Tarafdar, J.C. (1998). Selection of plant species for rehabilitation of gypsum mine spoil in arid zone. *J. Arid Environ.*, **39**(4): 559–567.

Saison, C., Perrin-Ganier, C., Amellal, S., Morel, J.L. and Schiavon, M. (2004). Effect of metals on the adsorption and extractability of 14C-phenanthrene in soils, *Chemosphere*, 55 (3):477–485.

Shu, W.S., Ye, Z.H., Lan, C.Y., Zhang, Z.Q. and Wong, M.H. (2001). Acidification of lead/zinc mine tailings and its effect on heavy metal mobility. *Environ. Internat.*, **26**(5-6): 389–394.

Singh, A.N., Raghubanshi, A.S. and Singh, J.S. (2004a). Impact of native tree plantations on mine spoil in a dry tropical environment. *Forest Ecol. Mgmt.*, **187**(1): 49–60.

Suciu, I., Cosma, C., Todica, M., Bolboaca, S.D. and Jantschi, L. (2008). Analysis of soil heavy metal pollution and pattern in Central Transylvania, *Internat. J. Molecular Sci.*, **9** (4) : 434-453.

Vandeligt, K.K., Nkongolo, K.K., Mehes, M. and Beckett, P. (2011). Genetic analysis of Pinus banksiana and Pinus resinosa populations from stressed sites contaminated with metals in Northern Ontario (Canada). *Chem. Ecol.*, **27** (4) : 369-380. DOI: 10.1080/02757540.2011.561790.

Vitousek, P.M., Mooney, H.A., Lubchenco, J. and Melillo, J.M. (1997). Human domination of Earth's ecosystems: *Sci.*, 277 (5325):494–499.

Wiegleb, G. and Felinks, B. (2001). Primary succession in post-mining landscapes of Lower Lusatia—chance or necessity. *Ecological Engg.*, **17**(2): 199-217.

Wong, M.H. (2003). Ecological restoration of mine degraded soils, with emphasis on metal contaminated soils. *Chemosphere*, **50**(6): 775–780.

Zobel, C.E. (1946). *Marine microbiology. Chron. Bot.* Wathampress, Massachusetts, USA.

