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Assessment of herbaceous biomass: A study in Rowghat mining areas of Chhattisgarh, India

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Abstract: We studied Rowghat sites of Chhattisgarh, India, with the objective to assess herbaceous layer composition, biomass and to prepare management implications for conservation of ecologically sensitive species in mined areas. Ten sites (Anjrel, Khodgaon, Khadkagaon, Takrel, Rav Dongri, Tarhur, Godenmar Dongri, Parmad Dongri, Bhusujkun Dongri and Bedhiyar Nala) were selected for the study. We randomly placed quadrats of 1x1 m size in each site. A sum of 36 species distributed in 15 families were encountered in Rowghat mining site. The total density of all herbs was highest (724000) in Bhusujkun Dongri followed by Khadkagaon (678000), Rav Dongri (662000) and lowest was recorded from Godenmar Dongri (502000). The density of herbs across the study area ranged from 9,000 (*D. ciliaris*) to 2,50,000 (*S. viridis*) in the areas of Tarhur and Bediyar Nala. The herb species were unevenly distributed across mined areas. The *Chlorophytum tuberosum* and *Cassia tora* were recorded only from Tarkel and Godenmar Dongri sites, respectively. The total belowground biomass ranged between 0.097 t/ha in Godenmar Dongri to 0.18 t/ha in Rav Dongri. An ecological approach is must to restore the collieries. Protection of ecologically sensitive herbs is necessary. Prolonged ban on mining activity in Rowghat forest area is needed to restore degraded forest.

Keywords: Biomass, Herbaceous, Mined areas, Rowghat

INTRODUCTION

India having 329 million hectare land of which about 47 million hectare (14%) is degraded. The mining activity has great impact on forest species. The extent of negative impact of mining varies with time and intensity of activity. Reports are available on the prospects and environmental issues related to the North-East (N-E) collieries (Akala, 1995; Chaoji, 2002). Due to the presence of high sulphur content (2–12%), the mine overburden of the N-E collieries is highly acidic (pH 32 2.0–3.0) (Deka Boruah *et al*., 2008). Consequently, ecological succession takes even longer than 50 years (Dowarah *et al*., 2009). Several studies has been done on tree diversity in mined areas, but hardly few concentrated on herbaceous layer diversity in the mined areas (Jhariya *et al*., 2013; Kumar *et al*., 2015). Productivity of ecosystems is maintained by under storey herbaceous vegetation (Sabo *et al*., 2008).
Empharical studies state that disturbance cause negative impact; destroy climax communities and forms instability in the ecosystem (Clements, 1936). Niyogi *et al*. (2002) studied the response of ecosystems to stress in streams affected by mine and reported that plant diversity decreased with increasing stress from the mine drainage. Some researchers reported positive impacts (Paine, 1966; Huston, 1979). The disturbance may increase species diversity in the community by preventing competitive exclusion (Lubchenco, 1978). Connell (1978) reported that diversity in the rainforests was greatest in moderately disturbed areas. Though large number of studies are available on documentation of species diversity in India. But very limited information available on mining impacts cause to ecological instability (Dowarah *et al*., 2009; Bohre *et al*., 2012; Jhariya *et al*., 2013). However, the present study was undertaken to assess the impact of large scale mining on herbaceous layer composition and biomass in Rowghat forest of Chhattisgarh.

MATERIALS AND METHODS

Study site: Geographically, Chhattisgarh is divided into three distinct land areas *viz*., Chhattisgarh Plains, Bastar Plateau and Northern Hill Zones. The Bastar Plateau occupies an area of 6640 km² and cover 366 villages. The Rowghat mines contain the second largest iron ore deposits in Chhattisgarh state of India. The area of deposits is covered in Topo sheets No.-65 E/1. The study area (Fig. 1) is located between 19^0 01'20'' to 19^0 41'04'' N latitudes and 81^0 02''11' to 81^0 59''12' E longitudes. The Rowghat area is home to various floral species, including a variety of medicinal

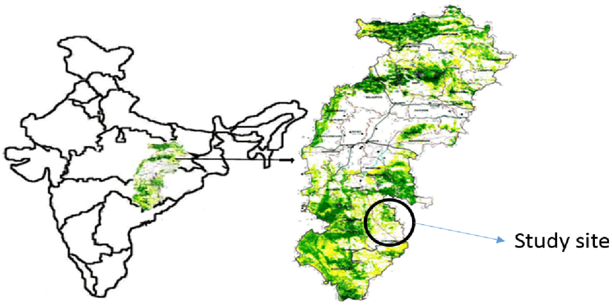

Fig.1. *Location map of the Rowghat Forest area, Chhattisgarh, India.*

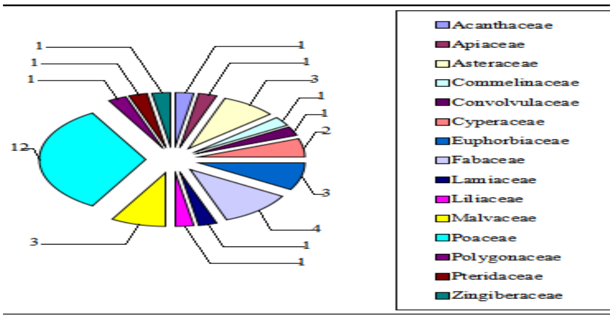

Fig.2. *Family-wise distribution of the species in Rawghat Mining areas of Chhattisgarh.*

plants. The area is also part of an important wildlife corridor that stretches from southeastern Maharashtra to northwestern Odisha. It's surrounded by several tiger reserves and forms part of the tiger's migratory route to the Eastern Ghats. The Mean annual rainfall is 1365 mm and mean temperature ranged between 25 to 38 ^{0}C. The forest in this plateau was divided in to four belts, namely, Northern Mixed forests, Central Moist Region comprising of sal belts, teak belts and Dry region cover mixed forests (Champion and Seth, 1968).

Ten mined areas of Rowghat viz., Anjrel, Khodgaon, Khadkagaon, Takrel, Rav Dongri, Tarhur, Godenmar Dongri, Parmad Dongri, Bhusujkun Dongri and Bedhiyar Nala were selected for the study. The herbaceous species were analysed by randomly laying quadrats of size 1 × 1 m. Vegetational data were quantitatively analysed for frequency, density and abundance (Curtis and McIntosh, 1950). The herbaceous above and belowground biomass was estimated by destructive sampling. The below-ground biomass was harvested from each monolith (25 cm×25 cm×30 cm) from each quadrat after the above-ground components had been sampled following Kuramoto and Bliss (1970). The aboveground and belowground herb biomass was separately carried to the laboratory in a double sealed polythene bag for fresh weight. The samples were oven dried at 70ºC to get dry weight. The herbaceous total biomass of sample plot was then extrapolated to tonnes per hectare basis.

RESULTS

Herbaceous composition: A total of 36 species representing 15 families were encountered in Rowghat mining site (Fig. 2). The most dominating family was poaceae which covered nearly one third of the total. The maximum numbers of species (15) were recorded in Bedhiyar Nala and Godenmar Dongri followed by Parmad Dongri (14), Anjrel, Bhusujkun Dongri and Tarhur (12). Least were recorded from Khodgaon and Rav Dongri (10) sites. The density of herbs across the study area ranged from 9,000 (*D. ciliaris*) to 2,50,000 (*S. viridis*) in the areas of Tarhur and Bediyar Nala (Table 1 & 2). The *C. tuberosum* and *Cassia tora* are only recorded from Tarkel and Godenmar Dongri sites respectively. *M. pudica* recorded from four sites except in Khadkogaon, Tarkel, Rav Dongri, Parmad Dongri and Bhusujkun Dongri. The total density of all herbs was highest (724000) in Bhusujkun Dongri followed by Khadkagaon (678000), Rav Dongri (662000) and lowest was recorded from Godenmar Dongri (502000). Across all sites *S. viridis* was recognized as dominant species. Abundance/Frequancy (A/F) ratio of herbs found contagious and random distribution pattern whereas regular distribution was negligible across the study sites.

The contribution of species according to the family to the total density was ranged between 5.05-51.03% being least by fabaceae and highest by poaceae for Anjrel, 3.18 (cyperaceae) -54.68% (poaceae) for Khodgaon, 3.24-75.66% for Khadkagaon, 3.48-43.79% for Takrel and 6.95-32.33% for Rav Dongri (Table 3), respectively. Whereas in Tarhur it varied from 2.50-50.09%, 1.79-68.33% for Godenmar Dongri, 2.34-70.40% for Parmad Dongri, 5.80-44.61% for Bhusujkun Dongri and 1.84-57.36% for Bedhiyar Nala, respectively (Table 4).

Biomass accumulation pattern: The aboveground biomass of herbaceous species were found highest (0.127 t/ha) from Bediyar Nala (*S. viridis.*) and lowest (0.001 t/ha) in Godenmar Dongri (*P. bicalyculata* and *Z. gibbosa*) (Table 1 & 2). However, *M. pudica*, *F. dichotoma*, *P. hordeiformis*, *P. vittata*, *P bicalyculata*, *C. procerus* recorded significantly lesser belowground biomass. The total belowground biomass was ranged between 0.097 t/ha in Godenmar Dongri to 0.180 t/ha in Rav Dongri. However, the total aboveground biomass was lowest (0.226 t/ha) from Tarhur and highest (0.408 t/ha) in Rav Dongri. The total biomass in the herbaceous species was highest in *M. indica* (0.184 t/ha) in Khadkagaon followed by *S. viridis* (0.154 t/ha) in Khodgaon site and *C. angustifolia* (0.149 t/ha) from Bhusujkun Dongri site. However, accordingly the lowest was recorded by *P*. vittata from Khodgaon, *P. bicalyculata* from Khadkagaon, *C. purpurea* from Takrel. Total biomass across the mined areas was ranged from 0.342 t/ha in Tarhur to 0.588 t/ha in Rav Dongri site. The overall average biomass of the Rowghat site was 0.288±0.093 t/ha (aboveground), 0.135±0.064 t/ha (belowground) and 0.424±0.107 t/ha (total biomass), respectively.

Table 1. Herbaceous biomass (t ha^{-1}) in different mined areas (Anjrel, Khodgaon, Khadkagaon, Takrel and Ravdongari) of Rowghat.

Species	Anjrel				Khodgaon				Khadkagaon				Takrel				Rav Dongri			
	D	AGB	BGB	Total	D	AGB	BGB	Total	D	AGB	BGB	Total	D	AGB	BGB	Total	D	AGB	BGB	Total
Ageratum conyzoides L.	33000	0.012	0.007	0.019	23000	0.008	0.005	0.014	36000	0.013	0.008	0.021	--	--	--	--	44000	0.016	0.010	0.026
Chlorophytum tuberosum (Roxb.) Baker	--	--	--	--	--	--	--	--	--	--	--	--	30000	0.029	0.028	0.056	--	--	--	--
Coriandrum Sativum L.	--	--	--	--	--	--	--	--	22000	0.026	0.008	0.034	--	--	--	--	--	--	--	--
Curcuma angustifolia Roxb.	45000	0.035	0.040	0.075	66000	0.051	0.059	0.110	--	--	--	--	47000	0.037	0.042	0.078	69000	0.054	0.062	0.115
Cyathocline purpurea Kuntze	--	--	--	--	--	--	--	--	--	--	--	--	23000	0.002	--	0.002	--	--	--	--
Cyperus procerus Rottb.	--	--	--	--	--	--	--	--	31000	0.005	0.001	0.006	--	--	--	--	--	--	--	--
Desmodium heterophyllum (Willd.)	14000	0.011	0.003	0.014	--	--	--	--	--	--	--	--	--	--	--	--	127000	0.096	0.028	0.123
Digitaria ciliaris (Retz.) Koeler	--	--	--	--	34000	0.015	0.009	0.024	--	--	--	--	--	--	--	--	--	--	--	--
Echinochloa frumentacea Link	--	--	--	--	--	--	--	--	--	--	--	--	20000	0.008	0.004	0.012	--	--	--	--
Echinochloa crus-galli (L.) Beauv	16000	0.004	0.003	0.006	--	--	--	--	42000	0.012	0.003	0.014	--	--	--	--	--	--	--	--
Eragrostis japonica (Thunb.)	--	--	--	--	--	--	--	--	--	--	--		25000	0.007	0.003	0.009	--	--	--	--
Eragrostis atropioides	--	--	--	--	--	--	--	--	41000	0.012	0.004	0.015	--	--	--	--	--	--	--	--
Eragrostis amabilis (L.) Wight & Arn. ex Nees	--	--	--	--	--	--	--	--	17000	0.006	0.003	0.009	--	--	--	--	--	--	--	--
Euphorbia heterophylla L.	--	--	--	--	--	--	--	--	--	--	--	--	232000	0.039	0.009	0.049	--	--	--	--
Chamaescye hirta (L.) Millsp	--	--	--	--	--	--	--	--	--	--	--	--	39000	0.017	0.010	0.026	--	--	--	--
Evolvulus nummularius (L.)	43000	0.012	0.003	0.015	--	--	--	--	--	--	--	--	--	--	--	--	46000	0.013	0.003	0.016
Fimbristylis dichotoma (L.) Vahl	--	--	--	--	17000	0.002	0.001	0.003	--	--	--	--	--	--	--	--	46000	0.005	0.002	0.007
Floscopa scandens Lour.	48000	0.048	0.024	0.072	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Heteropogon contortus (L.) P.Beauv.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	50000	0.010	0.004	0.014
Malva coromandelica Panz.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	18000	0.038	0.012	0.049
Microchloa indica (Lf) P.Beauv.	17000	0.010	0.009	0.018	--	--	--	--	171000	0.096	0.088	0.184	--	--	--	--	--	--	--	--
Mimosa pudica L.	13000	0.002	0.001	0.003	37000	0.006	0.002	0.008	--	--	--	--	--	--	--	--	--	--	--	--
Ocimum basilicum L.	--	--	--	--	61000	0.045	0.021	0.066	--	--	--	--	--	--	--	--	--	--	--	--
Peristrophe bicalyculata Nees	--	--	--	--	--	--	--	--	29000	0.002	0.001	0.002	--	--	--	--	--	--	--	--
Perotis hordeiformis Nees ex Hook. & Arn.	27000	0.003	0.001	0.004	24000	0.002	0.001	0.003	--	--	--	--	--	--	--	--	--	--	--	--
Phyllanthus niruri L.	31000	0.013	0.003	0.016	19000	0.008	0.002	0.010	--	--	--	--	18000	0.007	0.002	0.009	--	--	--	--
Pteris vittata L.	35000	0.003	0.001	0.004	19000	0.002	0.001	0.002	--	--	--	--	--	--	--	--	--	--	--	--
Setaria grandis Stapf	--	--	--	--	--	--	--	--	--	--	--	--	21000	0.007	0.002	0.009	--	--	--	--
Setaria homonyma (Steud.) Chiov.	--	--	--	--	--	--	--	--	67000	0.023	0.006	0.029	--	--	--	--	--	--	--	--
Setaria viridis (L.) P.Beauv.	213000	0.108	0.033	0.141	234000	0.119	0.036	0.154	175000	0.089	0.027	0.116	149000	0.075	0.023	0.098	164000	0.083	0.025	0.108
Sida cordifolia L.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	41000	0.014	0.009	0.024
Tridax procumbens L.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	57000	0.080	0.025	0.105
Waltheria indica L.	--	--	--	--	--	--	--	--	--	--	--	--	56000	0.015	0.003	0.019	--	--	--	--
Zornia gibbosa Span.	--	--	--	--	--	--	--	--	47000	0.006	0.001	0.008	--	--	--	--	--	--	--	--
Total	535000	0.260	0.127	0.387	534000	0.258	0.136	0.394	678000	0.290	0.150	0.439	660000	0.243	0.126	0.369	662000	0.408	0.180	0.588

Table 2. Herbaceous biomass (t ha^{-1}) in different mined areas (Tarhur, Godenmar Dongri, Parmad Dongri, Bhusujkun Dongri and Bedhiyar Nala) of Rowghat.

Species	Tarhur				Godenmar Dongri				Parmad Dongri				Bhusujkun Dongri				Bedhiyar Nala			
	D	AGB	BGB	Total	D	AGB	BGB	Total	D	AGB	BGB	Total	D	AGB	BGB	Total	D	AGB	BGB	Total
Ageratum conyzoides L.	--	--	--	--	11000	0.004	0.002	0.006	40000	0.015	0.009	0.024	--	--	--	--	62000	0.023	0.014	0.037
Cassia tora (L.) Roxb.	--	--	--	--	33000	0.073	0.019	0.093	--	--	--	--	--	--	--	--	--	--	--	--
Coriandrum Sativum L.	--	--	--	--	--	--	--	--	15000	0.018	0.005	0.023	--	--	--	--	--	--	--	--
Curcuma angustifolia Roxb.	49000	0.038	0.044	0.082	--	--	--	--	--	--	--	--	89000	0.069	0.080	0.149	56000	0.043	0.05	0.094
Cyathocline purpurea Kuntze	--	--	--	--	--	--	--	--	--	--	--	--	42000	0.003	0.001	0.004	--	--	--	--
Cyperus procerus Rottb.	--	--	--	--	--	--	--	--	14000	0.002	0.001	0.003	--	--	--	--	20000	0.003	0.001	0.004
Desmodium heterophyllum (Willd.)	--	--	--	--	--	--	--	--	--	--	--	--	65000	0.047	0.013	0.060	--	--	--	--
Digitaria ciliaris (Retz.) Koeler	9000	0.004	0.002	0.006	27000	0.012	0.007	0.019	--	--	--	--	--	--	--	--	9000	0.004	0.002	0.006
Echinochloa frumentacea Link	--	--	--	--	--	--	--	--	23000	0.010	0.004	0.014	18000	0.008	0.003	0.011	23000	0.010	0.004	0.014
Echinochloa crus-galli (L.) Beauv	--	--	--	--	--	--	--	--	28000	0.006	0.005	0.011	--	--	--	--	--	--	--	--
Eragrostis japonica (Thunb.)	--	--	--	--	22000	0.006	0.002	0.008	--	--	--	--	31000	0.008	0.004	0.012	29000	0.008	0.003	0.011
Eragrostis atropioides	25000	0.007	0.002	0.009	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eragrostis amabilis (L.) Wight & Arn. ex Nees (L.)	--	--	--	--	--	--	--	--	20000	0.007	0.004	0.011	--	--	--	--	18000	0.006	0.003	0.010
Euphorbia heterophylla L.	--	--	--	--	--	--	--	--	--	--	--	--	121000	0.021	0.005	0.025	--	--	--	--
Chamaescye hirta (L.) Millsp	--	--	--	--	28000	0.012	0.007	0.019	--	--	--	--	--	--	--	--	--	--	--	--
Evolvulus nummularius (L.)	36000	0.010	0.002	0.012	--	--	--	--	--	--	--	--	--	--	--	--	31000	0.009	0.002	0.011
Fimbristylis dichotoma (L.) Vahl	110000	0.012	0.006	0.018	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Floscopa scandens Lour.	--	--	--	--	10000	0.010	0.005	0.015	--	--	--	--	--	--	--	--	11000	0.011	0.005	0.017
Heteropogon contortus (L.) P.Beauv.	25000	0.005	0.002	0.007	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Malva coromandelica Panz.	--	--	--	--	--	--	--	--	28000	0.058	0.018	0.077	16000	0.033	0.010	0.044	--	--	--	--
Microchloa indica (Lf) P.Beauv.	--	--	--	--	9000	0.005	0.005	0.010	48000	0.027	0.025	0.052	--	--	--	--	--	--	--	--
Mimosa pudica L.	12000	0.002	0.001	0.003	12000	0.002	0.001	0.003	--	--	--	--	--	--	--	--	13000	0.002	0.001	0.003
Ocimum basilicum L.	--	--	--	--	9000	0.007	0.003	0.010	--	--	--	--	--	--	--	--	--	--	--	--
Peristrophe bicalyculata Nees	--	--	--	--	23000	0.001	0.000	0.002	--	--	--	--	--	--	--	--	--	--	--	--
Perotis hordeiformis Nees ex Hook. & Arn.	--	--	--	--	--	--	--	--	30000	0.003	0.001	0.004	--	--	--	--	--	--	--	--
Phyllanthus niruri L.	--	--	--	--	11000	0.004	0.001	0.006	--	--	--	--	19000	0.008	0.002	0.010	29000	0.012	0.003	0.015
Pteris vittata L.	--	--	--	--	--	--	--	--	25000	0.002	0.001	0.003	--	--	--	--	--	--	--	--
Rumex dentatus L.	14000	0.024	0.014	0.038	--	--	--	--	--	--	--	--	--	--	--	--	12000	0.021	0.012	0.033
Setaria grandis Stapf	43000	0.015	0.005	0.019	70000	0.024	0.008	0.032	--	--	--	--	54000	0.018	0.006	0.024	14000	0.005	0.002	0.006
Setaria homonyma (Steud.) Chiov.	--	--	--	--	--	--	--	--	43000	0.015	0.004	0.018	--	--	--	--	--	--	--	--
Setaria viridis (L.) P.Beauv.	179000	0.091	0.027	0.118	215000	0.109	0.033	0.142	229000	0.116	0.035	0.151	220000	0.111	0.034	0.145	250000	0.127	0.038	0.165
Sida cordifolia L.	48000	0.017	0.011	0.028	12000	0.004	0.003	0.007	--	--	--	--	21000	0.007	0.005	0.012	21000	0.007	0.005	0.012
Waltheria indica L.	--	--	--	--	--	--	--	--	41000	0.011	0.002	0.014	28000	0.008	0.002	0.009	--	--	--	--
Zornia gibbosa Span.	11000	0.002	--	0.002	10000	0.001	--	0.002	14000	0.002	--	0.002	--	--	--	--	--	--	--	--
Total	**561000**	**0.226**	**0.116**	**0.342**	**502000**	**0.275**	**0.097**	**0.371**	**598000**	**0.292**	**0.115**	**0.407**	**724000**	**0.341**	**0.163**	**0.504**	**598000**	**0.290**	**0.146**	**0.436**

D= Density/ha, AGB=Aboveground biomass, BGB=Belowground biomass.

Table 3. Family-wise distribution of species, density, relative % and contribution to the biomass (t ha^{-1}) in different mined areas of Rowghat.

Family	Anjrel	AGB	BGB	Total	Khodgaon	AGB	BGB	Total	Khadkagaon	AGB	BGB	Total	Takrel	AGB	BGB	Total	Rav Dongri	AGB	BGB	Total
Acanthaceae	--	--	--	--	--	--	--	--	1 (29000) 4.28%	0.0017	0.0003	0.002	--	--	--	--	--	--	--	--
Apiaceae	--	--	--	--	--	--	--	--	1 (22000) 3.24%	0.026	0.008	0.034	--	--	--	--	--	--	--	--
Asteraceae	1 (33000) 6.17%	0.01199	0.0075	0.019	1 (23000) 4.31%	0.008	0.005	0.014	1 (36000) 5.31%	0.013	0.008	0.021	1 (23000) 3.48%	0.0015	0.0005	0.002	2 (101000) 15.26%	0.096	0.035	0.131
Commelinaceae	1 (48000) 8.97%	0.04832	0.0237	0.072	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Convolvulaceae	1 (43000) 8.04%	0.01204	0.0027	0.015	--	--	--	--	--	--	--	--	--	--	--	--	1 (46000) 6.95%	0.013	0.003	0.016
Cyperaceae	--	--	--	--	1 (17000) 3.18%	0.002	0.001	0.003	1 (31000) 4.57%	0.005	0.001	0.006	--	--	--	--	1 (46000) 6.95%	0.005	0.002	0.007
Euphorbiaceae	1 (31000) 5.79%	0.013	0.003	0.016	1 (19000) 3.56%	0.008	0.002	0.010	--	--	--	--	3 (289000) 43.79%	0.0634	0.02064	0.084	--	--	--	--
Fabaceae	2 (27000) 5.05%	0.013	0.004	0.017	1 (37000) 6.93%	0.006	0.002	0.008	1 (47000) 6.93%	0.006	0.001	0.008	--	--	--	--	1 (127000) 19.18%	0.096	0.028	0.123
Lamiaceae	--	--	--	--	1 (61000) 11.42%	0.045	0.021	0.066	--	--	--	--	--	--	--	--	--	--	--	--
Liliaceae	--	--	--	--	--	--	--	--	--	--	--	--	1 (30000) 4.55%	0.0285	0.0279	0.056	--	--	--	--
Malvaceae	--	--	--	--	--	--	--	--	--	--	--	--	1 (56000) 8.48%	0.0153	0.0034	0.019	2 (59000) 8.91%	0.052	0.021	0.073
Poaceae	4 (273000) 51.03%	0.124	0.045	0.169	3 (292000) 54.68%	0.136	0.046	0.182	6 (513000) 75.66	0.237	0.130	0.367	4 (215000) 32.58%	0.0975	0.0319	0.129	2 (214000) 32.33%	0.093	0.029	0.123
Pteridaceae	1 (35000) 6.54%	0.003	0.001	0.004	1 (19000) 3.56%	0.002	0.001	0.002	--	--	--	--	--	--	--	--	--	--	--	--
Zingiberaceae	1 (45000) 8.41%	0.035	0.040	0.075	1 (66000) 12.36%	0.051	0.059	0.110	--	--	--	--	1 (47000) 7.12%	0.0365	0.042	0.078	1 (69000) 10.42	0.054	0.062	0.115
	12 (535000)	**0.260**	**0.127**	**0.387**	**10 (534000)**	**0.258**	**0.136**	**0.394**	**11 (678000)**	**0.290**	**0.150**	**0.439**	**11 (660000)**	**0.243**	**0.126**	**0.369**	**10 (662000)**	**0.408**	**0.180**	**0.588**

Table 4. Family-wise distribution of species, density, relative % and contribution to the biomass (t ha^{-1}) in different mined areas of Rowghat.

Family	Tarhur	AGB	BGB	Total	Godenmar Dongri	AGB	BGB	Total	Parmad Dongri	AGB	BGB	Total	Bhusujkun Dongri	AGB	BGB	Total	Bedhiyar Nala	AGB	BGB	Total
Acanthaceae	--	--	--	--	1 (23000) 4.58%	0.0014	0.0002	0.0016	--	--	--	--	--	--	--	--	--	--	--	--
Apiaceae	--	--	--	--	--	--	--	--	1 (15000) 2.51%	0.018	0.005	0.0234	--	--	--	--	--	--	--	--
Asteraceae	--	--	--	--	1 (11000) 2.19%	0.0040	0.0025	0.0065	1 (40000) 6.69%	0.015	0.009	0.0236	1 (42000) 5.80%	0.003	0.001	0.0036	1 (62000) 10.37%	0.023	0.014	0.037
Commelina-ceae	--	--	--	--	1 (10000) 1.99%	0.0101	0.0049	0.0150	--	--	--	--	--	--	--	--	1 (11000) 1.84%	0.011	0.005	0.017
Convolvu-laceae	1 (36000) 6.42%	0.010	0.002	0.012	--	--	--	--	--	--	--	--	--	--	--	--	1 (31000) 5.18%	0.009	0.002	0.011
Cyperaceae	1 (110000) 19.61%	0.012	0.005	0.018	--	--	--	--	1 (14000) 2.34%	0.0023	0.0005	0.0028	--	--	--	--	1 (20000) 3.34%	0.003	0.001	0.004
Euphorbiaceae	--	--	--	--	2 (39000) 7.77%	0.0164	0.0080	0.0244	--	--	--	--	2 (140000) 19.34%	0.0283	0.0067	0.0350	1 (29000) 4.85%	0.0118	0.003	0.015
Fabaceae	2 (23000) 4.10%	0.004	0.001	0.004	3 (55000) 10.96%	0.0769	0.0201	0.0970	1 (14000) 2.34%	0.0019	0.0004	0.0023	1 (65000) 8.98%	0.0470	0.0128	0.0598	1 (13000) 2.17%	0.002	0.001	0.003
Lamiaceae					1 (9000) 1.79%	0.0066	0.0031	0.0097	--	--	--	--	--	--	--	--	--	--	--	--
Malvaceae	1 (48000) 8.56%	0.017	0.011	0.028	1 (12000) 2.39%	0.0042	0.0027	0.0069	2 (69000) 11.54%	0.0695	0.0208	0.0903	3 (65000) 8.98%	0.0483	0.0169	0.0652	1 (21000) 3.51%	0.007	0.005	0.012
Poaceae	5 (281000) 50.09%	0.122	0.039	0.160	5 (343000) 68.33%	0.1551	0.0553	0.2104	7 (421000) 70.40%	0.1839	0.0776	0.2615	4 (323000) 44.61%	0.1454	0.0467	0.1921	6 (343000) 57.36%	0.159	0.054	0.212
Polygonaceae	1 (14000) 2.50%	0.024	0.014	0.038	--	--	--	--	--	--	--	--	--	--	--	--	1 (12000) 2.01%	0.0208	0.012	0.033
Pteridaceae	--	--	--	--	--	--	--	--	1 (25000) 4.18%	0.0023	0.0008	0.003	--	--	--	--	--	--	--	--
Zingiberaceae	1 (49000) 8.73%	0.038	0.044	0.082	--	--	--	--	--	--	--	--	1 (89000) 12.29%	0.0691	0.0795	0.1486	1 (56000) 9.36%	0.043	0.050	0.094
	12 (561000)	**0.226**	**0.116**	**0.342**	**15 (502000)**	**0.275**	**0.097**	**0.371**	**14 (598000)**	**0.292**	**0.115**	**0.407**	**12 (724000)**	**0.341**	**0.163**	**0.504**	**15 (598000)**	**0.290**	**0.146**	**0.436**

The family wise contribution to the biomass in different study sites were represented in table 3 & 4. The individually family wise total biomass varied from 0.004-0.169 t/ha for Anjrel, 0.002-0.182 t/ha for Khodgaon, 0.002-0.367 t/ha for Khadkagaon, 0.002-0.129 t/ha for Takrel, 0.007-0.131 for Rav Dongri, 0.004-0.160 t/ha for Tarhur, 0.0016-0.2104 t/ha for Godenmar Dongri, 0.0023-0.2615 t/ha for Parmad Dongri, 0.0036-0.1921 t/ha for Bhusujkun Dongri and 0.004-0.212 t/ha for Bedhiyar Nala, respectively.

DISCUSSION

Ecologically important changes: The reduced herbaceous density in Godenmar Dongri, Khodgaon and Anjrel sites presumably affected by greater mining activity. Conversely, the extent of herb regeneration and intensity of mining may directly related. Considerably greater herb density in Bhusujkun Dongri and Khadkagaon sites omits greater total herb biomass. Sometimes partial disturbances may increase the plant population (Jhariya *et al*., 2012). Therefore, mild disturbance is in accordance with the intermediate disturbance hypothesis (Connell, 1978). Mild disturbances may enhance the productivity of ecosystems by releasing chemicals and nutrients locked up in the old herbage (Kodandapani, 2001).

Herb species showed contagious and random distribution pattern in the present study. Similar findings were also reported by Jhariya *et al*. (2012); Kittur *et al*. (2014); Oraon *et al*. (2014) and Sinha *et al*. (2015). Shadangi and Nath (2005) also reported maximum species in contagious distribution pattern in the region. In natural condition contagious distribution is most common type of distribution pattern described by Odum (1971). Greater A/F ratio (1.54) in Bhusujkun Dongri presumably dominancy of one community over the other. This (A/F) measure quantifies the dominancy in a community and is consequently closely related to the “mass ratio hypothesis” (Grime, 1998; Roscher *et al*., 2012) proposing that ecosystem processes are mainly determined by the functional characters of dominant species in a community. The lower un-evenly distribution of herbs might be attributed to the effect of open cast mining. In which the sensitive species would dis-appear from the region (Bargali *et al*., 1987). Other factors shrinking herb distribution might have been biotic and abiotic factors, the true character of the forests, depending on the degree of impact (Champion and Seth, 1968).

About 67% more aboveground total biomass recorded in Rav Dongri site as compared to Tarhur. Same way about 36% belowground total biomass decreased in Parmad Dongri site compared to Rav Dongri. The decrease in aboveground and belowground biomass may attribute to grazing. The study region experienced potential grazing by domesticated cattles. Nonetheless, the repeated grazing may produce more succulent herbs and grasses; this is a potential method to increase species diversity in rangelands (Howe, 1999; Knapp *et al*., 1999), but this tool raises concerns for many conservation managers (Vavra, 2005).

Management perspectives: The Bastar Plateau of Chhattisgarh, India is ecologically rich as compared to other tropical forests of the country in terms of structure, composition and diversity. Surface mining particularly mountain-top removal, is the most severe disturbance followed by grazing, illicit felling etc. These activities are slowly decreasing stability of Rowghat ecosystem. An ecological approach to landscape management is must and should be based on knowledge of vegetation structure and composition. Protection of ecologically sensitive herbs like *F. scandens*, *E. heterophylla*, *P. hordeiformis,* etc. are ut-most important. Urgent need for eco-restoration of mined areas by the active tree planting and shelter belts. Though there are many success stories of eco-restoration around the world (Wong, 2003; Gonzalez and Gonzalez-Chavez, 2006; Mendez and Maier, 2008), and in different parts of the country (Ghose, 2004; Maiti, 2007; Juwarkar and Jumbalkar, 2008). The study suggest the introduction of herbs which have ability of rhizo-deposition of toxic elements from mined areas. Prolonged ban of mining activities in eco-sensitive areas is imperative.

Conclusion

The present study revealed substantial number of herb species and their density in different sites. The colonization of herbceous species on these degraded sites due to mining was a good sign and can be used to restore degraded ecosystems of Rowghat. The major challenges in this regions included loss of top soil, erosion, reduction of forest cover and destruction of habitats due to various interference. A comprehensive strategy, regular monitoring, appropriate regulations and applied research are indispensable to alleviate the negative effects of mining upon ecology and environment and to develop and design management options to facilitate restoration of mined out habitats.

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