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# Floristic Diversity Assessment in Ecologically Restored Limestone (Building Stone) Mine Near Chechat Village, Kota District, Rajasthan

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## ABSTRACT
A phytosociological study of ecologically restored lime stone (Building stone) mine near Chechat village, District Kota, Rajasthan has been undertaken to evaluate the impact of restorative interventions on floristic structure and composition. Chechat is located at 24.77°N 75.88°E. It has an average elevation of 333 meters (1092 feet). Mining in the present study area, Chechat Village, Kota District, Rajasthan is a major source of economy but is a major cause of ecological disturbance too due to the land degradation and related changes in the structural and functional characteristics of the native vegetation. In Chechat village only 3.6% of the total geographical area is covered under mines. This study describes the floristic composition and phytodiversity assessment of mining and restored area.

**Key words:** Phytosociological study, ecologically restored, degraded land, floristic composition, phytodiversity assessment

## INTRODUCTION
Mining and mineral processing adversely affects the ecology of the area by disturbing the land mass, the water systems and floral faunal population and in turn the quality of human life. Rajasthan is India's largest state by area (342,239 square kilometers (132,139 sq m) or 10.4% of India's total area). Several prominent chemical and engineering companies are located in the city of Kota, in southern Rajasthan. Rajasthan is pre-eminent in quarrying and mining in India. Availability and optimal utilization of its resources, mainly natural resources make the foundation of economic development of a region. The state of Rajasthan has varied ecosystems (Chouhan, 1996) and is also rich in mineral resources. Open cast mining is a major cause of ecological disturbances due to the land degradation and related changes in the structural and functional characteristics of the native vegetation. Mining causes the destruction of natural ecosystems through removal of top soil and vegetation and their burial beneath the waste disposal sites. Anthropogenic disturbances caused due to mining produces shifts in the structure/richness of the vegetation of the hitherto native species which dominated the ecosystem. Disturbance to an ecosystem means any discrete event that disrupts the ecosystem, community or population structure, or the physical environment (Pickett and White, 1985). In India, major disturbances to forest ecosystems include habitat destruction, over exploitation, environmental pollution and other anthropogenic pressure. Understanding of the effects of the disturbances on ecosystem function and

plant biodiversity of the site may play useful role in the restoration attempts through re-vegetation of native plant species.

On the vegetation aspect Majumdar (1976) has carried out an appreciable work under the title "Synoptic Flora of Kota Division" in which he has reported 700 species occurring in this region. Other researchers who have studied the vegetation of Kota division are Maheshwari and Singh (1976) etc. Ecology and vegetation of Kota and Shahabad have been studied plants) and/or persistence of native species (Jain and Kotwal, 1960; Gupta, 1965). Forests constitute an important component of the physical environment of the State. The total forest cover of the state is 15,850 $km^2$ which constitute 4.63% of the geographic area. The recorded forest area of the state is 32,639 $km^2$ which is 9.54% of the state's geographical area (ISFR, 2011). District Kota covers 11.30% forest cover of its geographical area (ISFR, 2011).

The dry tropical forests accounts for 38.2% of the total forest cover of India (MoEF, 1999) and are under constant disturbances of both the climatic and anthropogenic origin. Disturbances, mainly anthropogenic, lead to the conversion of species-rich forests into species-poor forest ecosystems. Habitat destruction is the leading cause of species extinction and biodiversity loss in natural ecosystems (Koh *et al.*, 2004; Pimm and Raven 2000). Unfortunately, studies on tropical dry deciduous forests in relation to the disturbances are much limited in India (Khera *et al.*, 2001; Puyravaud *et al.*, 1995) particularly, in context of mining in the present study area. Exhaustive knowledge of the species and ecosystem diversity and distribution is pre-requisite for identification of conservation areas (Angelstam *et al.*, 2004; Felix *et al.*, 2004). Hence, the present study focuses on the assessment of the plant diversity in and around the areas with extensive mining operations where huge quantities of mining wastes are present changing the topography and related hydrological regime of the study area.

Mining of Kota stone started in 1945 and the mining process remained manual till 1993. Ramganjmandi, Modak and Chechat are major limestone producing areas in district Kota which is the second largest producer of building stones in Rajasthan after Jodhpur district. There are extensive deposits of Vindhyan limestone in the southern part of Kota district. The flaggy limestone belonging to Suket shale of Lower Vindhyan, occurs near village Suket, Chechat areas and tehsil Ramganjmandi of Kota district. These are famous with the popular trade name as "Kota stone". There are enormous flaggy limestone (Kota stone) deposits with an estimated production of 1.62 million tons in 1999-2000. There are a total of 63 stone mines, 6 large, 37 medium (lease area more than 5 hectares or above) and 20 small (lease area less than 5 hectares) in district Kota. Chechat is a Village in Khairabad Tehsil in Kota District of Rajasthan State, India. It belongs to Kota division.

On the basis of physical relief, out of five sub regions of Hadoti region, Northern part of Ramganjmandi and Chechat comes under Mukundwara hills area and southern part of Ramganjmandi comes under Jhalawar plateau. The physiography and climate of south-eastern part of Rajasthan favors mixed-miscellaneous forest type of vegetation. The forests of this region are under the category of Tropical Dry and Mixed Deciduous Forests which are degraded form of mixed-miscellaneous forests. Forest areas in study area come under Morak range which covers12 forest zones and cover an area of 63219.5 hectares under the Forest division Kota. Out of these 12 forest zones, 6 zones are covered under the present study site. The region experiences the humid type or monsoonal type of climatic conditions. Soil of study area is characterized by two types of soil. The southern part is dominated by moderately deep, well drained fine soils on very gently sloping plains with clayey surface, slightly eroded, associated with shallow, well drained, clayey soil, slightly eroded and the northern part is characterized by the rock out crops associated with shallow, well drained, loamy skeletal soils on very gently sloping foot slopes, severely eroded.

## METHODOLOGY

**Phytosociological analysis:** The study was aimed at enumeration of the available plant resources and obtaining a broad representation of the existing floristic variations in the mine lease area and surrounding mine Buffer areas. Enumeration of the plant wealth was done by surveying the area through walking followed by identification of plant specimens. Phyto-sociological aspects of the study were carried out by perambulating and sampling through quadrates method. Sample plots were selected in such a way to get maximum representation of different types of vegetation and plots were laid out in different parts of the areas within the mine area as well as the surrounding mine area (Buffer zone). Selection of sites for vegetation data was done by random sampling procedure.

Ecological study of the vegetation includes the investigation of species composition and the sociological interactions of the species in communities (Muller-Dombois and Ellenberg, 1974). It lays emphasis on study of species association, development, geographic distribution and environmental relationships of plant communities. Their interactions among different plants and between plants and their environment result in the outcome of different vegetation types in different areas. The quantitative relationship between rare and profusely growing species is an important structural property of a community.

Nested quadrates techniques were used for the sampling of the vegetation. The size and number of quadrates needed were determined using the species area curve (Mishra, 1968) and the running mean method (Kershaw, 1973). Summarization of previously used methods and recommendations led to the use of more than ten (10×10 m) quadrates have been laid out for sampling the tree stratum and 1×1 m quadrates for herbs, grasses and seedlings of tree species. The shrub species and saplings were sampled by using 3×3 m sample plots or quadrates. The enumeration of the vegetation in each of the quadrate was done by measuring dbh individually in case of woody vegetation and collar diameter in case of herbs and grasses, with the help of tree caliper and electronic digital caliper. In case of grasses and sedges, each erect shoot is considered to a plant tiller and the enumeration was done by lying 1×1 m quadrates at random, further subdivided into 10×10 cm segments. Four such segments selected at random were analyzed from each quadrate by counting the tillers individually as per the method used was that of Singh and Yadava (1974).

The vegetation data were quantitatively analyzed for density, frequency and abundance following the methods of Curtis and McIntosh (1950). The relative values of frequency, density and dominance were determined as per Philips (1959). These values were summed up to represent IVI (Importance Value Index) of individual species (Curtis, 1959).

Formulae used for various calculations are:

$$\text{Density} = \frac{\text{Total no. of individuals of a species in all the quadrats}}{\text{Total no. of quadrats studied}}$$

$$\text{Frequency (\%)} = \frac{\text{Total no. of quadrats in which species occurred}}{\text{Total no. of quadrats studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total no. of individuals of a species in all quadrats}}{\text{Total no. of quadrats in which species occurred}}$$

$$\text{Mean basal area} = \frac{C^2}{4\pi} \text{ (C = Mean of the circumference)}$$

$$\text{Total basal area} = \text{Mean basal area} \times \text{Density}$$

$$\text{Mean of the circumference (C)} = \frac{\text{Sum of all cbh of a species}}{\text{Total no. of individuals of a species}}$$

$$\text{Relative density} = \frac{\text{Density of a species}}{\text{Total density of all species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Total basal cover of a species}}{\text{Total basal cover of all species}} \times 100$$

Importance Value Index (IVI) = Relative density + Relative frequency + Relative dominance

## RESULT

**Mine lease area:** There are no vegetation occur under mine lease area as shown in Fig. 1.

**Surrounding mine lease area (buffer zone):** Vegetation parameters of woody species, shrubs and herbs encountered in the buffer zone are provided in Table 1-3. The density of tree species

Fig. 1: A General view of mine lease area

Table 1: Tree species of surrounding mine lease area

| Name | Occ | No | ABA | TBA | Density/100 m$^2$ | Freq. | RDo | RD | RF | IVI |
|---|---|---|---|---|---|---|---|---|---|---|
| *Acacia arabica* | 7 | 19 | 3646.31 | 10045.46 | 1.27 | 0.47 | 11.29 | 10.86 | 10.00 | 32.15 |
| *Acacia catechu* | 7 | 20 | 3509.40 | 10431.30 | 1.33 | 0.47 | 11.73 | 11.43 | 10.00 | 33.16 |
| *Adina cordifolia* | 3 | 6 | 1657.62 | 3315.24 | 0.40 | 0.20 | 3.73 | 3.43 | 4.29 | 11.44 |
| *Aegle marmelos* | 4 | 5 | 1806.30 | 2419.70 | 0.33 | 0.27 | 2.72 | 2.86 | 5.71 | 11.29 |
| *Azadirecta indica* | 6 | 10 | 3210.75 | 5030.11 | 0.67 | 0.40 | 5.66 | 5.71 | 8.57 | 19.94 |
| *Butea frondosa* | 11 | 26 | 5465.67 | 13385.53 | 1.73 | 0.73 | 15.05 | 14.86 | 15.71 | 45.62 |
| *Cordia mixa* | 3 | 4 | 1657.62 | 2252.44 | 0.27 | 0.20 | 2.53 | 2.29 | 4.29 | 9.10 |
| *Dendrocalamus strictus* | 3 | 41 | 1520.71 | 19709.34 | 2.73 | 0.20 | 22.16 | 23.43 | 4.29 | 49.87 |
| *Ficus benghalensis* | 4 | 5 | 1988.69 | 2456.67 | 0.33 | 0.27 | 2.76 | 2.86 | 5.71 | 11.33 |
| *Ficus religiosa* | 6 | 6 | 3190.54 | 3190.54 | 0.40 | 0.40 | 3.59 | 3.43 | 8.57 | 15.59 |
| *Mangifera indica* | 4 | 7 | 2177.68 | 3861.35 | 0.47 | 0.27 | 4.34 | 4.00 | 5.71 | 14.06 |
| *Phoenix dactylifera* | 7 | 19 | 3507.78 | 9296.51 | 1.27 | 0.47 | 10.45 | 10.86 | 10.00 | 31.31 |
| *Pongamia glabra* | 3 | 4 | 1431.78 | 2045.18 | 0.27 | 0.20 | 2.30 | 2.29 | 4.29 | 8.87 |
| *Tectona grandis* | 2 | 3 | 915.30 | 1510.12 | 0.20 | 0.13 | 1.70 | 1.71 | 2.86 | 6.27 |
| Grand total | 70 | 175 | 35686.13 | 88949.48 | 11.67 | 4.67 | 100.00 | 100.00 | 100.00 | 300.00 |

Table 2: Shrub species of surrounding mine lease area

| Name | Occ | No | ABA | TBA | Density/9 m$^2$ | Freq. | RDo | RD | RF | IVI |
|---|---|---|---|---|---|---|---|---|---|---|
| *Acacia arabica* | 4 | 9 | 1988.69 | 4604.62 | 0.60 | 0.27 | 6.92 | 7.20 | 8.89 | 23.01 |
| *Acacia catechu* | 3 | 4 | 1520.71 | 2147.95 | 0.27 | 0.20 | 3.23 | 3.20 | 6.67 | 13.09 |
| *Butea frondosa* | 4 | 6 | 2317.28 | 3412.50 | 0.40 | 0.27 | 5.13 | 4.80 | 8.89 | 18.81 |
| *Calotropis procera* | 7 | 18 | 3509.40 | 9007.48 | 1.20 | 0.47 | 13.53 | 14.40 | 15.56 | 43.49 |
| *Ipomea cornea* | 4 | 18 | 2284.86 | 10042.98 | 1.20 | 0.27 | 15.09 | 14.40 | 8.89 | 38.37 |
| *Phoenix dactylifera* | 7 | 16 | 3837.99 | 8601.87 | 1.07 | 0.47 | 12.92 | 12.80 | 15.56 | 41.28 |
| *Prosopis juliflora* | 4 | 23 | 1956.27 | 11946.96 | 1.53 | 0.27 | 17.95 | 18.40 | 8.89 | 45.23 |
| *Ricinus cummunis* | 4 | 16 | 2147.95 | 8920.40 | 1.07 | 0.27 | 13.40 | 12.80 | 8.89 | 35.09 |
| *Zizyphus mauritiana* | 4 | 6 | 2317.28 | 3380.08 | 0.40 | 0.27 | 5.08 | 4.80 | 8.89 | 18.77 |
| *Zizyphus nummularia* | 4 | 9 | 1956.27 | 4507.36 | 0.60 | 0.27 | 6.77 | 7.20 | 8.89 | 22.86 |
| Grand total | 45 | 125 | 23836.70 | 66572.20 | 8.33 | 3.00 | 100.00 | 100.00 | 100.00 | 300.00 |

varied from 0.20 individuals 100 m$^{-2}$ to 2.73 individuals 100 m$^{-2}$. Highest density was shown by *Dandrocalamus strictus* (2.73 individuals 100 m$^{-2}$) followed by Butea frondosa (1.73 individuals 100 m$^{-2}$).

The number of shrubs and tree saplings together from surrounding mine lease area was ten species. The surrounding mine lease area was dominated by *Prosopis juliflora* with highest density of 1.53 individuals 9 m$^{-2}$. The density values (Individuals 9 m$^{-2}$) for different species of shrubs varied from 0.27 to 1.53 individuals 9 m$^{-2}$ (Table 2). *Prosopis juliflora* recorded the highest IVI value (45.23). This particular shrub has very good capacity for regeneration under drought climate.

Herbaceous vegetation accounted for 33 species including tree seedlings in the surrounding mine lease area. The stand density in the case of herbaceous species was 41.11 stems m$^{-2}$ (Table 3) and this stratum was dominated by *Cynodon dactylon* (11.17 individuals m$^{-2}$) and *Tridex procumbens* (6.22 individuals m$^{-2}$).

Dominance and ecological success of a species is expressed as a single value in terms of Importance Value Index (IVI). This index utilizes three parameters viz., relative frequency, relative density and relative dominance or basal area. In case of shrubs and herbs, only two former parameters are taken into consideration. High IVI values of a species indicate its high regeneration

Table 3: Herb species of surrounding mine lease area

| Name | OCC | No. | ABA | TBA | Density/m² | Freq. | RDo | RD | RF | IVI |
|---|---|---|---|---|---|---|---|---|---|---|
| *Achyranthus aspera* | 16 | 40 | 102.10 | 254.66 | 2.22 | 0.89 | 13.94 | 5.41 | 9.14 | 28.48 |
| *Ageratum conyzoides* | 3 | 16 | 21.89 | 117.04 | 0.89 | 0.17 | 6.40 | 2.16 | 1.71 | 10.28 |
| *Alternanthera sessilis* | 1 | 3 | 3.33 | 10.00 | 0.17 | 0.06 | 0.55 | 0.41 | 0.57 | 1.52 |
| *Argemone mexicana* | 4 | 5 | 22.18 | 28.78 | 0.28 | 0.22 | 1.58 | 0.68 | 2.29 | 4.54 |
| *Bidens pilosa* | 2 | 4 | 6.87 | 13.16 | 0.22 | 0.11 | 0.72 | 0.54 | 1.14 | 2.40 |
| *Calendula officinalis* | 1 | 7 | 0.85 | 5.95 | 0.39 | 0.06 | 0.33 | 0.95 | 0.57 | 1.84 |
| *Calotropis procera* | 6 | 8 | 21.24 | 28.96 | 0.44 | 0.33 | 1.58 | 1.08 | 3.43 | 6.09 |
| *Cenchrus cilliaris* | 1 | 9 | 0.65 | 5.85 | 0.50 | 0.06 | 0.32 | 1.22 | 0.57 | 2.11 |
| *Commelina benghalensis* | 7 | 15 | 35.29 | 74.12 | 0.83 | 0.39 | 4.06 | 2.03 | 4.00 | 10.08 |
| *Cynodon dactylon* | 18 | 201 | 16.42 | 183.33 | 11.17 | 1.00 | 10.03 | 27.16 | 10.29 | 47.48 |
| *Eleusine indica* | 13 | 63 | 13.44 | 64.65 | 3.50 | 0.72 | 3.54 | 8.51 | 7.43 | 19.48 |
| *Eragrostis tenella* | 4 | 19 | 0.41 | 1.94 | 1.06 | 0.22 | 0.11 | 2.57 | 2.29 | 4.96 |
| *Euphorbia hirta* | 3 | 13 | 5.17 | 21.27 | 0.72 | 0.17 | 1.16 | 1.76 | 1.71 | 4.64 |
| *Evolvulus alsinoides* | 3 | 16 | 5.83 | 27.78 | 0.89 | 0.17 | 1.52 | 2.16 | 1.71 | 5.40 |
| *Evolvulus nummularis* | 1 | 1 | 1.54 | 1.54 | 0.06 | 0.06 | 0.08 | 0.14 | 0.57 | 0.79 |
| *Gulancha tinospora* | 1 | 1 | 1.09 | 1.09 | 0.06 | 0.06 | 0.06 | 0.14 | 0.57 | 0.77 |
| *Ocimum canum* | 12 | 16 | 39.20 | 53.30 | 0.89 | 0.67 | 2.92 | 2.16 | 6.86 | 11.94 |
| *Paspalidium flavidum* | 1 | 3 | 0.85 | 2.55 | 0.17 | 0.06 | 0.14 | 0.41 | 0.57 | 1.12 |
| *Paspalum distichum* | 8 | 57 | 7.16 | 51.03 | 3.17 | 0.44 | 2.79 | 7.70 | 4.57 | 15.07 |
| *Paspalum scrobiculatum* | 1 | 4 | 0.92 | 3.66 | 0.22 | 0.06 | 0.20 | 0.54 | 0.57 | 1.31 |
| *Phyllanthus niruri* | 6 | 23 | 2.43 | 9.21 | 1.28 | 0.33 | 0.50 | 3.11 | 3.43 | 7.04 |
| *Polygonum barbatum* | 7 | 14 | 84.51 | 169.01 | 0.78 | 0.39 | 9.25 | 1.89 | 4.00 | 15.14 |
| *Prosopis juliflora* | 1 | 1 | 3.73 | 3.73 | 0.06 | 0.06 | 0.20 | 0.14 | 0.57 | 0.91 |
| *Ricinus communis* | 2 | 3 | 12.22 | 17.88 | 0.17 | 0.11 | 0.98 | 0.41 | 1.14 | 2.53 |
| *Sida acuta* | 2 | 4 | 13.08 | 26.16 | 0.22 | 0.11 | 1.43 | 0.54 | 1.14 | 3.12 |
| *Solanum vivarum* | 7 | 9 | 51.48 | 63.91 | 0.50 | 0.39 | 3.50 | 1.22 | 4.00 | 8.71 |
| *Tribulus terrestris* | 11 | 27 | 52.13 | 127.55 | 1.50 | 0.61 | 6.98 | 3.65 | 6.29 | 16.91 |
| *Tridex procumbens* | 16 | 112 | 45.21 | 310.93 | 6.22 | 0.89 | 17.01 | 15.14 | 9.14 | 41.29 |
| *Triumfetta rhomboidea* | 12 | 40 | 38.22 | 126.20 | 2.22 | 0.67 | 6.91 | 5.41 | 6.86 | 19.17 |
| *Withania somnifera* | 1 | 1 | 3.73 | 3.73 | 0.06 | 0.06 | 0.20 | 0.14 | 0.57 | 0.91 |
| *Xanthium indicum* | 1 | 2 | 3.33 | 6.67 | 0.11 | 0.06 | 0.36 | 0.27 | 0.57 | 1.21 |
| *Zizyphus nummularia* | 1 | 1 | 6.42 | 6.42 | 0.06 | 0.06 | 0.35 | 0.14 | 0.57 | 1.06 |
| *Zizyphus oenoplia* | 2 | 2 | 5.30 | 5.30 | 0.11 | 0.11 | 0.29 | 0.27 | 1.14 | 1.70 |
| Grand total | 175 | 740 | 628.22 | 1827.37 | 41.11 | 9.72 | 100.00 | 100.00 | 100.00 | 300.00 |

capacity and greater ecological amplitude. Among trees species, *Dandrocalamus strictus* showed highest IVI (49.87) followed by *Butea frondosa* (45.62). Among shrubs, highest IVI was recorded as 45.23 by *Prosopis juliflora* and 43.49 by *Calotropis procera*. On the basis of IVI highly regenerating species in the study site among trees and shrubs were *Dandrocalamus strictus*, *Prosopis julifora* and *Butea frondosa*.

**Plantation in surrounding mine lease area:** Vegetation parameters of woody species, shrubs and herbs encountered in the plantation zone are provided in Table 4. The density of tree species varied from 0.29 individuals 100 $m^{-2}$ to 0.57 individuals 100 $m^{-2}$. Highest density was shown by *Dalbergia sissoo* and *Ricinus cummunis* (0.57 individuals 100 $m^{-2}$).

The number of shrubs and tree saplings together from surrounding mine lease area was six species. The plantation in mine lease area was dominated by *Psidium guajava* with highest density

Table 4: Tree species of plantation surrounding mine lease area

| Name | Occ | No | ABA | TBA | Density/100 m² | Freq. | RDo | RD | RF | IVI |
|---|---|---|---|---|---|---|---|---|---|---|
| *Butea frondosa* | 1 | 2 | 99.40 | 198.80 | 0.29 | 0.14 | 9.98 | 12.50 | 12.50 | 34.98 |
| *Dalbergia sissoo* | 2 | 4 | 269.56 | 539.13 | 0.57 | 0.29 | 27.06 | 25.00 | 25.00 | 77.06 |
| *Delonix regia* | 2 | 3 | 291.10 | 423.83 | 0.43 | 0.29 | 21.27 | 18.75 | 25.00 | 65.02 |
| *Eucalyptus camaldulensis* | 1 | 2 | 237.79 | 475.57 | 0.29 | 0.14 | 23.87 | 12.50 | 12.50 | 48.87 |
| *Ricnus indica* | 1 | 4 | 54.54 | 218.17 | 0.57 | 0.14 | 10.95 | 25.00 | 12.50 | 48.45 |
| *Toona ciliata* | 1 | 1 | 136.85 | 136.85 | 0.14 | 0.14 | 6.87 | 6.25 | 12.50 | 25.62 |
| Grand total | 8 | 16 | 1089.24 | 1992.35 | 2.29 | 1.14 | 100.00 | 100.00 | 100.00 | 300.00 |
| Name | Occ | No | ABA | TBA | Density/9 m² | Freq. | RDo | RD | RF | IVI |
| *Azadirecta indica* | 1 | 1 | 26.42 | 26.42 | 0.14 | 0.14 | 5.50 | 4.35 | 10.00 | 19.84 |
| *Calotropis procera* | 1 | 2 | 6.61 | 13.21 | 0.29 | 0.14 | 2.75 | 8.70 | 10.00 | 21.44 |
| *Delonix regia* | 1 | 2 | 23.76 | 47.52 | 0.29 | 0.14 | 9.88 | 8.70 | 10.00 | 28.58 |
| *Pongamia glabra* | 1 | 2 | 23.76 | 47.52 | 0.29 | 0.14 | 9.88 | 8.70 | 10.00 | 28.58 |
| *Psidium guajava* | 4 | 9 | 86.06 | 198.24 | 1.29 | 0.57 | 41.24 | 39.13 | 40.00 | 120.37 |
| *Ricnus cummunis* | 2 | 7 | 41.35 | 147.82 | 1.00 | 0.29 | 30.75 | 30.43 | 20.00 | 81.18 |
| Grand total | 10 | 23 | 207.96 | 480.73 | 3.29 | 1.43 | 100.00 | 100.00 | 100.00 | 300.00 |
| Name | Occ | No | ABA | TBA | Density/m² | Freq. | RDo | RD | RF | IVI |
| *Argemone mexicana* | 5 | 10 | 30.37 | 61.94 | 1.43 | 0.71 | 4.23 | 4.27 | 8.06 | 16.56 |
| *Bothriochloa macra* | 5 | 26 | 32.03 | 162.57 | 3.71 | 0.71 | 11.09 | 11.11 | 8.06 | 30.26 |
| *Cassia tora* | 2 | 5 | 10.40 | 27.35 | 0.71 | 0.29 | 1.87 | 2.14 | 3.23 | 7.23 |
| *Commelina benghalensis* | 2 | 4 | 15.01 | 30.02 | 0.57 | 0.29 | 2.05 | 1.71 | 3.23 | 6.98 |
| *Cynodon dactylon* | 6 | 70 | 35.86 | 413.74 | 10.00 | 0.86 | 28.22 | 29.91 | 9.68 | 67.81 |
| *Eleusine indica* | 2 | 6 | 14.33 | 44.19 | 0.86 | 0.29 | 3.01 | 2.56 | 3.23 | 8.80 |
| *Euphorbia hirta* | 6 | 18 | 39.27 | 118.10 | 2.57 | 0.86 | 8.06 | 7.69 | 9.68 | 25.43 |
| *Evolvulus alsinoides* | 1 | 6 | 3.84 | 23.02 | 0.86 | 0.14 | 1.57 | 2.56 | 1.61 | 5.75 |
| *Oxalis corniculata* | 5 | 24 | 36.06 | 171.67 | 3.43 | 0.71 | 11.71 | 10.26 | 8.06 | 30.03 |
| *Parthenium hysterophorus* | 6 | 17 | 35.71 | 95.81 | 2.43 | 0.86 | 6.54 | 7.26 | 9.68 | 23.48 |
| *Paspalum scrobiculatum* | 1 | 7 | 7.24 | 50.70 | 1.00 | 0.14 | 3.46 | 2.99 | 1.61 | 8.06 |
| *Phyllanthus nirurrii* | 1 | 2 | 7.24 | 14.48 | 0.29 | 0.14 | 0.99 | 0.85 | 1.61 | 3.46 |
| *Polygonum glabrum* | 4 | 11 | 24.78 | 68.39 | 1.57 | 0.57 | 4.67 | 4.70 | 6.45 | 15.82 |
| *Solanum viarum* | 3 | 4 | 18.16 | 25.93 | 0.57 | 0.43 | 1.77 | 1.71 | 4.84 | 8.32 |
| *Tridex procumbens* | 6 | 14 | 39.27 | 90.74 | 2.00 | 0.86 | 6.19 | 5.98 | 9.68 | 21.85 |
| *Triumfetta rhomboidea* | 1 | 1 | 3.84 | 3.84 | 0.14 | 0.14 | 0.26 | 0.43 | 1.61 | 2.30 |
| *Xanthium indicum* | 2 | 3 | 14.33 | 22.10 | 0.43 | 0.29 | 1.51 | 1.28 | 3.23 | 6.02 |
| *Zizyphus nummularia* | 4 | 6 | 27.97 | 41.46 | 0.86 | 0.57 | 2.83 | 2.56 | 6.45 | 11.84 |
| Grand total | 62 | 234 | 395.70 | 1466.06 | 33.43 | 8.86 | 100.00 | 100.00 | 100.00 | 300.00 |

of 1.29 individuals 9 $m^{-2}$. The density values (Individuals 9 $m^{-2}$) for different species of shrubs varied from 0.14 to 1.29 individuals 9 $m^{-2}$ (Table 4). *Psidium guajava* recorded the highest IVI value (120.37). This particular shrub has very good capacity for regeneration under drought climate.

Herbaceous vegetation accounted for 18 species including tree seedlings in the plantation in mine lease area. The stand density in the case of herbaceous species was 33.43 stems $m^{-2}$ (Table 4) and this stratum was dominated by *Cynodon dactylon* (10.00 individuals $m^{-2}$) and *Bothrichola macra* (3.71 individuals $m^{-2}$).

Dominance and ecological success of a species is expressed as a single value in terms of Importance Value Index (IVI). This index utilizes three parameters viz., relative frequency, relative density and relative dominance or basal area. In case of shrubs and herbs, only two former parameters are taken into consideration. High IVI values of a species indicate its high regeneration capacity and greater ecological amplitude. Among trees species, *Dalbergia sissoo* showed highest IVI (77.06) followed by *Delonix regia* (65.02). Among shrubs, highest IVI was recorded as 120.37 by *Psidium guajava* and 81.18 by *Ricinus cummunis*. On the basis of IVI highly regenerating species in the study site among trees and shrubs were *Dalbergia sissoo, Psidium guajava* and *Ricinnus cummunis*.

## DISCUSSION AND CONCLUSION

The phytosociological study is imperative to understand the structure and function of a particular vegetation community. The structure and distribution of trees, shrubs and other ground flora are very sensitive to change within a short span of time and the major factors influencing these changes are bio-edaphic including two factors that influenced growth performance of species in forestland, which are edaphic factors (Soil texture, moisture content, bulk density, particle density, organic matter and nutrient content) and climatic factors (Hassan *et al.*, 2007). These factors exert strong influences on plant development which in turn improve the micro-habitat by regulating the community structure and ecosystem functioning (Soni *et al.*, 1994).

Importance Value Index (IVI) is a device to rank species in a community and often used to elucidate features of the community (Lamont *et al.*, 1977). Natural invasion of trees into revegetated sites can be affected by the types of plant species already growing in the site as well as by resource availability. The establishment of tree plantations in degraded areas may facilitate regeneration of native species that could not otherwise establish in open micro-sites or in competition by herbaceous species (Rajdeep *et al.*, 2011). This increase in biodiversity is of great importance due to the functional role, especially of soil fauna, for soil properties and self regulation potential of intensive forest ecosystems. Gibson *et al.* (1985) reported that natural re-vegetation by trees was a complex process controlled primarily by dispersal mechanisms of the tree species.

Primary impacts of mineral exploration are the removal of vegetation and disturbance of the ground in the immediate vicinity of the principal activities. Excavation of the substrate materials and dumping of the mine-spoils also alter the soil profile, hydrology, topography and nutrient status of the substrate. These secondary factors have the potential to result in deleterious effects on the local biodiversity. The change in vegetation affects the rates of C and N cycling, ecosystem productivity, microbial community and structure and soil functional processes; thus, causing the change in whole status of the biodiversity. At the landscape level, environmental impacts occur generally in the form of alteration of the land-form features and fragmentation of the biological habitats that may cause isolation of populations of floral and faunal species. Generally, plant species with high tolerance of such disturbances are at a competitive advantage during initial colonization and subsequent establishment. There is, therefore, a great need to protect or conserve remnants of primary forests and late succession species in such tracts of vegetation. Natural succession on the degraded lands due to mining is the most suitable process of restoration. Thus to accelerate the process of natural succession, species to be used in restoration projects should be chosen from among the local vegetation. The success of bio-restoration of the degraded landscapes for environmental protection may be built on the recruitment of native components of biodiversity for re-vegetation.

In terms of the restoration planning, the analysis of natural regeneration processes represents a valuable starting point for the selection of suitable species to be used. There is need to conserve the floristic diversity of the remnant patches of the vegetation-stands because these vegetation-stands play important role in colonization after the disturbance. There is tremendous scope to develop the disturbed sites, in and around mining areas, as range lands through silvi-pastoral land use approach in an attempt to restore the native vegetation. Selected plant species can be introduced inappropriately prepared mine spoils or degraded soils in suitable climatic conditions to get established easily in such areas. Silvi-pastoral approach is the best means of restoration because it may involve human systems approach as well by fulfilling the requirement of fuel and fodder of local inhabitants.

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