Journal of Tropical Forestry
Jan.-June, 2007 Vol. 23 (I&II)

VEGETAL PROFILE OF NATURAL PLANT SUCCESSION AND ARTIFICIALLY RE-VEGETATED LIMESTONE MINES OF HIMACHAL PRADESH, INDIA .

Syed Mubashir Hanief, Shalu Devi Thakur and B.Gupta
Dr. Y. S .Parmar University of Horticulture & Forestry,
Nauni, Solan, H.P-173230

ABSTRACT Studies carried out in Sal forest of Sirmaur district in Himachal Pradesh revealed that the artificially reclaimed sites develop much faster in terms of soil and vegetation as compared to abandoned mines. The community developed on artificially reclaimed site was altogether different from the naturally occurring one but the naturally reclaimed site was approaching slowly towards the climax species

Key Words: *IVI, Density, Climax, Succession*

INTRODUCTION

The Himalaya is a repository of varied variety of commercially viable and economically important minerals. There has been continuous pressure from industrial sector of the country for extraction of these minerals and the same has flourished at the expense of ecology of the region. Mining invariably includes deforestation, removal of fertile topsoil, topographical alterations, siltation of water bodies, changes in the socio-economic status of the local inhabitants. Mining of these minerals in the Himalayas is important but one need to develop strategies with clear concept of sustainable development where technological advancements need to be related with eco-friendly concepts.

In all 101 limestone mines have been leased out in district Sirmaur, which has converted about 6415.25 ha of fertile land to poor quality land (Kapoor *et al.* 2005). In the state of Himachal Pradesh, the area leased out for limestone mining is 19.10 Km^2. To rehabilitate such degraded mined area is a great challenge to the ecologists, foresters, mine owners and engineers as well. The best approach to stabilization is to provide a protective vegetal cover to dump the surface through vegetation. The establishment of vegetal permanent cover of vegetation not only involves growing plants. It necessitates bringing into being a plant community that will maintain itself indefinitely without attention or artificial aid, which in turn will support native vegetation. Morever, the overburden is deficient in physical, chemical and biological properties of soil as compared to normal soils (Dhadwal *et al*, 1991). Not much of the work has been carried out in the country to curb this ecological menace, the strategy for which of course varies from the nature and type of mining.

The present study was undertaken in limestone mines of Himachal Pradesh where only few efforts are visible to rehabilitate the mined sites through plantations, otherwise these areas are abandoned after mining for natural succession to take its own course for its recuperation. The study aims at to ascertain the best possible way to revegetate degraded limestone mined sites.

MATERIAL AND METHODS

The study was carried out in Sirmaur district of Himachal Pradesh which lies in its south-eastern part between 77°1'12" and 77°49'40" east longitudes and 30°22'30" and 31°1'20" north latitudes. Total area of the district is 2825 sq. km. *Limestone mines are the* prominent type of mines in the area. Moist Shiwalik Sal forests cover large area and thus were considered for study. Vegetal cover of Sal forest was studied in undisturbed forest, 6 years old abandoned mined site and 13 years old artificially reclaimed mined site located at an altitude of 780-840m above mean sea level.

Vegetational analysis in forest area / abandoned mine / reclaimed area was done by laying out sample plots of 0.1 ha in each area. In each sample plot vegetation analysis was done from quadrats of 10 x 10 m^2, 5 x 5 m^2 and 1 x 1 m^2 replicated thrice, five times and ten times respectively for trees, shrubs and herbs. Following Phillips (1959), important value index (IVI) was calculated for trees, shrubs and herbaceous vegetation in each sample plot. Seprate composite soil samples were taken from 0-20 cm and 20-40 cm depth in each area studied. Following standard procedures the soil samples were analysed.

RESULTS AND DISCUSSION

(A) Vegetational studies: Under Moist Shiwalik Sal forest three sites viz. (a) Undisturbed Sal forest (b) 6 years old abandoned mine site and (c) Reclaimed mine site (13 years old) revealed the following:

Undisturbed Sal forest comprised of 3 trees, 8 shrubs and 8 herbs. 1165 trees/ha were recorded in this forest with their basal area as 7902.45 x 10^2 cm^2/ha. S. *robusta* accounted for 88.66 per cent (1033 trees/ha) and 87.22 percent (6892.49 x 10^2 cm^2/ha) of the total density of and basal area of trees respectively. Thus, it was the dominant tree species. Among shrubs, highest density (248.00 x 10^2 stems/ha) and basal area (1321.68 x 10^2 cm^2/ha) was recorded for *Eupatorium reveesii* followed by *Boehmeria platyphylla* (125.32 x 10^2 stems/ha) and *Adhatoda vasica* (70.68 x 10^2 stems/ha). Lowest density was recorded for *Randia tetrasperma* (8.00 x 10^2 stems/ha) whereas, lowest basal area was recorded for *Carissa spinarium* (51.92 x 10 cm /ha). *Eupatorium reveesii* was the dominant shrub species with IVI as (119.12). Only one grass species *(Oplismenus compositus)* was recorded on this site, which showed highest values of density (3900.00 x 10^2 ind./ha.), basal area (361.00 x 10^2 cm^2/ha) and IVI (104.36) among different herbs. Rest of the herbaceous species recorded were forbs whose density ranged from 250.00 x 10^2 ind./ha to 850.00 x 10^2 ind./ha and basal area ranged from 14.00 x cm^2/ha to 263.00 x10cm^2/ha (Table 1).

In abandoned mined site (6 years old) adjacent to the undisturbed Sal forest in the limestone mined area one tree, 2 shrubs and 4 herbs were recorded.

Wendlandia exserta, the only tree recorded in this site exhibited stunted growth with average height of 2-3 ft. The density of this species was 200 trees/ha and basal area as 9.76 x 10^2 cm^2/ha. *Eupatorium reveesii* dominated the shrubs as it accounted for 80.09 per cent (148.00 x 10^2) ind/ha of the total population (168.00 x 10^2 ind/ha) of shrubs. Like wise, 64.90 per cent (311.56 x 10^2 cm^2/ha) of the total basal area (480.00 x 10^2 cm^2/ha) of shrubs was represented by this species. The presence of the *W. exserta* on the abandoned site is an indication of progressive succession as this tree often grows with Sal in shady places (Working plan, Forest working circle Nahan, H.P., 1976-1986). Clements (1916) contended that given indefinite time without disturbances to the community or the site, the plant communities in a given climatic region would approach to same composition and structure. If this hypothesis is followed then invasion of *Wendlandia exserta* on the abandoned site is an indication that *Shorea* *robusta,* which is climax species, is likely to invade the site with passage of time.

Among herbaceous vegetation, grasses exhibited higher population of individuals compared to forbs in the total density (1232.00 x10^2 ind/ha). The forb, *Scutellaria grossa* exhibited highest density (384.00 x 10^2 ind/ha) among different herbs. Lowest density (44.00 x 10^2 ind/ha) was represented by *Rumex hastatus.* Forbs accounted for 74.85 per cent (99.40 x 10^2 cm^2/ha) of the total basal area (132.80 x 10^2 cm^2/ha) of herbs.R. *hastatus* achieved the highest (75.76 x 10^2 cm^2/ha) basal area whereas, the lowest basal area (7.00 x 10^2 *cm^2/ha)* was reported for *Chrysopogon montanus.* IVI values indicated that *R. hastatus* (82.84) and *S. grossa* (71.19) were the dominant species (Table 2).

The dominance of vegetation by *R,. hastatus* and *E. reveesii* can be related to their massive root system makes them to survive under water and nutrient stresses which are the characteristic features of colonizers (Dwivedi, 1992). *Eupàtorium odoratum* is a nurse crop for Sal natural regeneration in its early stages of development in Kamrup and Goalpara divisions in Assam (De, 1941). The low The percentage of density and the basal aera of E. reveesii in the sal forest compared to abandoned site can be accounted for overhead shade created by the Sal trees. *Eupatorium* spp. is a light demander (Papiya and Ramakrishnan, 2002, Mogali, 1981). This species can be called as pioneer species in this area as being present in the mine spoils of active mine zone.

The reclaimed site, where *S. robusta* existed prior to mining, revealed occurrence of 5 trees, 8 shrubs and 8 herbs. Among trees, highest density (8.00 x 10^2 ind/ha), and basal area (363.20 x10^2 cm^2/ha) was recorded for *Dalbergia sissoo,* whereas, lowest density (0.3 3 x10^2 ind/ha) and basal area was recorded for *Pyrus pashia* (2.31 x 10^2 cm^2a). Comparison of the IVI values of different trees indicated that Dalbergia *sissoo* (99.39) and *W. exserta* (91.17) were the dominant species. *E. reveesii* represented 70.57 per cent (1205.72 x 10^2 stems/ha) of the total density of shrubs (1708.52 x 10^2 ind/ha) followed by *Lantana camara* (468.00 x 10^2 stems/ha). Highest basal area was recorded for *L. camara* (3512.16 x $10^2$$cm^2$ ha) as against total basal area of shrubs (6324.12 x $10^2$$cm^2$/ha). Lowest density (2.28 x 10^2 stems/ha) and basal area (14.92 x 10^2 cm^2/ha) was recorded for *Murraya koenigii.* IVI values of shrubs indicated that *E. reveesii* (136.83) and *L. camara* (110.19) were the dominant and co-dominant species respectively. Forbs exhibited higher population of individuals and basal area compared to grasses. *Fjmbristylis rigidula* exhibited highest density (10633.00 x 10^2 ind/ha) and basal area (829.00 x 10^2 cm^2/ha) among herbaceous vegetation. The density of the three grasses, *Saccharum spontaneum, Arundinella nepalensis* and *Digitaria stricta,* recorded on this site was comparatively low with their respective densities as 2600.00 x 10^2 ind/ha; 1367.00 x 10^2 ind/ha and 1267.00 x 10^2 ind/ha. Least density among herbs was recorded for *Viola serpens* and *Pilea scripta* as (350.00 x 10^2ind/ha) whereas, the lowest basal area was recorded for *D. stricta* (22.00 x 10^2 cm^2/ha). IVI value of the herbs indicated that *F. rigidula* wa the dominant species with IVI value of 112.: whereas, *S. spontaneum* and *Diclipt bupleuroides* were the co-dominant spec (Table 3).

The other way to speed up t revegetation process in mined areas is to a artificial plantations to curtail time-gap i revegetating the area. In the reclaimed site fou trees *(Acacia catechu, D. sisso, W. exserta and Leuceana leucocephala)*, five shrubs *(E. reveesii, L. camara, Woodfordia fruiticosa, Adhatoda vasica, Dodonea viscosa)* and three herbs *(S. spontaneum, F. rigidula, and A. nepalensis)* were planted. These species are commonly used for the reclamation and stabilization of the mined areas. Soni *et al*, (1986) planted *Acacia catechu, W. exserta, D. sissoo, W. furiticosa, A. vasica, L. camara, S. spontaneum* and various other species for the reclamation of mine spoils in Doon valley (Maldeota).

The species diversity of the reclaimed site was higher as compared to naturally growing Sal forest. This may be due to the plantation of diverse species in the reclaimed site. Moreover, in plantations the competition from abiotic variables especially light is not as critical as in fully developed Sal forest, which hampers growth and development of understory vegetation. Soni *et al*, (1989) in their study recorded that diversity of plants increase significantly after 4 years of reclamation and is even higher than adjoining natural areas. In the present study, plant diversity as well as basal area and density of vegetation in the reclaimed site were high compared to abandoned site. This can be accounted for the management practices employed and improvement in the soil properties over the time. Verma *et al*, (2004) reported that diversity of the ground flora was higher under the plantations compared to those in exposed mine overburden area.

(B) Soil characteristics

Soil separates of reclaimed site (13 years old) in Moist Shiwalik Sal forest zone showed that proportion of sand increased from 47.37 per cent to 62.45 per cent in 0-20 cm soil depth, but silt and clay decreased from 35.50 per cent to 26.06 per cent and 17.13 percent respectivily (Table 4). In the lower depth of soil (20 - 40 cm) similar trend was observed (Table 4).

The bulk density of soil (0-20 cm) in mine free site was 1.18 Mgm^{-3}, whereas, the bulk density of the reclaimed site was 1.53 Mgm^{-3} (Table 5). Bulk density showed similar trend in the lower soil depth (20-40 cm) where it increased from 1.20 Mgm^{-3} to 1.73 Mgm^{-3} in reclaimed site. At respective soil depths, pH and electric conductivity (E.C) of the soil in the mine free site were lower whereas, organic carbon, nitrogen, phosphorus and potassium were higher compared to reclaimed site.

The reason for higher sand content and lower clay content in the reclaimed site can be attributed to mining as it exposes the lower soil horizons which are coarser in nature and the mine spoil is a mixture of rock fragment, and sub- soil particles. Accumulation of organic matter due to broad-leaved species and its simultaneous decomposition over the years is another reason for reduced sand content in the mine free zone. Soni *et al* 1989 also reported that mining increase the sand percent and decreases the clay percent in soil. The increase in bulk density of the soil in reclaimed site can be attributed to high percentage of sand and less organic matter in the soils compared to mine free area. Mine spoils have higher bulk density and coarse fragment, lower porosity, clay content and water holding capacity than reference soils (Masoodi, 1999).

The increased pH and E.C of the soil in the reclaimed site gives an indication that it has high quantities of salts and exchangeable bases, which will reach to that of normal soils if the present conditions persist with our disturbances. Soni *et al* (1989) analyzed the chemical characteristics of mine soil at Maldeota and found that pH and E.C of the mine soil was higher than the soils of undisturbed adjacent forest. The loss of vegetation cover and topsoil layer on account of mining is the cause of depletion of the nutrients and organic carbon in the reclaimed site. Similar work done by Panwar (1999) at Solan, also revealed that mining leads to depletion of nutrient contents and organic matter.

CONCLUSION:

From the above discussion it can be concluded that revegetation process in abandoned mined site under Shiwalik Sal forest is showing progressive succession, though it is difficult to predict with certainty the time it will take to restore original flora. Artificial regeneration of mines through plantations is better way to re-green them in short tenure, but the type of plant community established is altogether different from the otherwise long term natural succession process. Soil properties of the mined sites will approximate to the natural soils of the area with the passage of time as the revegetation process will progress. However, the improvement in soil texture and nutrients is faster in reclaimed mines as compared to abandoned mines.

Table 1: Species composition of Sal forest in limestone mine area of district Sirmaur (H.P.)

Species	Density (no./ha) x 10^2	Basal area (cm^2/ha) x 10^2	Freq	IVI
Phoenix acaulis (Roxb.)	0.66	989.36	0.33	38.19
Pyruspashia (Buch.-Ham.)	0.66	20.60	0.33	25.93
Shorea robusta (Gaertn.f.)	10.33	6892.49	1.00	235.88
Total	**11.65**	**7902.45**		
Adhatoda vasica (Nees.)	70.68	216.84	0.66	35.77
Boehmeria platyphylla (Don.)	125.32	217.36	0.66	45.73
Carissa spinarium (Linn.)	29.32	51.92	0.66	21.68
Eupatorium reveesii (Wall.)	248.00	1321.68	1.00	119.12
Lantana camara (Linn.)	37.32	130.32	0.33	19.14
Maesa chisia (Buch.-Ham.ex D.Don)	14.68	365.80	0.33	24.37
Murraya koewgii (Spreng)	16.00	157.04	0.66	23.44
Randia tetrasperma (Roxb.)	8.00	54.00	0.33	10.75
Total	**549.32**	**2514.96**		
Opiismenus compositus (Linn.)	3900.00	361.00	0.66	104.36
Ariseama spp.	617.00	263.00	0.33	43.23
Bidens pillosa (Linn.)	533.00	23.00	0.50	22.27
Blepharis maderaspatensis (Roth.)	300.00	16.00	0.33	14.20
Dicliptera bupleuroides (Nees.)	750.00	127.00	0.50	35.57
Oxalis comiculata (Linn.)	250.00	14.00	0.33	13.35
Curculigo orchioides (Gaert.)	517.00	63.00	0.66	30.45
Carex setigera (D.Don.)	850.00	124.00	0.50	36.57
Total	**7717.00**	**991.00**		

Table 2: Species composition of abandoned limestone mine site (6 years) in Sal forest of district Sirmaur (H.P.)

Species	Density (no./ha) x 10^2	Basal area (cm^2/ha) x 10^2	Freq	IVI
Wendlandia exserta (D.C.)	2.00	9.76	0.50	
Boehmeria platyphylla (Don.)	20.00	168.44	0.50	80.01
Eupatorium reveesii (Wall.)	148.00	311.56	1.00	219.99
Total	**168.00**	**480.00**		
Chrysopogon montanus (Trin.)	154.00	7.00	0.50	28.89
Heteropogon contortus (Linn)	310.00	13.28	1.00	57.38
Capillipediwnheugelln (Hack.)	340.00	13.12	1.00	59.70
Rumex hastatus (Don.)	44.00	75.76	1.00	82.84
Scutellaria grossa (Wall.)	384.00	23.64	1.00	71.19
Total	**1232.00**	**132.80**		

Table 3: Species composition of reclaimed limestone mined (13 years old) in Sal forest of district Sirmaur (H.P.)

Species	Density (no./ha) x 10^2	Basal area (cm^2/ha) x 10^2	Freq	IVI
Acacia catechu (Willd.)	3.33	263.33	0.66	57.00
Dalbergia sissoo (Roxb.)	8.00	363.20	1.00	99.39
Leuceana leucpcephala(Lam deWit)	4.67	109.97	0.33	40.78
Pyrus pashia (Buch-Ham)	0.33	2.31	0.33	11.66
Wendlandia exserta (D C.)	6.67	337.60	1.00	91.17
Total	**23.00**	**1049.41**		
Adhatoda vasica (Nees.)	4.00	23.12	0.14	5.13
Berberis lycium (Royle.)	4.56	15.76	0.14	5.06
Carissa spinarium (Linn.)	4.56	28.44	0.14	5.26
Dodonea viscosa (L. Jacq.)	10.84	262.52	0.28	13.88
Eupatorium reveesii (Wall)	1205.72	2178.76	1.00	136.33
Lantana camara (Linn.)	468.00	3512.16	0.86	110.19
Murraya koenigii (Spreng.)	2.28	14.92	0.28	9.49
Woodfordiafruiticosa (L. Kurz)	8.56	288.44	0.28	14.16
Total	**1708.52**	**6324.12**		
Arvndinella nepalensis (Trin.)	1367.00	72.00	3.63	25.11
Digitaria stricta (Roth.)	1267.00	22.00	1.11	22.11
Saccharum spontanevm (Linn.)	2600.00	342.00	12.33	39.56
Dicliptera bupleuroides (Nees.)	3883.00	297.00	14.96	48.38
Fimbristylis rigidula (Nees.)	10633.00	829.00	41.76	112.20
Fragaria vesca (linn.)	633.00	40.00	2.01	15.01
Pilea scripta (Wedd.)	350.00	250.00	12.60	24.27
Viola serpens (Wall.)	350.00	133.00	6.70	13.36
Total	**21083.00**	**1985.00**		

Table 4: Soil separates (%) in mine free zone and reclaimed sites under Moist Shiwalik Sal forest of district Sirmaur (H.P)

Soil separates	Mine free zone		Reclaimed site	
	0-20 cm	20-40 cm	0-20 cm	20-40 cm
Sand	47.37	55.38	62.45	73.15
Silt	35.50	25.52	26.06	17.04
Clay	17.13	18.90	11.49	09.81

Table 5: Soil properties at different depths in mine free zone and reclaimed sites under Moist Shiwalik Sal forest of Sirmaur district (H.P.)

Soil separates	Mine free zone		Reclaimed site	
	0-20 cm	20-40 cm	0-20 cm	20-40 cm
Bulk density (Mgm-^{3})	1.18	1.20	1.53	1.73
pH	6.21	6.36	8.52	8.66
E.C.(dsm-1)	0.109	0.130	0.128	0.143
O.C.(%)	1.22	0.95	0.86	0.69
Nitrogen (kg/ha)	352.72	338.80	196.80	168.30
Phosphorus (kg/ha)	42.22	34.12	32.46	26.60
Potassium (kg/ha)	276.40	296.80	178.35	190.40

REFERENCES:

Clements, F.E. 1916. Plant succession : an analysis of the development of vegetation. Carneg Institute of Washington Publication.

De, R.N. 1941. Sal regeneration de novo. *Indian Forester.* 67: 283-292.

Dhadwal, K.S., Singh, B., Kavita, V.S. and Diwedi V K. 1991. Characteristics of limestone mined lands. A review. *Indian Journal of Soil Conservation.* 19:12-26

Dwivedi, A.P. 1992. Principles and practices of Indian Silviculture. Surya Publication: Dehradun. 189-204 p.

Kapoor, K.S, Verma, R.K and Vaneet Jishtu. 2005. Performance of different t.ee species in limestone mine spoil. *Annals of Forestry.* Vol (XIII): 1. 79-81

Masoodi, T.H. and Soni, P. 1999. Physical properties of limestone mine restored for forest land use. *Indian Journal of Forestry.* 22: 30-36.

Mogali, S.G. and Hosmani, M.M. 1981. A noxious weed of the plantation crops- *Eupatorium.* Annual Conference of Indian Society of Weed Science.

Panwar Pankaj. 1999. Vegetational survey of mined areas afforestration techniques for their rehabilitation. M.Sc. Thesis. Department of Silviculture and Agro forestry. Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). 94 p.

Pappiya Ramanujam and Ramakrishan, P.S. 2002. Comparative studies on germination behaviour and seedling establishment of *Eupatorium* L., species. *My Forest.* 38(2): 191-200.

Phillips, E. A. 1959. Methods of vegetation study. Henry Holt Company.

Soni, P., Varistha, H.B., and Om Kumar.1986. Regeneration of an abandoned limestone mine in Mussorie hills. *Advances in Forestry Research in India.* 11: 25-38.

Soni, P., Vasistha, H.B. and Om Kumar. 1989. Surface mining its role on site quality. *Indian Journal of Forestry.* 12(3): 233-235.

Verma, R. K., Kapoor, K. S., Subramani, S. P. and Rawat, R. S. 2004. Evaluation of plant diversity and soil quality under plantations raised in surface mined areas. *Indian Journal of Forestry.* 27(2): 227-233.