A STEP TOWARDS RECLAIMING SILICA MINING SITE AT ALLAHABAD DISTRICT, UTTAR PRADESH, INDIA[1]

Kumud Dubey[2]*, V.K. Singh, and K. P. Dubey

Abstract. Mining is a vital sector of economy all over the world. Since mining and quarrying of mineral ores lead to conflicts between the ideals of economic prosperity and landscape preservation, a scientific mining approach accompanied by reclamation of these mined wastelands is needed. The present study is an effort of reclaiming a silica mine site. As a prelude step, ecologically compatible, economically viable and stress tolerant species were identified through vegetation and socio-economic survey of adjacent locality of mining area. For reclamation, two plantation trials were established under natural rainfall condition. Since the soil of selected site has low moisture content and site suffers from high temperature during most of the year, the first plantation trial was established for studying the effect of different mulches on the growth performance and survival of planted species. Mulch of wheat straw, rice husk and dry leaves of *Butea monosperma* were used for the study. Species planted were: *Pongamia pinnata, Prosopis juliflora, Acacia nilotica, Albizia procera, Azadirachta indica, Madhuca iindica* and *Pithecellobium dulce.* It was found that *P. juliflora, P. dulce, A. indica* and *P. pinnata* performed well and in most of the cases wheat straw mulching was performed better than other treatments. The second plantation trial was established for studying the relative suitability of different tree species for reclamation of silica mining area. Species planted were: *Prosopis juliflora, Acacia catechu, Pithecellobium dulce, Zizyphus maurtiana, Emblica officianalis, Butea monosperma, Carissa carandus, Ficus religiosa, Dendrocalamus strictus, P. pinnata* and *Dalbergia sissoo.* It was found that *P. juliflora, P.dulce, P.pinnata and Z.maurtiana* were doing well in such condition. It can be concluded that species like *P.juliflora, P.dulce, and P.pinnata* can be used to reclaim such area and the use of crop residue mulch is an important strategy in reclamation. It is helpful in moisture conservation and for soil health both through stimulation of micro biota beneficial to plant nutrient uptake and through addition of organic matter to soil after its decomposition.

Additional Key Words: reclamation, silica mining, mulch, moisture conservation, socio-economic survey, and vegetation study.

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[2]Kumud Dubey, Scientist, Centre for Social Forestry and Eco-Rehabilitation.337-Ashok Nagar, Allahabad-211001. India; V.K. Singh, Conservator of Forest, Centre for Social Forestry and Eco-Rehabilitation.337-Ashok Nagar, Allahabad-211001. India. Presently posted at Dharmshala, Himachal Pradesh, India; K.P. Dubey, Divisional Forest Officer, Allahabad Forest Division, Minto Park Allahabad, U.P. India

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Introduction

Mining is essentially a destructive developmental activity, where ecology suffers at the alter of economy. Unfortunately, in most regions of the earth, the underground geological resources are superimposed by biological resources i.e. forests. Hence mining operations necessarily involve deforestation, habitat destruction, biodiversity erosion and destruction of geological records, which contain information about past biodiversity. Extraction and the processing of ores and minerals also lead to widespread environmental pollution (Saxena and Chatterji, 1988a, 1988b).

However, mankind cannot afford to give up the underground geological resources that are the basic raw materials for development. An unspoiled nature can provide ecological security to people but cannot bring economic prosperity. A scientific mining operation accompanied by ecological restoration and reclamation of mined wastelands and judicious use of geological resources, with search for eco-friendly substitutes and alternatives may provide the answer. In India an area of 683,671 ha is under mining leases (Chatterji, 1988, 1992). From the literature it follows that serious and sincere reclamation measures based on scientific research findings have not been taken in most of the mining areas. An important mine of Silica, a major mineral used in glass industry, is situated in Vindhyan Hills of Allahabad District, Uttar Pradesh ,India and its extensive quarrying and open cast mining have resulted into long barren, unproductive and deeply irregular sloppy lands. But no measures pertaining to rehabilitation of silica-mined area of Uttar Pradesh have been reported. Thus the development of suitable technological package for reclamation of silica mined areas through a systematic research programme becomes imperative to counter environmental hazards and to restore the ecological balance. The present study is a prelude towards reclaiming this degraded site.

Material and Methods

Site selected for the study was located at Shankargarh, Allahabad District of Uttar Pradesh state, India and situated in the catchment's area of river Tons between an altitude of 350' to 550' (Singh, 1971). The area is hilly and rocky and rich in silica. The forest is dry deciduous type and highly degraded due to open cast silica mining and other biotic interferences. Overburden in the area is not uniform and varies from place to place. Mining areas include 46 villages covering an area of about 150 sq. Km. For reclaiming this mining area, proper selection of the native species that will adapt with the climatic and local soil condition is a critical step. As first step towards reclamation, a study was conducted with an aim to screen important forestry species of local value. For this a socio-economic survey was conducted in nearby villages of silica mining area to study the social structure of the villagers, existing resources of the villages and species preferred by the local people. The study was carried out by questionnaire-based interviews. The Questionnaire was containing the questions seeking the information regarding personal characteristics, their awareness about forest and forestry related issues, their dependency on forest, choice of species and existing agro-forestry systems. Total two hundred people were interviewed. The respondents were selected so as to comprise all strata of people - economic, social and educational and all age classes. Adequate representation of ladies was also considered to avoid gender bias. Vegetation surveys was conducted at undisturbed silica mining site and compartments of nearby forest using standard quadrate method during peak growth season in October .The quadrates of 10 m x 10 m were laid randomly for tree species. Nested quadrates of

5 m x 5 m for shrubs and 1 m x 1 m for grasses and herbs were taken up inside tree quadrates. Ten replications were taken. On the basis of socio-economic and vegetation studies, potential tree species for reclamation were identified. Two plantation trials were established under the reclamation program. Since the soil of the selected site has low moisture content and it suffers from the high temperature during most of the period of the year, a plantation trial is established to study the effect of different mulches on growth performance and survival of planted species under natural rainfall condition. To conserve moisture of the soil, four treatments of mulches were tried for studying their effect on growth performance and survival of planted species. The mulch treatments were: mulch of wheat straw, mulch of rice husk, mulch of dry leaves of *Butea monosperma* and control (without mulch). These mulches are locally available. The species planted at reclamation site were *Pongamia pinnata, Prosopis juliflora, Acacia nilotica, Albizia procera, Azadirachta indica, Madhuca indica* and *Pithecellobium dulce*. These species were selected on the basis of choice of the local people as studied during socio economic survey and ecological condition of the site. The plantation trial was established in Split Plot (factorial) Design under rain fed conditions with spacing of 2m x 2m. The mulches of wheat straw were procured from the local villagers. Plenty of rice husks were easily available in the vicinity of rice mills. Since it does not have any other utility of economic importance at time it poses serious problem for its disposal due to its bulkiness. *Butea monosperma* trees are abundantly present in the area; collected leaves were dried and coarsely powdered for the purpose. The mulches used were applied in the quantity of 2 kg per plant every year after rainy season. The Control treatment was without mulch. The growth attributes viz. height, girth and survival percentage were recorded annually.

The second plantation trial was aimed for studying the relative suitability of different tree species for reclamation of silica mining area of Shankargarh, Allahabad. The plantation trial was established in Randomized Block Design under rain fed condition with spacing of 2m x 2m. The species planted were *Prosopis juliflora, Acacia catechu, Pithecellobium dulce, Zizyphus maurtiana, Emblica officianalis, Butea monosperma, Carissa carandus, Ficus religiosa, Dendrocalamus strictus, Pongamia pinnata* and *Dalbergia sissoo.* The factors like vegetation of the area, choice of the local people, the characteristics of the soil and their suitability to the site conditions were considered in species selection. Growth attributes viz. height, girth and survival percentage were recorded annually.

Results and Discussion

The socio-economic profile of the local people was obtained from the questionnaire based socio- economic survey. The most of the local people are tribals known as Kole. Literacy level was very poor and almost all females were illiterate. Most of the children (5-12yrs.) were school going. The main occupation was mine laborer in silica mines. Monthly income (Approx.) of most of the respondents was Rs.1000-1500/family. Economic strata of people lie in one class only, as all are under very poor group. The community land and surrounding area are stony and rocky. Thus, there is no possibility of agriculture or any existing agro forestry system. Agriculture land holding is completely absent to the people. The source of fuel wood was basically dry branches of *Butea monosperma, Pithecellobium dulce, Acacia nilotica* and *Prosopis Juliflora* etc. species from local forest and cow-dung cake. Average requirement of fuel wood was about 1.5qtl/month/family. The main livestock was cows and goats. Due to unavailability of agriculture products, the fodder source for livestock was wild grasses, leaves of

Zizuphus sps. *Acacia* sps, Azadirechta indica, *Carissa. carndus,* etc. from nearby forest. Mango and Bamboo were the major species used for timber. Fruits of *Emblica officinalis, Carissa carandus* and *Zizyphus mauritiana* are consumed by local people. Requirement of fodder and fuel were two most important considerations among the respondents. So the species meeting these two requirements were preferred by most of the people. The species like *Emblica officinalis, Carissa carandus,Acacia* sps., *Prosopis juliflora , Mangifera indica, Madhuca indica, Zizyphus mauritiana, Pithocilobium dulce ,Azadirechta indica,* Bamboo,and *Psidium guajawa* were the major choice of local people. As far as vegetation of the area was concerned, the major tree species of the area were *Zizuphus mauritiana, Emblica officinalis, Butea. monosperma, Acacia* sps., *Prosopis juliflora and Pithecellobium dulce.*. Among shrub species, *Blepharis repens, Crotalaria anagyroides, Hemidesmus indicus* and *Dendrocalamus. strictus* were the major species. Among herbs and grasses, *Evolvulus nummularious, Euphorbia hirtas, Hetropogon contortus, Euphorbia hirta* and *Indigofera cordifolia* were the predominating species. The selection of planting species was based on the bases of choice of the local people, local vegetation and their suitability to the site conditions.

The growth data viz. height, girth and survival percentage of the plantation trial for studying the effect of different mulches on growth performance and survival of planted species under natural rain condition are given in Table 1 and Table 2 respectively**.** Analysis of variance (ANOVA) was carried out to detect the significance and data (height, collar circumference and survival) was found significant at 5% level of significance. For *Pongamia pinnata, Prosopis juliflora and Azadirachta indica*, growth performance (height and collar circumference) was found best in case of the wheat straw mulch. Similarly, in *Albizia procera and Acacia nilotica* height was found best with wheat straw treatment followed by other mulches as compared to control. In *Albizia procera*, the collar circumference was best with mulch of *B. monosperma* leaves. Where as in *Acacia nilotica* collar circumference was best with rice husk mulching. Growth performance of *Madhuca indica* was best with mulch of *B. monosperma* leaves. In *Pithecellobium dulce,* the height wise performance was best with mulch of rice husk where as, in case of collar circumference mulch of B. *monosperma* leaves has shown better results over other treatments. Except *A. nilotica*, all species has shown the best survival with wheat straw mulch treatment. However the mulching is not very effective in case of survival of *Prosopis juliflora and Pithecellobium dulce.* In A. *nilotica,* the best survival was obtained with mulch of *B. monosperma* leaves.

The height, girth and survival percentage of the planted tree species for the second plantation trial are given in Table 3. The growth data were statistically analyzed through ANOVA and found significant at 5% level of significance. As far as survival percentage is concerned, after three years of the plantation the survival of *Prosopis juliflora* was found best i.e. 87%. The survival percentage of *Pithecellobium dulce* and *Acacia catechu* was also better in comparison to the other species. As far as growth is concerned, the increment both in height and girth, after three years of plantation, is the best in case of *Prosopis juliflora*. After analyzing the overall growth and survival percentage of planted species, it was found that out of the eleven species planted, *Prosopis juliflora*, *Pithecellobium dulce*, *Zizyphus maurtiana*, *Dalbergia sissoo* and *Acacia catechu* performed well on the reclamation site.

It is well known fact that environment, ecology ands development must be balanced to meet the needs of the society. In the interest of sustainable development it would be necessary to take measures to preserve, conserve and nurture the fragile and critical ecosystem (Khoshoo T.N.,

1991). This needs a participatory approach and without involving the local people it is very difficult to reclaim a site. In the above case, the selected site, Shankargarh, is a backward area despite the rich mineral resources that it has and despite the revenues that the state gets from mining. Illiteracy was high. The majority of the landless laborers were tribals, and, therefore at the bottom of the social heap. Their choice of the species was taken in consideration for the reclamation program. Local vegetation was also taken in account.

Use of crop residue mulch is an important strategy to reclaim a degraded land (Panwar et. al., 2000; Singh and Singh, 1999; Mishra et al., 1996; Munir et al., 1998). It reduces evaporation, controls weeds and reduces excessive heating (Bhattacharya and Mitra, 2000; Rahman and Khan, 2001; Sharma et. al., 2001; Kumar Dinesh et al., 2003). Its application may also increase soil health both through stimulation of micro biota beneficial to plant nutrient uptake and through addition of organic matter to soil after its decomposition. It also helps in the proliferation of root system which is essential for speedy establishment of plantation and imparting tolerance against droughts and famines. It may be concluded that the moisture holding capacity of the soil has been increased after application of various mulches, thus, better growth results could be achieved in dry area of silica mining site. It is suggested that as wheat straw and *Butea* leaves are easily available in the area, their application can be utilized further for plantation of these species as well as for other plantation trials.

So from the result of the above reclamation study, subsequent monitoring, survival, and growth analysis shows that the species like *Prosopis juliflora, Pithecellobium dulce, Zizyphus maurtiana* can be planted to reclaim such sites and mulch can be applied for a better performance. **Literature Cited**

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Table 1. The effect of different mulches on growth performance of planted species in silica mined area.

Species	Mulch treat.	Initial growth		After one year		After two year		After three year		After four year		Growth Increment after four years	
		Av. Ht (cm)	Av. cc (cm)	Av. Ht (cm)	Av. cc (cm)	Av. Ht (cm)	Avg.cc (cm.)	Av. Ht.(cm)	Avg. cc/ (cm)	Av. Ht (cm)	Avg. cc/ (cm)	Ht. (cm.)	Cc (cm.)
Pongamia pinnata	M_0	28.2	3.0	78.5	4.7	94.0	4.02	142.37	6.00	187.50	9.50	159.30	6.50
	M_1	28.8	3.6	113	7.5	150.5	9.19	210.50	14.40	318.80	19.60	290.00	16.00
	M_2	26.5	3.0	80.9	5.5	139.0	7.66	178.00	9.20	270.19	13.50	243.69	10.50
	M_3	28.2	3.1	74.6	5.3	103.0	5.25	161.00	8.34	230.00	12.40	201.80	9.30
Prosopis juliflora	M_0	104	5.0	268	10.5	337.0	12.86	420.00	15.00	475.00	17.00	371.00	12.00
	M_1	112	5.2	300	11.2	410.0	15.37	535.25	18.78	618.00	23.40	506.00	18.20
	M_2	99.2	4.7	261	9.8	353.0	13.41	478.40	15.88	542.00	18.50	442.80	13.80
	M_3	116	5.2	283	11.5	375.0	15.04	496.00	17.98	565.00	20.24	449.00	15.04
Acacia nilotica	M_0	70.2	3.2	82.8	5.1	73.0	5.14	95.10	6.50	112.00	7.60	41.80	4.40
	M_1	72.2	3.2	86.3	5.8	96.0	5.66	140.56	7.85	173.50	9.50	102.30	6.30
	M_2	80.4	3.8	95.9	6.9	91.0	7.14	122.00	9.30	138.89	12.89	58.49	9.09
	M_3	72.7	3.5	92.3	6.5	100.0	6.61	155.45	8.60	170.80	11.90	98.10	8.40
Albizia procera	M_0	50.8	2.7	56.7	4.4	62.0	4.58	110.00	6.15	148.20	8.00	97.40	5.30
	M_1	36.5	2.5	51.9	4.1	74.0	4.96	165.00	6.98	240.30	8.50	203.80	6.00
	M_2	28.1	2.0	34.8	2.7	46.0	5.81	101.00	8.00	145.00	9.24	116.90	7.24
	M_3	32.2	2.4	54.6	3.8	48.0	6.70	105.00	9.52	152.00	10.45	119.80	8.05
Azadirachta indica	M_0	32.0	2.1	31.4	1.9	54.8	4.00	82.90	9.56	113.00	6.90	81.00	4.80
	M_1	38.1	3.0	55.1	3.8	75.0	5.16	125.70	6.80	182.00	8.61	143.90	5.61
	M_2	40.4	3.1	58.3	4.3	74.9	6.06	118.60	7.65	168.50	8.50	128.10	5.40
	M_3	32.6	3.2	58.6	4.3	71.0	5.34	111.92	7.01	154.40	8.20	121.80	5.00
Madhuca indica	M_0	26.8	2.6	29.5	3.3	36.0	2.80	50.20	3.50	67.90	4.45	41.10	1.85
	M_1	18.2	2.5	23.5	2.7	32.0	2.90	47.50	3.89	81.50	4.95	63.30	2.45
	M_2	18.0	2.5	25.7	2.9	31.6	2.79	45.80	3.40	65.70	4.80	47.70	2.30
	M_3	12.6	1.0	16.1	1.9	38.0	3.18	57.31	4.20	84.50	5.25	71.90	4.25
Pithecellobium dulce	M_0	62.3	2.8	105.5	5.6	166.0	7.92	230.00	8.75	278.00	10.80	215.70	8.00
	M_1	62.6	3.1	109.1	5.8	191.0	9.40	295.00	11.50	345.00	13.79	282.40	10.69
	M_2	56.0	3.0	116.1	5.8	217.0	10.55	350.00	13.80	397.00	15.90	341.00	12.90
	M_3	57.0	2.5	102.0	5.1	192.0	11.61	310.00	15.00	340.00	18.50	283.00	16.00

Ht.: Height, Cc: Collar circumference, M_0 Control, M_1 mulch of wheat straw, M_2 mulch of rice husk , M_3 mulch of dry leaves of *B. monosperma*
The significance was calculated by ANOVA with interaction at 5 % level of significance.

Table 2. The effect of different mulches on Survival Percentage of Planted species after four year of plantation in silica mined area under Rain fed condition.

S. No.	***SPECIES***	**MULCH TREATMENTS**			
		CONTROL	**WS**	**RH**	**BL**
1.	*Pongamia pinnata*	16	50	38	40
2.	**Prosopis juliflora**	90	98	94	96
3.	**Acacia nilotica**	22	44	66	70
4.	*Albizia procera*	12	42	32	30
5.	*Azadirachta indica*	26	76	70	60
6.	**Madhuca indica**	18	30	20	26
7.	*Pithecellobium dulce*	82	88	84	84

Control: without mulch**,** WS: mulch of wheat straw, RH: mulch of rice husk, BL: mulch of dry leaves of *B. monosperma.*
The significance was calculated by ANOVA with interaction at 5 % level of significance.

Table 3. The Growth Performance of Selected Species in Silica Mining Area.

S. No.	Name of the Species	Initial		After 1 Year		After 2 Years		After 3 Years		Growth Increment After 3 Years		Survival % After 3 Years
		Height (cm)	Cc (cm)	Height (cm)	Cc (cm)	Height (cm)	Cc. (cm)	Height (cm)	Cc. (cm)	Height (cm)	Cc. (cm)	
1	*Ficus relegiosa*	22.40	3.67	26.66	4.50	33.85	5.70	42.50	7.25	20.10	2.03	02
2	*Butea monosperma*	17.50	0.8	26.20	1.99	35.73	2.80	49.80	4.42	32.30	2.02	08
3	*Casrissa carandas*	23.12	0.8	25.14	1.73	34.55	2.40	42.00	3.50	18.88	1.6	34
4	*Emblica officinalis*	38.65	2.85	42.56	3.78	108.10	5.60	165.00	9.50	126.35	2.75	40
5	*Ziziphus mauritiana*	47.68	0.8	64.08	2.72	95.50	4.85	130.90	7.80	83.22	4.05	42
6	*Dalbergia sissoo*	51.79	2.88	57.09	3.42	160.88	6.78	182.42	8.90	103.63	3.90	49
7	*Pithecellobium dulce*	79.89	2.06	108.63	4.82	182.68	7.42	230.40	9.60	150.51	5.36	68
8	*Acacia catech*	48.16	0.9	54.37	3.03	120.50	5.00	142.00	7.50	93.84	4.10	75
9	*Prosopis juliflora*	132.0	3.44	256.58	8.40	385.88	11.5	434.60	15.8	302.60	8.06	87
10	*Dendrocalamus strctus*	24.68	0.9	35.55	1.49	115.00	4.95	145.00	7.00	120.30	4.05	11
11	*Pongamia pinnata*	61.72	3.42	51.60	5.09	170.00	6.89	224.95	8.80	163.23	3.47	08

Cc: Collar circumference. The significance was calculated by ANOVA with interaction at 5 % level of significance.