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Research Article

AUTOPHYTOREMEDIATION POTENTIALITY OF AN OPEN CAST COAL MINING AREA: A STUDY FROM RANIGANJ COLLIERY, BURDWAN, WEST BENGAL

Priyanka Chatterjee*

Department of Botany, Vivekananda Mahavidyalaya, Haripal, Hooghly, West Bengal, India

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ABSTRACT

Open cast coal mining resulting into the derangement of soil pattern and destruction of overlying vegetations. In this context present work was under taken. Objectives of this work were botanization of deranged overburdens, assessment of physicochemical properties and seed bank potentiality of the spoils, and ear-marking the species suitable for ecorestoration. The present work revealed the floristic assemblage and the physico- chemical characters of the over-burdens (OB) resulting from dumping of residues (spoil) from the opencast mining of coal at Raniganj Colliery of Burdwan district, West Bengal. Values of pH of the spoils collected from six sites ranged from 6.6 to 8.63. The organic carbon content of the spoils ranged from >0.5% to 0.5%. Negligible amount of nitrate-nitrogen could be found in the spoil of Sahebkothi where as it was found to be very high in Nathman colliery. The phosphate content of spoils of Sahabkothi was negligible and those of Nidha and Bhuimpara were low. Nathman colliery (Site IIA) was exceptional in having high content of phosphate in their spoil samples. From the study sites as many as 37 species of angiosperms belonging to 15 families were detected. Interestingly all the individual plants were highly reduced in size under extreme xeric conditions. So far the dominant families are concerned Poaceae with six species and followed by Acanthaceae with four species. The most prevalent species is *Croton bonplandianum* which is present in 4 out of 5 sites studied (80%) which is followed by *Tephrosia purpurea* with prevalence value of 60%.

INTRODUCTION

Botanization of mined wasteland is a pre-requisite to finding Stress tolerant species or ecotypes of species of fertile tracts. Moreover an assessment of the physico-chemical properties of their underlying substrata is certain to give guidelines for appropriate amendments for expediting eco-restoration of these areas by these and other invasive species. It has been observed in nature that plants have capability to adapt all sorts of adverse environmental conditions. The over-dumped areas which remain barren for certain length of time are invaded by certain stress tolerant plants which take their own time to trigger an ecological succession for transformation of the spoil into soil. It was considered worthwhile to find out whether a seed bank has been initiated by wind and other agencies in the areas spoiled by open cast mining and also to identify the plants established in the mean time in such areas where mining has been stopped in the past and now tending to be naturally vegetated.

Identification of such stress tolerant species may find practical application in manipulative ecorestoration of the areas deteriorated by coal mining. Keeping this in mind the work was undertaken to study some of the basic physicochemical qualities of the spoil collected from those mining sites , their seed content through germination studies and species struggling hard to establish in such deteriorated sites.

Objectives

1. To botanize certain open cast coal mining and mined sites within Raniganj and prepare a checklist of stress tolerant species of angiosperms.
2. To assess the phytochemical characteristics of the spoil i.e. earthy materials dumped over top soil of the areas adjoining open-cast mining sites and identify the stress factors.
3. To find out the seed content of the spoils by providing optimum conditions for germination.
4. To ear-mark the species suitable for ecorestoration of sites of derangement by mining activities.

Corresponding author:* **Priyanka Chatterjee
Department of Botany, Vivekananda Mahavidyalaya, Haripal, Hooghly, West Bengal, India

MATERIALS AND METHODS

The present study was carried out in Raniganj opencast coal mine area namely Sahebkothi, Nathman, Nidha, Bhuianpara, Mahabir chanak, in Burdwan district, West Bengal. Five overburden dumps of different sites viz. OB_1, OB_2, OB_3, OB_4 and OB_5 were selected as data points within the study site. From each data point spoil samples were collected along with specimens of the plants composing the overlying vegetation. The collected plant specimens were identified with the help of standard literature (Prain, 1903) and processed for herbarium preservation for future reference. For further scrutiny authors also followed a number of research works of different times (Singh *et al*.,2 002; Vogel, 1982; Shu *et.al.,* 2002; Sheoran *et. al.,* 2010; Sheoran *et al.,* 2008; Roy *et.al.,* 2014a&b; Roy and Mukherjee, 2011; Rai *et. al.,*2011; Namdeo,1989; Mitchell, 1959; Maiti *et.al.,* 2002; MacArthur and Wilson, 1963; Jha and Singh,1991; Jaccard ,1901; Hao *et.al.,* 2004; Das *et.al*., 2015; Dobson *et. al.,*1997; Ekka and Behera, 2011; Das *et. al.,* 2013; Baruah and Barthakur,1997; Biswas *et.al.,* 2013; Agarwal *et.al*., 1993). The spoils collected from five sites were analysed for revealing different physicochemical characteristics such as pH, organic carbon, phosphate, and nitrogen were determined by using analytical methods (Brady, 1920).

RESULT

Physicochemical characteristics study: The analysis of the physicochemical characteristics of spoils collected from six sites was revealed (Table 1) the highest ph value in Mahavir chanak (OB_5) where as the lowest value obtained from Nidha(OB_3). Percentile ratios of Organic carbon also show an increasing manner from Nathman (OB_2) to Mahavir chanak (OB_5) by following Bhuianpara(OB_4), Sahebkothi (OB_1) and Nidha(OB_3). The result also showed the presence of highest amount of nitrogen and phosphorous in Nathman (OB_2).

Table 1 Table showing the analytical result of some physicochemical properties of the spoil collected from different overburdens

Parameters	OB_1	OB_2	OB_3	OB_4	OB_5
P^H	8.08	7.74	6.6	7.35	8.63
Organic Carbon (%)	0.56	0.46	0.58	0.54	0.59
Nitrogen (ppm)	8.42	24.68	10.15	11.2	13.65
Phosphate (ppm)	2.4	15.6	4.8	2.6	14.2

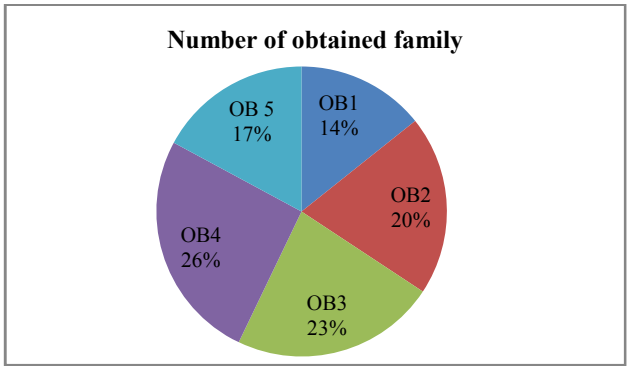

Fig 1 Figure showing percentile ratios of different families obtained from different overburdens.

Taxonomic Study: From the fringe area of five sites as many as 35 species (Figure 2) of angiosperms belonging to 18 families (Figure 1) were detected interestingly all the individual plants were highly reduced in size under extreme xeric conditions. The number of species as shown in Table 2 was highest in Nidha(OB_3) being successively followed by Bhuianpara(OB_4), Nathman (OB_2), Mahavir chanak (OB_5) and Sahebkothi (OB_1).

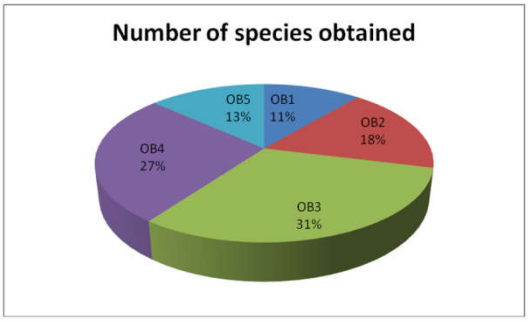

Fig 2 Figure showing percentile ratios of different specieses obtained from different overburdens.

Table 2 An Account of the Species Associated With the Overburdens (OBs) Studied

Name of the plant	Family	Attendence in over burdens				
		OB_1	OB_2	OB_3	OB_4	OB_5
Boerhaavia repens	Nyctaginaceae	+	-	-	-	+
Sida cordifolia	Malvaceae	+	-	-	+	-
Blumea lacera	Asteraceae	+	-	-	-	-
Tephrosia purpurea	Papilionaceae	+	-	+	-	+
Croton bonaplandianum	Euphorbiaceae	+	+	+	+	-
Cassia tora	Caesalpiniaceae	-	+	-	-	-
Alternanthera philoxeroides	Amaranthaceae	-	+	-	-	-
Lantana camara	Verbenaceae	-	+		-	+
Phyllanthus reticulates	Euphorbiacea	-	+	-	-	+
Ruellia tuberose	Acanthaceae	-	+	-	-	-
Phoenix aculis	Arecaceae	-	+	-	-	-
Hemigraphis latebrosa	Acanthaceae	-	+	-	-	-
Heteropogon contoretus	Poaceae	-	-	+	-	-
Polygonum plebium	Polygonaceae	-	-	+	-	-
Eragrostis coarctata	Poaceae	-	-	+	-	-
Sporobolus diander	Poaceae	-	-	+	-	-
Sida acuta	Malvaceae	-	-	+	-	-
Vernonia cinerea	Asteraceae	-	-	+	+	-
Brachiaria cinerea	Poaceae	-	-	+	-	-
Indoneesiella echeoides	Acanthaceae	-	-	+	-	-
Saccharum munja	Poaceae	-	-	+	-	-
Oplismenus composites	Poaceae	-	-	+	-	-
Antigonan leptopus	Polygonaceae	-	-	+	-	-
Nerium indicum	Apocynaceae	-	-	+	-	-
Crozophora plicata	Euphorbiaceae	-	-	-	+	-
Scoparia dulcis	Scrophulariaceae	-	-	-	+	-
Blepharis Sp.	Acanthaceae	-	-	-	+	-
Borreria articularis	Rubiaceae	-	-	-	+	-
Microchloa setacea	Poaceae	-	-	-	+	-
Alternanthera paronycheoides	Amaranthaceae	-	-	-	+	-
Launea pinnatifida	Asteraceae	-	-	-	+	-
Borreria hispida	Rubiaceae	-	-	-	+	-
Argemone mexicana	Papaveraceae	-	-	-	+	-
Calotropis procera	Asclepiadaceae	-	-	-	-	+
Solanum sisymbrifolium	Solanaceae	-	-	-	-	+

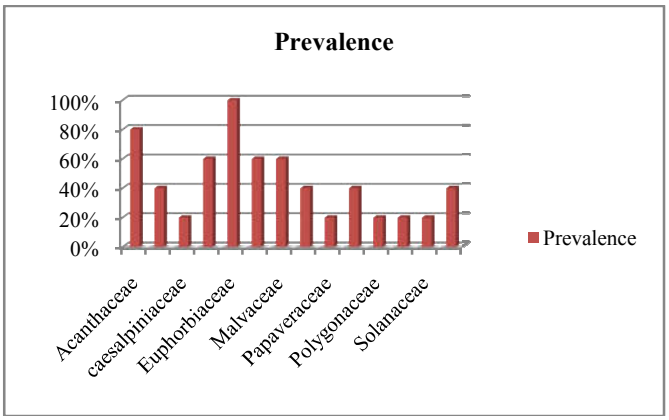

Figure 3 Figure showing coparative prevalence percentages of different families obtained from different overburdens.

Table 3 Prevalence percentiles of different families obtained from overburdens

Name of the families	Prevalence
Acanthaceae	80%
Amaranthaceae	40%
Caesalpiniaceae	20%
Asteraceae	60%
Euphorbiaceae	100%
Papilionaceae	60%
Malvaceae	60%
Nyctaginaceae	40%
Papaveraceae	20%
Poaceae	40%
Polygonaceae	20%
Rubiaceae	20%
Solanaceae	20%
Verbenaceae	40%

Table 4 Table showing the seed bank potentiality of the spoil collected from different overburdens

Site no.	Name of the sites	Total no. of germinating seedling
OB_1	Sahebkothi	-
OB_2	Nathman	2
OB_3	Nidha	-
OB_4	Bhuianpara	4
OB_5	Mahabir Chank	5

Study of seed bank potentiality

The soil of wasteland often acts as repository of seeds of the different species with germinates when conditions are suitable. Ecesis of the seedlings involves a struggle of survival against dehydrating stress and nutrient deficiency. The problems are more acute in case of spoils or overburdens in and around open cast mining sites of coal. The experiment concerning germinability of seeds contained in the spoil shows the highest germinating seeds in Mahavir chanak (OB_5) successively followed by Bhuianpara(OB_4) and Nathman (OB_2).

DISCUSSION

So far pH is concerned the values do not speak of conveying much harm to establishment of plants is case of spoils in mining sites of Nidha (pH-6.6) Mahabir chanak (pH-7.35) Nathman colliery(site IIA & IIB pH-7.74) Both Bhuianpara and Sahebkothi pose threat to establishment of vegetation by alkaline soil-pH being 8.63and 8.08 respectively. Organic carbon content of the soil which indicate the bio-edaphic and concomitant soil microbial metabolic activities a specific ecological realm was found to be very discouraging in all cases. Excepting Sahebkothi where the level of organic carbon was medium. Thus the spoils at the present state are at a very preliminary state to initiate process of xerosere.

So far the nitrogen is poor in although the same is high in others. Sample from the overwhelming nitrate is possible of a biotic origin from deep subterranean strata since it is not in good co-ordination with organic carbon content. The C: N ratio shows equilibrium of relationship being directly proportional the driving force of which is certainly the soil microbial metabolism. Another important nutrient i.e. phosphorus which is procured from soil by plants in form of phosphate was found in very low to negligible quantities in most of the cases .This is also a limiting factor to establishment of community.

So far the dominant families are concerned poaceae laps the list with six species and is followed by Acanthaccae with 4 species. The most prevalent species is croton bonplandianum which is present in 4 out of 5 sites studies, i.e.the values is 80%. It is followed by teprosia purpurea with prevalence value of 60% . So far prevalence of different families (Table 3 & Figure 3) are concerned the values of 16 concerned families range from 20% (Caesalpriniaceec Solanaceae, Asclepiadaccae, Papaveraccae, Polygonaceae, Rubiaceae and Arecaceae) to100% (euphorbiaceae) Acanthaceae occur in 80% and Asteraceae fabaceae and Malvaceae occur in 60% of the mining sites botanized. Families like Amaranthaceae, Nyetaginaceae, Poaceae and verbenaceae are prevalent in 40% of the study sites from these finding it is clear that the laticiferous enphorbiaceae are extremely tolerant to high temperatures (macrotherms) and have restoratir potential. It is close relatur the mucilaginous. Malvaceae is also highly stress tolerant and found in 60% of the study sites. Members of Acanthaceae and Asteraceae (both of Asteridae) have also high prevalence being 80 and 60% respectively. The leguminous plant (Tephrosia purpurea) being atmosphere nitrogen fixers have proved their worth in stress tolerance by registering their attendance in 60% of the mining sites studied. The role of co-families Amaranthaecae and Nyctaginaccae in excuser in no insignificant.

Although a few seeds contained in the spoil germinated when exposed to water, light (12 hours) and 25degree centigrade the condition in most of the cases are unsuitable for the seed materials contained in them through their migration to nude spoil areas. The spoils are likely to be amended by nature and processed for natural eco-restoration. However that would require a long span of time with a rhythmic increase in water holding capacity of the soil successful invasion of species through immigration, ecesis colonization, aggregztion comp ebon etc. However from the multitrade of limiting factor it may be presumed that a community might establish and change following the tolerance model of ecological successions. The stress tolerant species which could be detected in the fringe areas of the over dumping speak of their ability to revegetate the area. In Bhuianpara where the spoils showed at least three species of seedlings, the fringe area chiversity is high. However at Nidha the fringe spoils showed much more hospitability than its core area by the highest number of species i.e. 14 species belonging to 8 families of angiosperms. The process of recovery being centripetal is much rapid at Nidha .It seems that poaccae with six species at Nidha might have played a

significant role in such recovery. The restreature role of poaccae has been much co- laterally encouraged by co-existence of fephrosia purpose of fiacre. At other sites the number of species ranges from 5(Sahebkothi no.1) to 8 (Nathman). At Mahavir chanak the number of species is six only. All the species to have established in the colliary sites certainly have appreciable stress tolerance and have adopted xeric adaptatruos to encounter the environmental resistance. The most successful family in this encounter is euphorbiaceae in general and croton bonplandianum in particular since it has managed to establish itself in all the study sites. The latex in there plants is likely to be a weapon against delrydrating stress. Malvaceae, a chse relater of enphotiaccre might have achieved similar adaptation by vistie of its mucilage. Asteraceae has been moderately successful in ecesis in 60% of the mining sites studied. Acanthaccae also could manage to encounter stress and amchor firmly in 80% the areas studied. In the periling condition Boerhaavia repens, Achyranthes aspera, Atternanthera paraycheaides, A.philoxeraides etc. have been successful for having adopted C-4 mechanism of shong xerophytic grass hetropogon contortes could also be identified which has tremendous potential to revegetate mined areas especially when foosted by the co-existance of leguminous plants.It is interesting to find that under the existing conditions it is Tephrosia pumpurea of Fabaceae ,an present in 60% of the study sites. A joint venture of legume and grasses is very much helpful in conversion of spoils to soils conditions in the mining sites with deranged environment. The species already established in the fringe area may also encroach the spoil sites excersing their inhibitory potential (allelopathic potential) implementing the process of ecological succession through 'Inhabitation Model'. The speed of the process of succession may be enhanced through well planned manipultory strategy of revegetation with appropriate stress- tolerant plants and necessary amendment in the substratum so as to convert spoil to soils. It is only revegetation that can optimize environmental hazards.

CONCLUSION

Developmental activities are always necessary for human well being and such well- beings must not be at the cost of environmental degradation and deterioration. Mining, which is an essential activity for industrial and economic development has been always dewgatry to the environmental conditions conveying harm to the biota and changing ecosystem structure and function considerably. The problem have been more acute in areas covered by open cast coal mining conversion of soils to spoil through over dumping have been accelerating spread of waste land. Present work revealed improvised vegetation and stretches of vacant land area posing threat to the establishment of vegetation.

One of the steps to reclamation is assessment of the seed-bank potential of the wasteland and identification of the constraints and threats precluding germination and establishment of seedlings. Seed of species overcoming such constrains and threats to establish plants are a few in number which were identified. This is essential since this species are highly stress tolerant and would gradually succeed toward ecorestoration. However it is obvious that the pace of such phyto-remediation is very slow. In order to expedite the process it is also essential to determine to physicochemical properties of the substation (soil and spoil) for identification of the threats posed by then and recommendation of appropriate amendments for restoration through re-vegetation.

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