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Phytosociology and Floristic composition of mining area of Lodna Coal Mines of Jharia, Jharkhand

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Abstract: *Mining is a process which leads to significant adverse impact on the environment. It causes massive damage to earth crust, soil profile and biodiversity of the area. Native vegetation get disturbed and the habitats become impoverished due to mining, presenting a very rigorous condition for plant growth. Vegetation is an important part of the environment and is subjected to disturbance in areas close to coal mines. This results in a slowing of the rate of biomass growth, which is caused by fading of vegetation. Simultaneously, carbon stored in vegetation is constantly released, weakening vegetation ability to act as a carbon sink.*

In the present investigation the floristic composition and Phytosociology of vegetation in the five distinct sites of degraded land areas of Lodna coal mines, Jharia (Jharkhand) was studied. The results revealed that the mining severely alter the ecology of coalfield and it is vividly express in vegetation pattern as well as phytosociology. Dichanthium annulatum was the dominating species in control area i.e. station 5 having very high important value index 42.2. Because of this reason the vegetation type is described as Dichanthium complex. Another herb having important value index of 40.3 was Heteropogan controrus showed its remarkable presence in control area. These two herbs were conspicuously absent at mining area. There was the most notable change in vegetation pattern. Cynodon dactylon was the most significant species found in almost all coal mine area studied having high important value index. Eragrostis plumbosa and Tridex procumbens were also evenly distributed in all five stations, however, the earlier genus was better represented than the later. Demodius triflorum and Imperata cylindrical was also uniformly present in all stations. Plants with almost uniform presence exhibit tolerance of these species and capacity of ecological resilience. Presence of Echinochloa colonum and Cyperus rotundus, although in small number at control station but its complete absence in coal mine area proves its comparatively susceptible nature. It is another noteworthy change in herb diversity because of coal mining.

So far as the shrubs are concerned, one species, Leonotis neptifolia was found to possess unique adaptability as the species showed impressive presence with very high important value index in all stations and in all seasons. This means that the plant is having some remarkable adaptability in coal mines and it opens a new possibility of research at molecular level. Lantana camara was also uniformly present in all stations. Eupatorium odoratum was having appreciable presence in control. Although present in coal mines also, their important value index was low. This shows that this shrub is struggling for its survival. Croton sparciflorus was also having high important value index at control area but much less value at coal mines suggesting its vulnerability to changed ecology. Xanthium strumarium was also uniform in their presence.

Key Words: *Floristic composition, Vegetation, Phytosociology, Coal mines, Frequency, Density, Abundance, Important Value Index (IVI*)

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I. Introduction

Mining is a process which leads to some significant adverse impact on the environment. The severity of impacts varies depending on, the mining methods used, and the local ecological and geological conditions (Bell *et al.,* 2001) [1]. It causes massive damage to earth crust, soil profile and biodiversity of the area (Down and Stock, 1977) [2]. Native vegetation get disturbed and the habitats become impoverished due to mining, presenting a very rigorous condition for plant growth. The unscientific mining of minerals poses a serious threat to the environment, resulting in the reduction of forest cover, erosion of soil in a greater scale, pollution of air, water and land and reduction in biodiversity (UNESCO, 1985) [3]. The problems of over burden damps become devastating to the landscape around mining areas (Goretti, 1998) [4].

Vegetation is an important part of the environment and is subjected to disturbance in areas close to coal mines. This results in a slowing of the rate of biomass growth, which is caused by fading of vegetation.

Simultaneously, carbon stored in vegetation is constantly released, weakening vegetation ability to act as a carbon sink. The factors that severely affect vegetation can be divided into: natural factors; human surface activities; and coal mining,with each of these directly reflected in the spatial and temporal variation of the Normalized Difference
Vegetation Index (NDVI) (Yi Huang *et al*., (2015) [5].

Mining activity exerts a long lasting impact on landscape, eco-system and socio-cultural-economic considerations. The actual land mass available to mankind is about 30% of total global surface area. India's land area is about 2-3% of the global land area, where as it supports more than 16% of the global population. This important statistics reveals that the poor per capita land holding stands at 0.32 hectares, which calls for due attention to restoration/reclamation of land after mining in order to utilize the land for useful purpose. Mining and its subsequent activities have been found to degrade the land to a significant extent. Overburden removal from the mine area results in a very significant loss of rain forest and the rich top soil. Overburden removal is normally done by the process of blasting or using excavators, which results in generation of large volume of waste (soil, debris and other material). This is useless for the industry and is normally just stored in big piles within the mine lease area, and sometimes, on public land. The bigger the scale of the mine, greater is the quantum of waste generated. Opencast mines are therefore more pollution intensive as they generate much higher quantities of waste compared to the underground mines. Open-pit mines produce 8 to 10 times as much waste as underground mines (Anon, 2006) [6].

Coal mining seriously jeopardizes the ecological environment of the mining area, with the potential to cause a variety of impacts including surface subsidence, land desertification, soil degradation, surface and groundwater pollution, vegetation destruction, ecosystem degradation, undermined biodiversity, landscape damage and crop failures (Fan *et al*., 2003) [7]. These impacts may directly or indirectly affect and harm growth of the mining vegetation. This can lead to damaged vegetation releasing substantial carbon to the atmosphere, which further weakens the overall carbon sink effect of the vegetation and increases the environmental impact of coal mining. Many quantitative studies on carbon emissions, the global carbon cycle or the low-carbon economy focus on the carbon release mechanism during the use of carbon resources. However, there have been fewer studies focused on the environmental damage from the process of coal mining which also releases considerable carbon to the atmosphere and is a key component of anthropogenic greenhouse gases. A large amount of carbon is fixed in the vegetation in the mine area. Vegetation is therefore not only one of the key factors to consider during the analysis and evaluation of the ecological environment in the mining area, but also crucial to maintaining the environmental stability and carbon sequestration ability of the mining area.

In recent years 3S (GIS, GPS, RS) technology has been applied as studies that analyze the impact on vegetation in mining areas owing to mining activities have evolved, as the following paragraph details. The Normalized Difference Vegetation Index (NDVI) and unary linear regression were applied to analyze the dynamic variation of vegetation cover and land desertification (Wu *et al*., 2009) [8]. The cumulative effect on the ecological environment in mining areas was analyzed by clarifying interactions between mining area development and ecosystems, such as vegetation (Wang *et al*., 2010) [9].

The ratio of overburden excavated to the amount of mineral removed is called the stripping ratio. For example a stripping ratio of 4:1 means that 4 tons of waste rock are removed to extract one ton of ore. Lower the ratio, the more productive the mine. Stripping ratio varies with the area under mining.

The coal mines of Coal India Limited (CIL) removed about 500 million cubic meters (Mcum) of overburden (OB) to produce 260 MT of coal in 2003-04 at an average stripping ratio of 1.92 m^3 of OB against per ton of coal production (Sanyal, 2006) [10]. As demand for coal increases to meet the country's energy requirement, the coal companies are digging deeper and deeper and even opting for lower grades of coal. The country is even planning for production from 300 m depths at stripping ratio of 1:15 for D and F grade quality of coal. If these mines were operational, it would mean that even if 1 million tons of coal were extracted, it would generate 15 million tons of waste material. This is huge quantity and in a country like India where land is at premium, it would be very difficult to find enough land to store this waste.

The coal mining can influence the carbon sink effect of vegetation directly and indirectly. This complicates the process of calculating the biomass and carbon loss of vegetation owing to coal mining and quantifying the change in carbon sequestration of vegetation in the mining area. Several workers studied the variation of net primary productivity (NPP) of vegetation in mining areas and employed the remote sensing Carnegie–Ames–Stanford approach (CASA) model and eco-environmental parameters to analyze the eco-environment conditions (Xu *et al*., 2012; Hou *et al*., 2012) [11, 12].

The Vegetation cover in Lodna coalfield area (Jharkhand) comprises following five classes: Dense Forest, Open Forest, Scrubs, Plantation on Over Burden (OB) Dumps / Backfilled area, and Social Forestry.

Dense forest: Forest having crown density of above 40% comes in this class. Dense forest over the area is same as in year 2013.. A total dense forest is estimated to be 0.29sq km, i.e. 0.07% of the coalfield area. The area of the dense forest within the coalfield has remained same since 2013.

Open Forest: Forest having crown density between 10% to 40% comes under this class. Open forest cover over Jharia coalfield which was estimated to be 8.51 sq km (2,16%) in 2013 has marginally decreased to 6.27 sq km, i.e. 1.60 % of the coalfield area. Thus the area reduced is 2.24 sq km which is 0.56 % of the total coalfield area. This reduction is due to deforestation by local inhabitants.

Scrubs: Scrubs are vegetation with crown density less than 10%. Scrubs in the coalfield are seen to be scattered signature all over the area mixed with wastelands. There is 105.87 sq km, of scrubs, ie 26.95% of the coalfield area. In year 2013 the scrubs covered 122.50 sq km which were 31.20% of the coalfield area. There is a decrease of 16.63 sq km which is 4.25% of the coalfield area .The decrease is due to increase in mining areas and conversion of underground mine into open cast ones & also increase in agricultural land and waste land.

Social Forestry: Plantation which has been carried out on wastelands, along the roadsides and colonies on green belt come under this category. Analysis of data reveals Social Forestry covers 19.52 sq km, which is 4.97% of the coalfield area. In 2013 the area covered under social forestry was 19.41 sq km (4.94%). there is an increase of 0.11 sq km (0.03%). This increase is due to creation of some ecological restoration sites.

Plantation over OB Dump and backfilled area: Analysis of the data reveals that BCCL has carried out significant plantation on OB dumps as well as backfilled areas during the period for maintaining the ecological balance of the area. The plantation on the OB dumps and backfilled areas are estimated to be 8.59 sq km, i.e. 2.19% of the coalfield area. In year 2013 the plantation on OB Dumps were estimated to cover an area of 11.94 sq km which was 3.04% of the coalfield area. There is a decrease of 3.35 sq km (0.85%) in plantation over OB dumps. This is due to increase in mining activity & conversion of UG mines into OC mines.

Agricultural Land:

Land primarily used for farming and production of food, fiber and other commercial and horticultural crops falls under this category. It includes crop land (irrigated and unirrigated) and fallow land (land used for cultivation, but temporarily allowed to rest). Total agricultural land is 44.39 sq km in year 2016, which is 11.31 % of the coalfield area in year 2013 the total agricultural area was estimated to be 39.79 sq km which was 10.12% of the coalfield area. There is an increase on 4.60 sq km which is 1.19% of the coalfield area.

Surface mining not only destroys the existing land use pattern, air quality, water quality and vegetation but there is also a loss of topsoil in pedagogical or a biological sense. In addition, flora and fauna along with its hydrological relations are also drastically disturbed due to open-cast mining operations.

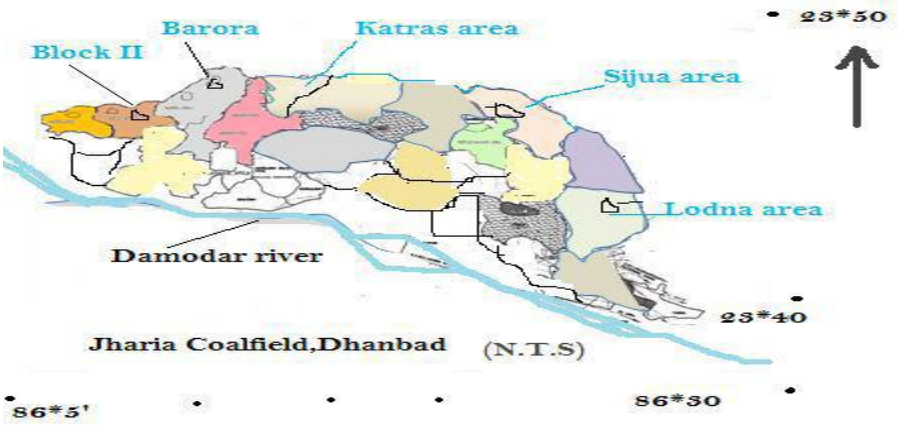
The floristic composition of the mining areas has been studied by several workers in different parts of the world viz. Cornwell, 1971 [13], Fyles *et al*., 1985 [14], Singh and Jha, 1987 [15], Prasad and Pandey, 1985 [16]. An understanding of the impact of mining on the environment particularly on vegetation characteristics is a prerequisite. However, only a few studies have been conducted in this field of research in the coal mine affected areas except some fragmentary report by Lyngdoh *et al.,* 1992 [17], Lyngdoh, 1995 [18], Pandey *et al.,*1993 [19], Das Gupta, 1999 [20], Das Gupta *et al.,* 2002 [21], Dkhar, 2002 [22], Rai, 2002 [23], Swer and Singh, 2004 [24] etc.

The aim of the present research work is to study the floristic composition and Phytosociology of vegetation in the degraded land areas of Lodna coal mines, Jharia (Jharkhand).

II. Materials and Methods

Study area

The Jharia Coalfields (JCF) is one of the Lower Gondwana coalfields of India, covering an area of about 72 km^2. It is one of the most important coalfields in India, located in Dhanbad district, between latitude 23° 39' to 23° 48' N and longitude 86° 11' to 86° 27' E. This sickle shaped coalfields is about 40 km in length and approximately 12 km in width stretches from West to East and finally turns southward covering an area of about 450 sq.km. Jharia coalfield (Jharkhand) is the single source of coking coal for prime quality in India. The coalfield has been a centre of coal mining activity for more than a century. The average maximum temperature recorded during April and May is about 37^0C - 41^0C. The average minimum temperature is about 7^0C-10^0C recorded usually during the months of December and January.



Map of study area (Jharia Coal field)

Five study sites selected for present study in the coal mine area were:
Station – 1 Site in coal mine area
Station – 2 Site in coal mine area
Station – 3 Site in coal mine area
Station – 4 Site in coal mine area
Station – 5 Control areas away from coal mine area

The phytosociological study was conducted in rainy season, summer and winter seasons. Structures of the selected sites were studied with the help of 50 x 50 cm quadrate which has been confirmed by following the species area curve method. The parameters used for study Phytosociology were Frequency, Density, Abundance and Important Value Index (IVI) which were for each species using specific formulae as follows:

$$\textbf{Frequency:} \quad \frac{\text{Total number of hits made on species}}{\text{Total number of hits made}} \times 100$$

$$\textbf{Density:} \quad \frac{\text{Total number of individual of a species}}{\text{Total number of sampling stations}} \times 100$$

$$\textbf{Abundance:} \quad \frac{\text{Total number of individual of a species}}{\text{Total number of sampling unit in which the species occurred}} \times 100$$

$$\textbf{Important Value Index:} \quad \frac{\text{Frequency + Density + Dominance}}{3}$$

Results related to phytosociological studies of vegetation at different study stations have been presented presented in Table- 1 to 15.

Table-1: Phytosociological Study of the plant Community in Rainy Season at different sites of Lodna – (Station - 1)

Sl. No.	Name of plants	Frequency %	Abundance (Plant/m)	Density (No./m)	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	35.9	76.0	21.9	44.6
2	*Eragrostis plumosa*	31.2	75.7	22.0	42.96
3	*Tridax procumbens*	43.9	21.0	7.9	24.26
4	*Desmodium triflorum*	51.0	51.9	25.9	42.93
5	*Imperata cylindrica*	21.0	40.9	9.1	23.66
6	*Boerhaavia diffusa*	31.0	7.9	2.0	13.63
7	*Euphorbia hirta*	26.0	8.2	3.4	12.53
8	*Digitaria longi*	+			
9	*Echinochloa colorun*	+			

10	*Dichanthium annulatum*	+			
11	*Ageratum conyzoides*	+			
12	*Evolvulus alsinoides*	+			
13	*Cyperus rotandus*	+			
14	*Heteropogon contorus*	+			
15	*Cenchrus ciliaris*	+			
16	*Saccharum spontaneum*	+			
17	*Dactyloctenium aeqypyium*	+			
Shrubs					
1	*Lantana camara*	36.2	7.9	1.5	15.2
2	*Eupatorium odoratum*	21.0	4.9	1.9	9.26
3	*Xanthium strumarium*	29.2	3.2	1.1	11.16
4	*Croton sparciflorus*	16.2	2.0	0.39	6.19
5	*Leonotis neptifolia*	91.0	40.2	36.0	55.73
6	*Cleoma visccosa*	26.0	3.9	13.0	14.23
7	*Cassia tora*	21.0	14.0	2.7	12.57
8	*Parthenium hysterophorus*	16.0	3.1	0.5	6.53

Table- 2: Phytosociologiarl Study of the Plant Community in Rainy Season at different sites of Lodna – (Station - 2)

Sl. No.	Name of plants	Frequency %	Abundance (Plant/m)	Density (No./m)	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	35	75.0	22.5	44.16
2	*Eragrostis plumosa*	30	76.7	23	43.23
3	*Tridax procumbens*	45	20.0	8.0	24.33
4	*Desmodium triflorum*	50	52.0	26.0	42.66
5	*Imperata cylindrica*	20	42.5	8.5	23.66
6	*Boerhaavia diffusa*	30	7.3	2.2	13.16
7	*Euphorbia hirta*	25	8.0	2.4	11.8
8	*Digitaria longi*	+			
9	*Echinochloa colorun*	+			
10	*Dichanthium annulatum*	+			
11	*Ageratum conyzoides*	+			
12	*Evolvulus alsinoides*	+			
13	*Cyperus rotandus*	+			
14	*Heteropogon contorus*	+			
15	*Cenchrus ciliaris*	+			
16	*Saccharum spontaneum*	+			
17	*Dactyloctenium aeqypyium*	+			
Shrubs					
1	*Lantana camera*	35	8.0	1.6	14.86
2	*Eupaloriunt odoratum*	20	5.0	1.0	8.66
3	*Xanthium strumarium*	30	3.3	1.0	11.43
4	*Croton sparciflorus*	15	2.0	0.4	5.8
5	*Leonotis neptifolia*	90	39.3	35.4	55.6
6	*Cleoma viscosa*	25	4.0	1.2	10.06
7	*Cassia tora*	20	13.0	2.6	11.86
8	*Pothenium hystesophorus*	15	2.0	0.4	5.8

Table -3: Phytosociological Study of the Plant Community in Rainy Season at different sites of Lodna – (Station - 3)

Sl. No.	Name of plants	Frequency %	Abundance (Plant/m)	Density (No./m)	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	35.9	73.4	21.9	43.73
2	*Eragrostis plumosa*	31.2	77.2	21.9	43.43
3	*Tridax procumbens*	43.2	21.0	7.2	23.8
4	*Desmodium triflorum*	51.2	50.2	25.9	42.43
5	*Imperata cylindrica*	23.0	40.2	7.9	23.7
6	*Boerhaavia diffusa*	+			
7	*Euphorbia hirta*	25.9	7.2	2.9	12
8	*Digitaria longi*	+			
9	*Echinochloa colorun*	+			
10	*Dichanthium annulatum*	+			
11	*Ageratum conyzoides*	+			
12	*Evolvulus alsinoides*	+			
13	*Cyperus rotandus*	31.0	8.2	3.2	14.13

14	*Heteropogon contorus*	+			
15	*Cenchrus ciliaris*	+			
16	*Saccharum spontaneum*	+			
17	*Dactyloctenium aeqypyium*	+			
Shrubs					
1	*Lantana camera*	30.2	8.1	1.2	13.1
2	*Eupaloriunt odoratum*	22.0	4.9	1.1	9.33
3	*Xanthium strumarium*	32.0	3.3	1.5	12.26
4	*Croton sparciflorus*	16.0	2.2	0.39	6.19
5	*Leonotis neptifolia*	91.0	40.2	37.2	56.12
6	*Cleoma viscosa*	26.0	3.9	1.3	10.4
7	*Cassia tora*	21.0	15.1	2.3	12.8
8	*Pothenium hystesophorus*	16.0	2.1	0.39	6.18

Table -4: Phytosociogical Study of the Plant community in Rainy Season of different sites of Lodna- (Station - 4)

Sl. No.	Name of plants	Frequency %	Abundance (Plant/m)	Density (No./m)	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	36.2	76.0	23.3	45.16
2	*Eragrostis plumosa*	31.2	77.2	20.3	42.9
3	*Tridax procumbens*	46.2	23.2	7.9	25.76
4	*Desmodium triflorum*	51.0	53.1	25.9	43.33
5	*Imperata cylindrica*	21.0	40.3	7.9	23.06
6	*Boerhaavia diffusa*	31.5	8.1	2.9	14.16
7	*Euphorbia hirta*	+			
8	*Digitaria longi*	+			
9	*Echinochloa colorun*	+			
10	*Dichanthium annulatum*	+			
11	*Ageratum conyzoides*	+			
12	*Evolvulus alsinoides*	26.2	7.9	2.3	12.13
13	*Cyperus rotandus*	+			
14	*Heteropogon contorus*	+			
15	*Cenchrus ciliaris*	+			
16	*Saccharum spontaneum*	+			
17	*Dactyloctenium aeqypyium*				
Shrubs					
1	*Lantana camera*	30.2	7.9	1.9	13.33
2	*Eupaloriunt odoratum*	22.0	6.1	2.0	10.03
3	*Xanthium strumarium*	31.2	3.5	1.2	11.93
4	*Croton sparciflorus*	16.0	2.1	0.39	18.49
5	*Leonotis neptifolia*	91.0	40.3	36.2	55.83
6	*Cleoma viscosa*	25.2	5.0	1.3	10.5
7	*Cassia tora*	21.0	15.2	2.9	13.03
8	*Pothenium hystesophorus*	16.1	2.1	0.3	6.16

Table- 5: Phytosociogical Study of the Plant community in Rainy Season of different sites of Lodna- (Station - 5)

Sl. No.	Name of plants	Frequency %	Abundance (Plant/m)	Density (No./m)	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	35.9	76.2	23.0	45.03
2	*Eragrostis plumosa*	43.2	22.2	7.9	24.43
3	*Tridax procumbens*	51.2	51.0	25.9	42.7
4	*Desmodium triflorum*	21.2	40.5	7.9	23.2
5	*Imperata cylindrica*	31.2	7.1	2.0	13.43
6	*Boerhaavia diffusa*	26.2	7.9	2.3	12.13
7	*Euphorbia hirta*	+			
8	*Digitaria longi*	+			
9	*Echinochloa colorun*	+			
10	*Dichanthium annulatum*	31.2	75.2	20.2	42.2
11	*Ageratum conyzoides*	+			
12	*Evolvulus alsinoides*	+			
13	*Cyperus rotandus*	+			
14	*Heteropogon contorus*	30.2	69.3	21.2	40.23
15	*Cenchrus ciliaris*	+			
16	*Saccharum spontaneum*	+			

17	*Dactyloctenium aeqypyium*	+			
Shrubs					
1	*Lantana camera*	35.3	9.0	1.7	15.33
2	*Eupaloriunt odoratum*	21.2	5.9	1.7	28.8
3	*Xanthium strumarium*	31.0	3.3	1.9	12.06
4	*Croton sparciflorus*	16.2	2.1	0.5	18.8
5	*Leonotis neptifolia*	92.0	39.9	36.0	55.96
6	*Cleoma viscosa*	26.2	4.9	1.3	10.8
7	*Cassia tora*	22.2	14.9	2.7	13.26
8	*Pothenium hystesophorus*	16.2	2.1	0.39	6.23

Table- 6: Phytosociological Study of the plant Community in Summer Season at different sites of Lodna- (Station - 1)

Sl. No.	Name of Plants	Frequency	Abundance	Density	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	16.0	17.1	2.6	11.9
2	*Tridax Procumbens*	30.3	15.18	4.29	16.49
3	*Desmodium triflorum*	+			
4	*Boerhaavia diffusa*	24.0	4.9	1.35	10.08
5	*Euphorbia hirta*	+			
6	*Digitaria longi*	15.0	4.9	0.6	6.83
7	*Dichanthium annulatum*	+			
8	*Evolvutus alsinoides*	30.5	18.9	5.8	18.4
9	*Solamum Xantho carpus*	26.0	5.9	1.95	11.28
Shrubs					
1	*Lantana camera*	21.0	42.10	34.9	32.66
2	*Eupatorium odoratum*	26.0	14.9	2.9	14.6
3	*Croton sparciflorus*	16.0	2.8	0.41	6.40
4	*Leonotis neptifolia*	86.0	42.1	34.9	54.33
5	*Pathenium hysterophorus*	16.0	17.9	2.7	12.2
6	*Datura stramonium*	+			

Table-7: Phytosociological Study of the plant Community in Summer Season at different sites of Lodna- (Station - 2)

Sl. No.	Name of Plants	Frequency	Abundance	Density	IVI
Herbs & Grasses					
1	*Tridax Procumbens*	2.9	13.9	4.21	7.003
2	*Digitaria longi*	+			
3	*Dichanthium annulatum*	14.3	3.9	0.6	6.26
4	*Evolvutus alsinoides*	31.0	20.3	5.3	18.96
Shrubs					
1	*Croton sparciflorus*	14.0	2.1	0.41	5.41
2	*Leonotis neptifolia*	85.5	41.3	34.3	53.7
3	*Datura stramonium*	+			

Table- 8: Phytosociological Study of the plant Community in Summer Season at different sites of Lodna- (Station - 3)

Sl. No.	Name of Plants	Frequency	Abundance	Density	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	13.0	15.78	2.3	10.36
2	*Tridax Procumbens*	29.7	15.1	4.29	16.36
3	*Desmodium triflorum*	24.0	14.9	3.26	14.05
4	*Boerhaavia diffusa*	+			
5	*Euphorbia hirta*	+			
6	*Digitaria longi*	29.3	18.1	4.3	17.23
7	*Dichanthium annulatum*	23.0	7.6	1.29	10.63
8	*Evolvutus alsinoides*	29.5	18.1	5.2	17.6
9	*Solamum Xantho carpus*	25.0	7.3	1.39	20.23
Shrubs					
1	*Lantana camera*	21.0	10.9	2.1	11.33
2	*Eupatorium odoratum*	26.0	13.5	1.9	10.46
3	*Croton sparciflorus*	+			

4	*Leonotis neptifolia*	84.0	40.3	33.3	52.53
5	*Pathenium hysterophorus*	13.0	16.9	2.7	10.86
6	*Datura stramonium*	14.0	2.9	0.41	5.77

Table- 9: Phytosociological Study of the plant Community in Summer Season at different sites of Lodna- (Station - 4)

Sl. No.	Name of Plants	Frequency	Abundance	Density	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	18.0	19.3	2.9	13.4
2	*Tridax Procumbens*	32.0	15.19	3.29	16.82
3	*Desmodium triflorum*	26.0	6.8	1.95	11.58
4	*Boerhaavia diffusa*	+			
5	*Euphorbia hirta*	+			
6	*Digitaria longi*	15.9	4.1	0.51	6.83
7	*Dichanthium annulatum*	+			
8	*Evolvutus alsinoides*	29.2	18.9	5.1	17.23
9	*Solamum Xantho carpus*	16.0	3.9	0.6	6.83
Shrubs					
1	*Lantana camera*	21.0	10.8	3.4	11.73
2	*Eupatorium odoratum*	26.0	13.5	3.4	14.3
3	*Croton sparciflorus*	+			
4	*Leonotis neptifolia*	83.0	40.9	34.9	52.93
5	*Pathenium hysterophorus*	16.0	17.9	2.1	12.00
6	*Datura stramonium*	16.0	2.9	0.39	6.43

Table- 10: Phytosociological Study of the plant Community in Summer Season at different sites of Lodna – (Station - 5)

Sl. No.	Name of Plants	Frequency	Abundance	Density	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	13.3	15.9	1.5	10.23
2	*Tridax Procumbens*	31.9	15.0	4.21	17.03
3	*Desmodium triflorum*	+			
4	*Boerhaavia diffusa*	26.0	5.9	2.0	11.3
5	*Euphorbia hirta*	15.0	3.9	0.6	6.5
6	*Digitaria longi*	+			
7	*Dichanthium annulatum*	14.0	3.1	0.59	5.89
8	*Evolvutus alsinoides*	25.0	20.7	5.1	16.93
9	*Solamum Xantho carpus*	+			
Shrubs					
1	*Lantana camera*	21.0	11.0	2.1	11.36
2	*Eupatorium odoratum*	23.0	13.3	2.2	12.83
3	*Croton sparciflorus*	16.0	2.9	0.39	6.43
4	*Leonotis neptifolia*	83.0	41.3	34.2	52.83
5	*Pathenium hysterophorus*	16.0	14.9	3.0	12.63
6	*Datura stramonium*	+			

Table- 11: Phytosociological Study of the plant Community in Winter Season at different sites of Lodna – (Station - 1)

Sl. No.	Name of Plants	Frequency	Abundance	Density	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	14.3	17.30	3.1	11.56
2	*Tridax Procumbens*	31.0	13.9	3.29	16.07
3	*Digitaria longi*	+			
4	*Evolvulus alsinoides*	32.2	20.2	6.0	19.46
5	*Desmodium triflorum*	26.0	5.0	2.1	11.03
6	*Boerhaavia diffusa*	+			
7	*Euphorbia hirta*	29.1	12.1	2.29	14.49
8	*Dichanthium annulatum*	16.0	3.9	0.7	6.86
9	*Solamum xanthocarpus*	16.2	4.0	0.71	6.97
Shrubs					
1	*Leonotis neptifolia*	84.1	40.3	30.4	51.6
2	*Lantana camera*	21.0	10.8	3.1	11.63

3	*Eupatorium odoratum*	26.0	12.5	3.1	13.86
4	*Pathenium hysterophorus*	16.0	19.1	2.9	12.66
5	*Datura stramonium*	16.0	3.1	0.5	6.53
6	*Croton sparciflorus*				

Table- 12: Phytosociological Study of the plant Community in Winter Season at different sites of Lodna – (Station - 2)

Sl. No.	Name of Plants	Frequency	Abundance	Density	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	13.9	17.2	3.1	11.4
2	*Tridax Procumbens*	31.2	14.37	3.29	16.28
3	*Digitaria longi*	16.0	4.3	0.69	6.99
4	*Evolvulus alsinoides*	31.0	17.3	5.0	17.83
5	*Desmodium triflorum*				
6	*Boerhaavia diffusa*	26.2	5.2	1.95	11.11
7	*Euphorbia hirta*	17.2	6.2	1.55	8.31
8	*Dichanthium annulatum*				
9	*Solamum xanthocarpus*				
Shrubs					
1	*Leonotis neptifolia*	87.1	43.2	36.3	55.53
2	*Lantana camera*	21.0	10.7	3.1	11.6
3	*Eupatorium odoratum*	26.0	13.2	3.1	14.1
4	*Pathenium hysterophorus*	14.0	19.2	2.9	12.03
5	*Datura stramonium*	+			
6	*Croton sparciflorus*	16.0	2.0	0.39	6.13

Table- 13: Phytosociological Study of the plant Community in Winter Season at different sites of Lodna – (Station - 3)

Sl. No.	Name of Plants	Frequency	Abundance	Density	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	16.3	16.1	3.1	11.63
2	*Tridax Procumbens*	32.3	13.37	3.29	16.32
3	*Digitaria longi*	+			
4	*Evolvulus alsinoides*	31.0	20.7	5.0	18.7
5	*Desmodium triflorum*	26.0	7.1	1.25	11.45
6	*Boerhaavia diffusa*	23.9	7.1	1.40	10.8
7	*Euphorbia hirta*	16.0	3.9	0.69	6.86
8	*Dichanthium annulatum*	17.1	3.1	0.7	6.96
9	*Solamum xanthocarpus*	+			
Shrubs					
1	*Leonotis neptifolia*	84.3	40.2	31.25	51.91
2	*Lantana camera*	21.0	10.8	3.1	11.63
3	*Eupatorium odoratum*	26.0	13.9	3.1	14.33
4	*Pathenium hysterophorus*	16.0	17.3	3.1	12.13
5	*Datura stramonium*				
6	*Croton sparciflorus*	16.0	3.7	0.39	6.69

Table- 14: Phytosociological Study of the plant Community in Winter Season at different sites of Lodna – (Station - 4)

Sl. No.	Name of Plants	Frequency	Abundance	Density	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	16.3	17.29	3.5	12.36
2	*Tridax Procumbens*	31.0	15.20	4.21	16.80
3	*Digitaria longi*	+			
4	*Evolvulus alsinoides*	31.2	20.2	6.2	19.2
5	*Desmodium triflorum*	+			
6	*Boerhaavia diffusa*	26.0	5.1	1.30	10.8
7	*Euphorbia hirta*	16.2	4.30	0.6	7.03
8	*Dichanthium annulatum*	17.2	3.30	0.7	7.06
9	*Solamum xanthocarpus*	+			
Shrubs					
1	*Leonotis neptifolia*	84.0	41.3	30.2	51.83

2	*Lantana camera*	21.0	13.2	3.0	12.4
3	*Eupatorium odoratum*	26.0	15.2	3.1	14,26
4	*Pathenium hysterophorus*	16.2	18.1	2.9	12.4
5	*Datura stramonium*	+			
6	*Croton sparciflorus*	17.1	3.1	0.5	6.9

Table- 15: Phytosociological Study of the plant Community in Winter Season at different sites of Lodna – (Station - 5)

Sl. No.	Name of plants	Frequency %	Abundance (Plant/m)	Density (No./m)	IVI
Herbs & Grasses					
1	*Cynodon dactylon*	34.3	70.3	23.0	42.53
2	*Eragrostis Plumosa*	31.2	70.7	23.9	41.43
3	*Tridax Procumbens*	46.2	20.9	9.0	25.36
4	*Desmodium triflorun*	51.0	53.0	27.0	43.66
5	*Imperata cylindrica*	20.2	40.5	9.2	23.3
6	*Boerhaavia diffusa*	+			
7	*Euphorbia hirta*	+			
8	*Digitaria longi*	+			
9	*Echinochloa colorun*	26.0	9.0	3.1	12.7
10	*Dichanthium annulatum*	+			
11	*Ageratum coonyzaides*	+			
12	*Evolvulus alsinoides*	31.0	8.3	3.0	14.1
13	*Cyperus rotandus*	+			
14	*Heteropogon contorus*	+			
15	*Cenchrus ciliaris*	+			
16	*Saccharum spontaneum*	+			
17	*Dactyloctenium acqypium*	+			
Shrubs					
1	*Lantana camera*	36.0	7.0	1.7	14.9
2	*Eupaloriunt odoratum*	21.0	4.2	1.2	8.8
3	*Xanthium strumarium*	39.0	3.9	1.2	14.7
4	*Croton sparciflorus*	14.9	3.0	0.5	6.13
5	*Leonotis neptifolia*	92.0	40.3	40.3	57.53
6	*Cleoma viscosa*	26.2	5.0	1.3	1083
7	*Cassia tora*	21.0	14.2	2.7	12.53
8	*Pothenium hystesophorus*	16.0	3.0	0.5	6.5

III. Results

In station 1 *Cyanodon dactylon* had an important value index 44.6 which was closely followed by *Eragrostis plumbosa* which had important value index 42.9 and *Demodius triflorum* which represented important value index 42.9. *Euphorbia hirta* had an important value index 37.6. *Tridax procumbanse* and *Boerhaaavia diffusa* also had significant important value index. Some other herbs were also present but their population was very low hence their important value index was also low.These plants include, *Digitaria longii, Echinochloa colonum, Dichanthium annulatum, Ageratum conyzoides, Evolvulus alsonoides, Cyperus rotundus, Heteropogon contours, Cenchurus ciliaris, Saccharum spontaneum and Dactyloctenium acqypatium.* Out of shrub species,*Leonotis neptifolia* had highest important value index 55.7. *Lantana camara* and *Cleome viscose* had 14.3 1nd 15.2 important value index. *Cassia tora* and *Xanthium strumarium* had an important value index 12.56 and 11.1 respectively. *Eupatorium odoratum* and *Parthenium hysterophorus* also showed their presence.

In station 2 highest important value index 44.16 of *Cyanodon dactylon* was recorded which was closely followed by *Eragrostis plumbosa* i e. 43.23 and *Demodius iriflorum* having 42.66 important value index. Other plants having significant presence in this study area are *Tridax procumbanse* and *Boerhaaavia diffusa. Euphorbia hirta* had an important value index varying from 24.33 to 11.8. *Digitaria longii, Echinochloa colonum, Dichanthium annulatum, Ageratum conyzoides, Evolvulus alsonoides, Cyperus rotundus, Heteropogon contours, Cenchurus ciliaris, Saccharum spontaneum and Dactyloctenium acqypatium.* Out of shrub species, *Leonotis neptifolia* had highest important value index 55.0. *Lantana camara* and *Cleome viscose* had 15 nd 10.6 important value index. *Cassia tora* and *Xanthium strumarium* had an important value index 11.86 and 11.4 respectively. *Eupatorium odoratum* and *Parthenium hysterophorus* showed their presence.

In station 3, *Cyanodon dactylon, Eragrostis plumbosa* and *Demodius triflorum* had 43.73, 43.43 and 42.43 important value index respectively. *Tridax procumbanse, Imperata cylindrica, .Euphorbia hirta* and *Cyperus rotundus* had important value index varying from 23.8 to 12.0. *Digitaria longii, Echinochloa colonum, Dichanthium annulatum, Ageratum conyzoides, Evolvulus alsonoides, Cyperus rotundus, Heteropogon contours, Cenchurus ciliaris, Saccharum spontaneum and Dactyloctenium acqypatium* are other noteworthy herbs of this place. Out of shrub species, *Leonotis neptifolia* had highest important value index 56.12. *Lantana*

camara exhibited important value index 39.5. *Xanthium stramonium, Cleome viscose, Cassia tora* also had significant important value index.

Cyanodon dactylon had highest important value index at station 4 also and the value was 45.16, closely followed by *Demodius triflorum and Eragrostis plumbosa* which had important value index 43.33 and 42.9 respectively. *Tridax procumbanse, Imperata cylindrical, Boerhaaavia diffusa* and *Evolvulus alsonoides* had important value index varying from25.78 to 12.13. *Digitaria longii, Echinochloa colonum, Dichanthium annulatum, Ageratum conyzoides, Evolvulus alsonoides, Cyperus rotundus, Heteropogon contours, Cenchurus ciliaris, Saccharum spontaneum and Dactyloctenium acqypatium* are other noteworthy herbs of this place. *Leonotis neptifolia* once again was found to be the most significant shrub species and its important value index was 55.23. *Croton sparciflorus, Lantana camara, Cassia tora , Cleome viscose, Eupatorium odoratum* are some other shrubs having important value index varying from 18.49 to 10.03.

At station 5 *Cyanodon dactylon* and *Demodius triflorum* had important value index 45.03 and 42.7 respectively. *Eragrostis plumbosa* had important value index 24.43. *Imperata cylindrical, Boerhaaavia diffusa* and *Euphorbia hirta* had important value index varying from 12.13 to 23.2. Most significant was the presence of *Dichanthium annulatum* which was having important value index 42.2. *Heteropogon contours* also had a remarkable presence with 40.23 important value index. Among shrubby vegetation once again *Leonotis neptifolia* showed highest important value index 55.96. *Croton sparciflorus,. Lantana camara, Cassia tora, Cleome viscose, Eupatorium odoratum* are some other shrubs having important value index varying from 18.8 to 10.8. *Eupatorium odoratum* was significant with28.8 important value index.

SUMMER SEASON

At station 1, *Evolvulus alsonoides* had important value index 18.4 which was the highest value and it was followed by *Tridax procumbans* having 16.49 important value index *Cyanodon dactylon, Boerhaaavia diffusa, Solanum xanthocarpus, Digitaria logi* were other herbaceous species having noteworthy important value index varying from11.9 to 6.83. *Lantana camara, Eupatorium odoratum, Parthenium hysterophorus* and *Croton sparciflorus* had important value index in descending order from 32.66 to 6.40. *Leonotis neptifolia* showed highest important value index 54.6.

Station 2 had only three note worthy herbaceous species and their important value index ranged from 18.96 to 6.26. The species were *Eupatorium odoratum, Tridax procumbans* and *Dichanthium annulatum* respectively. Among shrubs, *Leonotis neptifolia* showed highest important value index 53.7. The only other visible species was *Croton sparciflorus* with5.41 important value index.

In station 3, *Evolvulus alsonoides, Digitaria logi and Tridax procumbans* were prominent and their important value index varied from 17.6 to 16.36. The most vital was presence of *Solanum xanthocarpus* having highest important value index 20.23. *Demodius triflorus, Dichanthium annulatum* and *Cyanodon dactylon* are other three herbs having important value index 14.04, 10.63 and 10.36 respectively. Among shrubby species, *Leonotis neptifolia* had an important value index 52.53. *Lantana camara, Eupatorium odoratum, Parthenium hysterophorus* had important value index ranging from 11.33 to 5.77.

At station 4, *Evolvulus* alsonoides and *Tridax procumbans* was most prominent having important value index 17.73 and 16.82 respectively. *Cyanodon dactylon* is the other important herb having important value index 13.4. *Demodius triflorus* had important value index 11.5 while *Digitaria logi* and *Solanum xanthocarpus* had important value index 6.8 each. Out of shrubby species, as in all other stations, *Leonotis neptifolia* had highest important value index 52.43. *Eupatorium odoratum* was represented by important value index 14.3. *Parthenium hysterophorus* and *Lantana camara* had important value indices 12 and11.73 respectively.

At station 5, *Euphorbia hirta, Tridax procumbans* and *Evolvulus alsonoides* were prominent herbs and they were having important value indices 19.5, 17.03 and 16.93 respectively. *Boerhaavia diffusa* and *Cyanodon dactylon* had 11.3 and 10.23 important value index. *Dichanthium annulatum* was also present. Among shrubs, *Leonotis neptifolia* had 52.83 important value index which was highest. *Eupatorium odoratum* possessed 12.83 important value index which was closely followed by *Parthenium hysterophorus* with important value index 12.63. *Lantana camara* was also visible with Important value index 11.36.

WINTER SEASON

At station 1, *Evolvulus alsonoides* was the most prominent herb having an important value index 19.96. *Tridax procumbans* and *Euphorbia hirta* were other two notable herbs having important value index 16.06 and 14.46 respectively. *Cyanodon dactylon* had an important value index 11.56. *Dichanthium annulatum and Solanum xanthocarpus* were *also present. Leonotis neptifolia* with important value index of 51.6 was most prominent. *Eupatorium odoratum, Lantana camara* and *Parthenium hysterophorus* were other shrubs with important value indices 13.86, 11.63 and 12.66 respectively.

At station 2, *Evolvulus alsonoides* and *Tridax procumbans* were prominent herb with important value indices 17, 83 and 16.28 respectively. *Cyanodon dactylon* and *Boerhaaavia diffusa* had almost similar important

value index and was near about 11. *Digitaria long*i and *Euphorbia hirta* were also conspicuous. Shrubs were dominated by *Leonotis neptifolia with* important value index 55.53. . *Eupatorium odoratum, Lantana camara* and *Parthenium hysterophorus* were also significantly represented.

At station 3, *Evolvulus alsonoides* and *Tridax procumbans* were prominent herb having important value indices 18.9 and 16.32 respectively. *Cyanodon dactylon* and *Desmodium triflorum* were the other two herbs having important value indices slightly over 11. *Euphorbia hirta,*and *Dichanthium annulatum* were other two conspicuous species. Out of shrubs, *Leonotis neptifolia* with 51.9 important value index was the dominant species. *Eupatorium odoratum* and *Parthenium hysterophorus* were also significantly represented with an important value index of 14.35 and 11.6 respectively.

At station 4, *Evolvulus alsonoides* with an important value index of 17.3 was the most prominent. *Tridax procumbans* and *Cyanodon dactylon* followed with important value indices 16.5 and 12.3 respectively. *Boerhaavia diffusa* and *Dichanthium annulatum* were other two significant herbs of this area. *Leonotis neptifolia* with 51.83 important value index was the dominant species. *Eupatorium odoratum, Lantana camara* and *Parthenium hysterophorus* were also significantly represented with an important value indices of 14.76, 17.6 and 12.13 respectively.

Desmodium triflorum and *Cyanodon dactylon* were significant herbs at station 5 with important value indices 43, 66 and 42.53 respectively. *Eragristus plumose* was also significant with 41.23 important value index. *Tridax procumbans, Imperata cylindrical, Echnocloa colonum and Evolvulolous alsonoides* were also important herb of this station. Among shrubs, *Leonotis neptifolia* with 57.53 important value index was the significant species. *Cassia tora, Xanthium strumarium* and *Lantana camara* were other noteworthy shrubs with important value indices, 17.62, 14.9 and 14.7 respectively.

IV. Discussion

Results obtained during this study clearly indicate that mining severely alter the ecology of coalfield and it is vividly express in vegetation pattern as well as phytosociology. *Dichanthium annulatum* was the dominating species in control area i.e. station 5 having very high important value index 42.2. Because of this reason the vegetation type is described as *Dichanthium* complex. Another herb having important value index of 40.3 was *Heteropogan controrus* showed its remarkable presence in control area. These two herbs were conspicuously absent at mining area. This was the most notable change in vegetation pattern. *Cynodon dactylon* was the most significant species found in almost all coal mine area studied having high important value index. *Eragrostis plumbosa* and *Tridex procumbens* were also evenly distributed in all five stations however the earlier genus was better represented than the later. *Demodius triflorum* and *Imperata cylindrical* was also uniformly present in all stations. Plants with almost uniform presence exhibit tolerance of these species and capacity of ecological resilience. Presence of *Echinochloa colonum* and *Cyperus rotundus*, although in small number at control station but its complete absence in coal mine area proves its comparatively susceptible nature. It is another noteworthy change in herb diversity because of coal mining.

So far as shrubs are concerned, one species, *Leonotis neptifolia* was found to possess unique adaptability as the species showed impressive presence with very high important value index in all stations and in all seasons. This means that the plant is having some remarkable adaptability in coal mines and it opens a new possibility of research at molecular level. *Lantana camara* was also uniformly present in all stations. *Eupatorium odoratum* was having appreciable presence in control. Although present in coal mines also, their important value index was low. This shows that this shrub is struggling for its survival. *Croton sparciflorus* was also having high important value index at control area but much less value at coal mines suggesting its vulnerability to changed ecology. *Xanthium strumarium* was also uniform in their presence.

Hange in the vegetation pattern due to mining and other industrial activities has been reported by other workers also like, Cornell (1971) [13] and Games (1982) 25]. Jha and Singh (1990) [26] have also reported occurrence of new species in the vegetation spectrum at the cost of native species. Dasgupta (1999) [20] reported impact of mining on change in diversity index and the trend was observed in present study as well. Survival attempt and resilience nature of ecosystem has been found in this study and the same has been indicated by Sarma (2002) [27] also.

V. Conclusions:

From the present results it can be concluded that:

1. Coal mining significantly changes ecology of the area which is manifested in vegetation cover as well as phytosociological.
2. Some representative but susceptible species fail to survive in changed condition.
3. Some hardy species on the other hand start showing their significant presence in affected area.
4. *Leonotis neptifolia*, a shrub was identified as highly tolerant species which was found growing in all stations.

Variation in plant diversity was observed but introduction of some tolerant species maintained the value to some extent. Results obtained during this study clearly indicate that mining severely alter the ecology of coalfield and it is vividly express in vegetation pattern as well as phytosociology. *Dichanthium annulatum* was the dominating species in control area i.e. station 5 having very high important value index 42.2. Because of this reason the vegetation type is described as *Dichanthium* complex. Another herb having important value index of 40.3 was *Heteropogan controrus* showed its remarkable presence in control area. These two herbs were conspicuously absent at mining area. This was the most notable change in vegetation pattern. *Cynodon dactylon* was the most significant species found in almost all coal mine area studied having high important value index. *Eragrostis plumbosa* and *Tridex procumbens* were also evenly distributed in all five stations however the earlier genus was better represented than the later. *Demodius triflorum* and *Imperata cylindrical* was also uniformly present in all stations. Plants with almost uniform presence exhibit tolerance of these species and capacity of ecological resilience. Presence of *Echinochloa colonum* and *Cyperus rotundus*, although in small number at control station but its complete absence in coal mine area proves its comparatively susceptible nature. It is another noteworthy change in herb diversity because of coal mining.

Leonotis neptifolia was found to possess unique adaptability as the species showed impressive presence with very high important value index in all stations and in all seasons. This means that the plant is having some remarkable adaptability in coal mines and it opens a new possibility of research at molecular level. *Lantana camara* was also uniformly present in all stations. *Eupatorium odoratum* was having appreciable presence in control. Although present in coal mines also, their important value index was low. This shows that this shrub is struggling for its survival. *Croton sparciflorus* was also having high important value index at control area but much less value at coal mines suggesting its vulnerability to changed ecology. *Xanthium strumarium* was also uniform in their presence.

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