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Species Diversity and Vegetation Structure of Coal Mine Generated Wasteland of Raniganj Coal Field, West Bengal, India

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ABSTRACT

Aim: The main aim of the study was to study the vegetation structure and species diversity of coal mine generated waste land, located in Raniganj coal field area, West Bengal.

Methodology: The survey of vegetation was conducted at both study sites by using standard quadrat method. Study of different phytosociological attribute and species diversity analysis was done using standard methods. Statistical analysis was performed to represent the importance of different phytosociological attributes.

Result: Distribution pattern in both wasteland indicate contagious or clumped type. *Butea monosperma* and *Streblus asper* was the most dominant tree species in the two study area respectively whereas, *Cynodon dactylon* was the most dominant herb species in the study areas. The diversity of herbs was much higher than the others layer of vegetation in both waste lands. Concentration of dominance or Simpson Dominance Index also exhibits variation among the vegetation layers. The Jaccard's Index of similarity for tree, herb shrub and climber vegetation was 57.14%, 71.11%, 50% and 33.33% respectively between the two waste lands. Hierarchical cluster analysis highlights 13 and 7 primary cluster in the two study area respectively based on their phytosociological attributes. Principle component analysis reveals 97.57% and 92% variance for the first two principle components in the study areas respectively.

Conclusion: The present investigation can be concluded that the data of vegetation analysis might be utilized as baseline information and tool to predict the best and effective reclamation procedure of these coal mined areas.

Key Words: Coal mining, Reclamation, Wasteland, Vegetation

INTRODUCTION

The resources from our mother earth are rapidly utilized for improvisation and maintaining the quality of the life in different way. Mining operation for extraction of coal is one of the most familiar and oldest activity but it tend to bring a notable impact on the environment by damaging landscapes and local floral population (Bell et al., 2001; Sarma, 2005). Moreover extensive mining activity can lead to massive destruction of natural ecosystem along with the biodiversity of the area (Ezeaku and Davidson, 2008). In this scenario, full recovery of these ecosystems with their biodiversity may take several years (Cooke, 1999). Therefore, needful attempts have to take to minimize the negative impacts as well as restoration of the degraded environments and these might highlights a significant contribution of the mining sector towards proper development of the impacted area in a sustainable way (Hoadley et al., 2002). The open coal excavations generate wide areas of degraded land or we can say it as wasteland, had gained primary succession conditions but the colonization process is very low, probably due to unfavorable conditions or minimum pioneer plants which suits the environment (Jochimsen et al., 1995). The Damalia and Nimcha-Harabhanga area (Raniganj block of Barddha-

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man Paschim District, West Bengal) is well known for open cast coal mining. Large-scale open cast mining of these area produced vast barren and unproductive lands and extensive damage to the vegetation. Hence, to counter ecological hazards and restoration of ecological balance, proper reclamation and basic knowledge about it is the priority for these mine area. Better and effective restoration and reclamation process requires detailed concept about the native vegetation and processes of their natural recovery. This study was conducted in coal mine generated waste land of Damalia and Nimcha-Harabhanga area with an aim of gaining knowledge and provide data of natural and compatible vegetation and to formulate any difference in the vegetation composition of these two mine areas of Raniganj Coal Field, West Bengal, India

MATERIALS AND METHODS

Study area

Damalia and Nimcha-Harabhanga coal mine generated waste land were selected as the study sites under Satgram mining area and are situated at Raniganj block and Asansol subdivision of West Bengal, India. Damalia waste land is located in between $23^0 36'31.9''$N and $87^0 4'6.1''$E at 80.2m elevation and Nimcha-Harabanga waste land is located between $23^0 36'32.9''$N and $87^0 4'2.4''$E at 83.8m elevation (Figure 1).

Vegetation Analysis

The survey of vegetation was conducted at both study sites by using standard quadrat method (Srivastava 2001) during peak growth season. Sums of 5 sites in each wasteland were selected for sampling. In each sites, 10 quadrats (10m X 10m for trees), within these 100 m^2 quadrats, 5 m X 5 m quadrats for shrubs and climbers, and 1m x 1 m quadrats for herbs) were laid to quantify various layers of vegetation. Quantitative community characteristics such as frequency, density, abundance and importance value index (IVI) of each plant species were determined, following Misra (1968) and A/F value (Whiteford, 1949). The resultant frequency values were classified into frequency classes following Raunkiaer, 1934 frequency class analysis, such as: class A (1%–20%), class B (21%–40%), class C (41%–60%), class D (61%–80%) and class E (81%-100%) (Hewit and Kellman, 2002).

Diversity indices analysis

Species diversity (Shannon and Weiner, 1963), Concentration of dominance (Simpson, 1949), Species richness (Margalef, 1978) and Evenness index (Pielou, 1966) were calculated for undisturbed and disturbed sites. The distribution pattern of the species was studied by using Whiteford's index (Whiteford, 1949). Similarity index of different layer of wasteland vegetation between two study areas was determined following Jaccard's index of similarity (Krebs, 1999).

Statistical analysis

Hierarchial cluster analysis was performed to interpret the similarity level of the tree species based on their phytosociological parameters for both the waste land and principle component analysis through statistical computer software.

RESULTS

The density, frequency, frequency class, abundance, importance value index (IVI), Whiteford's index of vegetation at two study area are shown in Table 1 and 2 respectively. The A/F ratio showed Contagious or clumped distribution pattern in both wasteland which stipulates fragmented and patchy type of natural vegetation because of mining. Similar types of distribution pattern were also observed by Sarma (2005) in the coal mining areas of Nokrek biosphere reserve of Meghalaya. At Damalia wasteland area, the most dominating tree species was *Butea monosperma* with the highest IVI value, whereas, *Streblus asper* was the most dominant one in Nimcha-Harabhanga (Table 1 and 2). *Cynodon dactylon* was the most dominant herb species in both Damalia and Nimcha-Harabhanga wasteland in terms of IVI value (Table 1 and 2). *Tephrosia purpuria* and *Jatropha gossipyfolia* was the dominant shrub species in Damalia and Nimcha-harabhanga waste land respectively (Table.1 and 2) Higher importance value indicated its ability to grow in the degraded environment. Species, family compositions of Damalia and Nimcha-Harabhanga waste land are represented in table 3. The study highlights that asteraceae and fabaceae (7 species each) are the most dominant family in Damalia waste land and asteraceae in case of Nimcha-Harabhanga waste land**.** Present study reflected density of tree in Damalia was higher than in Nimcha- Harabhanga but the density of herbs was lower in Damalia.

Diversity indices analysis

Species diversity indices (Shannon-Weaver) reveal variation among the tree, herb, shrubs and climber species (Table 4). Herbs species shows higher diversity than the other types of vegetation in both study area. Concentration of dominance or Simpson Dominance Index also exhibits variation among the vegetation layers. The Evenness Index (Pielous Index) and Margalef Index for species richness also highlights variation among different vegetation layers in both waste lands (Table 4). The Jaccard's Index of similarity for tree, herb shrub and climber vegetation was 57.14%, 71.11%, 50% and 33.33% respectively between the two waste lands (Table 4) The present study of the two wasteland flora according to Raunkiaer's life form (Raunkiaer 1934) reveals that the dominance of Phanerophyte in Damalia wasteland and therophytes in Nimcha-Harabhanga wasteland.(Table 5 & Fig.2).

Statistical analysis

Hierarchial cluster analysis based on different phytosociological attributes was done for the tree and herb layer of both waste lands (Figure 3 and 4). In Damalia waste land 13 primary clusters and in Nimcha-Harabhanga 7 primary cluster are formed. The more the distance scale of the clusters the more the plant species are remotely related to each other. In Damalia, the 1st cluster shows close similarity among the *Heliotropium indicum, Amaranthus spinosus, Acacia auriculiformis, Alstonia scholaris, Crotalaria juncea, Aerva lanata, Blumea lacera, Oldenlandia corymbosa* plant species. Cluster 2 comprises of *Hyptis suaveolens, Anisomeles indica, Melochia corchorifolia, Oxalis corniculata, Mimosa pudica Desmodium gangeticum.* Cluster 3 comprises of *Ailanthus excelsa, Albizzia lebbek, Azadirachta indica, Ziziphus jujube, Dalbergia sissoo, Phoenix dactylifera.* Cluster 4,7,8,9,10,11,12 and 13 comprises only 2 plant species in each. Cluster 5 composed of *Boerhaavia repens, Achyranthus aspera, Alternanthera sessilis, Cleome viscose* and cluster 6 composed of *Parthenium histerophorus, Evolvulus nummularis, Gomphrena serrata, Euphorbia hirta, Eclipta alba, Oplismenus composites. In Nimcha-Harabhanga waste land cluster 1 comprises Heliotropium indicum, Amaranthus spinosus, Sida acuta, Eucalyptus globules, Senna siamea, Borassus flabellifer, Dalbergia sissoo, Phoenix dactylifera, Azadirachta indica, Crotalaria juncea, Oxalis corniculata, Mimosa pudica, Solanum virginianum, Desmodium gangeticum, Cyperus rotundus, Ailanthus excels, Alstonia scholaris, Acacia nilotica, Hyptissu aveolens, Anisomeles indica, Melochia corchorifolia, Senna obtusifolia, Albizzia lebbek. Cluster 2 composed of Acacia nilotica and Alangium salviifolium, cluster 3 contains Triumfetta rhomboidea, Achyranthus aspera, Desmodium triflorum, Parthenium histerophorus, Evolvulus nummularis, Euphorbia hirta, Eclipta alba, Oplismenus composites, Gomphrena serrata, Alternanthera sessilis, Aerva lanata, Boerhaavia repens and Cleome viscose.* Cluster 4 comprised of *Sida cordata and Blumea lacera.* Cluster 5 includes *Coldenia procumbens, Centella asiatica, Gmelina arborea, Lagerstroemia speciosa, Ficus religiosa* and *Ficus benghalensis.* Cluster 6 composed of *Eragrostis cilianensis, Dactyloctenium aegyptium* and *Eupatorium odoratum.* Cluster 7 composed of *Streblus asper* and *Ziziphus jujube.*

Principle component analysis was done for the tree layer of different phytosociological attributes for two coal mines generated waste lands. For the tree layer of Damalia waste land (Table 6 and Figure 5), the first two principle components account for 97.57% of the total variance in the data set. Therefore, 65 and 31% of variance were calculated for the first two principle components respectively. From this it can be concluded that the first principle component is probably the most important to represent the variation within the phytosociological attributes in the tree layer of Damalia. In Damalia, *Streblus asper* (12) *and Butea monosperma* (8) have similarity regarding their phytosociological attributes and exhibit high correlation with the first axis but *Borassus flabellifer* (7) and *Moringa oleifera* (10) shows negative correlation with first axis for the same phytosociological attributes. In Nimcha-Harabhanga waste land (Table 7 and Figure 6), the total variance were 92% for the first two principle components. Therefore, 65 and 26% of variance were calculated for the first and second principle components and first principle is important for representing the variation within the phytosociological attributes of the tree layer like Damalia. Maximum tree species of Nimcha-Harabhanga were located on or near of axis 1 and 2. Hence, indicates strong positive correlation of the concerned species along with the phytosociological attributes represented by the axis respectively. Due to higher distance from both the axis, *Butea monosperma* (9) has a weak relation with the phytosociological attributes of the respective axis.

CONCLUSION

The principle objective of this research was to analyze the natural occurrence of different plant species native to different habitats across two different coal mine generated waste land of Raniganj Coalfield, West Bengal aiming to enhance diversity and functioning of huge area of coal mine generated waste land. The potentiality of vegetation of an area is based on various environmental constrain and regional variables (Nath 2004). The present study shows that phytosociological analysis can be utilized as important tools to predict the nature of mine soil for the growth of vegetation as well as eco-restoration. The waste land areas of coal field are invaded by some stress tolerant floras which are able to initiate ecological succession and gathering data and information of such kind of stress tolerant plant species have enormous practical application in terms of eco-restoration. The study of natural vegetation in details of coal mine affected area can be implicit to formulate and conduct revegetation programme in any coal mine generated waste lands. Furthermore, this type of data can be utilized to maintain genetic diversity and equally to confirm the use of ecosystem in a sustainable way (Jha and Singh, 1990; Bannerjee et al., 1996).

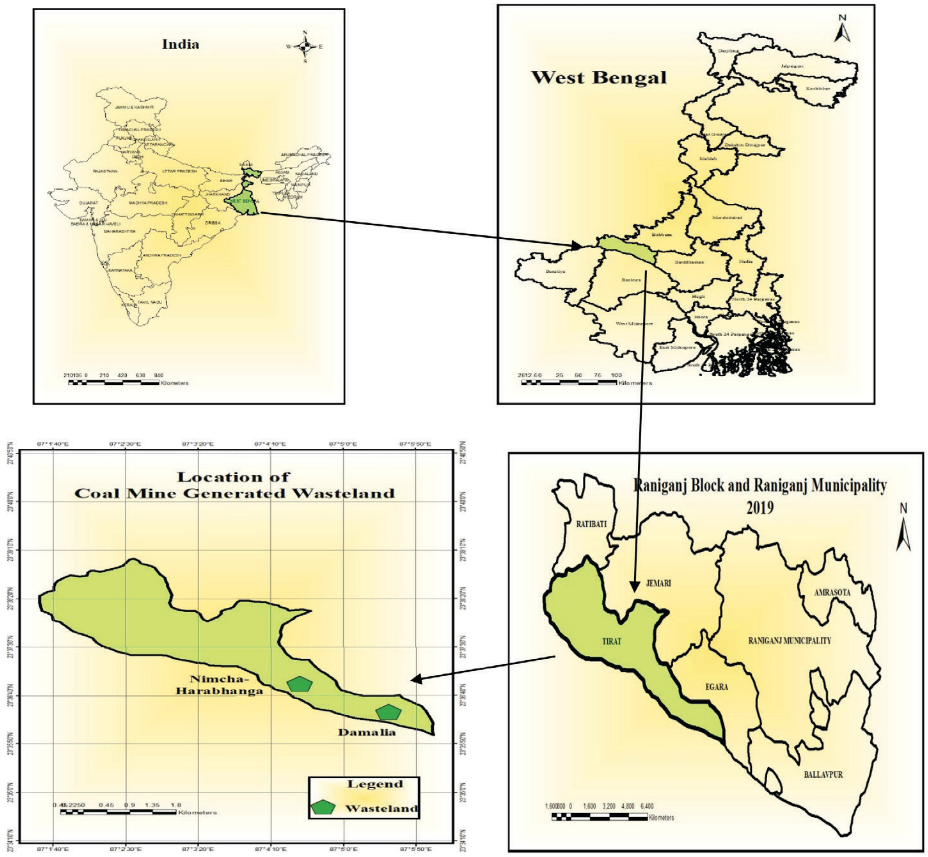

Figure 1: Location map of the study area.

Table 1: Phyto-sociological attributes of different plant species of Damalia wasteland

SL. NO	PLANT NAME	family	Life- form	D	A	F	FC	A/F	IVI
				TREES					
1	*Acacia auriculiformis*	Fabaceae	PH	0.06	1.50	4	A	0.375	9.09
2	*Ailanthus excelsa*	Simaroubaceae	PH	0.16	1.33	12	A	0.111	15.71
3	*Alangium salviifolium*	Cornaceae	PH	0.28	1.27	22	B	0.058	24.38
4	*Albizzia lebbek*	Fabaceae	PH	0.14	1.40	10	A	0.140	14.28
5	*Alstonia scholaris*	Apocynaceae	PH	0.06	1.50	4	A	0.375	9.09
6	*Azadirachta indica*	Meliaceae	PH	0.18	1.80	10	A	0.180	16.73
7	*Borassus flabellifer*	Arecaceae	PH	0.06	3.00	2	A	1.500	13.17
8	*Butea monosperma*	Fabaceae	PH	0.96	3.20	30	B	0.107	53.71
9	*Dalbergia sissoo*	Papilionaceae	PH	0.18	1.50	12	A	0.125	16.82
10	*Moringa oleifera*	Moringaceae	PH	0.06	3.00	2	A	1.500	13.17
11	*Phoenix dactylifera*	Arecaceae	PH	0.26	1.63	16	A	0.102	21.66
12	*Streblus asper*	Moraceae	PH	0.72	3.27	22	B	0.149	43.04
13	*Vitex negundo*	Lamiaceae	PH	0.46	2.09	22	B	0.095	32.01
14	*Ziziphus jujuba*	Rhamnaceae	PH	0.18	2.25	8	A	0.281	17.16

SL. NO	PLANT NAME	family	Life- form	D	A	F	FC	A/F	IVI
			HERBS						
1	*Tridax procumbens*	Asteraceae	Th	0.70	3.18	22	B	0.145	7.86
2	*Solanum sisymbriifolium*	Solanaceae	TH	0.32	0.59	54	C	0.011	6.26
3	*Solanum virginianum*	Solanaceae	Th	0.18	4.50	4	A	1.125	5.84
4	*Rungia pectinata*	Acanthaceae	TH	0.98	7.00	14	A	0.500	12.37
5	*Phyllanthus annus*	Phyllanthaceae	TH	0.10	5.00	2	A	2.500	5.92
6	*Parthenium histerophorus*	Asteraceae	TH	1.14	1.58	72	D	0.022	11.90
7	*Oxalis corniculata*	Oxalidaceae	HC	0.22	1.00	22	B	0.045	3.71
8	*Oplismenus compositus*	Poaceae	TH	1.18	1.97	60	C	0.033	11.48
9	*Mimosa pudica*	Mimosaceae	HC	0.24	1.00	24	B	0.042	3.94
10	*Merremia tridentata*	convolvulaceae	HC	0.10	5.00	2	A	2.500	5.92
11	*Melochia corchorifolia*	malvaceae	HC	0.04	1.00	4	A	0.250	1.55
12	*Hyptis suaveolens*	lamiaceae	TH	0.10	1.25	8	A	0.156	2.38
13	*Heliotropium indicum*	Boraginaceae	TH	0.08	2.00	4	A	0.500	2.78
14	*Gomphrena serrata*	Amaranthaceae	TH	1.16	2.07	56	C	0.037	11.19
15	*Gamochaeta coarctata*	asteraceae	TH	1.68	5.60	30	B	0.187	14.81
16	*Evolvulus nummularis*	Convolvulaceae	HC	1.12	1.60	70	D	0.023	11.67
17	*Euphorbia hirta*	Euphorbiaceae	TH	1.04	1.79	58	C	0.031	10.60
18	*Eupatorium odoratum*	Asteraceae	CH	1.78	2.12	84	E	0.025	15.87
19	*Eragrostis cilianensis*	Poaceae	HC	1.74	3.11	56	C	0.055	14.49
20	*Eclipta alba*	Asteraceae	TH	1.02	1.82	56	C	0.033	10.39
21	*Desmodium triflorum*	Papilionaceae	HC	0.56	1.00	56	C	0.018	7.77
22	*Desmodium gangeticum*	Papilionaceae	HC	0.38	1.12	34	B	0.033	5.42
23	*Dactyloctenium aegyptium*	Poaceae	TH	2.22	2.71	82	E	0.033	18.00
24	*Cynodon dactylon*	Poaceae	HC	2.84	3.16	90	E	0.035	21.47
25	*Croton bonplandianus*	Euphorbiaceae	TH	0.82	3.15	26	B	0.121	8.61
26	*Crotalaria juncea*	Papilionaceae	TH	0.42	2.33	18	A	0.130	5.57
27	*Cyperus rotundus*	Cyperaceae	CRY	0.04	2.00	2	A	1.000	2.46
28	*Cleome viscosa*	Cleomaceae	TH	0.62	2.21	28	B	0.079	7.01
29	*Centella asiatica*	Apiaceae	HC	0.04	2.00	2	A	1.000	2.46
30	*Boerhaavia repens*	Nyctaginaceae	CH	0.82	1.95	42	C	0.046	8.63
31	*Blumealacera*	Asteraceae	TH	0.22	2.75	8	A	0.344	4.44
32	*Anisomeles indica*	Lamiaceae	TH	0.08	1.33	6	A	0.222	2.23
33	*Amaranthus spinosus*	Amaranthaceae	TH	0.08	2.00	4	A	0.500	2.78
34	*Alternanthera sessilis*	Amaranthaceae	HC	0.98	2.04	48	C	0.043	9.82
35	*Aerva lanata*	Amaranthaceae	TH	0.32	1.78	18	A	0.099	4.59
36	*Achyranthus aspera*	Amaranthaceae	TH	0.72	1.71	42	C	0.041	8.00
37	*Ocimum basilicum*	Lamiaceae	TH	0.16	4.00	4	A	1.000	5.23
38	*Oldenlandia corymbosa*	Rubiaceae	HC	0.26	2.60	10	A	0.260	4.59
			SHRUBS						
1	*Cassia sophera*	Caesalpiniacea	CH	0.10	2.50	4	A	0.625	13.50
2	*Calotropis gigantea*	Asclepiadaceae	CH	0.10	1.25	8	A	0.156	8.86
3	*Clerodendrum infortunatum*	Lamiaceae	CH	1.54	4.05	38	B	0.107	33.36

SL. NO	PLANT NAME	family	Life- form	D	A	F	FC	A/F	IVI
4	*Abutilon indicum*	Malvaceae	CH	0.92	1.92	48	C	0.040	26.34
5	*Jatropha gossipyfolia*	Euphorbiaceae	CH	0.28	2.00	14	A	0.143	14.64
6	*Mucuna pruriens*	Fabaceae	PH	0.14	1.17	12	A	0.097	9.87
7	*Ricinus communis*	Euphorbiaceae	CH	0.30	1.67	18	A	0.093	14.44
8	*Tephrosia purpuria*	Papilionaceae	CH	1.34	1.52	88	E	0.017	38.56
9	*Sennaalata*	Fabaceae	PH	0.52	1.86	28	B	0.066	18.93
10	*Ziziphus oenoplia*	Rhamnaceae	CH	0.78	2.79	28	B	0.099	23.49
			CLIMBERS						
1	*Cajanus scarabaeoides*	Fabaceae	PH	0.84	2.33	36	B	0.065	58.79
2	*Gymnema sylvestre*	Apocynaceae	PH	0.14	1.75	8	A	0.219	18.38
3	*Pergularia daemia*	Asclepiadaceae	PH	0.24	1.09	22	B	0.050	25.07
4	*Ipomoea obscura*	Convolvulaceae	PH	0.36	1.80	20	A	0.090	31.95
5	*Paederia foetida*	Rubiaceae	PH	0.22	1.22	18	A	0.068	23.13
6	*Cocculus hirsutus*	Menisper-maceae	PH	0.74	1.12	66	D	0.017	63.91
7	*Cayratia trifolia*	Vitaceae	PH	0.06	3.00	2	A	1.500	19.67
8	*Cardiospermum hali-cacabum*	Sapindaceae	PH	0.10	2.50	4	A	0.625	19.21
9	*Abrus precatorius*	Fabaceae	PH	0.10	1.67	6	A	0.278	15.59
10	*Mikania scandens*	Asteraceae	PH	0.24	1.50	16	A	0.094	24.32

Table 2: Phyto-sociological attributes of different plant species of Nimcha-Harabhanga wasteland

SL. NO.	PLANT NAME	FAMILY	Life-form	D	A	F	FC	A/F	IVI
			TREES						
1	*Acacia auriculiformis*	Mimosaceae	PH	0.06	1.00	6	A	0.167	6.48
2	*Acacia nilotica*	Mimosaceae	PH	0.30	1.88	16	A	0.117	18.52
3	*Ailanthus excelsa*	Simaroubaceae	PH	0.04	1.00	4	A	0.250	5.20
4	*Alangium salviifolium*	Cornaceae	PH	0.42	1.40	30	B	0.047	25.71
5	*Albizzia lebbek*	Mimosaceae	PH	0.10	1.25	8	A	0.156	8.90
6	*Alstonia scholaris*	Apocynaceae	PH	0.04	1.00	4	A	0.250	5.20
7	*Azadirachta indica*	Meliaceae	PH	0.12	1.50	8	A	0.188	10.03
8	*Borassus flabellifer*	Arecaceae	PH	0.10	1.67	6	A	0.278	9.20
9	*Butea monosperma*	Fabaceae	PH	0.92	3.54	26	B	0.136	41.69
10	*Dalbergia sissoo*	Papilionaceae	PH	0.10	1.67	6	A	0.278	9.20
11	*Eucalyptus globulus*	Myrtaceae	PH	0.06	1.50	4	A	0.375	7.01
12	*Ficus benghalensis*	Moraceae	PH	0.04	2.00	2	A	1.000	7.06
13	*Ficus religiosa*	Moraceae	PH	0.04	2.00	2	A	1.000	7.06
14	*Gmelina arborea*	Lamiaceae	PH	0.04	2.00	2	A	1.000	7.06
15	*Lagerstroemia speciosa*	Lythraceae	PH	0.04	2.00	2	A	1.000	7.06
16	*Phoenix dactylifera*	Arecaceae	PH	0.08	2.00	4	A	0.500	8.81
17	*Senna siamea*	Caesalpiniaceae	PH	0.06	1.50	4	A	0.375	7.01
18	*Streblus asper*	Moraceae	PH	0.96	1.60	60	C	0.027	51.10
19	*Ziziphus jujuba*	Rhamnaceae	PH	0.68	1.21	56	C	0.022	41.81

SL. NO.	PLANT NAME	FAMILY	Life-form	D	A	F	FC	A/F	IVI
			HERBS						
	Plant Name	**Family**		D	A	F	FC	A/F	IVI
1	*Triumfetta rhomboidea*	Tiliaceae	TH	0.56	0.80	70	D	0.011	7.03
2	*Tridax procumbens*	Asteraceae	TH	0.96	0.77	124	E	0.006	11.51
3	*Solanum virginianum*	Solanaceae	TH	0.30	1.00	30	B	0.033	4.09
4	*Solanum sisymbriifolium*	Solanaceae	TH	0.32	1.00	32	B	0.031	4.27
5	*Sida cordata*	malvaceae	TH	0.30	3.75	8	A	0.469	6.42
6	*Sida acuta*	malvaceae	TH	0.06	1.50	4	A	0.375	2.40
7	*Senna obtusifolia*	Caesalpiniaceae	TH	0.12	1.00	12	A	0.083	2.42
8	*Saccharum spontaneum*	Poaceae	TH	0.64	0.25	260	E	0.001	17.45
9	*Cyperus rotundus*	Cyperaceae	CRY	0.24	0.55	44	C	0.012	4.08
10	*Parthenium histerophorus*	Asteraceae	TH	1.14	1.58	72	D	0.022	10.23
11	*Oxalis corniculata*	Oxalidaceae	HC	0.22	1.00	22	B	0.045	3.34
12	*Oplismenus compositus*	Poaceae	TH	1.18	1.97	60	C	0.033	10.19
13	*Mimosa pudica*	Mimosaceae	HC	0.24	1.00	24	B	0.042	3.53
14	*Merremia tridentata*	Convolvulaceae	HC	0.10	5.00	2	A	2.500	6.99
15	*Melochia corchorifolia*	Malvaceae	HC	0.04	1.00	4	A	0.250	1.68
16	*Hyptiss uaveolens*	Lamiaceae	TH	0.10	1.25	8	A	0.156	2.44
17	*Heliotropium indicum*	Boraginaceae	TH	0.08	2.00	4	A	0.500	3.12
18	*Gomphren aserrata*	Amaranthaceae	TH	1.16	2.07	56	C	0.037	10.03
19	*Gamochaeta coarctata*	asteraceae	TH	1.68	5.60	30	B	0.187	14.99
20	*Evolvulus nummularis*	Convolvulaceae	HC	1.12	1.60	70	D	0.023	10.07
21	*Euphorbia hirta*	Euphorbiaceae	TH	1.04	1.79	58	C	0.031	9.35
22	*Eupatorium odoratum*	Asteraceae	CH	1.78	2.12	84	E	0.025	13.89
23	*Eragrostis cilianensis*	Poaceae	HC	1.74	3.11	56	C	0.055	13.44
24	*Eclipta alba*	Asteraceae	TH	1.02	1.82	56	C	0.033	9.20
25	*Desmodium triflorum*	Papilionaceae	HC	0.56	1.00	56	C	0.018	6.50
26	*Desmodium gangeticum*	Papilionaceae	HC	0.38	1.12	34	B	0.033	4.75
27	*Dactyloctenium aegyptium*	Poaceae	TH	2.22	2.71	82	E	0.033	16.11
28	*Cynodon dactylon*	Poaceae	HC	2.84	3.16	90	E	0.035	19.36
29	*Croton bonplandianus*	Euphorbiaceae	TH	0.82	3.15	26	B	0.121	8.52
30	*Crotalaria juncea*	Papilionaceae	TH	0.42	2.33	18	A	0.130	5.57
31	*Coldenia procumbens*	Boraginaceae	TH	0.04	2.00	2	A	1.000	2.87
32	*Cleome viscosa*	Cleomaceae	TH	0.62	2.21	28	B	0.079	6.69
33	*Centella asiatica*	Apiaceae	HC	0.04	2.00	2	A	1.000	2.87
34	*Boerhaavia repens*	Nyctaginaceae	CH	0.82	1.95	42	C	0.046	7.86
35	*Blumea lacera*	Asteraceae	TH	0.22	2.75	8	A	0.344	4.83
36	*Anisomeles indica*	Lamiaceae	TH	0.08	1.33	6	A	0.222	2.37
37	*Amaranthus spinosus*	Amaranthaceae	TH	0.08	2.00	4	A	0.500	3.12
38	*Alternanthera sessilis*	Amaranthaceae	HC	0.98	2.04	48	C	0.043	8.89
39	*Aerva lanata*	Amaranthaceae	TH	0.92	2.00	46	C	0.043	8.51
40	*Achyranthus aspera*	Amaranthaceae	TH	0.94	1.38	68	D	0.020	9.03
			SHRUB						
1	*Calotropis gigantea*	Asclepiadaceae	CH	0.10	1.25	8	A	0.156	15.34

SL. NO.	PLANT NAME	FAMILY	Life-form	D	A	F	FC	A/F	IVI
2	*Calotropis procera*	Asclepiadaceae	CH	0.06	1.50	4	A	0.375	14.73
3	*Clerodendrum infortunatum*	Lamiaceae	CH	0.52	4.33	12	A	0.361	52.28
4	*Jatropha gossipyfolia*	Euphorbiaceae	CH	0.98	1.32	74	D	0.018	64.14
5	*Ricinus communis*	Euphorbiaceae	CH	0.18	1.00	18	A	0.056	19.24
6	*Tephrosia purpuria*	Papilionaceae	CH	0.86	0.98	88	E	0.011	63.21
7	*Urena lobata*	Malvaceae	CH	0.58	1.53	38	B	0.040	41.61
8	*Ziziphus oenoplia*	Rhamnaceae	CH	0.34	1.00	34	B	0.029	29.46

CLIMBERS

SL. NO.	PLANT NAME	Family	Life-form	D	A	F	FC	A/F	IVI
1	*Mikania scandens*	Asteraceae	PH	0.38	1.06	36	B	0.029	95.35
2	*Melothria scabra*	Cucurbitaceae	PH	0.28	2.33	12	A	0.194	70.00
3	*Luffa aegyptiaca*	Cucurbitaceae	PH	0.12	1.00	12	A	0.083	39.02
4	*Ipomoea obscura*	Convolvulaceae	PH	0.26	1.86	14	A	0.133	65.01
5	*Cocculus hirsutus*	Menispermaceae	PH	0.04	2.00	2	A	1.000	30.58

Cry: Cryptophytes, Hc: Haemicryptophytes, Th: Helophytes, Ph: Phenerophytes, Che: Chamaephyte
D=Density, A=Abundance, F=Frequency, FC=Frequency Class, , IVI=Important Value Index

Table 3: Species, family compositions of Damalia and Nimcha-Harabhanga waste land.

Species composition	Damalia	Nimcha-Harabhanga
trees		
No. of species	14	19
No of genus	14	17
No. of family	11	14
Herbs		
No. of species	38	40
No of genus	36	37
No. of family	19	20
Shrubs		
No. of species	10	8
No of genus	10	7
No. of family	8	6
climber		
No. of species	10	5
No of genus	**10**	**5**
No. of family	**9**	**4**

Table 4: Species diversity in the two study area of Raniganj Coal Field, India

PARAMETERS	HABITAT	DAMALIA	HARABHANGA
Species richness (D)	Tree	3.742	2.760
	Herbs	1.044	1.067
	Shrubs	0.576	0.595
	climbers	0.811	0.680
Evenness	Tree	1.970	1.780
	Herbs	2.033	2.049
	Shrubs	1.962	1.999
	climbers	1.987	2.042
Shannon	Tree	2.258	2.276
	Herbs	3.212	3.283
	Shrubs	1.962	1.806
	climbers	1.987	1.427
Simpson co-dominance	Tree	0.138	0.146
	Herbs	0.050	0.046
	Shrubs	0.168	0.188
	climbers	0.172	0.263
Jacard similarity index	Tree	57.14%	
	Herbs	71.11%	
	Shrubs	50%	
	climbers	33.33%	

Table 5: Representation of different life-forms of two study area and comparison of obtained biological spectrum with Raunkiaer's standard spectrum

Life-forms	No. of species		Raunkiaer's standard	Obtained biological spectrum	
	DAMALIA	HARABHANGA		DAMALIA	HARABHANGA
Phanerophyte	26	24	46	36.11	33.33
Therophyte	23	26	13	31.94	36.11
Hemicryptophyte	12	11	26	16.67	15.28
Chamaephyte	10	10	9	13.89	13.88
Cryptophyte	1	1	6	1.39	1.39

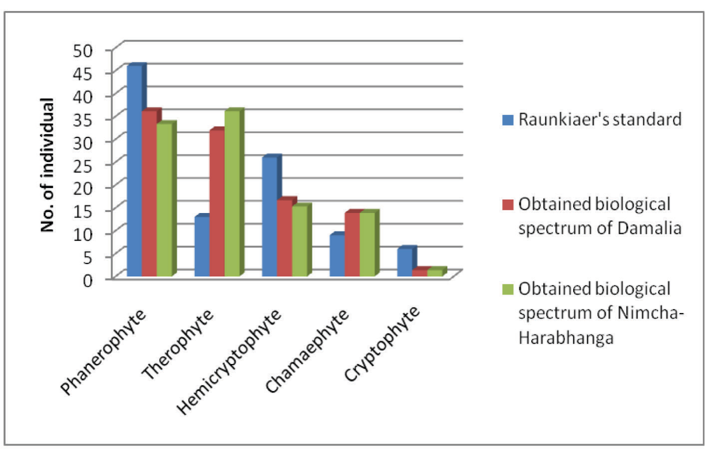

Figure 2: Graphical Representation of Different Life-forms of plant species of the study areas.

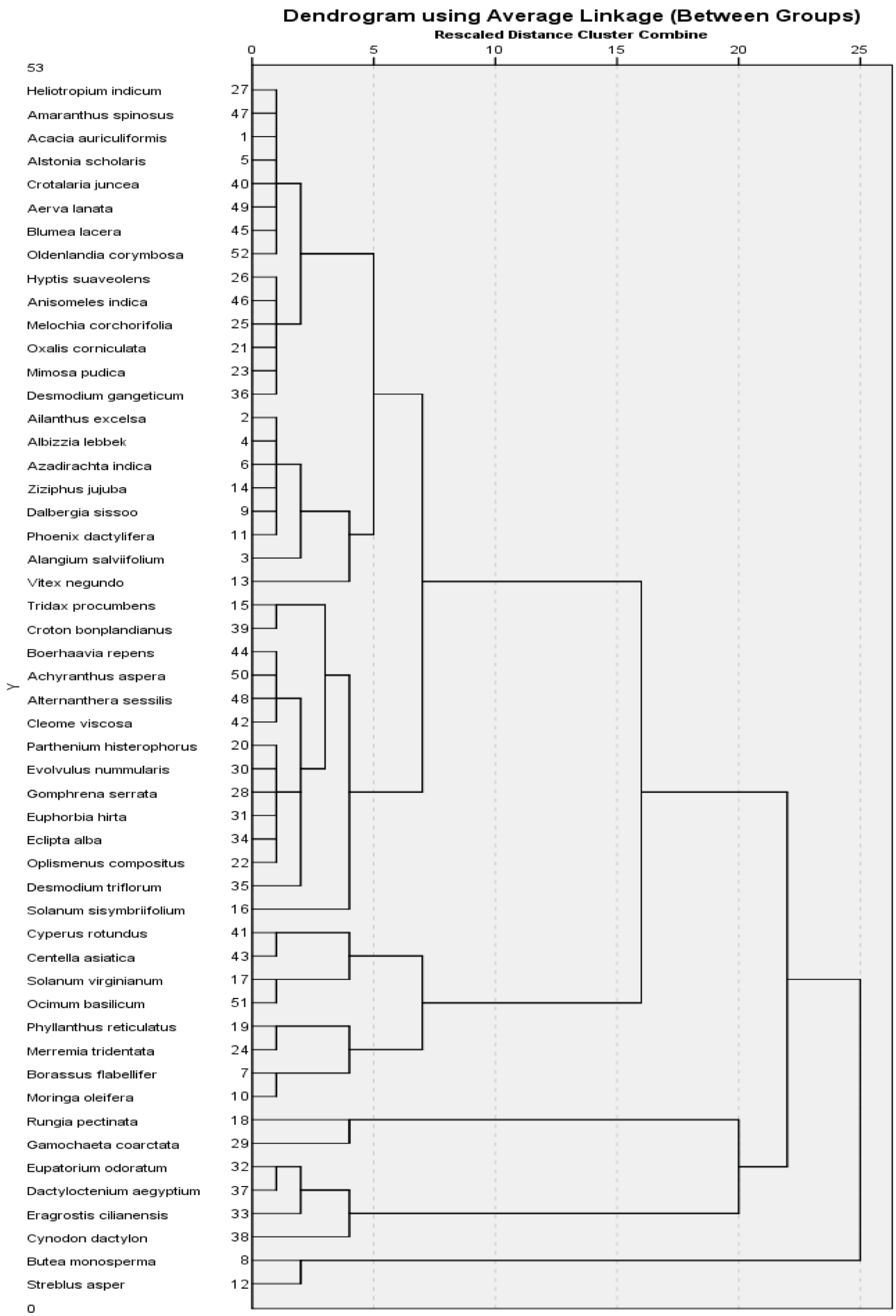

Figure 3: Dendrogram showing the relationship among tree and herb species of Damalia waste land based on their phytosociological attributes.

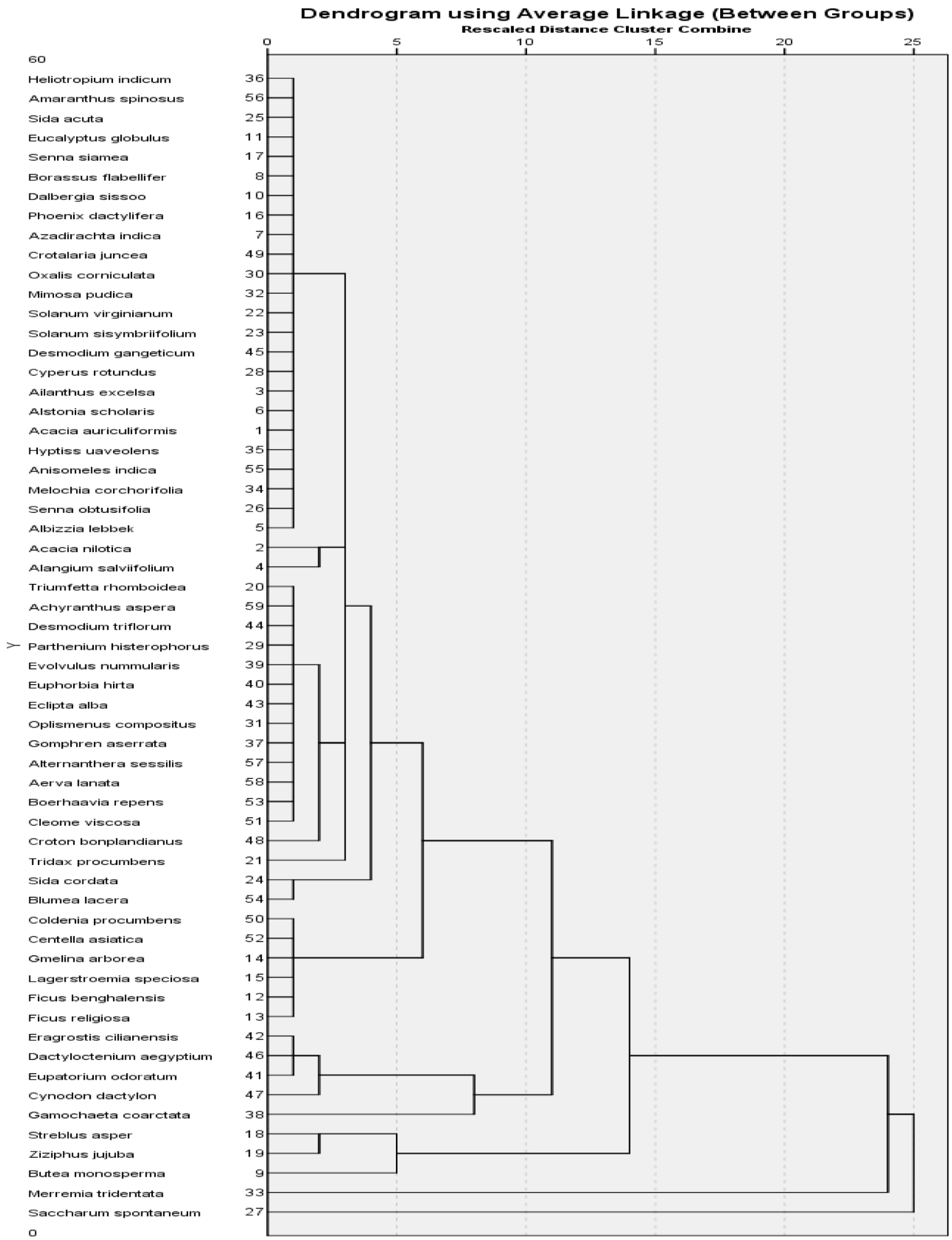

Figure 4: Dendrogram showing the relationship among tree and herb species of Nimcha-Harabhanga waste land based on their phytosociological attributes.

Table 6: PCA applied to the phytosociological parameters of tree layer in Damalia waste land

PC	Eigenvalue	% variance
1	3.28763	65.753
2	1.59083	31.817
3	0.1068	2.136
4	0.0147365	0.29473
5	2.31295E-07	4.6259E-06

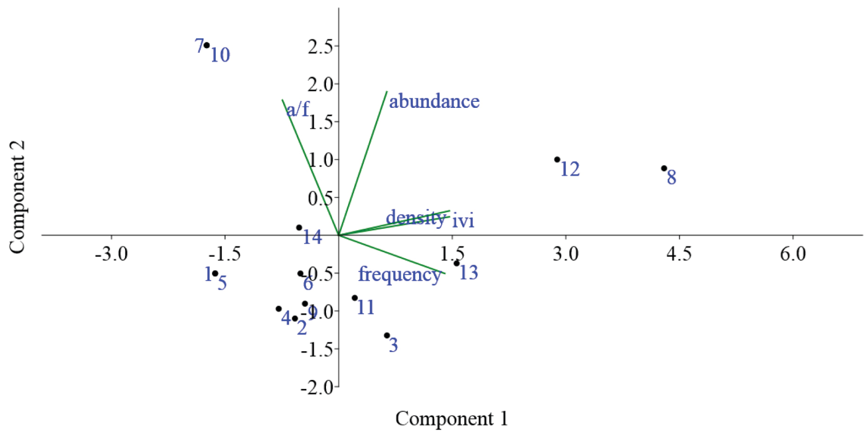

Figure 5: Bi-plot PCA-ordination diagram of the tree layer related to the phytosociological parameters in Damalia waste land. [Read the number (from 1-14) as individual tree species as represented in table 1].

Table 7: PCA applied to the phytosociological parameters of tree layer in Nimcha- Harabhanga waste land

PC	Eigenvalue	% variance
1	3.29629	65.926
2	1.30464	26.093
3	0.386264	7.7253
4	0.0128022	0.25604
5	5.7853E-08	1.1571E-06

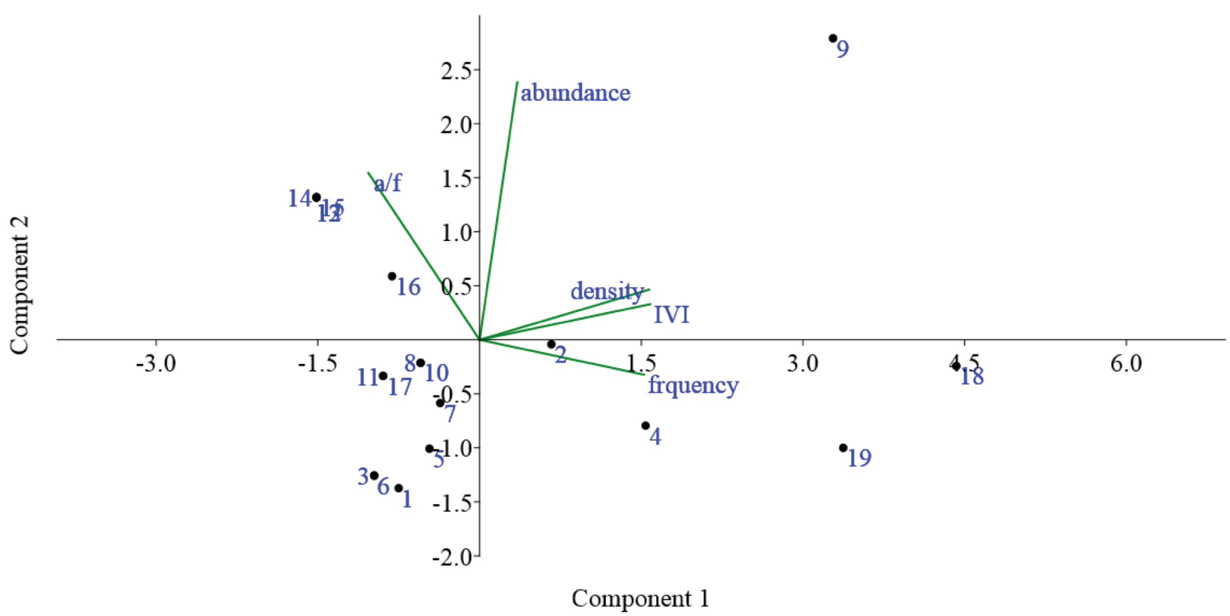

Figure 6: Bi-plot PCA-ordination diagram of the tree layer related to the phytosociological parameters in Nimcha-Harabhanga waste land. [Read the number (from 1-19) as individual tree species as represented in table 2].

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Conflict of Interest

As an author we do not have any conflict of interest in the present communication.

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