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Vegetational Diversity and Community Level Analysis in a Landfill Site for Solid Waste Disposal

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Abstract: A total of 177 species were recorded from all the three sites of the landfill/study area of Doon valley; cultivated species outnumbered the natural species in landfill sites and periphery. Dicots contributed 76.28% of the total vegetation. Herbs were dominating growth form. TWINSPAN classified the herbaceous vegetation of landfill site into five groups in rainy season, four groups in winter season and four groups in summer season. The high moisture content in the landfill site with high organic matter and other similar habitat parameters have clustered the vegetation of landfill sites and periphery. The results of a study indicating the great influence of soil parameters on the diversity and composition of vegetation are presented.

Key words: Community, diversity, landfill site, Twinspan.

Introduction

Municipal solid waste landfills are the ultimate means of disposal of all types of residual, residential, commercial and institutional waste as well as unutilized municipal solid waste from waste processing facilities and other types of inorganic waste and inerts that cannot be reused or recycled in the foreseeable future (Asnani, 2006). Landfill sites have become the essential component of any waste management concept.

The contaminants of landfill can negatively influence the plants (Nagendran et al., 2003). Many organic and inorganic components are known to be toxic to life forms including plants in dumpsites (Zacharias, 1995). Vegetation at completed landfill is often reported to be poor and damaged (Moffat and Houston, 1991; Gendebein et al., 1992). Bad odours, respiratory problems, headaches, nausea and dying vegetation are some common side effects (Berry and Bove, 1997).

Interestingly, plants have the marvelous capability to survive in many hostile environments on this planet (Larcher, 1995; Marmiroli and McCutcheon, 2003). At landfill sites, plants, fungi and bacteria develop and are continuously exposed to the polluted environment. They are affected by the surface environmental conditions. Landfills offer a large diversity of environmental niches for species. Alternate layers of waste and cover materials (soil) at landfills create microhabitats. In such conditions, a certain type of vegetation will have a competitive advantage and develop while other species will be rare. The growth of certain species indicates that they are tolerant to a given landfill environment. The vegetation composition and development on landfill could be used to indicate pollutant emissions (Maurice, 2001). Natural colonisation and succession depend not only on the age of the landfill, but also on the quantity and quality of the top covers (Konold and Zeltner, 1981; Huber-Humer and Klug-Pumpel, 2004). Singh (2006) and Borpujari (2008) observed sequential colonisation due to the plant succession.

The objective of this work was to monitor the soil parameters that have greatly influenced the diversity and composition of vegetation.

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Materials and Methods

Study Site

The study was carried out in 2009-2010 at municipal landfill site located in Dehradun, India. Dehradun is the capital of the state of Uttarakhand in India. It is situated at the Himalayan foothills. The picturesque Doon Valley has the Himalayas to its north, the Shivalik range to its south, the sacred river Ganga to its east and the river Yamuna to its west. The city of Dehradun is surrounded by river Song on the east, river Tons on the west, Himalaya ranges on the north and Sal forests in the south. Dehradun is surrounded by dense forest all around and number of streams and canals dissect the city in the north-south direction. The high hills in the east and north and the Sivaliks in the south give an interesting topographical setting to the city.

Municipal landfill site of Dehradun is located on the Sahastradhara Road (Figure 1). It is 4.5 km from the clock tower. Study site is located in 30° 20'53'' north latitudes and 78° 04'69'' east longitudes at an altitude of 720 metres (2362 ft.) above mean sea level. The landfill site covers the 4.5 acre area and is approximately flat with gentle slope of North to South direction. The plant diversity is rich at landfill site. This site is used for dumping the municipal waste for the last eight years. Landfill site is adjoining with the residential area. Many multistoried apartments have come up adjoining the present landfill site. The residents of the adjoining area experience several inconveniences due to the landfill site.

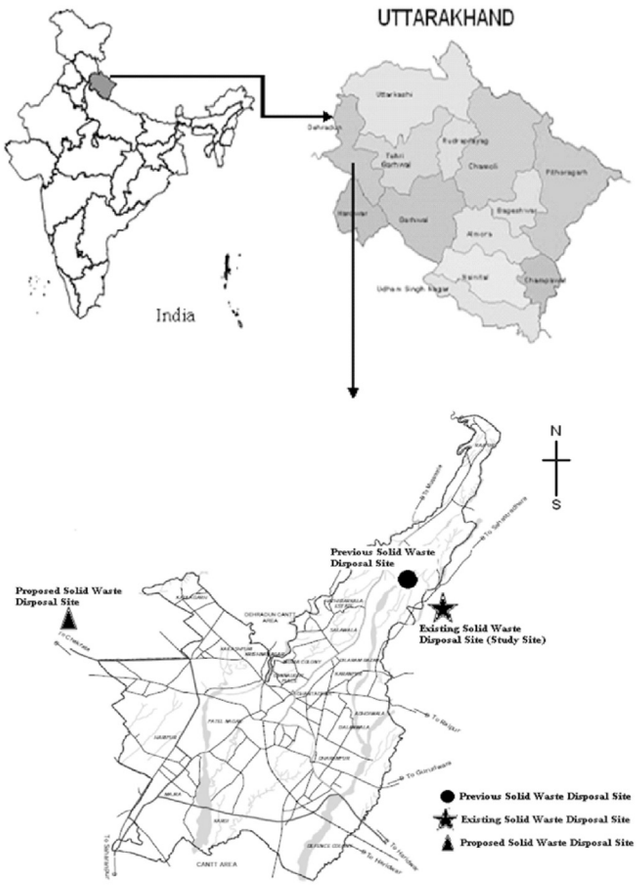

Figure 1: Map of study site situated in Dehradun, Uttarakhand, India.

Methods

Vegetation survey of plant communities was conducted in the selected sites during the mid of every three growing seasons like summer, rainy season and winter by using quadrate method. The vegetation was analyzed by means of random sampling to give most representative composition in three sites viz. landfill site, periphery of landfill site and adjoining area. Vegetation composition was evaluated by analyzing the frequency, density, abundance and importance value index (IVI) according to Mishra (1968) and Curtis and McIntosh (1951). A FORTRAN based computer package TWINSPAN was used to analyze the various associations between species.

Diversity index (H') of each sample stand was calculated using the method prescribed by Shannon and Wiener (1963) and Concentration of Dominance (CD) was calculated following the formula given by Simpson (1949). α-diversity was calculated according to Huston (1994). Evenness or equability index was calculated according to Pielou (1966 and 1969). The similarity among distributions of flora in different geographic areas was determined by Jaccard Similarity Index (Jaccard, 1912).

Composite soil site samples were collected from the selected site. Soil samples were analyzed for their physical and chemical characteristics according to Piper (1944).

Observations and Results

The municipal solid waste landfill site is rich in plant composition and has recorded the presence of 177 taxa. Of these, herbs show the maximum contribution of 121 plant species whereas 19 shrubs, 12 under-shrub, 8 climbers, 3 twiner and 14 tree species have been observed (Figure 2a). Dicots contributed maximum (76.28%) at species level. Herbs dominated the site over other growth forms (Figure 2b). 36 species recorded from the landfill site fall under cultivated plants category. Six species of ornamental plants and 135

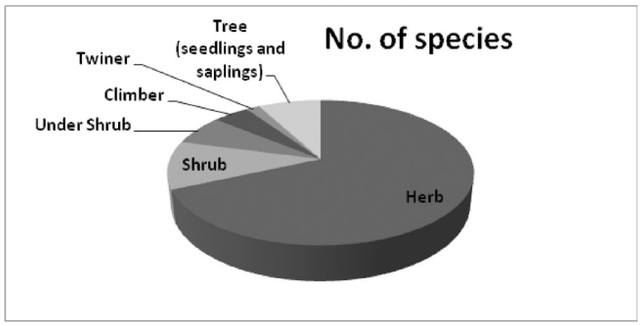

Figure 2a: Growth form in landfill site.

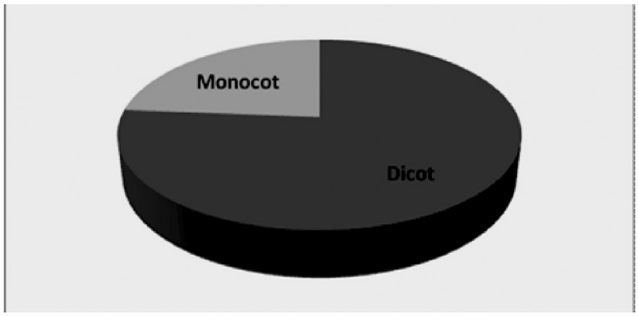

Figure 2b: Percentage contribution of dicots and monocots in the landfill site.

wild plant species were identified from the site. Thus, the diversity of landfill flora has 76.27% wild species, 20.34% cultivated species and 3.39% is ornamental species (Figure 3).

The physical analysis of soil reveals that soil moisture of top soil at landfill site is less than adjoining area. The highest water holding capacity of the soil (68.2%) was at landfill site. The soils of the study site are clayey-loam in texture. The chemical characteristics of the soil reveals the slightly acidic nature of soil at landfill site, pH ranging 4.61-7.41; soil conductivity primarily decreases and then slightly increases with depth at landfill site. The carbon percentage in the soil increases with the depth, it ranged between 0.95 and 2.01 percent at landfill site but it primarily decreases and then slightly increases with depth at adjoining area. Nitrogen percent increases with the depth at landfill site, it ranged 0.084-0.15 percent but it primarily decreases and then slightly increases with depth at adjoining area. Calcium, phosphorus and potassium contents increase with the depth at landfill site. Calcium decreases with depth in adjoining area. Phosphorus decreases in middle layer and slightly increases with lowest layer in adjoining area. Potassium content decreases with middle layer and the value of potassium content is same in middle and lower layers at adjoining area (Table 1).

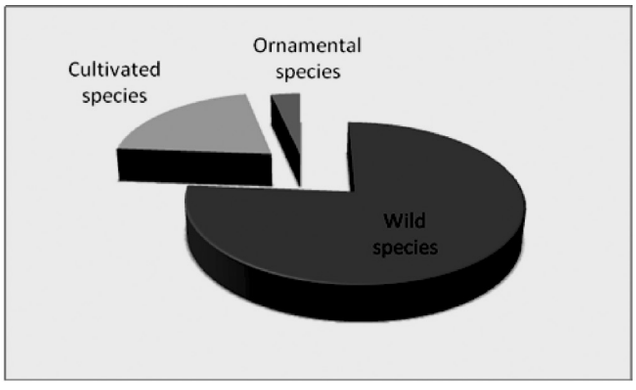

Figure 3: Life form (%) categories.

Phytosociological studies for herbs and shrubs at the selected sites were conducted at the mid of every three growing periods i.e., at the mid of February, May and August, to get an accountable change in the vegetation in different growing periods. On the basis of Importance Value Index (IVI), 12 communities have been reported from the site. *Cynodon dactylon* is highly dominant plant species in different sites in various seasons. At landfill site, *Xanthium strumarium* (IVI = 27.44), *Sesamum indicum* (IVI = 18.65) and *Cyperus rotundus* (IVI = 21.55) dominated in rainy season, *Sida rhombifolia* (IVI = 17.16), *Urochloa panicoides* (IVI = 20.75) and *Amaranthus spinosus* (IVI = 22.67) dominated in winter season and *Calotropis procera* (IVI = 40.0), *Chenopodium ambrosioides* (IVI = 41.18) and *Amaranthus spinosus* (IVI = 39.34) dominated in summer season (Table 2).

The Twinspan in the present study, based on IVI values of various species, classified all the three sites into various groups in different seasons on the basis of a common indicator species. The Twinspan classified 32 plant species into five groups in rainy season, 36 plant species into four groups in winter season and 16 plant species into four groups in summer season.

Species richness for herbs was recorded minimum in summer season and maximum in rainy season at landfill sites. At periphery of landfill site species richness was maximum in winter season and minimum in summer season. The value of species richness was same at adjoining area in summer and rainy season and less in winter season. Maximum species richness was recorded at periphery of landfill site (24) in winter season whereas the least value was recorded for landfill site and adjoining area (9) during the winter and summer seasons (Table 3).

Table 1: Physico-chemical characteristics of soils for the study sites

Site	*Soil depth (cm)*	*Mineral particles (%)*			*Texture class*	*Water holding capacity*	*pH*	*Conductivity (mmhos)*	*Organic carbon (%)*	*Nitrogen (%)*	*Calcium (ppm)*	*Phosphorus (ppm)*	*Potassium (ppm)*	*Organic matter (%)*	*C/N*
		Clay	*Silt*	*Sand*											
Landfill site	0-10	27.1	21.75	51.15	Clay loam	46.74	4.61	0.51	0.95	0.084	1125	28.0	117.0	4.14	01:11.3
	20-30	30.5	24.0	45.5	Clay loam	68.02	6.46	0.32	1.73	0.13	1300	35.2	170.2	7.49	01:13.3
	40-50	22.5	17.25	60.25	Loam	60.06	7.41	0.34	2.01	0.15	1800	36.4	264.0	8.71	01:13.4
Adjoining area	0-10	10.7	10.1	79.2	Sandy loam	48.41	7.42	0.1	1.28	0.11	2325	16.0	58.5	5.54	01:11.6
	20-30	13.8	12.0	74.2	Loam	49.14	7.09	0.07	0.83	0.091	1575	9.2	57.0	3.6	01:09.1
	40-50	13.8	12.2	74.0	Loam	48.0	7.15	0.07	0.92	0.092	1500	9.6	58.5	4.01	01:10

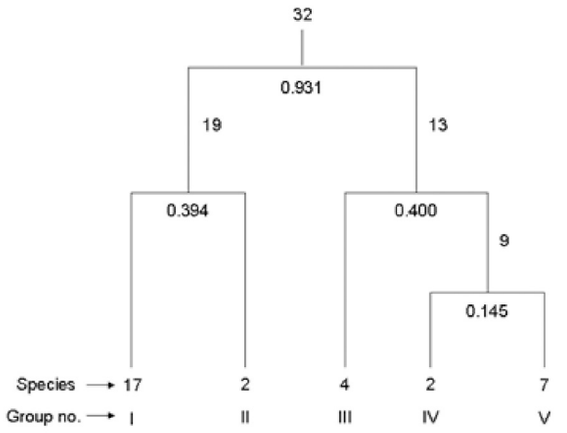

Figure 4a: Dendrogram of herb (rainy season) communities association formed through grouping of species composition by Twinspan (Eigen value inside the bar).

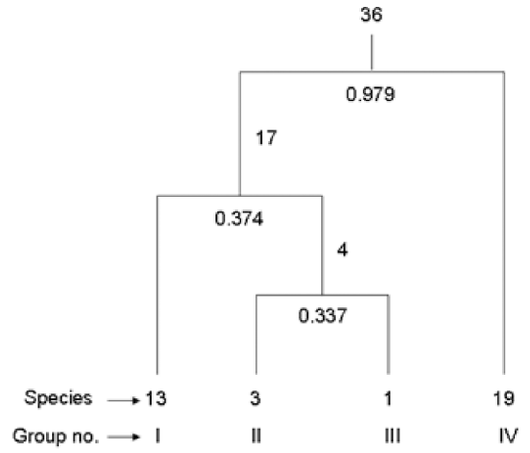

Figure 4b: Dendrogram of herb (winter) communities association formed through grouping of species composition by Twinspan (Eigen value inside the bar).

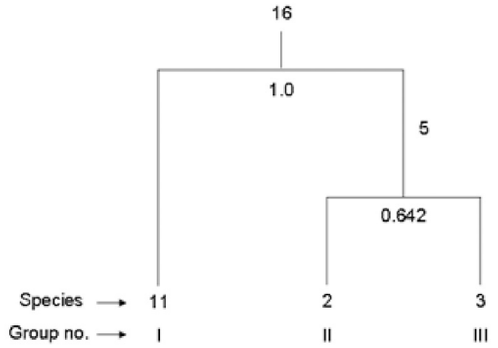

Figure 4c: Dendrogram of herb (summer) communities association formed through grouping of species composition by Twinspan (Eigen value inside the bar).

Table 2: IVI values of various herb species of different communities in different season at various sites

Botanical name	*Rainy season*			*Winter season*			*Summer season*		
	Land-fill site	*Periphery of landfill site*	*Ad-joining area*	*Land-fill site*	*Periphery of landfill site*	*Ad-joining area*	*Land-fill site*	*Periphery of landfill site*	*Ad-joining area*
Achyranthes aspera L.	7.7	14.86	16.25	9.59	-	-	-	-	-
Aerva sanguinolenta (L.) Blume	-	-	-	14.39	12.97	-	-	-	-
Ageratum conyzoides L.	-	7.91	10.35	19.98	-	43.44	-	-	-
Alternanthera sessilis L.	-	-	-	9.57	-	-	-	-	-
Amaranthus spinosus L.	9.6	11.39	-	22.67	11.34	-	39.34	30.97	-
Amaranthus viridis L.	10.14	12.65	-	-	29.86	-	-	-	-
Anisomeles indica (L.) Kuntze	-	-	-	-		25.86	-	-	-
Argemone mexicana L.	-	-	-	-	-	-	15.19	-	-
Benincasa hispida (Thunb.) Cogniaux	13.24	16.54	-	-	-	-	-	-	-
Bidens biternata (Lour.) Merr. & Sherff.	-	-	44.6	-	8.43	-	-	-	-
Boerhavia erecta L.	-	-	-	6.11	-	-	-	-	-
Calotropis procera (Aiton) Dryander	-	-	-	-	-	-	40	-	-
Cannabis sativa L.	-	-	-	-	11.19	-	-	14.23	-
Chenopodium album L.	-	-	-	-	13.07	-	19.02	12.4	-
Chenopodium ambrosioides L.	-	-	-	-	10.51	16.73	41.18	21.33	30.84
Cissampelos pareira L.	-	-	-	-	-	13.9	-	-	-
Citrullus fistulosus Stocks	-	-	-	-	-	-	-	21.93	-
Cleome viscosa L.	10.82	-	-	-	-	-	-	-	-
Commelina maculate Edgew	-	-	16.91	-	-	-	-	-	-
Coriandrum sativum L.	-	-	-	-	9.11	-	-	-	-
Cucurbita moschata Duchesne ex Poiret	11	-	-	-	-	-	-	-	-
Cynodon dactylon (L.) Persoon	78.52	44.48	27.8	93.2	33.13	94.97	84.18	95.97	109.72
Cyperus rotundus L.	21.55	16.58	-	-	-	-	-	-	-
Cyperus kyllingia Endl.	-	-	15.48	-	-	-	-	-	-
Eleusine indica (L.) Gaertner	-	-	-	13.82	-	-	-	-	-
Emilia sonchifolia (L.) DC.	-	-	-	-	7.77	-	-	-	-
Eupatorium adenophorum Spreng.	-	-	14.6	-	-	-	-	-	32.56
Euphorbia hirta L.	-	-	6.67	-	-	-	-	-	-
Foeniculum vulgare Mill.	-	-	-	-	12.01	-	-	-	-
Justicia simplex (D. Don) Yamazaki	-	-	-	8.84	-	-	-	-	-
Lapidagathis cuspidata Nees.	-	-	-	-	-	-	-	-	39
Lens culinaris Medik.	-	-	-	-	5.97	-	-	-	-
Lepidium virginicum L.	-	-	-	-	11.91	-	-	-	-

(*Contd.*)

Table 2: (*Contd.*)

Botanical name	*Rainy season*			*Winter season*			*Summer season*		
	Land-fill site	*Periphery of landfill site*	*Ad-joining area*	*Land-fill site*	*Periphery of landfill site*	*Ad-joining area*	*Land-fill site*	*Periphery of landfill site*	*Ad-joining area*
Luffa cylindrica (L.) M. Roemer	8.02	-	-	-	-	-	-	-	-
Lycopersicon lycopersicum (L.) Karsten	-	-	-	-	17.67	-	-	-	-
Malva verticillata L.	-	-	-	-	7.77	-	-	-	-
Malvastrum coromandelianum (L.) Garcke	-	21.45	11.42	14.89	-	25.14	-	-	-
Medicago laciniata (L.) Miller	-	-	-	-	7.37	-	-	-	-
Mimosa pudica L.	-	11.2	24.99	-	-	-	-	-	-
Momordica charantia L.	6.25	7.27	-	-	-	-	-	-	-
Mukia maderaspatana (L.) M. Roemer	9.28	14.79	-	-	-	-	-	-	-
Ocimum sanctum L.	8.27	-	-	-	-	-	-	-	-
Oxalis debilis Humb.	-	-	17.58	-	7.71	-	-	-	-
Parthenium hysterophorus L.	12.97	31.73	31.74	17.52	16.95	47.06	32.11	32.03	87.88
Pennisetum glaucum (L.) R.Br	5.21	-	-	-	-	-	-	-	-
Physalis minima L.	9.98	-	-	-	-	-	-	-	-
Physalis peruviana L.	-	17.59	-	-	-	-	-	-	-
Poa annua L.	5.55	35.86	38.03	-	-	-	-	-	-
Portulaca oleracea L.	-	-	-	-	-	-	-	18.28	-
Rumex hastatus D. Don	-	-	16.44	-	-	-	-	-	-
Rumex nepalensis Spreng.	-	-	-	8.78	17.36	-	-	-	-
Sesamum indicum L.	18.65	-	-	-	-	-	-	-	-
Sida rhombifolia L.	5.85	5.92	7.13	17.16	-	-	10.49	10.19	-
Solanum melongena L.	-	-	-	-	7.55	-	-	-	-
Solanum nigrum L.	6.64	8.17	-	11.11	12.22	13.34	-	13.5	-
Solanum tuberosum L.	-	-	-	-	10.23	-	-	-	-
Solanum indicum auct.non L.	-	-	-	11.55	-	19.56	-	-	-
Sonchus oleraceus L.	-	-	-	-	9.61	-	-	-	-
Tagetes erecta L.	-	-	-	-	8.27	-	-	-	-
Urochloa panicoides P. Beauv.	-	-	-	20.75	-	-	18.48	-	-
Xanthium strumarium L.	27.44	21.59	-	-	-	-	-	29.16	-

Table 3: Species richness, diversity, evenness and dominance for herbs of different sites (Municipal landfill site, Dehradun)

Period	*Site*	*Species richness*	*Diversity (H')*	*Evenness (E')*	*Dominance (Cd)*
Winter season	Landfill site	16	0.444	0.897	0.141
	Periphery of landfill site	24	0.667	0.992	0.058
	Adjoining area	9	0.250	0.906	0.178
Summer season	Landfill site	9	0.563	0.922	0.158
	Periphery of landfill site	11	0.688	0.903	0.160
	Adjoining area	15	0.313	0.915	0.264
Rainy season	Landfill site	21	0.656	0.908	0.110
	Periphery of landfill site	17	0.531	0.965	0.085
	Adjoining area	15	0.469	0.965	0.091

There was not much variation in the diversity of sites in different growing periods. For herbs, lowest diversity (H' = 0.313) was registered for adjoining area in summer season and high values (H' = 0.688) were recorded for periphery of landfill site in summer season. The diversity for herbs was always higher at landfill site and periphery of landfill site than adjoining area in different seasons (Table 3).

Evenness values for all the sites in different seasons did not show much variation. The value for evenness ranged between 0.897 and 0.992. The value dominance was ranged between 0.058 and 0.264.

Table 4 shows similarity between different communities at various sites in different seasons. It reveals highest vegetation similarity between landfill site and landfill periphery (48%) in rainy season and lowest similarity had high similarity in their vegetation during summer season between landfill periphery and adjoining area with 7.4%.

Discussion

Vegetation and population ecology on landfill sites helps us to know possible plant communities on different landfill top covers: the quality and quantity of soil seed banks in landfill top cover, to distinguish parts with a different history within one landfill, and to initiate a vegetation development on landfill top covers towards a plant community of higher ecological value.

It was observed that vegetation population is not equally spread at landfill site. Phytosociological plots of the vegetation on old landfill sites indicate not only the quality of the top cover, but also gaps in the cover where leachate emerges (Klug et al., 2008). The results of the study of vegetation generally regard the biodiversity, with floristic changes; the ecology, with increase in the ecological diversity, and the structure, with increase in the cover and complexity (Sartori and Assini, 2001).

The dichotomy in Figures 4a to 4c reveals that the organic matter, moisture, inconsistent soil substratum and relatively similar habitat conditions in landfill site and landfill periphery sites are the primary reason of clustering of these sites.

Evenness index indicates the even distribution of plant species on different patches. With respect to similarity index, dumps with smaller age difference are much closer in terms of species composition than the dumps with larger age difference and this point out the sequential nature of plant succession process on the different age series dumps.

Dominance of plant species showed decreasing trend with increase in the age of the dump. These point out the usual inverse relationship between the diversity and the dominance (Mishra and Mishra, 1981; Kullu and Behera, 2011).

Acknowledgement

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Table 4: Similarity % in various herb communities at study site in various seasons

Communities at various site	*Winter season*			*Summer season*			*Rainy season*		
	Landfill site	*Landfill periphery*	*Adjoining area*	*Landfill site*	*Landfill periphery*	*Adjoining area*	*Landfill site*	*Landfill periphery*	*Adjoining area*
Winter season									
Landfill site	1.0	0.14	0.32	0.19	0.17	0.11	0.9	0.27	0.15
Landfill periphery		1.0	0.14	0.14	0.13	0.7	0.10	0.14	0.11
Adjoining area			1.0	0.20	0.25	0.27	0.12	0.18	0.20
Summer season									
Landfill site				1.0	0.38	0.27	0.16	0.18	0.14
Landfill periphery					1.0	0.23	0.19	0.27	0.14
Adjoining area						1.0	0.9	0.20	0.18
Rainy season									
Landfill site							1.0	0.48	0.17
Landfill periphery								1.0	0.28
Adjoining area									1.0

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