RESEARCH ARTICLE

SEASONAL HERBS DIVERSITY AROUND DISTILLERY SPENTWASH DISCHARGE OF DISTRICT MEERUT (U.P.)

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Received-06.09.2016, Revised-26.09.2016

Abstract: The distillery spentwash contains a number of nutrients for plant growth but also heavy metals which became a serious concern for environment and human health after allowable concentration. The Importance Value Index of the species was estimated seasonally for each distillery spent wash discharge site. A total 57 species of herbaceous plants have been observed from three distilleries which belong to 28 families. Total species count was highest in rainy season and lowest in summer season although there is peak spent wash production in summer. The highest beta diversity was observed in winter season at central distillery while lowest at Daurala in summer season. The herbaceous vegetation showed a mosaic pattern which was more pronounced in rainy months than in summer and winter months. In conclusion, human population, climatic factors and concentration of industrial discharge influenced the species composition and diversity in these habitats.

Keywords: Beta diversity, Distillery spent wash, Importance Value Index, Species diversity, Species dominance.

INTRODUCTION

In the world, India is chief producer of sugar which contributes substantially to economic development of the country. The waste products of sugar factory like bagasse and molasses are also economically important. Molasses is the chief source of alcohol production in distillery unit by fermentation method. For the production of 1 liter of alcohol 3-10 kg of molasses is utilized. A large number of distilleries have been established in India to utilize molasses and is emitting huge quantities of distillery spent wash (Kumar *et. al*., 2011). As a result of rapid expansion of urban areas and due to increasing human settlements, the species composition of vegetation of peri-urban areas is getting changed. Land-use practices change the increase due to human population and have been recognized as major drivers of future changes in biodiversity (Sala *et al.*, 2000). The correlation between vegetation and its corresponding environmental parameters provides guidelines for understanding plant species composition and structure in a particular habitat, landscape and region (Munica, 1997). Attempts have been made to determine the factors that control plant species distribution and variation in vegetation composition (Glenn *et al*., 2002). All vegetation show more or less striking differences for every few feet.

Spatial patterns of species diversity change over multiple spatial scales. The pattern observed within a local community may be very different from those found over broader areas such as landscapes or regions (Willis & Whittaker 2002). According to Vellend (2001) “beta diversity” expresses the relationship between the total number of species in a set of study plots and average number of individuals, while “species turnover” is defined as the rate or magnitude of change in species composition along predefined spatial or environmental gradients. To him, “beta diversity” and “species turnover” are numerically equivalent, the difference being simply that "beta diversity" compares samples within a community while "species turnover" compares samples from different communities. Beta diversity has been the focus of theories relating species richness and the species-area function to habitat and distance (Arita & Rodriguez 2002; Balvanera *et al.* 2002; Tuomisto *et al*. 2003).

The herbaceous vegetation showed a mosaic pattern which was more pronounced in rainy months than in summer and winter months. Species dominance altered with sites and seasons with increasing tendency of herbs species like *Parthenium hysterophorus, Cannabis sativa* and *Chenopodium murale* (Kumar *et al*., 2010). According to them human population and industrial discharge influence the species composition and diversity in these habitats. The presence of *Cynodon dactylon, Boerhaavia diffusa, Parthenium hysterphorus* and *Xanthium strumarium* groups of species around waste water designated the area as land which strongly supporting the growth of such species (Shah *et. al.,* 2010). According to them Canonical Correspondence Analysis revealed that the distribution of vegetation has correlation with environmental variables, but their role in the grouping of species remained non-significant. The effect of disturbances on various vegetation parameters of the community had been analyzed. The information on the impact of such disturbances on the structure and composition of natural herbs vegetation is important for assessing plant diversity status and has implications for management of regional natural ecosystem.

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MATERIAL AND METHOD

Study Sites

Meerut is a metropolitan city located 56 km (35 mile) north-east of New Delhi. It is the fastest developing city of Uttar Pradesh after NOIDA and Ghaziabad. Meerut district is a part of upper Gangatic plain of Western Uttar Pradesh. The climate is sub-tropical having three seasons, rainy (July-October), winter (November-February) and summer (March-June). Three distilleries of district Meerut have been selected for this study (*i.e.* Daurala distillery, Central distillery Meerut cantt and Bajaj Hindustan distillery, Kinauni) and the vegetation is analyzed seasonally around each distillery spentwash discharge site to get a real picture of the entire natural vegetation growing under the studying distillery units.

Vegetation Analysis

A sample unit or quadrat of 1 m × 1 m area was used for observations on community organization. Total 9 sites representing herbaceous species were selected for vegetation sampling in one year (3 distilleries×3 seasons). At each site 10 quadrats were laid down to quantify the vegetation. The size and number of the quadrat required were decided by using species area curve (Misra, 1968) and the running mean method (Kershaw, 1973).

Species composition of the study sites was recorded at seasonal intervals from August 2008 to June 2012. The collective data was quantitatively analyzed for relative density, relative frequency and relative dominance. The Importance Value Index (IVI) for different species was calculated as a sum of relative frequency, relative density and relative dominance of each species. These values for different species of common habitat were summed to compare the species groups within the same stand and those of different stands.

Importance Value Index (IVI) = R.D. + R.Dom. + R.F.

Species diversity was calculated by using Shannon and Wiener information index (Shannon and Wiener, 1963):

$$H^I = \sum_{i=1}^{S} (Ni/N)\log_2(Ni/N)$$

Where:

H^I = Shannon and Wiener index

Ni = importance value of a species

N = Total importance value of all species in a community

The β diversity was calculated within vegetation at the study site following Whittaker (1975):

$$\beta D = SC/\bar{S}$$

Where:

SC is the total number of species occurring in a set of samples counting each species only once whether or not it occurs more than once and $\bar{S}$ is the average number of species per individual sample.

Concentration of dominance (CD) was calculated following Simpson (1949):

$$CD = \sum_{i=1}^{S} (Ni/N)^2$$

Where:

Ni = importance value of a species

N = Total importance value of all species in a community

Species richness indices

D1, Species count (Number of species/area; in the present study the no. of species that occurred in quadrats sampled)

D2, Margalef index (Clifford & Stephenson 1975)

$$D_2 = \frac{S-1}{\ln N}$$

D3, Menhinick index (Whittaker 1977)

$$D_3 = \frac{S}{\sqrt{N}}$$

D4, Evenness (Pielou 1966)

$$D_4 = \frac{D_3}{\ln N}$$

Similarity among the study sites within and across different seasons was estimated using the modified Sorenson similarity coefficient (Southwood, 1978) according to the following formula:

SC= 2jN/aN+bN

Where,

jN = sum of lesser values of RIVI in two communities;

aN = sum of RIVI of all species in community A;

bN = sum of RIVI of all species in community B.

RESULT AND DISCUSSION

In the present ecological investigation across various natural habitat conditions in developing areas of Meerut district 57 species of herbaceous plants have been observed which belong to 28 families. Papilionaceae (7), Poaceae (6), Asteraceae (7), Euphorbiaceae (3) and Malvaceae (3) had the maximum number of herbaceous species. Species dominant to three distilleries include *Chenopodium murale, Cannabis sativa, Parthenium hysterophorus, Medicago sativa, Argemone maxicana, Cynodon dactylon* and *Cyperus rotundus*. In the rainy season *Parthenium hysterophorus, Cyperus rotundus and Chenopodium murale* were dominant while in winter season *Chenopodium murale, Argemone maxicana, Cynodon dactylon and Medicago sativa* were dominant at different sites but in summer season

Cannabis sativa and Cynodon dactylon were dominant at the study sites. *Dactyloctenium aegypticum, Digitaria biformis, Trianthema portulacastrum, Cassia obtusifolia, Euphorbia hirta, Eragrostis ciliaris, Croton bonplandianum, Anagallis arvensis* and *Stelaria media* were also found, but around one or two distillery discharge site only.

Table 1. Variation in Importance Value Index (IVI) of herbs species in three seasons at three distillery spentwash discharge sites.

Species	**Rainy season**			**Winter season**			**Summer season**		
	DD	**CD**	**BHD**	**DD**	**CD**	**BHD**	**DD**	**CD**	**BHD**
Cynodon dactylon	27.73	17.32	28.29	31.74	17.52	19.62	18.46	54.04	31.54
Cenchrum biflorum								*11.73*	
Dactyloctenium aegypticum	15.16								
Digitaria biformis	24.16		22.19						
Parthenium hysterophorus	44.41	37.11	28.57				33.08	28.50	
Ageratum conyzoides					20.95				
Erigeron canadensis							15.81		
Chenopodium murale	37.01	28.63	50.98	38.88		33.55	29.23		
Chenopodium album						14.63			
Malvestrum coromendelium	14.44								
Malva sylvestris						13.99			20.46
Sida acuta		31.20					29.85		
Anagallis arvensis				30.99		12.20			
Argemone maxicana				61.65	50.34	48.13			
Cannabis sativa				31.65			60.33	65.53	67.04
Alternanthera sessilis				13.76	17.68	18.16	21.84		
Cocculus hirsutus							27.47	33.74	27.35
Oxalis corniculata	8.67	19.81	21.95		22.66	20.67			
Verbena brasiliensis	21.75								
Verbena officinallis	6.74								
Trianthema portulacastrum	23.66	12.72	22.38			7.12			
Medicago polymorpha						9.42			
Medicago sativa				33.05	45.40	22.27			
Eragrostis ciliaris		17.01							
Pluchea lanceolata							13.68	17.95	
Pluchea camphorata								20.92	
Alhagi pseudoalhagi							9.06		
Mililotus indica				12.34					
Crotalaria retusa			16.92						
Crotalaria medicaginea			12.79						
Cassia obtusifolia	7.84	26.13	27.74						
Portulaca quadrifolia	*7.33*								
Stelaria media	11.20		11.12		19.88	22.79		12.00	33.83
Fumaria indica				12.84					
Rumex dantatus					28.28				
Cyperus rotundus	23.64	9.74	22.79				10.62	17.82	12.04
Phyllanthus emblica		27.68							
Croton bonplandianum									22.73
Euphorbia hirta		17.32							
Coronopus didymus					*19.07*				
Blumea balsamifera					16.39				
Boerhavia diffusa									23.72
Sisymbrium officinale						10.69			

Withania somnifera						8.23			
Ipomea coptica	14.68								
Sonchus oleraceus	11.58	7.06							11.14
Amaranthus spinosus		15.10					19.65	37.79	
Leucas aspara		11.58							
Selliera radicans		7.63	8.12	9.50		11.89			9.57
Coccinia indica		13.98					10.92		14.15
Solanum surratense			9.95						
Commelina oxilaris			16.22						
Lepidium sativum				9.76	21.36				
Vicia sativa				13.85	8.29	12.99			
Verbascum chinense					11.82	13.66			
Achyranthes aspara									17.14
Dendalion blossom									9.24

DD=Daurala Distillery, CD=Central Distillery, BHD=Bajaj Hindustan Distillery

According to Odum (1971) in natural conditions contagious distribution is most common, preponderance of regular as well as random distribution reflects the magnitude of biotic interference such as grazing and looping in sites. Summer is the peak season for distillery spentwash production followed by winter and rainy season. Since, the spentwash is nutrient rich then it supports the vegetation. The high IVI of a species indicates its dominance and ecological success, its good power of regeneration and greater ecological amplitude. The Shannon-wiener diversity index (H^I) is one of the several diversity indices used to measure diversity in categorical data. The advantage of this index is that it takes into account the number of species and the evenness of species. Any given community will have a maximum Shannon index if and only if each species represented, is composed of same number of individuals. It is varied from 2.6479 (CD) to 3.3519 (BHD) in summer season, 2.2251 (BHD) to 3.4178 (CD) in rainy season and from 2.2407 (DD) to 3.3416 (BHD) in winter season. In this way the highest species diversity was found at CD in rainy season while lowest at BHD in rainy season.

Table:2 Comparative species diversity at three distillery sites in three seasons of the year

Year	Summer Season			Rainy Season			Winter Season		
	DD	**CD**	**BHD**	**DD**	**CD**	**BHD**	**DD**	**CD**	**BHD**
2008	--	-	-	2.6982	2.5019	2.2251	2.2407	2.5481	2.5239
2009	3.1033	2.7737	2.7100	3.2238	3.0695	2.9347	2.6851	2.6961	2.7172
2010	2.7407	2.6479	2.6570	3.2799	3.2824	3.2495	3.0081	3.0489	3.0924
2011	2.6927	2.6842	3.3519	3.3599	3.4178	3.2554	2.9494	3.0550	3.3416
2012	2.8904	2.7415	2.7974	-	-	-	-	-	-

DD=Daurala Distillery, CD=Central Distillery, BHD=Bajaj Hindustan Distillery

The higher value (2.143) of beta diversity observed at CD in winter season can be linked to distribution of plants along the discharge gradient. Low species turnover (1.455) at DD in summer season reflects the co-occurrence of species in those elevational ranges. Species turnover had fluctuation in values as the spentwash discharge differences became larger. Gupta and Rup Narayan (2006) reported beta diversity from 1.98 to 11.21. The low value of beta diversity indicates that species composition do not vary much from one site to another site or seasons.

Table 3. Comparative beta diversity at three distillery sites in three seasons of the year

Year	Summer Season			Rainy Season			Winter Season		
	DD	**CD**	**BHD**	**DD**	**CD**	**BHD**	**DD**	**CD**	**BHD**
2008	-	-	-	1.944	2.00	1.786	2.000	2.143	2.069
2009	2.093	1.842	2.121	1.852	1.957	2.105	1.556	1.750	1.667
2010	1.667	1.750	1.842	1.774	1.667	1.667	1.837	1.731	1.765
2011	1.795	1.795	1.964	1.618	1.692	1.786	1.667	1.636	1.961
2012	1.455	1.628	1.861	-	-	-	-	-	-

DD=Daurala Distillery, CD=Central Distillery, BHD=Bajaj Hindustan Distillery

Concentration of dominance (Cd) ranged from 0.0966 (CD) to 0.2275 (BHD). The values of concentration of dominance were generally low indicating that dominance was shared by more than one or many species but higher at BHD so, only few species are dominant. Risser and Rice (1971) have reported values of Cd as 0.10 to 0.99 for certain temperate vegetation indicating presence of a few species.

Table 4. Comparative concentration of dominance at three distillery sites in three seasons of the year

Year	Summer Season			Rainy Season			Winter Season		
	DD	**CD**	**BHD**	**DD**	**CD**	**BHD**	**DD**	**CD**	**BHD**
2008	-	-	-	0.1671	0.1868	0.2275	0.2215	0.1750	0.1810
2009	0.1228	0.1501	0.1627	0.1161	0.1274	0.1368	0.1697	0.1650	0.1559
2010	0.1565	0.1761	0.1743	0.1161	0.1057	0.1119	0.1423	0.1321	0.1271
2011	0.1695	0.1701	0.1069	0.1038	0.0966	0.1088	0.1340	0.1299	0.1169
2012	0.1464	0.1565	0.1692	-	-	-	-	-	-

DD=Daurala Distillery, CD=Central Distillery, BHD=Bajaj Hindustan Distillery

During rainy season soil moisture favored occurrence of larger number of the herbaceous plant species and their population on account of semi-arid climate of this area (Sharma & Upadhyaya, 2002). However, only a few species occurred throughout the study period (e.g. *Chenopodium murale, Cynodon dactylon, Parthenium hysterophorus* and *Cannabis sativa*), evidently due to the wide ecological amplitude of these species under the prevailing climatic conditions. Exotic species like *Parthenium hysterophorus* have become naturalized in India, and have affected the distribution of native flora by completing 2-3 generations annually. Occurrence of this species at all sites with increased dominance suggests that habitats modified due to persisting disturbance (e.g. grazing and anthropogenic pressure) create platform for the onset of biological invasion by such species (Schei, 1996).

Table 5. Spatial and seasonal similarity of the site vegetation based on similarity coefficient applying Modified Sorenson Index (using species RIVI).

	RCD	**RBD**	**WDD**	**WCD**	**WBD**	**SDD**	**SCD**	**SBD**
RDD	**.046**	.050	.054	.050	**.046**	.053	.062	.053
RCD		.051	.055	.051	.047	.054	.063	.054
RBD			.059	.055	.051	.057	.066	.059
WDD				.059	.055	.062	**.071**	.063
WCD					.051	.059	.067	.058
WBD						**.**054	.063	.055
SDD							.069	.061
SCD								.070

Higher number of species in a community is ecologically important as they showed great heterogeniosity within habitat. Results of the present study indicate that vegetation still posses comparatively higher species diversity even after under continuous biotic influences. It may be attributed to greater heterogeneity of physical conditions and a greater potential of regeneration and hardiness of the species. Highest similarity coefficient was found between central distillery in summer season and Daurala distillery in winter season while lowest similarity coefficient was found between Bajaj Hindustan distillery in winter season and Daurala distillery in rainy season (Table 5).

Dominance diversity curves were prepared by plotting species importance value index against the sequence of dominant species from highest to lowest IVI in each season among three distilleries (Whittaker, 1975).

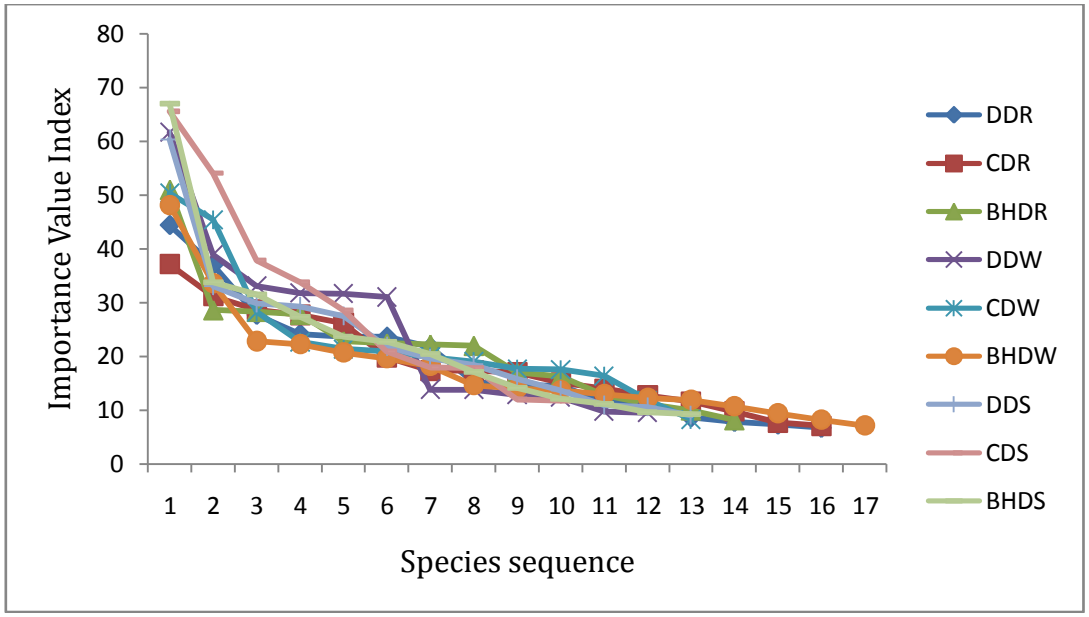

Figure 1: Dominance Diversity Curves of vegetation across different sites and seasons (W=Winter Season, S= Summer Season, R= Rainy Season**).**

Dominance-diversity curves for vegetation at different sites and seasons showed that generally one or two species in the vegetation at all sites exploited major share of resources (Fig. 1). This trend was more apparent in vegetation at BHD site in summer season where a near geometrical pattern of resource share was noticed. Here, *Cannabis sativa* seems to exploit major resources as evident by its largest share of IVI. Also in rainy season, this resource share pattern of species at BHD site is due to the top dominant *Chenopodium murale*. *Argemone maxicana* showed the highest resource share in winter season at Daurala distillery site.

Table 6. Diversity estimates of the vegetation at various study sites in three seasons using different diversity indices.

Diversity indices	**Summer Season**			**Rainy Season**			**Winter Season**		
	DD	**CD**	**BHD**	**DD**	**CD**	**BHD**	**DD**	**CD**	**BHD**
D_1(species count)	13	10	13	16	16	14	12	13	17
D_2(Margalef)	2.104	1.578	2.104	2.630	2.630	2.279	1.929	2.104	2.805
D_3(Menhinick)	0.751	0.577	0.751	0.924	0.924	0.808	0.693	0.751	0.981
D_4(Evenness, P.)	1.114	1.177	1.224	1.133	1.102	1.105	1.095	1.106	1.030

(DD=Daurala Distillery, CD=Central Distillery, BHD=Bajaj Hindustan Distillery)

Table 6 summarizes the seasonal diversity levels, in terms of four diversity indices at different sites using IVI of species (i.e. N = 300). Different indices ranked the site diversity differently. The values of richness indices viz. species count (D_1), Margalef index (D_2) and Menhinick's index (D_3) were found to be maximal in the winter season at BHD. In contrast, the CD site in summer season showed the lowest value. In terms of D_4 BHD site in summer season has highest value.

CONCLUSION

Summer is the peak season for distillery spentwash production but due to climatic factors and biotic interference, the number of species growing is lower than rainy and winter season. Some species are dominant due to favorable conditions and their high adaptation to the distillery spentwash while the presence of some species (*Cenchrum biflorum, Pluchea lanceolata, Pluchea camphorata, Alhagi pseudoalhagi*, *Croton bonplandianum, Boerhavia diffusa, Achyranthes aspara* and *Dendalion blossom*) at one or two sites is due to their less adaptation. The pattern of diversity change has often been related to the degree of disturbance in non-equilibrium ecosystems. Various diversity estimates were found higher rainy season followed by winter and summer season. It was further evident by low species turnover (β diversity) among the three sites indicating no significant difference in composition and structure among the three distilleries.

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