

Assessment and Distribution of Coastal Plant Species Diversity at Junagadh District, Gujarat

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ABSTRACT

Biodiversity explores and supports the ecological process baseline condition and it requires implementation of the biological diversity conservation and requires assessment and management of its effectiveness. Vegetation diversity measurement improves a protected ecosystem and maintains and restores a high diversity value and its potential significance. This study evaluated the potential seasonal diversity, based on vascular plant species across the particular twelve locations of the coastal region of Junagadh District. A total of 29 individual plant species representing 20 families to calculate analytical variance with three diversity indices, such as Shannon's index, Simpson index, and Pielou's index. The plant habitat requirements and potential biodiversity among the different coastal regions were associated with different coastal regions. The result revealed significant differences between the two seasons and the different ecological

areas to be performed with the ANOVA test. The present study shows remarkable differences in spatial distributions and ecological requirements. The plant diversity values change across the different coastal regions, it useful tool for conservation strategies and coastal landscape management.

Keywords Biodiversity, Conservation, Diversity indices, ANOVA, Landscape management.

INTRODUCTION

At about 1600 km, Gujarat on the west coast has the longest coastline amongst the Indian states and is bestowed with several good floras. Approximately 60% of the global population lives in coastal areas having high ecological and economic significance and values (Vyas and Joshi 2013). A halophyte is a plant that grows in the saline area and is also affected by salinity in the root area. Halophytes, as integral parts of many marines, coastal and terrestrial ecosystems are believed to play an important future role for biosaline agriculture, aquaculture, and habitat restoration (Böer 2004). The coastal organisms are directly dependent on coastal sand dune vegetation for food, fodder, health, reproduction, protection, manure, and recreation. Actually, a few numbers of publications are presented on the floral diversity of Indian sand dunes (Sridhar and Bhagya 2007). The vegetation of halophytic species is influenced by several stress factors such as ion toxicity, deficiency of nutrients, suboptimal soil pH, high osmotic pressure and unfavorable soil structure (Füzy *et al.* 2010).

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This study has investigated and provided quantitative and scientific data on the diversity of coastal flora growing in different habitats of selected sites in the coastal area of Junagadh district of Gujarat, India. Assessment of diversity status is important for their sustainable utilization, management and conservation (Podong and Krivutthinun 2018). It has been acknowledged that halophytic plants ecosystems provide ecological services to the coastal area (Hadiyanto *et al.* 2018). Vegetation analysis support to capture of information about vegetation configuration, niche, similarity as well as diversity and species richness in a particular habitat (Khan *et al.* 2017, Naidu and Kumar 2016), quantitative and comparative analysis of plant communities in ecological studies (Mandal and Joshi 2014, Tarin *et al.* 2017, Sorecha and Deriba 2017, Zhang *et al.* 2013). The information and awareness about the plant diversity in a particular habitat is a commencement detail for the conservation and management of biodiversity (Dutta and Devi 2013, Archer and Stokes 2000, Kharkwal 2009, Shaheen *et al.* 2012).

MATERIALS AND METHODS

A total of 12 locations included in Mangrol and Maliya Taluka of the Junagadh District region (21°13'N to 21°00'N and 69°59' E to 70°13' E) were selected as the study area for this investigation (Fig. 1). Diversity indices were studied by 3 twin belt transects (10×1 m) laid down at selected locations. Plant species

were recorded in five alternative segments (1×1 m) of either of the twin belt transect. Diversity indices such as Shannon's index, Simpson index, and Pielou's index (Kent 2011) were calculated.

RESULTS AND DISCUSSION

The study areas are composed of different habitats of the coastal region in the Junagadh District of Gujarat. The selected sites of the coastal region showed differences in terms of various structural attributes such as frequency, density, abundance, relative density and diversity indices like diversity index (Shannon's index), species richness (Simpson index) and species evenness (Pielou's index). Diversity, richness and similarity of the flora are providing vital information about the vegetation of coastal flora. Shannon's index (H') provides higher diversity in a particular location, Simpson index (D) provides species richness, whenever 1 value indicates low species richness and 0 value indicates higher species richness and Pielou's index (J) provides similarity or commonness of species, a higher value indicates similarity and less value indicate dissimilarity. Simpson's index of diversity gives very little weight to rare species, while Shannon-Wiener's index is most sensitive to rare species.

Location 1 Antroli

This sandy habitat supported five plant species *C.*

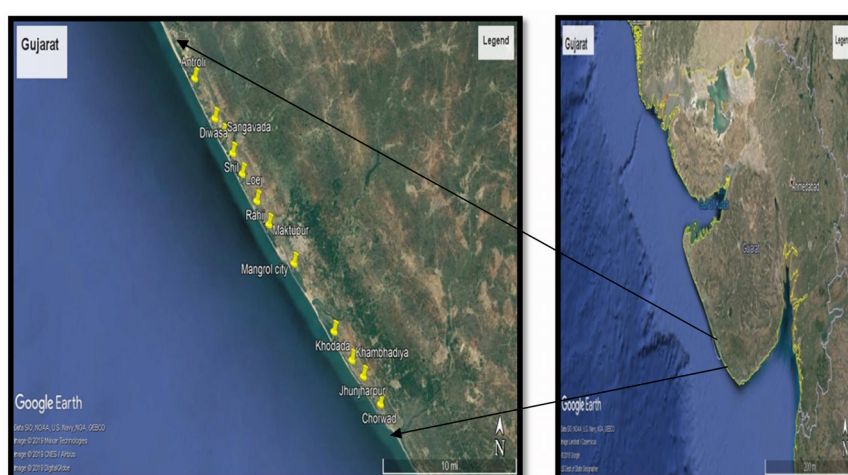


Fig. 1. Study area of Junagadh district Gujarat (Source: Google earth).

Table 1. Diversity indices for plant communities growing in the 'Junagadh' district coastal region.

Location	Seasons	S*	H'	D	1/D	J
L1	W	5	0.4817	0.3936	2.5406	0.6881
	M	5	0.4703	0.4009	2.4943	0.6724
	S	5	0.5120	0.3620	2.7624	0.7325
L2	W	4	0.4976	0.3289	3.0404	0.8254
	M	4	0.4893	0.3370	2.9673	0.8122
	S	4	0.5027	0.3262	3.0656	0.8338
L3	W	3	0.3220	0.5357	1.8667	0.6748
	M	3	0.3054	0.5441	1.8378	0.6392
	S	1	0	1	1	0
L4	W	4	0.4982	0.3538	2.8264	0.8271
	M	4	0.4957	0.3338	2.9958	0.8221
	S	3	0.3041	0.5859	1.7067	0.6371
L5	W	3	0.4666	0.1166	8.5763	0.9766
	M	3	0.4226	0.4083	2.4491	0.8844
	S	1	0	1	1	0
L6	W	3	0.4530	0.3721	2.6874	0.9494
	M	3	0.4721	0.3412	2.9308	0.9892
	S	1	0	1	1	0
L7	W	5	0.6121	0.2547	3.9261	0.8755
	M	5	0.6213	0.2457	4.0700	0.8884
	S	5	0.6171	0.2519	3.9698	0.8827
L8	W	5	0.6319	0.2481	4.0306	0.8483
	M	4	0.5115	0.3390	2.9498	0.8487
	S	4	0.5429	0.3190	3.1347	0.9002
L9	W	4	0.5932	0.2598	3.8491	0.9849
	M	4	0.5931	0.2600	3.8461	0.9849
	S	4	0.5768	0.2786	3.5893	0.9567
L10	W	2	0.3006	0.5008	1.9968	0.9965
	M	2	0.2974	0.5081	1.9681	0.9866
	S	2	0.3006	0.5008	1.9968	0.9965
L11	W	3	0.4703	0.3432	2.9137	0.9850
	M	3	0.4768	0.3337	2.9967	0.9976
	S	3	0.4752	0.3361	2.9753	0.9955
L12	W	1	0	1	1	0
	M	3	0.3859	0.4420	2.2624	0.8069
	S	1	0	1	1	0

conglomeratus, *T. mangolicum*, *P. juliflora*, *A. dumosus* and *S. pausiflorum* and collectively 216 (winter), 252 (monsoon) and 106 (summer) individuals were recorded in sample units. Shannon index was noted between 0.470 to 0.512 (Table 1). Simpson index and its reciprocal index fluctuated between 0.362 to 0.400 and 2.494 to 2.762, respectively. Pielou's index for evenness varied from 0.688 to 0.732. These observations were indicative of moderate diversity, moderately high degree of species richness and evenness distribution of 5 species at this sandy site.

Location 2 Diwasa

4 plant species grew at this site, a total number of individuals in the study area were 193, 253 and 113 during the winter, monsoon and summer season respectively. Shannon index was noted between 0.489 to 0.502; Simpson index and its reciprocal index ranged between 0.326 to 0.337 and 2.967 to 3.065; while Pielou's evenness index fluctuated between 0.812 to 0.833. These observations were indicative of a low degree of diversity and moderately good

richness and even distribution of plant species in this saline habitat.

Location 3 Sangavada

A collective number of 3 plant species occurring at this site were 442, 292 and 86, respectively in the winter, monsoon and summer seasons. Shannon index (0 to 0.322) suggested low diversity; Simpson index varying from 0.535 to 1, and its reciprocal index (1.183 to 1) were suggestive of low to moderate species richness. Pielou's index ranging from 0 to 0.674 reflected a low to moderately even distribution of 3 species.

Location 4 Shil

Shil region supported 4 plant species and collectively 96 (winter), 111 (monsoon) and 43 (summer) individuals were recorded in sample units. Shannon's index ranged between 0.304 to 0.498 showing low diversity, Simpson's index and its reciprocal index noted between 0.333 to 0.585 and 1.706 to 2.995 were suggestive of high to moderately good species richness; while Pielou's evenness index recorded between 0.637 to 0.827 reflected highly or moderately good even distribution of 4 plant species.

Location 5 Loej

3 plant species grew at this site, total number of individuals in study area were 215, 189 and 15 during the winter, monsoon and summer season respectively. Shannon index was noted between 0 to 0.466 reflecting low to moderately good diversity; Simpson index and its reciprocal index ranged between 0.116 (winter) to 1 (summer) and 8.576 (winter) to 1 (summer) reflecting very high to highly low species richness; while Pielou's evenness index fluctuated between 0 (summer) to 0.833 (winter). These observations were indicative of a low degree of diversity, species richness and evenness in the summer season; moderately good richness and even distribution of plant species in monsoon season; while the highly good diversity, species richness and even distribution of plant species in the winter season in this saline habitat.

Location 6 Rahij

The rocky habitat of Rahij village coastal belt was

inhibited by 3 species and their total number during winter, monsoon and summer reached 148, 100 and 19, respectively. During the summer season Shannon index (0), Simpson index (1), its reciprocal index (1) and Pielou's evenness index (0) were indicating a low degree of diversity, species richness and evenness; while the winter and summer seasons Shannon index was noted between 0.453 to 0.472 reflected moderate diversity, Simpson index and its reciprocal index recorded between 0.341 to 0.372 and 2.687 to 2.930, respectively, it reflects moderately good species richness; while Pielou's index ranged from 0.949 to 0.989 reflect a high degree of species similarity or evenness of distribution of plant species at this location.

Location 7 Maktupur

Maktupur village coastal region supported 5 plant species collectively 187, 185 and 144 in winter, monsoon and summer individuals recorded in sample units at this location. This rocky habitat Shannon index of 0.612 to 0.621 was recorded and reflected moderately good diversity; Simpson index (0.245 to 0.254) and its reciprocal index (3.926 to 4.070) reflected moderately good to high species richness; while Pielou's evenness index ranged between 0.875 to 0.888 to show a higher degree of similarity and evenness in the distribution of 5 plant species at this location during the different 3 seasons winter, monsoon and summer.

Location 8 Mangrol

5 plant species grew at this location collectively 110, 116 and 78 individual plant species in sample units during winter, monsoon and summer respectively. Shannon's index showed between 0.511 to 0.631 Simpson's index and its reciprocal index was noted between 0.248 to 0.339 and 2.949 to 4.030 respectively, when Pielou's index ranged between 0.848 to 0.900. Thus, the result interprets that the diversity of this location is moderately good to high, species richness was high and distribution of plant species or evenness was highly good at this location.

Location 9 Khodada

In this location total of 4 halophytic species were inhibited and the total number of individuals in sample

units during the winter, monsoon and summer seasons was 131, 175 and 99, respectively. Shannon index reached 0.576 to 0.593 reflecting moderate diversity; Simpson index and its reciprocal index were noted between 0.259 to 0.278 and 3.589 to 3.849 to show a high degree of species richness; Pielou's evenness index was recorded between 0.956 to 0.984 reflected very high even distribution of plant species in the different seasons at this saline habitat.

Location 10 Khambhadiya

At this location, 2 species were grown and collectively reported 133, 121 and 71 individuals during the winter, monsoon and summer seasons. Shannon index (0.297 to 0.300) was recorded; Simpson index and its reciprocal index ranged between 0.500 to 0.508 and 1.968 to 1.996; Pielou's index was noted between 0.986 to 0.996 thus, the result reflects a low degree of diversity, moderately good species richness and a high degree of even distributed plant species or similarity observed during the different three seasons winter, monsoon and summer in this saline habitat.

Location 11 Jujarpur

Collective number of 3 plant species occurring at this site were 185, 168 and 103, respectively in winter, monsoon and summer seasons. Shannon's index (0.470 to 0.476) suggested low to moderate diversity, Simpson's index varied from 0.333 to 0.343, and its reciprocal index (2.913 to 2.996) was suggestive of moderately good species richness (Table 1). Pielou's index ranging from 0.985 to 0.997 reflected highly even distribution of 3 plant species at this location.

Location 12 Chorvad

Chorvad village coastal region supported 3 plant species collectively 15, 108 and 14 individuals recorded in sample units during winter, monsoon and summer seasons at this location. During the summer and winter seasons Shannon index (0), Simpson index (1), its reciprocal index (1) and Pielou's evenness index (0) were indicating low degree of diversity, species richness and evenness; while the summer season Shannon index was noted 0.385 reflected low to slightly moderate diversity; Simpson index and its

Table 2. One-way ANOVA results of diversity indices in spatial variation of twelve different locations during 3 seasons.

Location	Simpson index (D)	Shannon index (H')	Pielou's index (J)
L1	5.87*	1.23 ^{ns}	2.1 ^{ns}
L2	1.79 ^{ns}	0.79 ^{ns}	0.14 ^{ns}
L3	57.34***	44.57***	154.27***
L4	3.07 ^{ns}	0.54 ^{ns}	0.07 ^{ns}
L5	140.85***	169.52***	169.52***
L6	69.53***	318.29***	318.27***
L7	0.1 ^{ns}	0.05 ^{ns}	0.05 ^{ns}
L8	2.53 ^{ns}	1.17 ^{ns}	4.41*
L9	1.47 ^{ns}	1.31 ^{ns}	0.12 ^{ns}
L10	0.59 ^{ns}	0.6 ^{ns}	0.6 ^{ns}
L11	1.77 ^{ns}	1.57 ^{ns}	1.45 ^{ns}
L12	718.38***	291.99***	99.47***

Note: *Significant at $p \leq 0.05$, ** highly significant at $p \leq 0.01$, *** very highly significant at $p \leq 0.001$, ^{ns} non-significant.

reciprocal index recorded 0.442 and 2.262, respectively, it reflects moderately good species richness; while Pielou's index was noted 0.806 to reflect high degree of species similarity or evenness of distribution of plant species at this location.

The Simpson index for location 1 (Antroli) was significant ($F=5.87$; $p \leq 0.05$), however, the very highly significant in 4 selected location L3 ($F=57.34$; $P \leq 0.001$), L5 ($F=140.85$, $P \leq 0.001$), L6 ($F=69.53$; $P \leq 0.001$) and L12 ($F=718.38$; $P \leq 0.001$) when the remaining 7 locations were non-significant (≥ 0.05) (Table 2). The one-way ANOVA for the Shannon index (H') were also indicated that seasonal changes in 4 locations were very highly significant L3 ($F=44.57$; $P \leq 0.001$), L5 ($F=169.52$; $P \leq 0.001$), L6 ($F=318.29$; $P \leq 0.001$) and L12 ($F=291.99$; $P \leq 0.001$) while the other locations were non-significant. The statistical observations were stated that the Pielou's index was significant in location 8 ($F=4.41$; $P \leq 0.05$), whenever the very highly significant in L3 ($F=154.27$; $P \leq 0.001$), L5 ($F=169.52$; $P \leq 0.001$), L6 ($F=318.27$; $P \leq 0.001$) and L12 ($F=99.47$; $P \leq 0.001$).

CONCLUSION

The biodiversity indicator measurements the Shannon index (H'), Simpson index (D), its reciprocal index ($1/D$) and Pielou's index (J) indicated low to mod-

erate diversity but moderately good to high species richness and evenness or similarity were observed in maximum sites. Two rocky habitat (L5 and L6) and two sandy habitat (L3 and L6) contained extremely low species diversity, richness and evenness. Plant biodiversity calculated for individual habitats were affected by temporal changes in 6 sites. One-way ANOVA showed statistically significant in L3, L5, L6 and L10 in Shannon index (H'), Simpson index (D), its reciprocal index ($1/D$) and Pielou's index (J), however, Simpson index (D) significant in L1 and Pielou's index (J) in L8. These findings reported that the much more seasonal changes of Shannon index (H'), Simpson index (D) and Pielou's index (J) were observed in two rocky habitats (L5 and L6) and two sandy habitats (L3 and L12). Also, significant seasonal change was shown in location 1 for Simpson index (D) and location 8 for Pielou's index (J), Both locations contain sandy habitats. Because of those results, it was stated that no significant difference was observed in marshy habitat (location 3) in any parameters of diversity indices.

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