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AN ASSESSMENT OF EDAPHIC FACTORS AND GRASS DIVERSITY IN CHOLISTAN DESERT (PAKISTAN)

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A phyto-sociological study of grasses vegetation was undertaken in Cholistan desert during 2010-11. Twenty releves were recorded from twenty different sites. The analysis of twenty releves delineated three plant associations inhabiting the sandy dune, inter-dune sandy and clayey saline habitats. Overall, twenty grass communities were documented based on importance value index of each species. Out of which eight were inter-dune sandy communities and four were sandy dune and clayey saline communities each. Physio-chemical analysis of soil has revealed that texture of sandy dune habitat was sandy; inter-dune was sandy loam while clayey saline was clayey. Results exposed that organic matter, and soil nutrients were better at inter-dune sandy habitat whereas pH, EC, Na, and soil moisture were high at clayey saline habitat and minimum at sandy dune habitat. Further, climatic extremities, overgrazing and anthropogenic actions were observed to be continuous threats to indigenous species. It was also observed that the studied rangeland was unstable, degraded and would vanish if not maintained properly. So, this needs proper protection, management and rehabilitation through ecological approaches. This would be only possible with the participation of government and native peoples to make these range resources sustainable.
Keywords: Desert, grass communities, phyto-sociology, physiochemical analysis, habitat, ecology

INTRODUCTION

Plants are the natural component of our earth landscape and no plant species occurs everywhere in the world, each species is being distributed according to its own specific characteristics that comprise its particular environmental conditions. These species with similar ecological character extend into the similar plant formations and at the broader scale they lead to the development of major biomes of the world (Perez and Frangi, 2000).

Phyto-sociology is a botanical study by which plant communities are recognized and defined. The identification of plant communities is important baseline information for the formulation of an ecological management plan. Individual plant community and its entities have special and unique plant composition and floristic structure. Once the plant communities have been identified, further research can be conducted on vegetation composition, plant production, grazing capacity, browsing capacity, diversity, and conservation of the vegetation. Managers need to optimize utilization when devising a management plan, and therefore classification of the vegetation into plant communities or alliance is essential (Van Rooyen, 2002). Phyto-sociology is a sub discipline of plant ecology that explains the co-occurrence of plant species within the communities (Ewald, 2003). The studies on phytosociological visualize the existing vegetation structure, species diversity, soil plant relationship; generate data on seasonal and temporal variation in available nutrients. There has been always a dire need to investigate and interpret the plant communities on different exposure and gather the first hand information of the vegetation. The concept of structure is used in all biological research as a complementary concept to function, which is related to physiological processes and structure (Mueller and Ellenberg, 1974).

***Geographical location of site*:** The current study was carried out in the Cholistan desert, located in South-West of Punjab province (Pakistan). This desert is an extension of Great Indian Desert lies between latitudes 27°42' and 29°45' North and longitudes 69°52' and 75°24' east (Baig*et al*., 1980). The total land area of Cholistan desert is about 2.6 million hectares (FAO, 1993), and has a length of about 480 km and width differ from 32 to 192 km (Khan, 1987). Based on parent material, topography, soil and vegetation, the whole desert can be separated into two geomorphic regions. Lesser Cholistan or northern region bordered by canal irrigated areas and covers about 7,770 km^2 and Greater Cholistan or southern region is comprised of 18,130 km^2 (Chaudhry, 1992).

***Climate*:** Cholistan is one of the hottest deserts in Pakistan. The climate of the area is hot and arid with rainfall being the major factor influencing the life of local people as well as livestock. Temperatures are high in summer and mild in winter with no frost (Table 1). In summer, temperature may

Table 1. Mean metrological data of Cholistan desert from 2001-2010.

Months	Mean annual temperature (°C)			Humidity	Wind speed	Evaporation	Rainfall
	Minimum	Maximum	Mean	%	KPH		Mm
January	6.47	21.93	14.32	48.92	5.00	71.7	7.5
February	9.70	25.90	17.76	42.27	6.00	92	12.5
March	15.98	32.83	24.40	38.09	7.34	192	5.2
April	21.51	39.24	30.77	28.86	8.34	276.4	2
May	26.72	43.15	34.93	25.92	10.94	362.6	13.2
June	29.15	43.14	35.86	28.67	13.02	490	17.2
July	29.30	40.27	34.80	48.80	12.24	431.2	44.6
August	27.85	38.90	33.37	52.85	11.17	336.6	70
September	25.56	38.66	31.80	48.28	9.25	292.9	14.6
October	19.87	36.51	28.23	40.54	6.01	253	0.2
November	12.41	30.15	21.19	42.84	4.70	167	-
December	7.58	24.40	15.99	45.95	4.40	110.7	3.7

Source: Pakistan Council of Research in Water Resources, Bahawalpur, Pakistan.

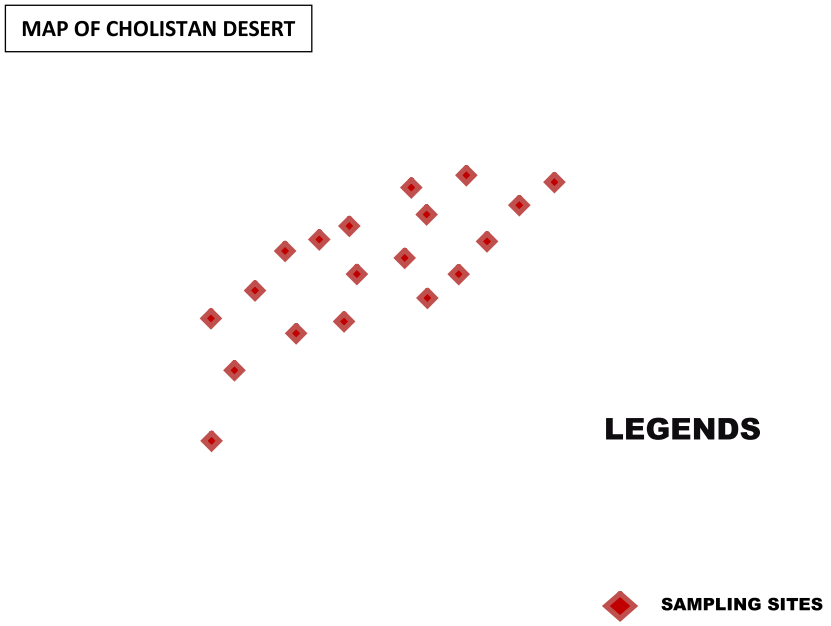

Figure 1. Map of Cholistan desert showing study sites.

reach to more than 51°C and in winter it drops down below freezing point (Hammed, 2002; Arshad *et al*., 2008). May and June are the hottest months with mean temperature of 34°C. Average annual rainfall varies from 100 mm to 200 mm. Most of the rainfall is received during monsoon (July-September) but winter rains (January-March) are also often (Arshad *et al*., 2006). Due to scanty and unpredictable rainfall along with long spells of droughts, water is a limited resource in Cholistan desert. Aridity is the most striking characteristic of the area with dry and wet years occurring in clusters (Akhter and Arshad, 2006).

***Soil features*:** The Lesser Cholistan consists of large saline compact areas (Dahars) alternating with low sandy ridges. Sand dunes are stabilized, semi-stabilized or shifting, while the valleys are mostly covered with sand. The soils of desert are categorized as either saline or saline sodic; with pH varied from 8.2 to 8.5 and 8.9 to 9.7 respectively. The Greater Cholistan is a wind sorted sandy desert and consist

of river terraces, large sand dunes and a lesser amount of inter-dune areas (Baig*et al*., 1980; Akbar *et al*., 1996; Naureen*et al*., 2008; Arshad *et al*., 2002, 2008).

***Vegetation*:** The vegetation comprises of wide variety of xerophytic species. These drought tolerant species are well adapted to severe seasonal temperature, moisture instability and large variety of soil conditions. The soil physical and chemical composition plays a significant role in vegetation distribution in the area (Chaudhary, 1992; Arshad and Akbar, 2002). Fortunately, a wide range of nutritious species of grasses, shrubs and trees occupy the entire desert. Although these plant species are slow growing, they respond very well under unfavorable climatic conditions and provide significant biomass for livestock consumption. Significant genera of grasses include *Cenchrus*, *Panicum* and *Lasiurus* while important genera of browsers include *Calligonum*, *Haloxylon, Prosopis, Zizyphus* and *Acacia*. Each site is represented by typical plant species based on availability of soil moisture, salinity and plant characteristics (Naz, 2011).

MATERIAL AND METHODS

The study area was divided into 20 different study sites on the basis of initial reconnaissance surveys (Table 2). Identification and selection of study sites were based on the altitude, physiognomy, aspect, degradation stage and floristic composition of the area. Species were identified with the help of available literature (Arshad and Rao, 1994; Ali and Qiaser, 1995-2004). The determined specimens were also matched in the National Herbarium, NARC Islamabad, Pakistan and Cholistan institute of desert studies, Islamia University Bahawalpur, Pakistan. This sampling was carried out soon after monsoon during 2009. Data on quantitative phyto-sociological attributes such as frequency, density and cover were recorded by using the transect and quadrate methods as applied by Cottam and Curtis (1956) and Phillips (1959). These methods have been extensively used for the evaluation of desert rangelands (Hussain, 1989; Mitchell, 2005). Five transects of each 100 meter in length, were used and quadrates (1×1 m^2) were placed with an interval of 10 meter of each transect.

***Importance value*:** Relative frequency, relative density, and relative cover each indicate a different aspect of the importance of a species in a community. Thus, the additions of relative values provide a good estimate of the importance of species. This sum is called the importance value.

The importance value of particular species was calculated following the methods described by Curtis and McIntosh (1951) and Stephenson (1986).

Importance value = Relative density + Relative Frequency + Relative Cover

***Community structure*:** The species within range sites were arranged on the basis of importance values and named after the leading species with the highest importance value. The closely approaching species were considered as co or sub-dominants of the community. Total importance value (TIV) was calculated by adding the value of three dominant plant species in a community, while the *remaining plants were added separately.*

***Physical and chemical analysis of soil*:** Soil samples were collected from 0-30 cm depth in labeled polythene bags from

Table 2.Name and geographical aspects of study sites.

Sr. No.	Name of Site	Coordinates	Elevation	Topography
1	Khavetal	N:29° 09.165'E:072° 00.806'	372 ft	Inter-dune
2	Thandikhoe	N:29°10.374'E:072° 09.437'	400 ft	Inter-dune
3	Mansoora	N:29° 23.476' E:071° 39.585'	406 ft	Clayey
4	Khirser	N:29° 05.052' E:072° 09.934'	392 ft	Sandy dune
5	Moujgarh	N:29° 01.169'E:072° 08.678	401 ft	Inter-dune
6	Dingarh	N:29° 03.864'E:072° 04.880'	377 ft	Inter-dune
7	Chahnagra	N:29° 00.265'E:071° 49.399'	372 ft	Inter-dune
8	Khanser	N:28° 56.891'E:071° 49.329'	343 ft	Sandy dune
9	Jindewalatoba	N:28° 59.356'E:071° 53.135'	347 ft	Inter-dune
10	Qiladerawer I	N:28° 34.326'E:071° 11.999'	323 ft	Sandy dune
11	Toba sawanwala	N:28° 57.848'E:072° 06.691'	410 ft	Inter-dune
12	Kora khu	**N**:28° 54.652'**E**:071° 40.800'	313 ft	Clayey
13	Chahbariwalatoba	**N**:28° 52.232'**E**:071° 42.781'	342 ft	Inter-dune
14	Dhori	**N**:28° 44.192' **E**:071° 46.441'	351 ft	Inter-dune
15	Khokharawalatoba	**N**:28° 55.450'**E**:071° 47.209'	355 ft	Inter-dune
16	Bari wala	**N**:28° 51.425'**E**:071° 43.728'	374 ft	Inter-dune
17	Channanpir I	**N**:28° 50.672'**E**:071° 25.324'	324 ft	Clayey
18	Channanpir II	**N**:28° 47.292'**E**:071° 21.299'	301 ft	Inter-dune
19	Qiladerawer II	**N**:28° 42.346'**E:**071° 17.862	310 ft	Clayey
20	Qemmawala Toba	**N**:28° 34.919'**E**:071° 11.999'	459 ft	Sandy dune

each investigated site and transferred to the Soil Testing Laboratory (Bahawalpur) for its physical and chemical analyses. Soil physical and chemical properties were determined by the methods described in AOAC (1984).

RESULTS

In present study, twenty different grass communities were identified on the basis of importance value index as presented in Table 3. Each community has different vegetation structure and soil physical and chemical properties as shown in Table 4. These communities are described one by one as below.

***1) Ochthochloa compressa–Cenchrus ciliaris–Lasiurus scindicus (OCL)*:** This community was recognized at the first study site named Khavetal. Based on soil topography, the site was classified as inter-dune. It was comprised of 13 species including five grasses, two herbaceous species and six shrubs. Total importance value contributed by grasses was 202.65, herbs 3.27 and shrubs 94.17. The *Ochthochloa compressa* (IV=91.45), *Cenchrus ciliaris* (IV=53.57) and *Lasiurus scindicus* (IV=32.38) were the dominant members of this stand. Total importance value contributed by three dominant grass species was 177.39 while total importance value by remaining species was 122.61. Soil texture of this stand was sandy loam with pH 7.9, electrical conductivity

Table 3. Floristic structure and phyto-sociological pattern of surveyed plots.

Sites	Grass Communities	No. of species in each community				IVI contributed by				Three dominants
		Grasses	Herbs	Shrubs	Trees	Grasses	Herbs	Shrubs	Trees	
S1	*Ochthochloa compressa–Cenchrus ciliaris–Lasiurus Scindicus*	5	2	6	0	202.65	3.27	94.17	0	177.39
S2	*Ochthochloa compressa –Lasiurus scindicus –Stipagrostis plumosa*	6	3	5	1	166.50	9.78	98.91	24.81	159.36
S3	*Cymbopogon jwarancusa – Ochthochloa compressa – Aristida hystricula*	5	2	4	2	174.65	3.94	107.50	13.91	160.49
S4	*Stipagrostis plumosa –Panicum turgidum–Cenchrus biflorus*	6	3	5	0	192.94	20.16	86.91	0	156.12
S5	*Lasiurus scindicus –Panicum turgidum – Ochthochloa compressa*	7	4	6	2	150.34	37.48	107.09	5.09	120
S6	*Ochthochloa compressa –Panicum turgidum –Lasiurus scindicus*	7	6	6	1	178.23	23.46	84.13	14.18	151.8
S7	*Lasiurus scindicus–Cenchrus ciliaris– Stipagrostis plumose*	6	4	8	0	156.12	25.15	118.73	0	144.56
S8	*Panicum turgidum –Stipagrostis plumosa –Cenchrus ciliaris*	6	2	6	2	173	64.37	57.45	5.18	139.48
S9	*Ochthochloa compressa–Pennisetum divisum–Lasiurus scindicus*	9	6	6	0	201.48	53.88	44.64	0	149.3
S10	*Panicum turgidum –Lasiurus scindicus – Cenchrus ciliaris*	8	2	7	0	183.58	24.5	91.92	0	148.99
S11	*Cenchrus biflorus–Lasiurus scindicus– Stipagrostis plumosa*	11	1	4	0	218.79	25.39	55.82	0	154.38
S12	*Cymbopogon jwarancusa –Aeluropus lagopoides –Sporobolus iocladus*	6	2	7	1	188.4	5.73	96.19	9.68	153.5
S13	*Lasiurus scindicus –Ochthochloa compressa –Cenchrus setigerous*	9	1	7	0	182.86	23.04	94.10	0	153.42
S14	*Lasiurus scindicus –Stipagrostis plumosa –Ochthochloa compressa*	7	6	5	0	179.32	51.96	68.72	0	160.56
S15	*Lasiurus scindicus–Cenchrus biflorus– Ochthochloa compressa*	9	1	5	0	191.01	34.24	74.75	0	148.49
S16	*Cenchrus biflorus– Cymbopogon jwarancusa–Ochthochloa compressa*	7	3	7	0	203.96	30.69	65.34	0	164.78
S17	*Sporobolus iocladus –Aeluropus lagopoides –Ochthochloa compressa*	6	2	5	1	179.34	5.48	111.69	3.49	150.79
S18	*Pennisetum divisum–Cenchrus biflorus– Lasiurus scindicus*	7	3	6	0	191.97	10.99	97.05	0	158.27
S19	*Aeluropus lagopoides –Sporobolus iocladus– Cymbopogon jwarancusa*	7	1	4	2	188.06	3.81	97.06	11.07	152.37
S20	*Stipagrostis plumosa-Panicum turgidum – Cenchrus ciliaris*	8	1	6	0	188.11	11.22	100.67	0	143.44

Table 4. Physical and chemical analysis of soil of studied sites.

Site No.	Floristic combination at the stand	Texture	EC (dSm^{-1})	pH	Moisture (%)	Saturation (%)	OM (%)	Na (ppm)	P (ppm)	K (ppm)
1	*Ochthochloa compressa–Cenchrus ciliaris–Lasiurus Scindicus*	Sandy loam	2.3	7.9	0.74	28	0.39	29.5	5.33	47
2	*Ochthochloa compressa –Lasiurus scindicus –Stipagrostis plumosa*	Sandy loam	2.5	8.15	0.69	25	0.38	32.2	5.29	46
3	*Cymbopogon jwarancusa – Ochthochloa compressa – Aristida hystricula*	Clayey	10.9	8.6	0.77	61	0.21	62.1	3.9	29.6
4	*Stipagrostis plumosa –Panicum turgidum–Cenchrus biflorus*	Sandy	1.85	8.03	0.39	19	0.26	15.98	2.29	24.8
5	*Lasiurus scindicus –Panicum turgidum –Ochthochloa compressa*	Sandy loam	2.63	8.18	0.7	29	0.43	27.6	5.8	70
6	*Ochthochloa compressa –Panicum turgidum –Lasiurus scindicus*	Sandy loam	2.9	8.32	0.68	29	0.31	28.4	4	56
7	*Lasiurus scindicus–Cenchrus ciliaris–Stipagrostis plumose*	Sandy loam	2.5	8.12	0.65	27.5	0.36	22.5	4.71	61
8	*Panicum turgidum –Stipagrostis plumosa –Cenchrus ciliaris*	Sandy	1.75	8.09	0.44	18	0.28	14.95	2.94	22.8
9	*Ochthochloa compressa–Pennisetum divisum–Lasiurus scindicus*	Sandy loam	2.3	8.21	0.71	23	0.25	27.8	4.5	56
10	*Panicum turgidum –Lasiurus scindicus –Cenchrus ciliaris*	Sandy	1.83	7.7	0.48	17	0.29	14.23	2.2	24
11	*Cenchrus biflorus–Lasiurus scindicus–Stipagrostis plumosa*	Sandy loam	2.91	8.13	0.57	29	0.35	35.4	4.51	51
12	*Cymbopogon jwarancusa –Aeluropus lagopoides –Sporobolus iocladus*	Clayey	12.8	8.36	0.79	65	0.2	89.3	3.33	32
13	*Lasiurus scindicus –Ochthochloa compressa –Cenchrus setigerous*	Sandy loam	2.78	7.8	0.59	25	0.38	26.4	4.6	63
14	*Lasiurus scindicus –Stipagrostis plumosa –Ochthochloa compressa*	Sandy loam	2.69	8.23	0.66	28	0.41	28.5	5.29	69
15	*Lasiurus scindicus–Cenchrus biflorus–Ochthochloa compressa*	Sandy loam	2.62	8.29	0.68	29	0.34	27.9	3.78	57
16	*Cenchrus biflorus– Cymbopogon jwarancusa–Ochthochloa compressa*	Sandy loam	3.57	8.38	0.53	45	0.36	37.5	4.82	64
17	*Sporobolus iocladus –Aeluropus lagopoides –Ochthochloa compressa*	Clayey	11.9	8.62	0.93	64	0.23	76.4	3.35	31.2
18	*Pennisetum divisum–Cenchrus biflorus–Lasiurus scindicus*	Sandy loam	3.68	8.1	0.58	43	0.4	36.3	5	61.7
19	*Aeluropus lagopoides –Sporobolus iocladus–Cymbopogon jwarancusa*	Clayey	12.4	8.5	0.88	62	0.2	90.2	2.9	35
20	*Stipagrostis plumosa-Panicum turgidum –Cenchrus ciliaris*	Sandy	0.96	7.9	0.36	18	0.25	13.94	2.3	26.8

(EC) 2.3 dSm^{-1}, organic matter (OM) 0.39%, moisture (M) 0.74%, and saturation 28%. However, concentration of sodium (Na) was 29.5 ppm, phosphorus (P) 5.33 ppm and potassium (K) 47 ppm.

***2)Ochthochloa compressa –Lasiurus scindicus –Stipagrostis plumosa (OLS)*:** This community was recognized at second study site Thandikhoe. Based on soil topography, this study site was classified as inter-dunal area. Present community was comprised of 15 species that included six grasses, three herbs, five shrubs and one tree. Total importance value contributed by grasses was 166.50, herbs 9.78, shrubs 98.91 and trees 24.81.*Ochthochloa compressa* (IV =98.93), *Lasiurus scindicus* (IV=37.74) and *Stipagrostis plumosa* (IV=22.69) were the dominant members of this stand. Total importance value contributed by three dominant species was 159.36 while total importance value by remaining species was 140.64. The soil of this stand was sandy loam with EC 2.5dSm^{-1}, pH 8.15, organic matter (OM) 0.38%, moisture 0.69 %, and saturation 25%, whereas, sodium (Na) was 32.2, phosphorous (P) 5.29 ppm and potassium (K) 46 ppm.

***3) Cymbopogon jwarancusa – Ochthochloa compressa – Aristida hystricula (COA)*:** This community was identified at third study site MansoraChocki. Based on soil topography, present study site was classified as clayey saline area. It was comprised of 13 species, which included five grasses, two herbs, four shrubs and two trees. Total importance values contributed by grasses, herbs, shrubs and trees were 174.65,

3.94, 107.5 and 13.91 respectively. *Cymbopogon jwarancusa* (IV=78.31), *Ochthochloa compressa* (IV=53.33) and *Aristida hystricula* (IV=28.85) were the dominant members of this stand. Total importance value contributed by three dominant species of this stand was 160.49 while total importance value by remaining species was 139.51. The soil of this stand was clayey with EC 10.9 dSm^{-1}, pH 8.6, organic matter (OM) 0.21%, moisture (M) 0.77% and saturation 61%, whereas sodium was 62.1%, phosphorous (P) 3.9 ppm and potassium (K) 29.6 ppm.

***4) Stipagrostis plumosa –Panicum turgidum–Cenchrus biflorus (SPC)*:** This community was recognized at fourth study site named as Khirser. Based on soil topography, the study site was classified as sandunal. It was comprised of 14 species which included six grasses, three herbs and five shrubs. Total importance values contributed by grasses, herbs and shrubs were 192.94, 20.16 and 86.91 respectively. *Stipagrostis plumosa*(IV =79.32), *Panicum turgidum* (IV=56.46) and *Cenchrus biflorus* (IV=20.34) were the dominant members of this stand. Total importance value contributed by three dominant grass species of the stand was 156.12 while total importance value by remaining species was 143.88. The soil texture in this stand was sandy with EC 1.85 dSm^{-1}, pH 8.03, organic matter (OM) 0.26%, moisture (M) 0.39%, and saturation 19%, whereas sodium (Na) was 15.98 ppm, phosphorous (P) 2.29 ppm and potassium (K) 24.8 ppm.

***5) Lasiurus scindicus –Panicum turgidum –Ochthochloa compressa (LPO)*:** This community was recognized at fifth study site called Moujgarh. Based on topography this site was classified as inter-dune habitat. It was comprised of 19 species including seven grasses, four herbs, six shrubs and two trees. Total importance values contributed by grasses, herbs, shrubs and trees were 150.34, 37.48, 107.09 and 5.09 respectively. *Lasiurus scindicus*(IV =64.12), *Panicum turgidum* (IV=32.19) and *Ochthochloa compressa* (IV=23.70) were the dominant members of this stand. Importance value contributed by three dominant grasses was 120 while the importance value by remaining species was 180. The soil of this stand was sandy loam with EC 2.63 dSm^{-1}, pH 8.18. Whereas, concentration of organic matter (OM) was 0.43%, moisture(M) 0.70%, saturation 29%, sodium(Na) 27.6 ppm, phosphorous (P) 5.8 ppm and potassium (K) 70 ppm.

***6) Ochthochloa compressa –Panicum turgidum –Lasiurus scindicus (OPL)*:** This community was identified at sixth study site called Dingarh. Based on topography, the site was classified as inter-dune habitat. Present stand was comprised of 20 species including seven grasses, six herb, six shrubs and one tree. Total importance value contributed by grasses was 178.23, herbs 23.46, shrubs 94.17 and tree 14.18.*Ochthochloa compressa* (IV =81.31), *Panicum turgidum* (IV=50.34) and *Lasiurus scindicus* (IV=20.25) were the dominant species of this stand. Importance value contributed by three dominant species of this stand was 151.8 while importance value by remaining species was 148.2. The soil of this stand was sandy loam with EC 2.9 dSm^{-1}, pH 8.32, organic matter (OM) 0.31%, moisture (M) 0.68%, saturation 29%, whereas, sodium (Na) was 28.4ppm, phosphorous (P) 4 ppm and potassium (K) 56 ppm.

***7) Lasiurus scindicus–Cenchrus ciliaris–Stipagrostis plumosa (LCS)*:** This community was recognized at seventh study site named as Chahnagra. On the basis of topography, this site was classified as inter-dune habitat. It was comprised of 18 species that included 6 grasses, four herbs and eight shrubs. Total importance value contributed by grasses was 156.12, herbs 25.15 and shrubs 118.73.*Lasiurusscindicus* (IV=75.78), *Cenchrus ciliaris* (IV=37.73) and *Stipagrostis plumosa* (IV=31.05) were the dominant members of this stand. Total importance value contributed by three dominant grass species was 144.56 while total importance value by remaining species was 155.44. The soil of this stand was sandy loam with EC 2.5 dSm^{-1}, pH 8.2, organic matter (OM) 0.36%,moisture (M) 0.65%, and saturation 27.5 %, whereas, sodium (Na) was 22.5ppm, phosphorous (P) 4.71 ppm and potassium (K) 61ppm.

***8) Panicum turgidum –Stipagrostis plumosa –Cenchrus ciliaris (PSC)*:** This community was recognized at eighth study site named as Khanser. Based on topography of soil, present study site was classified as sandy dune. The present stand was comprised of 16 species that included six grasses, two herbs, six shrubs and two trees. Total importance value contributed by grasses was 173, herbs 64.37, shrubs 57.45 and trees 5.18.*Panicumturgidum* (IV =75.47), *Stipagrostis plumosa* (IV=37.36) and *Cenchrus ciliaris* (IV=26.66) were the dominant members of the stand. Total importance value contributed by three dominant grass species of this stand was 139.48 while total importance value by remaining species was 160.52. The soil of this stand was sandy with EC 1.75 dSm^{-1} and pH 8.09. Whereas, organic matter (OM) was 0.28%, moisture (M) 0.44%, saturation 18%, sodium (Na) 14.95ppm, phosphorous (P) 2.94 ppm and potassium (K) 22.8 ppm.

***9) Ochthochloa compressa–Pennisetum divisum–Lasiurus scindicus (OPL)*:** This community was identified at ninth study site called as Jindewalatoba. Based on soil topography, this study site was classified as inter-dune. It was comprised of 21 species, which included nine grasses, six herbs and six shrubs. Importance value contributed by grasses was 201.48, herbs 53.88 and shrubs 44.64. *Ochthochloa compressa*(IV =71.39), *Pennisetum divisum* (IV=40.40) and *Lasiurus scindicus* (IV=37.51) were the dominant members of this stand. Total importance value contributed by three dominant grass species was 149.3 while total importance value by remaining species was 150.7. The soil of this stand was sandy loam with EC 2.3 dSm^{-1}, pH 8.21, organic matter (OM) 0.25%, moisture (M) 0.71%,and saturation 23%, whereas

sodium (Na) was 27.8ppm phosphorous (P) 4.5 ppm and potassium (K) 56 ppm.

***10) Panicum turgidum –Lasiurus scindicus –Cenchrus ciliaris (PLC)*:** This community was recognized at tenth study site named as Qiladerawer. Based on soil topography, the site was classified as sandy dune habitat. Present stand was comprised of 17 species that included eight grasses, two herbs and seven shrubs. Total importance value contributed by grasses was 183.58, herbs 24.5 and shrubs 91.92.*Panicumturgidum* (IV=72.98), *Lasiurus scindicus* (IV=52.11) and *Cenchrus ciliaris*(IV=23.90) were the dominant members of this stand. Total importance value contributed by three dominant grasses was 148.99 while total importance value by remaining species was 151.1. The soil of this stand was sandy with EC 1.83 dSm^{-1} and pH 7.7. Whereas organic matter (OM) was 0.29%, moisture (M) 0.48%, saturation 17%, sodium (Na) 14.23 ppm, phosphorous (P) 2.2ppm and potassium (K) 24ppm.

***11) Cenchrus biflorus–Lasiurus scindicus–Stipagrostis plumosa (CLS)*:** This community was recognized at eleventh study site called Toba Sawanwala. Based on soil topography, study site was classified as inter-dune. It was comprised of 16 species, which included eleven grasses, one herb and four shrubs. Total importance value contributed by grasses was 218.79, herbs 25.39 and shrubs 55.82. *Cenchrus biflorus* (IV=74.11), *Lasiurus scindicus* (IV=45.41) and *Stipagrostis plumosa* (IV=34.85) were the dominant members of this stand. Total importance value contributed by three dominant grass species was 154.38 while total importance value by remaining species was 145.62. The soil of this stand was sandy loam with EC (2.91) dSm^{-1} and pH (8.13).Organic matter (OM) percentage was 0.35%, moisture 0.57%, saturation 29%, sodium (Na) 35.4ppm, phosphorous (P) 4.51 ppm and potassium (K) 51 ppm.

***12) Cymbopogon jwarancusa –Aeluropus lagopoides – Sporobolus iocladus (CAS)*:** This community was recognized at twelfth study site called Kora khu. Based on soil topography, study site was classified as clayey saline area. Present stand was comprised of 16 species, which included six grasses, two herbs, seven shrubs and one tree. Total importance value contributed by grasses was 188.4, herbs 5.73, shrubs 96.19 and trees 9.68. *Cymbopogon jwarancusa* (IV =73.69), *Aeluropus lagopoides* (IV=53.67) and *Sporobolus iocladus* (IV=26.14) were the dominant members of the stand. Total importance value contributed by three dominant grass species was 153.5 while total importance value by remaining species was 146.5. The soil of this stand was clayey with EC 12.8 dSm^{-1}, pH 8.6, organic matter (OM) 0.21%, moisture 0.79%, and saturation 65%, whereas sodium (Na) was 89.3ppm phosphorous (P) 3.33 ppm and potassium (K) 32 ppm.

***13) Lasiurus scindicus –Ochthochloa compressa – Cenchrus setigerous (LOC)*:** This community was recognized at thirteenth study site, Chahbariwalatoba. Based on soil topography, study site was classified as inter-dune area. It was comprised of 17 species that included nine grasses, one herb and seven shrubs. Total importance value contributed by grasses was 182.86, herbs 23.04 and shrubs 94.10.*Lasiurusscindicus* (IV=71.86), *Ochthochloa compressa* (IV =50.88) and *Cenchrus setigerous* (IV=30.68) were the dominant members of this community. Total importance value contributed by three dominant grass species of the community was 153.42 while total importance value by remaining species was 146.58. The soil in this stand was sandy loam with EC 2.78 dSm^{-1}, pH 7.8, organic matter (OM) percentage 0.38%, moisture (M) 0.59%, and saturation 25%, whereas sodium (Na) was 26.4ppm, phosphorous (P) 4.6 ppm and potassium (K) 63 ppm.

***14) Lasiurus scindicus –Stipagrostis plumosa – Ochthochloa compressa (LSO)*:** This community was recognized at fourteenth study site named Dhori. Based on soil topography, this study site was classified as inter-dune area. The stand was comprised of 18 species which included seven grasses, six herbs and five shrubs. Total importance value contributed by grasses was 179.32, herbs 51.96 and shrubs 68.72. *Lasiurus scindicus* (IV=73.28),*Stipagrostis plumosa*(IV =47.49) and *Ochthochloa compressa* (IV=39.79) were the dominant members of this stand. Total importance value contributed by three dominant grass species of the stand was 160.56 while total importance value by remaining species was 139.44.The soil in this stand was sandy loam with EC 2.69 dSm^{-1}, pH 8.23, organic matter (OM) 0.41%, moisture (M) 0.66%, and saturation 28%, whereas sodium (Na) was 28.5ppm, phosphorous (P) 5.29 ppm and potassium (K) 69 ppm.

***15) Lasiurus scindicus–Cenchrus biflorus–Ochthochloa compressa (LCO)*:** This community was recognized at fifteenth study site named Khokhrawalatoba. Based on soil topography, study site was classified as inter-dune area. It was comprised of 15 species, which included nine grasses, one herb and five shrubs. Total importance value contributed by grasses was 191.01, herbs 34.24 and shrubs 74.75. *Lasiurus scindicus* (IV=73.31), *Cenchrus biflorus* (IV=55.03) and *Ochthochloa compressa* (IV=20.15) were the dominant members of this stand. Total importance value contributed by three dominant grass species was 148.49 while total importance value by remaining species was 151.51. The soil of this stand was sandy loam with EC 2.62 dSm^{-1}, pH 8.29, organic matter (OM) 0.34%, moisture (M) 0.68%, and saturation 29%, whereas sodium (Na) was 27.9 ppm, phosphorous (P) 3.78 ppm and potassium (K) 57 ppm.

***16) Cenchrus biflorus– Cymbopogon jwarancusa– Ochthochloa compressa (CCO)*:** This community was recognized at sixteenth study site called Bari wala. Based on soil topography, study site was classified as inter-dune area. It was comprised of 17 species that included seven grasses, three herb and seven shrubs. Total importance values contributed by grasses, herbs and shrubs were 203.96, 30.69

and 65.34 respectively. *Cenchrus biflorus* (IV=73.00),*Cymbopogon jwarancusa* (IV=56.16) and *Ochthochloa compressa* (IV =35.62) were the dominant members of this stand. Total importance value contributed by three dominant grass species was 164.78 while total importance value by remaining species was 135.22. The soil of this stand was sandy loam with EC 3.57 $dSm^{-1}$and pH 8.38. Whereas, Organic matter (OM) was 0.36%, moisture (M) 0.53%, saturation 45%, sodium (Na) 37.5ppm, phosphorous (P) 4.82 ppm and potassium (K) 64 ppm.

***17) Sporobolus iocladus –Aeluropus lagopoides – Ochthochloa compressa (SAO)*:** This community was identified at seventeenth study site named Chananpir. On the basis of soil topography, present study site was classified as clay saline area. Present stand was comprised of 14 species, which included six grasses, two herbs, five shrubs and one tree. Total importance values contributed by grasses, herbs, shrub and trees were 179.34, 5.48, 111.69 and 3.49 respectively. *Sporobolus iocladus* (IV=70.14) *Aeluropus lagopoides* (IV=50.31) and *Ochthochloa compressa*(IV =30.34) were the dominant members of this community. Total importance value contributed by three dominant grass species was150.79 while total importance value by remaining species was 149.21. The soil of this stand was clayey with EC 11.9 dSm^{-1} and pH 8.62. Whereas organic matter (OM) was 0.23%, moisture (M) 0.93%, saturation 64%, sodium (Na) 76.4ppm, phosphorous (P) 3.35 ppm and Potassium (K) 31.2 ppm.

***18) Pennisetum divisum–Cenchrus biflorus–Lasiurus scindicus (PCL)*:** This community was identified at eighteenth study site named ChannanPir II. Based on soil topography, study site was classified as inter-dunal area. It was comprised of 16 species, which included seven grasses, three herbs and six shrubs. Total importance value contributed by grasses was 191.97, herbs 10.99 and shrubs 97.05.*Pennisetumdivisum* (IV=78.96), *Cenchrus biflorus*(IV =55.28) and *Lasiurus scindicus* (IV=24.04) were the dominant members of this stand. Total importance value contributed by three dominant grass species of the stand was 158.27 while total importance value by remaining species was 141.73. The soil of this stand was sandy loam with EC 3.68 dSm^{-1} and pH 8.1 while organic matter (OM) percentage was 0.40%, moisture (M) 0.58%, saturation 43%, sodium (Na) 36.3ppm phosphorous (P) 5 ppm and potassium (K) 61.7 ppm.

***19) Aeluropus lagopoides –Sporobolus iocladus– Cymbopogon jwarancusa (ASC)*:** This community was recognized at nineteenth study site QilaDerawer II. Based on topography of soil, study site was classified as clay saline area. It was comprised of 14 species that included seven grasses, one herb, four shrubs and two trees. Total importance value contributed by grasses was 188.06, herbs 3.81, shrubs 97.06 and trees 11.07. *Aeluropus lagopoides* (IV=70.29) *Sporobolus iocladus* (IV=51.39) and *Cymbopogon jwarancusa* (IV =30.69) were the dominant members of this stand. Total importance value contributed by three dominant grass species of the stand was 152.37 while total importance value by remaining species was 147.63.The soil of this stand was clayey with EC 12.4 dSm^{-1} and pH 8.5. Whereas, organic matter (OM) was 0.2%, moisture (M) 0.88%, saturation 62%, sodium(Na) 90.2ppm, phosphorous (P) 2.9 ppm and potassium (K) 35 ppm.

***20) Stipagrostis plumosa–Panicum turgidum –Cenchrus ciliaris (SPC)*:** This community was recognized at twentieth study site named Khavetal. Based on soil topography, this study site was classified as sandy dune area. Present stand was comprised of 15 species included eight grasses, one herb and six shrubs and two trees. Total importance values contributed by grasses, herb and shrubs were 188.11, 11.22 and 100.67, respectively. *Stipagrostis plumosa* (IV =80.39), *Panicum turgidum* (IV=32.19) and *Cenchrus cili*aris (IV=30.86) were the dominant members of this stand. Total importance value contributed by three dominant grass species of this stand was 143.44 while total importance value by remaining species was 156.56. The soil texture of present stand was sandy with EC 0.96 dSm^{-1} and pH 7.9 while organic matter (OM) was 0.25%, moisture (M) 0.36%, saturation 18%, sodium (Na) 13.94ppm, phosphorous (P) 2.3ppm and potassium (K) 26.8ppm.

DISCUSSION

Combination of plant species which are living together in a habitat and held together by same ecological tolerances, form a community. All these species not have same impact, only few over topping species which amend the habitat and affect the growth of other species present in a community; these species are named as dominants (Gaston, 2000). Features of floristic structure and composition in an ecosystem such as frequency, density and cover might be influenced by anthropogenic, climatic and biotic stresses (Singh and Singh, 2010). Community structure reflects the outcome of the habitat, ecological conditions and existing types of vegetation (Westfall *etal*., 1996; Malik *et al*., 2007). Our results on phytosociological parameters (density, frequency, and cover) from three distinctive habitats (inter-dunal, sandy dunes and clayey) of Cholistan desert are in accordance with the work of some earlier ecologist (Sanderson *et al*., 2002; Ahmad *et al*., 2006), who supported the criteria for describing plant communities of various rangelands of the world.

In our findings, it was observed that saline habitat has very low species diversity due to high level of EC, pH and sodium in the soil. According to Arshad *et al.* (2008) several edaphic factors such as soil pH, EC, moisture and sodium are responsible for determination of vegetation pattern in clayey/saline habitats of Cholistan desert. Similarly, Arshad and Akbar (2002) reported that soils of clayey habitat were

brackish in color, extremely saline in nature and very poor in fertility with pH ranged from 8-9.Clayey/saline habitats particularly in the deserts are characterized by specific plant communities (Khan, 1990). In present study, halophytic grass species were the leading dominants such as *Cymbopogon jwarancusa*, *Sporobolus iocladus* and *Aeluropus lagopoides* in the clayey/saline sites (Naz*et al*., 2009). The distribution of halophytic grass species is mostly associated with inter-specific and intra-specific competition, management and grazing (Marc *et al*., 2003). Moreover, it was observed that the species variation with in habitat and from site to site was highly influenced by soil physical and chemical properties (Lenssen*et al*., 2004).

Results showed that inter-dune habitat have high species diversity as compared to other sites. Inter-dune habitat is a low-lying sandy flat area encircled by sand dunes. Based on soil physical and chemical analysis, the soil nutrients (P, K) and organic matter level was high at inter-dune plots. In these plots *Ochthochloa compressa*, *Lasiurus scindicus*, *Cenchrus biflorus* and *Pennisetum divisum* were leading dominant species. Similar to our findings, Arshad and Rao (1995) have also reported that highest floristic diversity was found on inter-dune plots in Cholistan desert. Further, it was observed that sandy dune plots were consisted of non-stabilized moving sand formations. Results of soil analysis showed that texture of this habitat was sandy with poor soil condition. Therefore, vegetation diversity was also low at these sites. However, dominant species in this type of habitat were *Stipagrostis plumosa*, *Cenchrus ciliaris* and *Panicum turgidum* (Rafay*et al*., 2013a,b; Abdullah *et al.,* 2013).

Our findings were almost in line with some earlier studies including those of Rao *et al*. (1989) and, Arshad and Akbar (2002) where vegetation patterns of Cholistan desert were reported. Similarly, Hameed *et al*. (2011) has studied the vegetation cover of Cholistan desert and found that sand dunes were dominated by *Stipagrostis plumosa, Panicum turgidum* and *Cenchrus ciliaris* communities, the inter-dune plains by *Ochthochloa compressa*, *Lasiurus scindicus, Cenchrus ciliaris* and *Panicum turgidum* communities, whereas clay-saline habitat was dominated by *Aeluropus lagopoides*, *Sporobolus iocladus* and *Cymbopogon jwarancusa* communities. The vegetation surveyed in present study was reflected the degrading stages of vegetation units identified by Li *et al.* (2008), Saima*et al*. (2010) and Durrani*et al*. (2010).

Soil features are key factors that are responsible for distribution of plant species and formation of community structure in Cholistan desert. However, variation in grasses combination from site to site may be result of some other factors like precipitation, human interference and grazing pressure (Allen, 2004). All these factors determine the category of grass species (Ahmad *et al*., 2007). Phyto-sociological data of the present study showed that the Cholistan desert has significant species diversity. Observations based on floristic composition of grass species are of a qualitative character and alone cannot give the complete picture of productivity value. Thus, the quantitative study of vegetation resources would be necessary for assessing the productive potential of Cholistan rangeland. The vegetation surveyed in present study actually reflected various remnants. Similar studies on soil-vegetation relationship of arid regions have been documented in other part of world such as in Australia (Bui and Henderson, 2003), China (Liu *et al*., 2003), USA (Omer, 2004), Italy (Silvestri*et al*., 2005) and Iran (Jafari*et al*., 2004).

***Conclusion*:** During present study, it has been observed that the vegetation of Cholistan desert is under massive biotic pressure of grazing, browsing and illegal cutting. These anthropogenic activities have been remained to be a continuous threat for indigenous plant species of Cholistan desert. Based on our findings it is recommended that species with lower IVI values should be provided immediate measures for their proper conservation and those with high IVI values need monitoring to preserve their diversity

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