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PHYTOSOCIOLOGY OF THE PLAINS OF QUETTA DISTRICT

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Abstract

Sixteen plant communities recognized on the basis of index of similarity were grouped into 4 steppe types (*Artemisis maritima* steppe, *Haloxylon griffithii* steppe, *Alhagi maurorum* steppe *Salsola baryosma* steppe) which correlated with the edaphic factors. Individual communities in each steppe type further segregated on the basis of edaphic factors. The total coverage as well as species diversity tended to be relatively high in protected areas and graveyards. The characteristic species of these areas were *Piptatherum baluchistanicum, Cymbopogon commutatus, Chrysopogon aucheri, Stipa arabica* and *Lycium ruthenicum, Alhagi maurorum, Atriplex turcomanica. H. griffithii, S. baryosma. C. stocksii* and *S. mollis* were the characteristic species of unprotected areas, whereas *A. maritima* was the most important dominant common to the protected except graveyards as well as non-protected regions. *Cousinia stocksii* and *Piptatherum baluchistanicum* were the characteristic species of fine-textured soils.

Introduction

Quetta District (Lat. 29°52′ – 30°18′ and long 66°55′ – 67°48′) is bounded to the north by Pishin District, to the west by Chaghai District and Afghanistan, to the east by Sibi District and to the south by Bolan pass and Lakpass of Kalat District. The climate is generally dry and cool with a mean annual precipitation of 250-320 mm confined to winter and spring. The snow fall may occur any time during December and February. The mean maximum temperature for the hottest month is 35.5°C and mean minimum temperature for the coldest month is – 2.7°C. According to Holdridge (1947) system, the whole area falls under temperate Desert Bush type of bioclimate (Qadir, 1968).

The vegetation of Quetta and neighbouring areas have been described dealing with indicator species (Beg, 1966), Isplingi valley (Repp & Khan, 1959), the rangelands (Baig, 1981), Jungle Bagh and some graveyards (Khilji, 1982), wastelands (Changezi, 1982, Kayani *et al,* 1984) and Hazaranji (Khan & Hussain, 1963; Nissar, 1982, Kayani *et al,* 1984; Majeed, 1984, Ahmad, 1984). In the present report, an analysis of vegetation and associated soils is described .

Material and Methods

Vegetation analysis: The vegetation of 20 sites covering diverse plains in Quetta District, (Lat. 29°52′ – 30°18′ and Log. 66°55′ – 67°48′) were studied (Table 1) by

Table 1. Location of sampled sites.

S. No.	Locality	Topography	Location
1.	Karkhasa	Plains	2 miles from gate to the west.
2.	Kuchlak	Graveyard	½ miles from kuchlak bazar on Pishin road.
3.	Kuchlak	Graveyard	Near Kuchlak bazar on Ziarat road.
4.	Killi Sheikhan	Plains	6 miles from Kuchlak on Pishin road.
5.	Nawa killi	Plains	1 mile from Nawa killi to the west.
6.	Zarghun	Plains	1 mile from Lakaria on way to Tor Shor.
7.	Hanna Lake	Plains	1 mile from Hanna Lake to east.
8.	Panjpai	Plains	Near levies post Panjpai.
9.	Kuch Dam	Plains	1 mile from Kach Dam on way to Quetta.
10.	Airport	Plains	¼ miles from Airport on way to Quetta.
11.	Baleli	Graveyard	1½ from Airport on way to Quetta.
12.	Hazarganji	Plains	Near rest house.
13.	Spazand	Plains	3 miles from Spazand on way to Quetta.
14.	Spazand	Plains	1½ miles from Spazand on way to Quetta.
15.	Chiltan	Plains	1 mile from gate on way to Chilta Baba.
16.	Hazarganji	Plains	2 miles from rest house to the west.
17.	Zarghun	Plains	1½ miles from Mangala on way to Quetta.
18.	Zaree Cheshma	Plains	1½ miles from Zaree Cheshama on way to Speen Kareze.
19.	Walitangi	Plains	1 mile from Walitangi Dam on way to Urak.
20.	Walitatangi	Plains	1½ miles from Walitangi Dam on way to Urak.

"Line intercept method" (Canfield, 1941). In each site 3 transects of 30 m length were laid at random. Species, their intercepting cover and number of individuals of each species intercepted by the lines were recorded. Relative density, relative cover and importance values were calculated. Index of similarity (Bray & Curtis, 1957) was computed using total cover (percentage) of species. Species diversity for each community using Odum's (1971) index was calculated.

$$\text{Species diversity: } \frac{\text{Total number of species in a community}}{\text{Total number of individuals counted}}$$

Nomenclature follows Stewart (1972) and to-date published Flora of Pakistan.

Soil analysis: Soil samples collected in each stand, from surface (0-15 cm) and from subsurface (30-60 cm) depth were analysed for their physical and chemical characteristics, texture (Bouyoucos, 1951), organic matter (Hussain & Qadir (1970), maximum water holding capacity (Keen & Raczkowski loc. cit. Piper, 1942), pH (Saturated paste) with glass electrode pH meter, electrical conductivity by Beckman conductivity meter; alkaline earth carbonates with acid neutralization method. Soluble ions, HCO_3^-, Cl^- and Ca^{++} plus Mg^{++} were determined by titration methods (Anon., 1954).

Results

Sixteen plant communities were recognized on the basis of index of similarity. The level of index of similarity used for integration of similar stands was 65%, because this level was found to be satisfactory for the study area (Tareen, 1986). These communities were further grouped (Table 3) on the basis of first and second dominants into 4 types of steppes viz.,:

1. *Artemisia maritima* steppe with 7 communities
2. *Haloxylon griffithii* steppe with 4 communities in unprotected areas.
3. *Alhagi maurorum* steppe with 3 communities in graveyards viz.,

   i. *Alhagi maurorum–Peganum harmala* community.
   ii. *Atriplex trurcomanica–Alhagi maurorum* community.
   iii. *Lycium ruthenicum–Alhagi maurorum* community.

4. *Salsola baryosma* steppe 2 communities in unprotected areas.

The phytosociological data have been summarized in Table 4. The most common and widespread steppe was *A. maritima* steppe.

Vegetation of protected areas: The following four plant communities were found in the protected areas of Hazarganji, Karkhasa and Walitangi:

1. *Artemisia maritima–Cymbopogon commutatus* community.
2. *Artemisia maritima–Chrysopogon aucheri* community.
3. *Artemisia maritima–Stipa arabica* community.
4. *Artemisia maritima–Piptatherum baluchistanicum* community.

Vegetation of Non-protected areas: Nine communities were found in unprotected areas (Table 5) in which *H. griffithii, A. maritima, S. mollis, S. baryosma* and *C. stocksii* were the most important dominants. The entire *H. griffithii* and *S. baryosma* steppe types were confined in unprotected areas of Quetta District. *A. maritima,* however, was found both in protected and unprotected areas.

Table 2. Similarity Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	xxx																			
2	0.00	xxx																		
3	0.00	44.46	xxx																	
4	0.00	10.96	25.03	xxx																
5	13.53	19.52	12.32	3.73	xxx															
6	32.97	4.55	3.23	3.79	9.71	xxx														
7	31.77	0.00	0.00	0.00	8.25	36.59	xxx													
8	1.07	0.00	0.00	0.00	53.06	0.00	19.70	xxx												
9	19.13	1.26	0.76	0.95	29.21	42.98	8.68	18.72	xxx											
10	0.00	26.17	23.52	26.92	22.01	6.54	0.00	0.00	2.48	xxx										
11	0.64	14.75	23.29	0.00	20.68	0.44	0.00	9.6	10.04	1.70	xxx									
12	54.51	0.00	0.00	0.00	7.58	48.68	45.35	0.00	9.84	0.00	0.00	xxx								
13	47.50	0.00	0.00	0.00	17.29	41.49	49.41	8.97	22.23	0.00	3.62	30.9	xxx							
14	49.77	0.00	0.00	0.00	15.28	38.82	49.35	4.57	20.67	0.00	2.10	54.04	90.04	xxx						
15	29.98	0.00	0.00	0.00	6.43	82.06	35.03	0.18	29.07	0.00	0.14	46.5	38.9	36.5	xxx					
16	57.38	0.00	0.00	0.00	8.47	47.92	44.01	1.06	18.28	0.00	0.00	88.85	53.5	50.00	45.7	xxx				
17	2.19	43.55	17.50	13.20	23.77	6.43	0.00	19.23	18.77	25.00	9.75	0.00	6.95	4.16	0.87	1.04	xxx			
18	31.55	7.72	5.28	6.19	10.70	86.59	36.77	0.00	34.55	10.72	0.44	48.94	41.51	39.08	77.53	48.16	9.86	xxx		
19	23.18	0.00	0.00	0.00	4.82	59.94	31.07	0.00	5.96	0.00	0.00	40.83	33.19	31.00	63.70	35.75	0.00	55.82	xxx	
20	23.23	0.00	0.00	0.00	4.83	57.23	31.14	0.00	6.39	0.00	0.00	37.64	33.44	31.09	48.03	35.83	0.00	52.49	62.63	xxx

Table 3. Summary of relative phytosociological data.

S. No.	Plant Name	Presence No. of stands	Average I.V.I.	Maximum I.V.I.	Minimum I.V.I.	No. of stands 1st dominant	No. of stands 2nd dominant
1.	*Artemisia maritima* L.	13	46.85	75.14	10.30	11	–
2.	*Scabiosa oliveri* Coult. Dips.	1	3.26	3.26	3.26	–	–
3.	*Astragalus anisacanthus* Boiss.,	2	3.13	3.93	2.33	–	–
4.	*Lactuca viminea* (L) F.W. Schmidt	2	2.36	2.48	2.23	–	–
5.	*Poa sineca* Steud.	1	0.57	0.57	0.57	–	–
6.	*Polygonum afghanicum* Meissn.	2	1.26	1.76	0.76	–	–
7.	*Cymbopogon commutatus* (Steud.) Stapf.	3	23.90	29.43	14.11	–	2
8.	*Sophora mollis* sub sp. *griffithii* (Stock) Ali.	8	19.40	59.2	1.08	1	3
9.	*Euphorbia osyridea* Boiss.	3	2.2	3.3	1.42	–	–
10.	*Haloxylon griffithii* (Moq.) Bunge ex Boiss.	8	27.48	60.76	1.38	2	4
11.	*Acantholimon longiflorum* Boiss.	2	3.56	6.35	0.76	–	–
12.	*Chrysopogon aucheri* (Boiss.) Stapf.	1	31.16	31.16	31.16	–	1
13.	*Peganum harmala* L.	10	17.13	50.56	1.74	1	2
14.	*Alhagi maurorum* Medic.	5	19.13	37.59	2.49	1	3
15.	*Heliotropium dasycarpum* Ledeb.	3	12.91	21.23	3.74	–	–
16.	*Phragmities karka* (Retz.) Trin. ex Steud.	1	15.01	15.01	15.01	–	–
17.	*Atriplex turcomanica* Fisch. & Mey.	2	15.65	30.50	0.79	1	–
18.	*Salsola baryosma* (R & S.) Dandy.	3	24.44	49.06	8.81	1	1
19.	*Lycium ruthenicum* Murray	2	39.30	70.16	8.44	1	–
20.	*Tamarix smyrnensis* Bunge	2	28.56	52.31	4.81	1	–
21.	*Descurania sophia* (Linn.) Webb ex Berth.	1	3.84	3.84	3.84	–	–
22.	*Centaurea bruguiriana* (D.C.) Hand. Mazz.	2	5.58	9.31	1.84	–	–

(Contd. Table 3)

S. No.	Plant Name	Presence No. of stands	Average I.V.I.	Maximum I.V.I.	Minimum I.V.I.	No. of stands 1st dominant	No. of stands 2nd dominant
23.	*Chenopodium album* L	1	0.44	0.44	0.44	–	–
24.	*Halocharis hispida* (C.A. Mcy) Bunge	1	2.96	2.96	2.96	–	–
25.	*Suaeda fruticosa* (L.) Forskk	1	3.11	3.11	3.11	–	–
26.	*Aeluropus littoralis* (Gouan) Parl	1	3.62	3.62	3.62	–	–
27.	*Saccharum griffithii* Munro ex Boiss.	1	1.08	1.08	1.08	–	–
28.	*Gaillonia criantha* Jaub & Spach	1	1.69	1.69	1.69	–	–
29.	*Cousinia stocksii* C. Winkler	3	22.16	42.35	1.41	–	2
30.	*Astragalus stocksii* Bunge	3	1.92	1.83	1.28	–	–
31.	*Hertia intermedia* (Boiss.) O. Ktze.	2	4.28	7.77	0.80	–	–
32.	*Alyssum desertorum* Stapf.	3	3.47	5.77	1.68	–	–
33.	*Tetrapogon villosus* Desf	3	4.10	4.52	3.38	–	–
34.	*Astragalus augunus* Bunge.	4	4.47	7.86	2.43	–	–
35.	*Plantago lanceolata* L.	1	0.65	0.65	0.65	–	–
36.	*Koelpinia linearis* Pallas	1	1.70	1.70	1.70	–	–
37.	*Bromus sericeus* Drobov.	5	3.94	7.35	1.96	–	–
38.	*Cymbolaena griffithii* (A. Gray) Wagentiz	1	2.62	2.62	2.62	–	–
39.	*Schismis arabicus* Nees	1	1.31	1.31	1.31	–	–
40.	*Anthemis odontostephana* Boiss.	1	0.65	0.65	0.65	–	–
41.	*Malcolmia africana* (Linn.) R. Br.	1	0.75	0.75	0.75	–	–
42.	*Iris sisyrinchium* L	1	4.12	4.12	4.12	–	–
43.	*Holosteum umbellatum* L.	1	3.46	3.46	3.46	–	–

44. *Lallemantia royleana* (Bth.) Bth.	2	2.00	2.26	1.74	–	–
45. *Tulipa stellata* HK. f	1	3.76	3.76	3.76	–	–
46. *Gentiana oliveri* Griseb.	1	1.78	1.78	1.78	–	–
47. *Arnebia linearifolia* DC.	1	3.45	3.45	3.45	–	–
48. *Trigonelia monantha* var. *incisa* (Benth.) Ali.	1	2.31	2.31	2.31	–	–
49. *Ferula oopods* (Boiss & Buhse) Boiss.	1	2.48	2.48	2.48	–	–
50. *Zizyphora tenuior* L.	1	1.73	1.73	1.73	–	–
51. *Convolvulus leiocalycinus* Boiss.	1	5.12	5.12	5.12	–	–
52. *Stipa arabica* Trin. & Rupr.	2	17.95	32.35	2.32	–	1
53. *Agrophyron desertorum* (Fisch. ex Link) Schult & Schult. f.	1	2.26	2.26	2.26	–	–
54. *Clypeola aspera* (Grauer) W.B. Turrill	1	4.55	4.55	4.55	–	–
55. *Psammogeton canescens* (DC.) Vatke	1	4.51	4.51	4.51	–	–
56. *Heteranthelium piliferum* (Banks & Soland.) Hochst.	1	8.74	8.74	8.74	–	–
57. *Henrardia persica* var. *persica* (Boiss.) C.E. Hubb.	1	2.66	2.66	2.66	–	–
58. *Hordeium murinum* sub sp. *glaucum* (Steud.) Tzvelve	1	2.37	2.37	2.37	–	–
59. *Centaurea iberica* Trev. ex Spreng	1	2.98	2.98	2.98	–	–
60. *Piptatherum baluchistanicum* Freitag	1	26.38	26.38	26.38	–	1
61. *Kochia stelaris* Moq.	1	1.07	1.07	1.07	–	–
62. *Ephedra geraradiana* Wall. ex Staff	1	4.62	4.62	4.62	–	–
63. *Ferula baluchistanica* Kitam.	2	2.83	5.23	0.43	–	–
64. *Bupleurum exaltatum* M. Bieb	1	5.44	5.44	5.44	–	–
65. *Caragana ambigua* Stocks.	2	1.68	1.47	1.89	–	–
66. *Prunus brahuica* (Boiss.) Aitch. & Hemsl.	1	0.94	0.94	0.94	–	–
67. *Prunus microcarpa* C.A. Mey.	1	1.34	1.34	1.34	–	–
68. *Salvia bucharica* M. Pop.	1	1.2	1.2	1.2	–	–

Species Diversity: The species diversity was generally low and ranged from 0.34 to 1.18. The following three communities had moderate (1.0-1-1.5) species diversity:

1. *Artemisia maritima–Chrysopogon aucheri* community.
2. *Artemisia maritima–Piptatherum baluchistanicum* community.
3. *Artemisia maritima–Cymbopogon commutatus* community.

The remaining 13 communities had low (< 1.0) species diversity. The lowest diversity (0.34) was in *Alhagi maurorum–Peganum harmala* community (Table 5).

Vegetational cover: The total coverage was consistently higher in protected areas than unprotected areas (Table 5). This increase in coverage was particularly remarkable in

Table 4. Total cover percentage and species diversity of different plant communities.

Site No.	Plant Communites	Cover %	Species diversity
Protected areas			
12, 16	*Artemisia maritima–Cymbopogon commutatus*	31.53	1.14
1	*Artemisia maritima–Chrysopogon aucheri*	32.22	1.18
19	*Artemisia maritima–Stipa arabica*	61.2	0.66
20	*Artemisia maritima–Piptatherum baluchistanicum*	60.99	1.17
Graveyards			
2	*Alhagi maurorum–Peganum harmala*	32.61	0.34
3	*Atriplex turcumanica–Alhagi maurorum*	64.9	0.82
11	*Lycium ruthenicum–Alhagi maurorum*	47.79	0.71
Unprotected Areas			
6, 15, 18	*Artemisia maritima–Sophora mollis*	47.46	0.64
13, 14	*Artemisia maritima–Haloxylon griffithii*	13.41	0.40
7	*Artemisia maritima–Cousinia stocksii*	37.01	0.44
5	*Haloxylon griffithii–Alhagi maurorum*	25.6	0.95
8	*Haloxylon griffithii–Cousinia stocksii*	16.79	0.97
9	*Sophora mollis–Haloxylon griffithii*	16.5	0.75
17	*Peganum harmala–Haloxylon griffithii*	18.87	0.64
10	*Salsola baryosma–Haloxylon griffithii*	8.65	0.38
4	*Tamarix smyrenensis–Salsola baryosma*	48.58	0.76

areas like Hazarganji National Park and Wali Tangi which have been protected for a long time. Graveyards also indicated high coverage although there did not seem to be any strict control over grazing. Total coverage in protected areas including graveyards was more than double the unprotected areas (Table 5). The species diversity was higher in protected areas than unprotected areas (Table 5). Although graveyards indicated high coverage yet the species diversity did not show any increase. This may be attributed to grazing pressure.

Edaphology of Plant Communities: Soil texture varied from loamy sand to sandy clay loam. Seven communities were found on sandy clay loam. Two communities were found on loamy sand and the remaining seven communites occurred on sandy loam (Table 6).

Organic matter ranged between 0.33 to 3.6%. The highest percentage (3.6, subsurface) was found in *Artemisia maritima–Sophora mollis* community and moderate level (1.5-3%) in seven communities, while the remaining communities had low (< 1.5%) percentage.

Maximum water holding capacity ranged between 17.19 to 43.60%. The highest percentage was found in *Artemisia maritima–Stipa arabica* community and moderate level (35.0-40.0% in ten communities, while five communities had low (< 35.0%) percentage. pH was found to vary from 7.6 to 8.5.

Electrical conductivity varied between 0.4 to 2.0 mmhos/cm. Five communities were found on soils with moderate level (1.0-2.0), while the remaining communities had low (< 1.0) E.C.

Calcium carbonate ranged between 12.50 to 40.52%. Eight communities had high (< 30.0%) calcium carbonate. The highest percentage was found in *Haloxylon griffithii–Alhagi maurorum* community and the remaining eight communities had moderate (25.0-30.0%) to low (< 25.0%) percentage. The soils did not differ much in respect to soil bicarbonates, varying from 1.0 to 4.0 meq/litre.

Chloride in the soil varied from 7.0 to 21.0 meq./litre with high chloride content (> 15.0) from in 5 communities. Highest chloride content was found in the soils of *Sophora mollis–Haloxylon griffithii* community, the remaining 11 communities had moderate (10.0-15.0) to low (< 10.0) chloride content.

Calcium and magnesium content varied from 5.0 to 16.0 meq./litre with highest amount found in *Sophora mollis–Haloxylon griffithii* community, moderate level (10.0-15.0) in five communities, while the remaining ten communities had low (< 10.0) content Table 6).

Table 5. Topographic and Soil (Physical) Characteristics of the Communities of Plains.

Name of communities	Total No. of stand	Topography	Sand %	Silt %	Clay %	Textural Class	Organic matter %	Maximum water Holding Capacity %
1. *Artemisia maritima* steppe								
Artemisia maritima–	3	Flat Plaina	70.48 ± 6.09	5.46 ± 2.60	24.05 ± 5.85	S.C.L.	1.32 ± 0.29	34.43 ± 9.72
Sophora mollis			74.0 ± 7.07	4.53 ± 2.46	21.46 ± 4.62	S.C.L.	3.61 ± 1.91	35.79 ± 9.26
Artemisia maritima–	2	Sloping	78.7 ± 0.06	4.98 ± 2.18	16.32 ± 2.24	S.L.	1.35 ± 0.69	34.89 ± 1.69
Cymbopogon commutatus		Plains	73.18 ± 1.58	9.38 ± 1.78	17.85 ± 3.77	S.L.	1.79 ± 0.46	36.61 ± 2.46
Artemisia maritima–	2	Sloping	62.0 ± 2.0	16.0 ± 4.0	22.0 ± 2.0	S.C.L.	2.15 ± 0.1	31.64 ± 0.76
Haloxylon griffithii		Plains	66.0 ± 2.0	8.0 ± 2.0	26.0 ± 2.0	S.C.L.	2.25 ± 0.1	30.42 ± 0.92
Artemisia maritima–	1	Flat Plains	79.36	7.52	13.12	S.L.	1.0	25.95
Chrysopogon aucheri			83.36	3.52	13.12	L.S	0.66	27.76
Artemisia maritima–	1	Sloping	71.12	6.08	22.8	S.C.L.	1.33	24.96
Cousinia stocksii		Plains	76.80	5.12	18.08	S.L	1.66	33.11
Artemisis maritima–	1	Sloping	68.0	8.0	24.0	S.C.L.	2.0	39.66
Stipa arabica		Plains	68.0	4.0	28.0	S.C.L.	1.95	43.60
Artemisia maritima–		Sloping	64.0	12.0	24.0	S.C.L.	1.95	39.27
Piptaterum baluchistanicum	1	Plains	68.0	8.0	24.0	S.C.L.	1.6	38.38

2. *Haloxylon griffithii* steppe								
Haloxylon griffithii–	1	Flat Plains	84.32	1.12	14.56	L.S	0.66	17.19
Alhagi maurorum			79.84	1.36	18.8	S.L	0.33	23.92
Haloxylon griffithii–	1	Sloping	64.0	8.0	28.0	S.C.L.	2.5	30.94
Cousinia stocksii		Plains	64.0	8.0	28.0	S.C.L.	2.7	29.86
Sophora mollis–	1	Flat Plains	91.2	0.64	8.16	L.S	0.66	24.37
Haloxylon griffithii			77.76	13.84	8.4	S.L	1.33	34.52
Peganum harmala–	1	Flat Plains	80.0	12.0	8.0	L.S	2.0	24.53
Haloxylon griffithii			88.0	8.0	4.00	L.S	2.4	21.83
3. *Alhagi maurorum* steppe								
Alhagi maurorum–	1	Graveyards	79.12	2.08	18.8	S.L.	0.66	31.65
Peganum harmala			79.12	2.08	18.8	S.L	0.33	27.09
Lycium ruthenicum–	1	Graveyards	75.12	2.08	22.8	S.C.L.	0.33	28.36
Alhagi maurorum			89.28	0.64	10.08	L.S	0.66	20.77
Atriplex turcomanica–	1	Graveyards	83.12	1.84	15.04	S.L	0.33	27.18
Alhagi maurorum			83.12	1.6	15.28	S.L	0.33	20.03
4. *Salsola baryosoma* stppe								
Salsola baryosoma–	1	Flat Plains	79.6	3.44	16.96	S.L	0.66	31.85
Haloxylon griffithii			83.12	2.72	14.16	L.S	0.33	29.75
Tamarix smyrnensis–	1	Flat Plains	84.56	3.28	12.16	L.S	0.33	24.57
Salsola baryosoma			85.76	4.16	10.08	L.S	0.33	33.97

± = Standard deviation; L.S. = Loamy sand; S.L. = Sandy loam; S.C.L. = Sandy clay loam.

Discussion

Of the 16 plant communites classified into 4 broad vegetation types, *A. maritima* steppe was most common and occupied extensive areas of the district. This steppe type also dominated the hills of Quetta District (Tareen, 1986). *H. griffithii* steppe was the second important type.

The vegetation of protected areas like Hazarganji, Karkhasa, Walitangi was distinctly better in respect of total coverage, species richness and abundance of grasses than the vast upprotected areas of Quetta District. This is in conformity with the observations of Khan & Hussain (1963), Nissar, (1982), Majeed (1984) and Ahmad (1984). The characteristic species of protected areas are *C. commutatus, C. aucheri, P. baluchistanicum, S. arabica* etc. The vegetation of graveyards significantly differed from the rest of the plains. *A. maurorum* steppe was dominant in these areas. *A. maurorum* and *L. ruthenicum* were the characteristic species of these areas. Khilji (1982) also found *H. griffithii* in the graveyards. The characteristic species of non-protected areas were *H. griffithii, S. mollis, S. baryosma* and *C. stocksii. A. maritima* was the most important dominant in both protected as well as unprotected regions.

The correlation of vegetation types with the edaphic factors was found not only with the various steppe types but also with the individual communities within each steppe type. The edaphic relations of *A. maritima–C. commutatus* community (*A. maritima* steppe) was more or less similar with the *C. commutatus–A. maritima* community (Majeed, 1984) particularly in respect of E.C. and calcium carbonate content. The soils relations of three communities of the wastelands of Quetta and Quetta-Pishin areas *P. harmala–H. murinum–P. annua* (Kayani *et al*, 1984a), *P. harmala–Malcolmia africana* and *P. harmala–Hordeum glaucum* (Kayani *et al.* 1984b) closely approach the *P. harmala–H. griffithii* community reported herein particularly in respect of organic matter, HCO_3, Cl^- and Ca + Mg.

The plains of Quetta District were found to show even distribution between coarse and fine-textured soils. *Cousinia stocksii* and *Piptatherum baluchistanicum* appear to be the characteristic species of fine-textured soils, whereas *A. maritima, H. griffithii, A. maurorum* and *P. harmala* occurred both on coarse and fine-textured soils though mostly on coarse texture, similar to that obtained by Majeed (1984) and Ahmad (1984).

Correlation of communities with edaphic factors: Artemisia martitima steppe. *Artemisia maritima* steppe was found on sandy clay loam to sandy loam soils, but mostly on sandy clay loam soils, having generally medium organic matter, low electrical conductivity, generally low HCO_3, medium chlorides and low Ca + Mg.

The seven plant communities included in this type of steppe segregated from one another in the following manner:

1. *Artemisia maritima–Sophora mollis:* High organic matter
2. *Artemisia maritima–Cymbopogon commutatus:* Moderate $CaCO_3$ and MWHC
3. *Artemisia maritima–Haloxylon griffithii:* High chlorides, low MWHC, medium HCO_3
4. *Artemisia maritima–Chrysopogon aucheri:* High $CaCO_3$, low chlorides and MWHC
5. *Artemisia maritima–Cousinia stocksii:* High $CaCO_3$, medium chlorides, and low MWHC
6. *Artemisia maritima–Stipa arabica:* Higher MWHC, medium Ca + Mg and low $CaCO_3$
7. *Artemisia maritima–Piptatherum baluchistancium:* Medium HCO_3 and chlorides and lowest E.C.

Alhagi maurorum steppe: *Alhagi maurorum* steppe was found on sandy loam to sandy clay loam soils having low organic matter, low MWHC, low HCO_3 and medium chlorides.

The three plant communities included in this type of steppe segregated from one another in the following manner:

1. *Alhagi maurorum–Peganum harmala:* Medium $CaCO_3$
2. *Lycium ruthenicum–Alhagi maurorum:* Medium E.C.
3. *Atriplex turcomanica–Alhagi maurorum:* Low E.C. and Ca + Mg.

Salsola baryosma steppe: *Salsola baryosma* steppe was found on loamy sand to sandy loam soils having low organic matter, low MWHC, high $CaCO_3$, low HCO_3 and low Ca + Mg.

The two plant communities included in this type of steppe segregated from one another in the following manner:

1. *Salsola baryosma–Haloxylon griffithii:* Low E.C., high chlorides.
2. *Tamarix smyrnensis–Salsola baryosma:* Medium E.C., medium chlorides.

Haloxylon griffithii steppe: *Haloxylon griffithii* steppe was found on loamy sand to sandy clay loam soils, having low MWHC, generally medium E.C., medium HCO_3 and high chlorides.

Table 6. Soil (Chemical) Characteristics of the Communities of Plains.

Name of communities	pH	E.C. mmhos/cm	$CaCO_3$ %	HCO_3 meq/l	Cl meq/l	Ca + Mg meq/l
1	2	3	4	5	6	7
1. *Artemisia maritima* steppe						
Artemisia maritima–	7.93 ± 0.19	0.63 ± 0.16	25.88 ± 10.27	1.66 ± 0.94	10.83 ± 2.89	10.0 ± 4.54
Sophora mollis	8.16 ± 0.09	0.7 ± 0.14	18.19 ± 6.57	1.33 ± 0.47	10.33 ± 2.62	7.32 ± 0.94
Artemisia maritima–	8.2 ± 0.1	0.65 ± 0.05	22.17 ± 3.02	2.25 ± 0.75	12.5 ± 2.5	8.5 ± 0.5
Cymbopogon commutatus	8.35 ± 0.15	0.7 ± 0.01	25.3 ± 1.2	2.75 ± 1.25	12.0 ± 1.0	9.5 ± 0.5
Artemisia maritima–	8.5 ± 0.1	0.75 ± 0.05	27.3 ± 0.95	3.5 ± 0.5	15.5 ± 0.5	8.5 ± 0.5
Haloxylon griffithii	8.4 ± 0.1	0.85 ± 0.05	29.07 ± 1.57	3.0 ± 0.00	13.5 ± 0.5	9.5 ± 0.5
Artemisia maritima–	8.0	0.9	29.85	1.5	7.0	7.0
Chrysopogon aucheri	8.3	0.9	35.31	1.5	9.0	9.0
Artemisia maritima–	7.7	0.5	31.17	1.5	10.0	7.0
Cousinia stocksii	7.8	0.6	14.46	1.0	13.0	7.0
Artemisis maritima–	8.1	0.6	12.50	2.0	13.0	9.0
Stipa arabica	8.2	0.4	20.01	2.0	13.0	11.0
Artemisia maritima–	8.5	0.6	21,37	3.0	11.0	7.0
Piptatherum baluchistanicum	8.3	0.4	19.78	4.0	13.0	7.0

2. *Haloxylon griffithii* steppe						
Haloxylon griffithii–	7.9	0.6	32.97	1.5	14.0	9.0
Alhagi maurorum	7.8	0.5	40.52	1.0	16.0	8.0
Haloxylon griffithii–	7.9	1.0	18.91	3.0	16.0	10.0
Cousinia stocksii	8.0	0.8	16.41	4.0	18.0	11.0
Sophora mollis–	8.1	1.0	28.65	3.0	19.0	15.0
Haloxylon griffithii	8,2	0.9	32.06	4.0	21.0	16.0
Paganum harmala–	7.9	1.9	20.92	3.0	15.0	10.0
Haloxylon griffithii	7.8	2.0	27.31	4.0	13.0	10.0
3. *Alhagi maurorum* steppe						
Alhagi maurorum–	7.8	0.8	25.87	1.5	10.0	8.0
Peganum harmala	7.9	1.0	23.87	1.5	10.0	7.0
Lycium ruthenicum–	7.6	1.3	22.14	1.5	15.0	10.0
Alhagi maurorum	7.8	0.9	30.65	1.5	15.0	11.0
Atriplex turcomanica–	7.8	0.5	30.56	1.5	11.0	8.0
Alhagi maurorum	7.9	0.5	33.90	1.5	14.0	7.9
4. *Salsola baryosoma* steppe						
Salsola baryosoma–	7.8	0.5	30.50	1.0	16.0	5.0
Haloxylon griffithii	7.8	0.6	29.25	1.5	18.0	5.0
Tamarix smyrnensis–	7.7	1.5	35.67	1.5	12.0	8.0
Salsola baryosoma	7.9	1.0	28.67	1.0	10.0	7.0

The four plant communities included in this type of steppe segregated from one another in the following manner:

1. *Haloxylon griffithii–Alhagi maurorum:* Low E.C., Low HCO_3 and low Ca + Mg.
2. *Haloxylon griffithii–Cousinia stocksii:* Low $CaCO_3$.
3. *Sophora mollis–Haloxylon griffithii:* High $CaCO_3$ and high Ca + Mg.
4. *Peganum harmala–Haloxylon griffithii:* Medium $CaCO_3$ and medium Ca + Mg.

Species diversity was found to be generally low similar to that obtained by Majeed (1984) in the plains of newly enclosed area of Hazarganji. Three communities, however, had medium species diversity and these belonged to the protected areas. Species diversity in atleast two of these communities (Hazarganji and Walitangi) seems to be related with high organic matter and maximum water holding capacity. Relatively high diversity was also found by Majeed (1984) in the communities of water courses with medium to high organic matter. The lowest species diversity found in the present work in *A. maritima–P. harmala* community also appears to be correlated with low organic matter and low moisture holding capacity (Table 6).

Of special interest are the following communities which have the lowest or the highest values of edaphic variables in the entire Quetta district:

1. *A. maritima–S. arabica:* High MWHC, lowest E.C. and lowest $CaCO_3$
2. *A. maritima–P. baluchistanicum:* Lowest E.C.
3. *A. maritima–C. laucheri:* Lowest Chlorides.
4. *H. griffithii–A. maurorum:* Lowest MWHC and the highest $CaCO_3$
5. *S. mollis–H. griffithii:* Highest chlorides and highest Ca + Mg
6. *A. maritima–A. maurorum:* Lowest O.M.
7. *T. smyrnensis–S. baryosma:* Lowest O.M.
8. *S. baryosma–H. griffithii:* Lowest Ca + Mg.

Apparently the habitats of communites 1-3 represent the most favourable environmental conditions in the Quetta district, while communities 5, 6, 7 and 8 and possibly community 4 indicate unfavourable sites. The communities 2 and 3 belong to protected areas (Walitangi and Hazarganji respectively) and have medium species diversity and relatively high total coverage (Table 5). The communities 4-8 were found in unprotected areas and have generally low species diversity as well as total coverage. The first community is recently protected and has quite high total coverage. From this it can be concluded that species diversity and total coverage tend to increase with the increased protection of vegetation. Both Hazarganji National Park and Wali Tangi areas have been enclosed for a long time.

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