Pak. J. Bot., 22(1): 52–65, 1990.

PHYTOSOCIOLOGY OF THE WATER COURSES OF QUETTA DISTRICT

RASOOL BAKHSH TAREEN AND S.A. QADIR

Department of Botany,
University of Baluchistan, Quetta, Pakistan.

Abstract

Twenty three plant communities recognized on the basis of compositional similarity were grouped into 7 steppe types which show the correlations with the edaphic factors viz., *Peganum harmala* steppe:- Medium $\overline{Cl}$; *Saccharum griffithii* steppe:- Mostly low $H\overline{CO}_3$.; *Perovskia* steppe:- Mostly medium to low $\overline{Cl}$; *Sophora mollis* steppe:- Low $H\overline{CO}_3$, low EC and medium organic matter; *Hertia intermedia* steppe:- Low to medium MWHC, Ca^{++} + Mg^{++}; *Artemisia maritima* steppe:- Medium to high $\overline{Cl}$; *Wet steppe:*- Low to medium MWHC, high $CaCO_3$, high to medium $\overline{Cl}$ and Ca^{++}+Mg^{++}. Individual communities in each steppe type also differentiated on the basis of edaphic factors. The total coverage was found to be low. Species diversity was generally high in protected areas as compared to unprotected areas.

Introduction

Topography and climatic conditions of Quetta district have been described by Tareen & Qadir (1987). In the present work 25 stands were studied in the water courses of Quetta district, with regards to vegetation and soils. No detailed work on these aspects of the water courses of Quetta district was carried out previously. However preliminary account of the vegetation of Quetta and some small areas were reported by some workers viz., indicator species in Quetta-Pishin (Beg, 1966), the rangelands in Quetta-Pishin (Baig, 1981), wastelands of Quetta (Changezi, 1982), Jungle Bagh and some grave yards (Khilji, 1982), wastelands of Quetta-Pishin districts (Kayani *et al.*, 1984a), Hazarganji (Khan & Hussain, 1963, Nisar, 1982; Kayani *et al.*, 1984b; Majeed, 1984; Ahmed 1984). From these reports complete picture of the vegetation of the water courses of Quetta district does not emerge. Therefore, an attempt has been made to carry out a comprehensive study of the vegetation and soils of the water courses of Quetta district.

Material and Methods

Location: Twenty five sites occupying considerable area covering various water courses in Quetta district were studied (Table 1).

Vegetation Analysis: The vegetation was studied by "line intercept method" (Canfield, 1941). In each site three lines of 30 m length were laid at random. Name of the species and their cover intercepting the line and the number of individuals were noted and phytosociological attributes (relative density, relative cover and importance values) were calculated.

Table 1. Location of Sampled Sites

Site No.	Locality	Location
1.	Brewery	Near Brewery nallah.
2.	Kanic	2 miles on way to Quetta.
3.	Kolli	8 miles from Kanic on way to Mastung.
4.	Hazarganji	1/4 mile from gate on way to Quetta.
5.	Hazarganji	1/4 mile from gate on way to rest house.
6.	Hazarganji	near 2nd gate.
7.	Hazarganji	1 1/2 miles from gate on way to rest house.
8.	Hazarganji	near rest house.
9.	Hanna	near Sorange hotel on Sorange-Quetta road.
10.	Hanna	near Hana-Urak road cross on way to Hanna lake.
11.	Hanna	one mile from Hanna lake to the east.
12.	Hanna	one mile from Hanna on way to Quetta.
13.	Hanna	$6\frac{1}{2}$ miles from Quetta on way to Hanna.
14.	Hanna	1/2 mile from Hanna lake to the west.
15.	Hanna	2 miles from Hanna on way to Quetta.
16.	Hanna	1 1/2 miles from red bridge to Hanna.
17.	Hazarganji	4 miles from Lakpass on way to Quetta.
18.	Hazarganji	1/2 mile from 2nd gate on way to the rest house.
19.	Zarghun	2 miles from Lakaria on way to Torshor.
20.	Urak	Urak kach, near Urak rest house.
21.	Karkhasa	1 1/2 miles from gate to the west.
22.	Zarghun	one mile from Lakaria on way to Torshor.
23.	Zarghun	3 miles from Mangala coal mines on way to Quetta.
24.	Zarghun	one mile from Mangala coal mine on way to Quetta.
25.	Walitangi	3 miles from Walitangi dam on way to Quetta.

Nomenclature of the plants followed is that of Stewart (1972). Wherever, subsequent nomenclatural changes have been promulgated (in under print Flora of Pakistan), and the valid names were followed. Index of similarity (Bray & Curtis, 1957) was computed using total cover of species. Species diversity was calculated by Menhinick (1964) index.

Soil analysis: Two soil samples were collected in each stand, one from surface (0-15 cm) and another from subsurface (30-60 cm) depth. These were analysed for physical and chemical characteristics. Texture was determined by hydrometer method (Bouyoucos, 1951). Organic matter was determined by the method described by Hussain & Qadir (1970), maximum water holding capacity was determined by (Keen & Raczkowski method as in Piper, 1942), pH (saturated paste) with glass electrode pH meter, electrical conductivity by Beckman conductivity meter and alkaline earth carbonates ($CaCO_3$) were determined with acid naturalization method of U.S.D.A. (Anon., 1954). Soluble ions, $\overline{HCO_3}$, $\overline{Cl}$ and $Ca^{++}+Mg^{++}$ were determined by titration methods of U.S.D.A. (Anon., 1954).

Results and Discussion

Twenty five stands were studied in the water courses of Quetta district. On the basis of index of similarity (Bray & Curtis, 1957), 23 plant communities were recognized. The level of index of similarity used for integration of similar stands was 65% (Table 2). Out of 23 communities, 20 communities were found in dry water courses and three communities were found in wet water courses. The communities of dry water courses were further groupd on the basis of first and second dominants into 6 common types of steppes whereas the three communities of wet water courses were placed under wet steppe. Thus water courses of Quetta district contained 7 types of steppes, which are as under:-

1. *Saccharum griffithii* steppe consisting of 4 communities.
2. *Perovskia* steppe composed of 4 communities.
3. *Hertia intermedia* steppe contains 4 communities.
4. *Artemisia maritima* steppe consisting of 3 communities.
5. *Peganum harmala* steppe contains 3 communities.
6. *Sophora mollis* steppe composed of 2 communities.
7. *Wet steppe* consisting of 3 communities.

The phytosociological data have been summarized in Table 3. *S. griffithii, Perovskia* and *Hertia intermedia* steppes were the most extensive types in the water courses, while *A. maritima, P. harmala* and wet steppes were more or less localised in distribution. The steppe types classification appears to be most appropriate to give a general account of the vegetation. When the whole cold region of Baluchistan is surveyed completely a formal classification could be attempted.

Topographic Relations of Plant Communities:

Topography was found to exert some influence on the distribution of vegetational types. Five communities were found in wide water courses (>80.0 meters wide). Four communities were found in narrow (20.0-59.0 meters) water courses and fourteen communities in medium (60.0-80.0 meters) water courses (Table 5). *Peganum harmala, Perovskia atriplicifolia* and *Artemisia maritima* were mostly found in the narrow water courses, *Hertia intermedia* and *Saccharum griffithii* in medium to wide and *Sophora mollis* in wide water courses.

This type of distribution appears to be closely linked with the amount of water flow in the winter and spring months and the resultant soil moisture regimes in the water courses. The wet type of steppe is of course associated with the running water (mountain streams).

Total vegetational Coverage:

The vegetational cover was generally low and ranged from 10.71 to 49.28%. The highest vegetational cover (49.28%) was found in *Saccharum griffithii-Sophora mollis*

Table 2. Similarity Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1																									
2	15.69																								
3	14.48	23.10																							
4	5.04	20.61	29.79																						
5	3.76	4.26	12.41	24.14																					
6	0.60	4.93	7.64	14.18	30.57																				
7	3.14	9.77	7.38	22.10	10.45	52.99																			
8	2.01	5.46	7.40	49.88	17.82	37.07	46.98																		
9	0.19	0.99	3.75	13.70	11.87	9.71	7.67	7.70																	
10	2.64	60.26	4.60	7.55	1.30	18.28	5.45	19.55	2.23																
11	6.55	7.39	15.37	37.28	25.14	18.36	16.19	10.42	59.62	4.45															
12	9.99	14.68	2.49	5.19	6.97	8.71	5.62	6.85	3.09	36.91	9.00														
13	6.25	6.17	5.24	8.82	14.90	1.77	22.09	14.88	16.98	5.46	36.66	15.36													
14	3.33	26.77	10.64	14.88	19.95	0.93	17.34	10.28	3.96	23.57	21.49	22.13	22.25												
15	7.24	50.09	16.64	18.37	29.87	18.20	8.09	14.42	6.15	45.94	23.12	49.22	12.57	41.82											
16	0.07	58.36	1.64	7.40	9.15	10.14	10.01	10.24	5.55	44.08	9.85	57.14	6.05	31.73	68.10										
17	30.74	24.08	28.3	26.14	31.71	19.90	0.62	10.21	5.45	4.63	45.14	9.18	35.63	9.85	25.78	8.41									
18	0.00	0.59	0.40	44.54	25.66	20.22	15.04	59.82	8.38	1.04	24.49	6.78	48.65	9.74	20.20	8.49	25.28								
19	2.91	2.60	5.20	4.38	21.41	29.51	13.86	18.00	1.91	12.01	13.25	6.52	9.18	8.56	9.72	5.42	14.54	29.13							
20	9.97	52.69	1.84	5.39	2.98	4.35	6.78	4.97	4.84	45.12	4.86	57.18	9.07	36.90	47.77	61.87	3.32	2.59	2.27						
21	0.71	49.49	2.85	6.33	8.28	9.92	13.75	17.69	4.17	39.91	6.81	47.10	4.86	23.9	48.96	64.09	5.60	4.63	4.58	50.73					
22	4.34	3.84	9.04	11.7	24.15	29.11	15.59	19.48	50.93	12.00	55.69	7.94	11.26	14.08	16.82	7.71	13.80	9.37	28.16	4.00	5.72				
23	2.89	3.25	6.12	26.83	23.24	24.11	4.51	8.78	51.03	3.81	14.73	9.20	6.31	4.55	19.47	7.70	20.81	35.34	31.86	2.84	6.03	22.79			
24	0.00	0.00	0.70	1.05	15.87	18.66	0.58	5.11	42.58	1.14	38.31	6.96	1.79	0.34	13.07	7.28	10.26	25.07	27.22	2.51	4.81	22.52	82.96		
25	0.00	9.54	0.00	5.52	0.00	2.39	8.56	7.07	1.43	7.06	20.85	9.72	28.83	23.77	11.57	13.71	19.89	0.00	2.24	22.42	9.41	3.07	3.82	0.40	

Table 3. Summary of relative phytosociological data.

S. No.	Plant Name	Presence No. of Stands	Average I.V.	Maximum I.V.	Minimum I.V.	No. of Stands 1st dominant	No. of Stands 2nd dominant
1	2	3	4	5	6	7	8
1.	*Peganum harmala* L.	9	22.98	67.55	1.45	2	3
2.	*Sophora mollis* subsp *griffithii* (Stocks) Ali	19	9.81	27.36	0.52	2	3
3.	*Astragalus auganus* Bunge	2	3.13	5.02	1.24	–	–
4.	*A. anisacanthus* Boiss.	2	1.21	2.10	0.32	–	1
5.	*A. stocksii* Bunge	6	1.66	18.99	2.87	–	–
6.	*Alhagi maurorum* Medic	3	2.02	4.52	0.56	–	–
7.	*Ebenus stellate* Boiss	2	3.39	5.13	1.65	–	–
8.	*Trigonella monantha var. incisa* (Bth.) Ali	3	1.59	3.59	0.56	–	–
9.	*Hordeum murinum* L.	4	1.78	3.26	0.51	–	–
10.	*Schismus arabicus* Nees	2	3.19	5.6	0.79	–	–
11.	*Cynodon dactylon* (L.) Pers	9	5.67	16.44	1.53	–	–
12.	*Saccharum griffithii* Munro ex Boiss.	15	15.47	54.67	1.29	6	2
13.	*Bromus sericeus* Drobov	8	4.55	14.78	0.53	–	1
14.	*Boissiera squarrosa* (Bank & Soland) Nevski	9	1.74	2.55	0.51	–	–
15.	*Tetrapogon villosus* Desf.	2	1.13	1.9	0.37	–	–
16.	*Cymbopogon commutatus* (Steud.) Stapf	4	10.17	22.91	2.44	–	1
17.	*Pennisetum orientale* L.C. Rich.	1	2.67	2.67	2.67	–	–
18.	*Heteranthelium piliferum* (Bank & Soland) Hochst	1	0.53	0.53	0.53	–	–
19.	*Avena fatua* L.	1	2.04	2.04	2.04	–	–
20.	*Piptatherum baluchistanicum* Freitag	2	3.83	5.12	2.55	–	–
21.	*Stipa arabica* Trin & Rupr.	2	2.78	3.77	1.80	–	–
22.	*Ennesapogon persicus* Boiss.	1	1.62	1.62	1.62	–	–
23.	*Aeluropus littoralis* (Gouan) Parl	1	8.95	8.95	8.95	–	–
24.	*Chrysopogon aucheri* (Boiss.) Stapf	5	4.82	10.34	1.30	–	–
25.	*Achillea santolina* L.	1	3.70	3.70	3.70	–	–
26.	*Artemisia maritima* L.	19	18.61	52.62	2.13	2	6
27.	*A. scoparia* Waldst & Kit.	1	1.26	1.26	1.26	–	–
28.	*Blumea obliqua* (L.) Druce	1	0.53	0.53	0.53	–	–
29.	*Carthamus oxycantha* M.B.	4	0.95	1.65	0.34	–	–
30.	*Centaurea iberica* Trev. ex Spreng	1	2.62	2.62	2.62	–	–
31.	*C. cyanus* L.	1	4.9	4.9	4.9	–	–
32.	*Cousinia heterophylla* Boiss.	3	2.11	4.87	0.32	–	–
33.	*C. minuta* Boiss.	1	2.68	2.68	2.68	–	–
34.	*Cymbolaena griffithii* (A. Gray) Wagentiz	4	1.66	3.51	0.81	–	–
35.	*Echinops griffithianus* Boiwss.	1	3.83	3.83	3.83	–	–
36.	*Hertia intermedia* (Boiss) O. Ktze.	7	32.68	69.13	0.45	5	–
37.	*Jurinea berardioides* (Boiss.) Diels	1	0.65	0.65	0.65	–	–
38.	*Koelpinia linearis* Pallas	2	4.65	6.63	2.68	–	–
39.	*Lactuca viminea* (L.) F.W. Schmidt	12	5.21	23.39	0.68	–	1
40.	*Pulicaria crispa* (Forssk.) Bth.	2	3.4	3.9	2.9	–	–
41.	*Senecio decaisnei* DC.	1	4.84	4.84	4.84	–	–
42.	*Sonchus asper* (L.) Hill	2	1.35	1.85	0.86	–	–

Table 3. (Contd.)

1	2	3	4	5	6	7	8
43.	*Lallemantia royleana* (Bth.) Bth.	2	2.13	5.36	1.58	–	–
44.	*Marrubium vulgare* L.	3	1.97	3.65	0.32	–	–
45.	*Mentha longifolia* (L.) Huds	4	10.24	28.25	0.4	1	–
46.	*Nepeta juncea* Bth.	9	4.99	14.77	0.71	–	–
47.	*Perovskia abrotanoides*Karel	8	15.01	54.74	0.95	1	2
48.	*P. atriplicifolia* Bth.	7	25.52	59.39	3.22	3	2
49.	*Chenopodium album* L.	1	2.71	2.71	2.71	–	–
50.	*Haloxylon griffithii* (Moq.) Bunge ex Boiss.	7	7.77	30.45	0.78	1	–
51.	*Alyssum desertorum* Stapf	4	0.93	1.32	0.57	–	–
52.	*Clypeola aspera*(Grauer) W.B. Turrill	1	1.0	1.0	1.0	–	–
53.	*Conringia planisiliqua* Fisch. & Mey.	1	5.75	5.75	5.75	–	–
54.	*Euclidium syriacum* (L.) R.Br.	1	0.34	0.34	0.34	–	–
55.	*Convolvulus leiocalycinus* Boiss.	2	5.28	8.23	2.33	–	–
56.	*Scrophularia striata* Boiss.	1	2.44	2.44	2.44	–	–
57.	*Verbascum erianthum* Bth.	2	1.68	2.35	1.02	–	–
58.	*Arnebia linearifolia* DC.	1	2.47	2.47	2.47	–	–
59.	*Heliotropium europaeum* L.	1	3.84	3.84	3.84	–	–
60.	*Lepyrodiclis holosteoides* (C.A. Mey) Fenzl ex. F.&M.	2	3.81	5.28	2.34	–	–
61.	*Limonium cabulicum* (Boiss.) O. Ktze.	2	1.0	1.13	0.87	–	–
62.	*Minuartia meyeri* (Boiss.) Bornm.	3	1.91	2.56	0.83	–	–
63.	*Clematis graveolens* Lindl.	1	7.34	7.34	7.34	–	–
64.	*Bunium persicum* (Boiss.) Fedtsch.	1	0.88	0.88	0.88	–	–
65.	*Ferula oopoda* (Boiss. & Buhse) Boiss.	2	7.71	13.06	2.37	–	–
66.	*Callipeltis cucularis* (Jusl.) Rothm.	1	2.21	2.21	2.21	–	–
67.	*Gaillonia eriantha* Jaub. & Spach	1	5.39	5.39	5.39	–	–
68.	*Diarthron vesiculosum* (Fisch. & Mey) Mey.	1	0.79	0.79	0.79	–	–
69.	*Scabiosa olivieri* Coult.	3	2.58	4.35	0.85	–	–
70.	*Euphorbia granulata* Forssk.	2	0.96	1.14	0.79	–	–
71.	*E. osyridea* Boiss.	10	5.92	29.65	0.90	1	–
72.	*Tamarix ramosissima* Ledeb	3	1.30	1.76	0.98	–	–
73.	*Campanula leucoclada* Boiss.	1	3.77	3.77	3.77	–	–
74.	*Ephedra gerardiana* Wall. ex Stapf	1	2.04	2.04	2.04	–	–
75.	*Acanthophyllum squarrosum* Boiss.	1	1.44	1.44	1.44	–	–
76.	*Cotoneaster nummularia* Fisch. & Mey.	1	3.54	3.54	3.54	–	–
77.	*Prunus brahuica* (Boiss.) Aitch. & Hemsl.	3	4.07	9.23	1.69	–	–
78.	*Papaver pavonium* Fisch. & Mey.	1	1.24	1.24	1.24	–	–
79.	*Roemeria hybrida* (L.) DC.	1	1.97	1.97	1.97	–	–
80.	*Polygonum afghanicum* Meissn.	1	0.53	0.53	0.53	–	–
81.	*P. aviculare* L.	4	2.65	4.67	0.69	–	–
82.	*Erodium cicutarium* (L.) L'Herit.ex. Ait.	1	2.46	2.46	2.46	–	–
83.	*Equisetum ramosissimum* Deaf	4	14.13	34.95	3.17	1	1
84.	*Juncus inflexus* L.	4	7.72	15.91	0.97	–	–
85.	*Malva neglecta* Wallr.	1	1.09	1.09	1.09	–	–
86.	*Berberis baluchistanica* Ahrendt	2	4.31	4.64	3.98	–	–

community and the lowest vegetational cover (10.71%) in *Hertia intermedia-Perovskia atriplicifolia* community (Table 5). Majeed (1984) and Khan & Hussain (1963) also reported low coverage in the water courses of Hazarganji. The water flow probably does not permit many plants to get themselves established.

When the total cover in the protected areas like Hazarganji, Karkhasa and Walitangi were compared with the unprotected areas, no significant difference was observed. This may be attributed to the type of species which are found in the water courses. None of the dominant species are palatable to the grazing animals. Since the annuals did not appear during the study period because of scanty rainfall, the difference between the protected and the unprotected water courses has narrowed down. The only significant difference, however has been the species diversity which was consistently higher in protected than in the unprotected water courses.

Species diversity:

The species diversity was generally high and ranged from 0.79 to 2.23. The following 9 communities had high (>1.5) species diversity.

Haloxylon griffithii - Peganum harmala - Koelpinia linearis, Saccharum griffithii - Artemisia maritima, Sophora mollis - Perovskia atriplicifolia - Ferula oopoda, Equisetum ramosissimum - Perovskia abrotanoides - Prunus brahuica, Peganum harmala - Artemisia maritima, Perovskia atriplicifolia - Sophora mollis, Perovskia abrotanoides - Cynodon dactylon, Sophora mollis - Cymbopogon commutatus - Artemisia maritima and *Saccharum griffithii - Lactuca viminea.*

The rest of the communities had moderate (1.0-1.5) to low (<1.0) species diversity. Species diversity was lowest in *Peganum harmala - Cynodon dactylon* community.

The species diversity was found to be consistently higher in protected areas than the unprotected areas (Table 4). This increase in species diversity in protected areas is apparently related to the increase in the number of species due to the absence of grazing. The species diversity was generally higher in water courses and is apparently related with the better soil moisture available in the water courses. Majeed (1984) and Ahmed (1984) also found high species diversity in the water courses of Hazarganji.

Edaphology of Plant Communities:

Soil texture varied from sand to sandy clay loam. Two communities were found on sandy clay loam. Two communities were found on sand and loamy sand (Table 5). pH was found to vary from 7.5 to 8.4 (Table 5). Electrical conductivity varied between 0.4 to 1.9 mmhos/cm. Eight communities were found on the soils having moderate E.C. (1.0-2.0). The soils of the rest of the communities has low (<1.0) EC. The lowest EC (0.4) was found in the soils of *Hertia intermedia - Astragalus stocksii - Sophora mollis* community.

Calcium carbonate varied from 20.31 to 41.65%. Fourteen communities had high (>30.0%) calcium carbonate content. The highest percentage (41.65, 39.56%) of calcium

Table 4. Total Cover Percentage and Species Diversity of different Plant Communities.

Site No.	Plant Communities	Cover %	Species diversity
	Protected areas		
21	*Saccharum griffithii - Lactuca viminea*	22.40	1.60
18	*Perovskia atriplicifolia-Artemisia maritima*	29.87	1.34
3	*Haloxylon griffithii - Peganum harmala - Koelpinia linearis*	19.54	2.23
25	*Equisetum ramosissimum - Perovskia abrotanoides - Prunus brahuica*	18.66	1.85
8	*Perovskia atriplicifolia - Sophora mollis*	31.75	1.76
7	*Sophora mollis - Perovskia atriplicifolia - Ferula oopoda*	31.10	1.87
6	*Sophora mollis - Cymbopogon commutatus - Artemisia maritima*	32.91	1.70
5	*Euphorbia osyridea - Bromus sericeus - Artemisia maritima*	21.12	1.80
	Unprotected areas		
15, 16	*Saccharum griffithii - Artemisia maritima*	19.67	1.99
10	*Saccharum griffithii - Sophora mollis*	49.28	0.81
20	*Saccharum griffithii - Equisetum ramosissimum*	31.71	1.40
17	*Peganum harmala - Artemisia maritima*	19.91	1.83
2	*Saccharum griffithii - Peganum harmala*	31.66	1.20
1	*Peganum harmala - Cynodon dactylon*	21.25	0.79
11	*Hertia intermedia - Perovskia abrotanoides*	14.97	1.20
23, 24	*Hertia intermedia - Artemisia maritima*	27.79	1.39
9	*Hertia intermedia - Perovskia atriplicifolia*	10.71	1.12
22	*Hertia intermedia - Astragalus stocksii - Sophora mollis*	23.55	1.32
12	*Artemisia maritima - Saccharum griffithii*	44.59	1.01
19	*Artemisia maritima - Sophora mollis*	37.45	0.96
14	*Mentha longifolia - Saccharum griffithii - Juncus inflxus*	27.74	1.15
4	*Perovskia atriplicifolia - Peganum harmala*	18.29	1.45
13	*Perovskia abrotanoides - Cynodon dactylon*	14.65	1.71

carbonate was found in the soil of the *Mentha longifolia - Saccharum griffithii - Juncus inflexus* community on wet water course. The soil of the rest of the communities had low percentage of calcium carbonate. The lowest percentage (20.31, 21.42%) of calcium carbonate was found in the soil of *Hertia intermedia - Artemisia maritima* community (Table 5).

The soils did not differ much in respect of soil bicarbonates, varying from 1.0 to 5.30 meq./1. The soils of ten communities had moderate bicarbonate content (>3.0). The remaining thirteen communities had low bicarbonate content (Table 5).

The soil chlorides were found to be varying from 6.0 to 28.0 meq./1. The soils of three communities had high chloride content (>15.0). The highest chloride content (28.0, 24.0) was found in the soil of *Mentha longifolia - Saccharum griffithii - Juncus inflexus* community of wet water course. The remaining twenty communities had moderate (10.0-15.0) meq./1. to low (<10.0) chloride content. The lowest chloride level meq./1. (6.0 surface) was found in *Perovskia atriplicifolia - Peganum harmala* community (Table 5).

The combined content of calcium plus magnesium varied from 5.0 to 17.0 meq./1. Three communities had moderate (10.0-15.0) content and remaining fifteen communities had low (<10.0) content. The lowest (5.0, surface) calcium plus magnesium was found in the soil of *Hertia intermedia - Perovskia abrotanoides* community (Table 5).

Correlations of Steppe Types and Communities with Edaphic Factors.

1. *Peganum harmala* steppe: *Peganum harmala* steppe was found on the soils having low MWHC, and $Ca^{++}+Mg^{++}$, medium Cl, high to medium $CaCO_3$ and low to medium EC, and O.M. The communities included in this steppe type differentiated as follows: *Peganum harmala - Cynodon dactylon* community: Medium EC, $CaCO_3$ and low HCO_3, *Peganum harmala - Artemisia maritima* community: Low O.M. *Haloxylon griffithii - Peganum harmala - Koelpinia linearis* community: Medium O.M.

2. *Saccharum griffithii* steppe: *Saccharum griffithii* steppe was found on the soils having low MWHC, mostly low HCO_3 and $Ca^{++}+Mg^{++}$, high to medium $CaCO_3$, medium to low Cl, and low to medium O.M. and E.C. The communities included in this steppe type differentiated as follows:

Saccharum griffithii - Artemisia maritima community: Low O.M., low HCO_3 and Cl.

Saccharum griffithii - Peganum harmala community: Medium O.M., EC, $CaCO_3$, HCO_3.

Saccharum griffithii - Sophora mollis community: Medium Cl.

Saccharum griffithii - Lactuca viminea community: Low Cl..

3. *Perovskia* steppe: *Perovskia* steppe was found on the soils having low MWHC and $Ca^{++}+Mg^{++}$, high to medium $CaCO_3$, low to medium O.M., EC and HCO_3 and mostly medium to low Cl. The communities included in this steppe type differentiated as follows:

Perovskia atriplicifolia - Sophora mollis community: Medium HCO_3.

Perovskia atriplicifolia - Peganum harmala community: Medium O.M.

Table 5. Topographic and Soil Characteristics of the Communities of Water Courses.

Name of communities	Total No. of Sand	Width of the water courses in meters	Sand %	Silt %	Clay %	Textural class	Organic matter %	Maximum water holding capacity	pH	EC: mmhos/cm	$CaCO_3$ %	HCO_3 meq./l.	Cl meq./l.	$Ca^{++}+Mg^{++}$ meq./l.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. *Peganum harmala steppe*														
Peganum harmala -	1	40.0-45.0	80.00*	12.00	8.00	L.S.	0.33	26.25	7.8	1.2	23.5	1.5	10.0	8.9
Cynodon dactylon		dry	84.00**	8.00	8.00	L.S.	0.66	22.40	7.7	1.3	25.6	1.5	12.0	9.0
Peganum harmala -	1	70.0-80.0	88.00	8.0	4.0	L.S.	0.95	23.98	7.8	0.7	30.1	5.0	12.0	8.0
Artemisia maritima		dry	84.0	12.0	4.0	L.S.	1.25	24.69	7.9	0.7	27.37	5.0	12.0	8.0
Haloxyon griffithii -														
Peganum harmala -	1	60.0-70.0	92.0	7.6	4.0	Sand	2.05	20.96	8.03	0.3	35.24	2.0	10.0	6.0
Koelpinia linearis		dry	88.00	11.6	0.4	L.S.	1.1	23.6	8.4	0.5	30.69	4.0	14.0	6.0
2. *Saccharum griffithii steppe*														
Saccharum griffithii -	2	60.0-70.0	88.0±2.83	8.8±2.26	3.2±0.56	Sand	1.13±0.33	22.63±0.89	7.7±0.14	1.05±0.17	24.5±0.74	2.25±0.53	9.5±1.06	7.5±1.06
Artemisia maritima		80.0-90.0	86±1.41	10.7±1.48	3.2±0.00	L.S.	3.48±0.12	21.61±0.34	7.7±0.7	1.05±0.10	26.6±0.70	2.75±0.88	10.0±1.41	8.5±1.06
community		dry												
Saccharum griffithii -	1	50.0-60.0	96.0	4.0	0.0	Sand	1.6	15.0	7.8	1.3	26.60	3.0	11.0	9.0
Peganum harmala		dry	92.0	8.0	0.0	Sand	1.3	17.4	7.9	1.0	25.24	4.0	12.0	10.0
Saccharum griffithii -	1	80.0-90.0	88.0	8.0	4.0	L.S.	1.0	24.64	8.2	0.7	31.32	1.0	12.0	8.0
Sophora mollis		dry	84.0	12.4	3.6	L.S.	1.33	24.95	8.1	0.8	32.25	1.5	12.5	9.0
Saccharum griffithii -	1	100.0-150.0	84.32	1.12	14.56	L.S.	0.33	26.43	8.1	0.7	37.67	1.0	7.0	6.0
Lactuca viminea		dry	84.12	5.84	10.04	L.S.	0.33	33.88	8.3	0.7	31.54	1.0	8.0	7.0
3. Perovskia steppe														
Perovskia atriplicifolia -	1	60-80	84.0	12.0	4.0	L.S.	0.6	22.16	7.5	0.8	33.18	3.0	12.0	9.0
Sophora mollis		dry	84.0	12.0	4.0	L.S.	1.6	21.75	7.9	0.9	30.28	4.0	11.0	8.0
Perovskia atriplicifoli -	1	20.0-25.0	88.0	4.0	8.0	L.S.	1.66	22.09	7.9	0.6	28.25	1.5	6.0	6.0
Peganum harmala		dry	84.0	12.0	4.0	L.S.	0.66	24.38	7.9	0.8	36.05	2.0	6.8	8.0
Perovskia atriplicifolia -	1	25.0-30.0	92.0	4.0	4.0	Sand	0.33	20.49	8.0	0.7	38.93	3.0	10.0	7.0
Artemisia maritima		dry	88.0	8.0	4.0	L.S.	0.66	21.95	8.1	0.7	36.45	3.0	11.0	8.0
Perovskia abrotanoides -	1	60.0-70.0	84.0	12.5	3.6	L.S.	0.66	21.94	7.5	1.2	22.5	1.0	10.0	9.5
Cynodon dactylon		dry	88.0	8.0	4.0	L.S.	1.45	21.02	7.8	1.4	27.9	1.5	11.5	7.5

Table 5. Contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4. *Sophora mollis steppe*														
Sophora mollis -	1	80.0-100.0	92.0	4.0	4.0	Sand	2.05	20.74	8.0	0.6	28.62	3.0	10.0	8.0
Cymbopogon commutatus		dry	92.0	4.0	4.0	Sand	1.33	21.09	7.9	0.6	34.33	2.0	10.0	7.0
Sophora mollis -	1	80.0-90.0	90.00	8.0	2.0	Sand	0.66	21.86	8.0	0.9	26.27	2.5	12.0	6.0
Perovskia atriplicifolia -		dry	92.0	4.0	4.0	Sand	1.66	20.93	8.0	0.5	28.36	2.5	13.0	8.0
Ferula Oopoda														
5. *Hertia intermedia steppe*														
Hertia intermedia -	2	40.0-50.0	81.0±1.32	1.06±0.08	17.04±1.24	S.L.	1.16±0.35	33.65±0.60	7.8±0.07	1.3±0.28	20.31±3.59	2.25±0.17	15.0±0.70	8.0±0.70
Artemisia maritima		50.0-60.0	83.08±0.19	3.6±1.07	18.32±2.69	S.L.	1.76±0.07	32.95±0.74	7.55±0.03	0.75±0.03	21.42±3.65	2.0±0.35	8.0±0.70	9.0±1.41
Hertia intermedia -	1	80.0-100.0	80.8	7.2	12.0±	S.L.	1.15	24.93	8.0	0.8	34.11	3.0	13.0	15.0
Perovskia atriplicifolia		dry	84.0	8.0	8.0	S.L.	1.95	21.76	8.3	0.6	31.38	5.0	12.0	12.0
Hertia intermedia -														
Astragalus stocksii-	1	60.0-100.0	82.88	1.84	15.28	S.L.	0.66	34.5	8.0	0.4	28.19	1.0	7.0	6.0
Sophora mollis		dry	68.32	9.6	22.08	S.C.L.	0.66	35.7	7.8	0.4	28.42	1.5	7.0	6.0
Hertia intermedia -	1	50.0-60.0	92.0	7.6	0.4	Sand	1.86	20.13	8.1	0.6	32.24	3.0	11.0	5.0
Perovskia abrotanoides		dry	88.0	11.6	0.4	Sand	1.66	21.78	8.1	0.7	31.72	4.0	13.0	6.0
6. *Artemisia maritima steppe*														
Artemisia maritima -	1	70.0-80.0	92.0	4.0	4.0	Sand	1.05	19.65	8.1	1.4	25.92	5.0	21.0	16.0
Saccharum griffithii		dry	92.0	4.0	4.0	Sand	0.8	19.05	8.1	1.9	29.56	3.0	15.0	17.0
Artemisia maritima-	1	60.0-80.0	79.12	2.08	18.8	S.L.	1.66	32.50	7.8	0.7	26.7	4.10	11.0	10.0
Sophora mollis		dry	83.36	2.08	14.56	L.S.	2.65	28.35	7.9	0.8	35.94	5.30	12.0	11.0
Euphoria osyridea -														
Bromus sericeus -	1	50.0-70.0	84.0	12.0	4.0	L.S.	1.66	24.89	8.2	0.5	27.87	3.0	11.0	7.0
Artemisia maritima		dry	88.0	8.0	4.0	L.S.	2.37	22.05	8.2	0.5	29.25	3.0	12.0	8.0
7. *Wet steppe*														
Equisetum ramosissimum -	1	60.0-70.0	76.0	8.0	16.0	L.S.	1.85	35.65	8.0	1.2	30.99	4.0	18.0	16.0
Perovskia abrotanoides -		Wet	68.0	8.0	24.0	S.C.L.	0.6	32.60	8.1	1.4	29.01	4.0	16.0	11.0
Mentha longifolia -	1	50.0-60.0	92.0	4.0	4.0	Sand	1.33	20.42	7.9	1.5	41.65	5.0	28.0	17.0
Saccharum griffithii -		wet	88.0	8.0	4.0	L.S.	0.66	21.85	7.8	1.8	39.56	4.0	24.0	15.0
Saccharum griffithii -	1	70.0-80.0	92.0	4.0	4.0	Sand	1.5	21.0	7.5	0.7	34.56	2.0	14.0	15.0
Equisetum ramosissimum		dry	92.0	4.0	4.0	Sand	1.8	21.43	7.8	0.7	35.24	2.0	15.0	15.0

*Surface, **Subsurface, L.S. = Loamy sand, S.L. = Sandy loam, S.C.L. = Sandy clay loam, ± Standard error.

Perovskia atriplicifolia - Artemisia maritima community: Low EC, high $CaCO_3$.

Perovskia abrotanoides - Cynodon dactylon community: Medium EC, $CaCO_3$.

4. *Sophora mollis* steppe was found on the soils having low MWHC, $Ca^{++}+Mg^{++}$, HCO_3, EC and medium O.M. The communities included in this steppe type differentiated as follows:

Sophora mollis - Cymbopogon commutatus community: High $CaCO_3$, low Cl.

Sophora mollis - Perovskia atriplicifolia - Ferula oopoda community: Medium $CaCO_3$, Cl.

5. *Hertia intermedia* steppe: *Hertia intermedia* steppe was found on the soils having medium to low O.M. and Cl, low to medium MWHC, $Ca^{++}+Mg^{++}$, EC, and HCO_3. The communities included in this steppe type differentiated as follows:

Hertia intermedia - Artemisia maritima community: Low $CaCO_3$.

Hertia intermedia - Astragalus stockssii - Sophora mollis community: Low O.M., Cl.

Hertia intermedia - Perovskia atriplicifolia community: Medium $Ca^{++}+Mg^{++}$.

Hertia intermedia - Perovskia abrotanoides community: Medium O.M., Cl.

6. *Artemisia maritima* steppe: *Artemisia maritima* steppe was found on the soils having low MWHC, medium to high Cl, $CaCO_3$, low to medium EC, medium to low O.M. and HCO_3. The communities included in this steppe type differentiated as follows:

Artemisia maritima - Saccharum griffithii community, low O.M. medium EC, high Cl and $Ca^{++}+Mg^{++}$.

Artemisia maritima - Sophora mollis community. High $CaCO_3$ and medium $Ca^{++}+Mg^{++}$.

Euphorbia osyridea - Bromus sericeus - Artemisia maritima community: Low HCO_3 and $Ca^{++}+Mg^{++}$.

7. *Wet steppe:* Wet steppe was found on the soils having medium to low O.M., EC., HCO_3, low to medium MWHC., high $CaCO_3$ and high to medium Cl, and $Ca^{++}+Mg^{++}$. The communities included in this steppe type differentiated as follows:-

Saccharum griffithii - Equisetum ramosissimum community, Low EC, HCO_3 medium Cl and $Ca^{++}+Mg^{++}$.

Mentha longifolia - Saccharum griffithii - Juncus inflexus community. Low MWHC and O.M.

Equisetum ramosissimum - Perovskia abrotanoides - Prunus brahuica community. Medium MWHC and O.M.

Comparison with the scanty previous work is very much limited. However, the edaphic relations of *S. griffithii - A. maritimia* community reported in the present work show conformity with Majeed's (1984) two communities (*A. maritima - S. griffithii* and *A. maritima - S. griffithii - S. mollis*) particularly in respect of soil texture, and low values of HCO_3, Cl and $Ca^{++}+Mg^{++}$. The *A. maritima* steppe reported (Tareen, 1986) from the plains of Quetta district also show similarity in the edaphic factors with the *A. maritima* steppe of the present work, which clearly indicates that the steppe type classification is quite satisfactory although it is a tentative arrangement.

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

1. *S. griffithii - P. harmala:* Lowest EC.
2. *H. intermedia - A. stocksii - S. mollis:* lowest EC.
3. *M. longifolia - S. griffithii - J. inflexus:* Highest $CaCO_3$, highest Cl.
4. *H. intermedia - A. maritima:* lowest $CaCO_3$.
5. *P. atriplicifolia - P. harmala:* lowest Cl.
6. *H. intermedia - P. abrotanoides:* Lowest $Ca^{++}+Mg^{++}$

Apparently the habitats of communities 1, 2 and 5 represent the favourable environmental conditions in the Quetta district, while communities 3, 4 and 6 indicate unfavourable sites. The communities 1-6 were found in unprotected areas and have generally medium species diversity.

Diagnostic edaphic features of various steppe types found in the water courses of Quetta district are as under:-

Peganum harmala steppe: Medium Cl.

Saccharum griffithii steppe: Low HCO_3.

Perovskia steppe: Low to medium HCO_3.

Sophora mollis steppe: Low EC, medium organic matter and low HCO_3.

Hertia intermedia steppe: Medium to low $Ca^{++}+Mg^{++}$ and low to medium maximum water holding capacity.

Artemisia maritima steppe: Medium to high Cl and $CaCO_3$ and medium to low HCO_3.

Wet steppe: High $CaCO_3$, high to medium Cl, high to medium $Ca^{++}+Mg^{++}$ and high water regime.

References

Ahmed, S. 1984. *Phytosociological study of Woodland communities of Hazarganji National Park, Quetta.* M.Sc. Thesis, Baluchistan, Univ., Quetta.

Anonymous. 1954. Diagnosis and Improvement of Saline and Alkali Soils. U.S.D.A. Hand Book, 60 Washington D.C.

Baig, M.S. 1981. *Vegetation classification for evaluation of Rangeland in Arid Zones.* Pakistan Soils Bulletin No. 15, Soils Survey of Pakistan, Lahore.

Beg, A.R. 1966. Preliminary study of vegetation of Quetta. *Proc. First West Pak. Range Management Conf.* Peshawar, Oct. 5-7, pp. 245-253.

Bouyoucos, F.J. 1951. A recalibration of the hydrometer method for making mechanical analysis of soil. *Agron. J.*, 43: 434-438.

Bray, J.R. and J.T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. *Ecol. Monogr.*, 27: 325-349.

Canfield, R. 1941. Application of the line intercept method in sampling range vegetation. *J. For.*, 39: 388-394.

Changezi, F.H. 1982. *Soil-investigation Relationship in Wastelands around Quetta.* M.Sc. Thesis, Baluchistan Univ. Quetta.

Hussain, S. and S.A. Qadir. 1970. An autecological study of *Euphorbia caducifolia* Haines. *Vegetatio,* 20: 529-580.

Kayani, S.A., A.K. Achakzai and S.A. Qadir. 1984a. Phytosociological studies in wastelands of Quetta-Pishin Districts, Baluchistan, Pakistan. *Pak. J.*, 16: 255-265.

Kayani, S.A., F. Hussain, S.R. Chagtai and Q. Marwat. 1984b. The effect of protection of the vegetational composition of Chiltan Park, Hazarganji, Quetta. Abst. Proc. 2nd National Conf. of Plant Scientists.

Khan. A.H. and S.M. Hussain. 1963. Ecological assessment of the closure in Quetta Division Forest, Hazarganji. *Pak. J. For.*, 13: 167-193.

Khilji, T.M. 1982. *Phyto-ecological studies in Quetta Valley*. M.Sc. Thesis, Baluchistan Univ., Quetta.

Majeed, A. 1984. *Phytosociological study of newly enclosed area of Hazarganji National Park, Quetta*. M.Sc. Thesis, Baluchistan Univ. Quetta.

Menhinick, E.F. 1964. A comparison of some species diversity indices applied to samples of field insects. *Ecology*, 45: 850-861.

Nissar, M. 1982. *Phyto-ecological studies in Hazarganji National Park, Quetta*. M.Sc. Thesis, Baluchistan Univ. Quetta.

Piper, C.S. 1942. *Soil and Plant Analysis*. Univ. of Adelaide, Adelaide.

Stewart, R.R. 1972. *An Annotated Catalogue of the Vascular Plants of West Pakistan and Kashmir*. Fakhri Printing Press, Karachi.

Tareen, R.B. 1986. *An eco-taxonomic study of Quetta District*. M. Phil. Thesis, Baluchistan Univ. Quetta.

Tareen, R.B. and S.A. Qadir. 1987. Phytosociology of the plain of Quetta District. *Pak. J. Bot.*, 19: 139-156.

(Received for publication 30 December 1989)