*Pak. J. Bot.*, 40(5): 1923-1931, 2008.

# EDAPHIC FACTORS AND DISTRIBUTION OF VEGETATION IN THE CHOLISTAN DESERT, PAKISTAN

**MOHAMMAD ARSHAD[1], ANWAR-UL-HUSSAN[2], M. YASIN ASHRAF[3], SAJIDA NOUREEN[4] AND MOHAMMAD MOAZZAM[4]**

[1]*Cholistan Institute of Desert Studies, The Islamia University of Bahawalpur, Pakistan,*
[2]*University College of Education, Satellite Town, Bahawalpur, Pakistan,*
[3]*Nuclear Institute for Agriculture and Biology, Jhang Road, Faisalabad, Pakistan,*
[4]*Department of Chemistry, The Islamia University of Bahawalpur, Pakistan.*
*Email: marshad54@hotmail.com*

**Abstract**

Relationship of soil characteristics with vegetation was evaluated for determing the most effective parameters responsible in the distribution of vegetation types in rangelands of the Cholistan desert. Soils of different vegetation types were analyzed for salinity, organic matter, moisture content and ionic concentration (Na, K, P). Vegetation types were analyzed for density, frequency, cover and importance value index. The association of certain plant species to certain soil types was common indicating the influence of chemical composition of the soils. The result showed marked important relationships between soil characteristics and plant species. *Suaeda fruticosa* and *Haloxylon recurvum* the high salinity levels and low organic matter. *Calligonum polygonoides, Aerva javanica, Dipterygium glaucum, Capparis deciduas* and *Haloxylon salicornicum* indicated better organic matter, low salinities and $Na^+$ concentration and Na/K ratio. Ecological characteristics, responsible for plant distribution in Cholistan desert seem to be salinity, organic matter and ionic concentration.

## Introduction

The Cholistan desert extends over an area of 26,000 sq. km., in the southern part of the Punjab, Pakistan. From the viewpoint of agriculture it is a highly fascinating wildness possessing a tremendous potential as a range-land provided it is managed and exploited resourcefully (Anon., 1993; Akbar *et al*., 1996). On the basis of its topography i.e., parent material, soil and vegetation, it is divided into two geomorphic regions. The northern region (Lesser Cholistan) bordering the canal-irrigated areas cover about 7770 $km^2$ while the southern region (Greater Cholistan) comprises 18130 $km^2$. The Lesser Cholistan consists of large saline, hard and compact areas (locally called 'Dahars') alternating with low sandy ridges. Sand dunes are stabilized, semi-stabilized or shifting, while the valleys are mostly covered with sand. The soils are classified as either saline or saline sodic, with pH ranging from 8.2 to 8.4 and 8.8 to 9.6, respectively. The Greater Cholistan is a wind sorted sandy desert and comprises river terraces, large sand ridges and less interdunal plain areas (Baig *et al*., 1980; Akbar *et al*., 1996; Akbar & Arshad, 2000; Arshad *et al*., 2003).

The vegetation of Cholistan desert is a typical of arid regions and comprises of xerophytic species, adapted to extreme seasonal temperature, moisture fluctuation and a wide variety of edaphic conditions. Vegetation cover is comparatively better in eastern region (200 mm rainfall zone) than the hyper arid southern region (100 mm rainfall zone). The soil topography and chemical composition is playing an important role in plant distribution in the area. The association of certain plant species to certain soils at

different places is very common. The compact saline 'dahars' without any soil cover are dominated by *Haloxylon recurvum, Haloxylon salicornicum* and *Suaeda fruticosa*, whereas *Salsola baryosma, Sporobolus ioclados, Aeluropus lagopoides, Capparis decidua, Cymbopogon jwarancusa, Ochthochloa compressa* and *Prosopis cineraria* are specific to the 'dahars' having some sandy cover. Similarly, the sand dunes are dominated by *Calligonum polygonoides, Aerva javanica, Panicum turgidum* and *Lasiurus scindicus* (Rao *et al*., 1989; Chaudhary, 1992; Arshad *et al*., 1994; Arshad & Akbar, 2002).

Within the Cholistan desert a number of different dominant plant species and soil types are found (Arshad & Akbar, 2002; Arshad *et al.,* 2007). For example, Arshad (2003) observed that major parameters responsible for vegetation distribution in Cholistan desert are salinity and pH. Baig *et al*., (1975) classified the vegetation of Cholistan desert soil-wise into six communities, i.e., *Haloxylon recurvum, Prosopis specigera, Eleusine compressa, Tribulus terrestris, Dipterygium glaucum* and *Calligonum polygonoides*. While exploring the interior of Cholistan desert Rao *et al*., (1989) recorded that phytosociological groups are determinant of soil types as the edaphic factors influence the vegetation more than any other factor. Furthermore, Arshad & Rao (1995) identified four soil divisions along with the dominant plant communities in Cholistan desert i.e., sand dunes dominated by *Calligonum polygonoides* community, sandy plains dominated by *Calligonum-Prosopis-Capparis* community, compact soils with gravels dominated by *Capparis-Prosopis* community and saline areas dominated by *Haloxylon-Suaeda-Tamarix* community. Relationships between environmental factors, soils and plants were determined by Boer (1996), Boer & Sargeant (1998), El-Ghani & Amer (2003), Jafri *et al*., (2004) & Noureen *et al.,* (2008).

The present study was conducted to determine the soil types and influence of various edaphic factors for the distribution of vegetation in the Cholistan desert, since determining the physico-chemical properties of soils which dictate the plant distribution in the Cholistan desert would assist in the management/restoration of vegetation in the desert.

## Materials and Methods

For the study of physico-chemical properties of soil and vegetation distribution in Cholistan, various locations viz., Dingarh Fort (28 56 30 N, 70 50 10 E), Nagrah Khu (71 35 05 N, 28 46 15 E), Moujgarh Fort (29 50 N, 72 08 30 E), Janu Wali (29 06 59 N, 72 05 13 E) and Jessa Khu (71 82 15 N, 28 66 27 E) were selected. Quadrate method was used for the quantitative study of vegetation at each locality. Three stands, each measuring 100 x 100 m were established at each locality and 15 sub-quadrates of 10 x 10 m size were laid randomly in each stand. In each sub-quadrate, plant density, frequency and cover were recorded (Mueller-Dombois & Ellenberg, 1974). Importance value index of each plant species was calculated and plant community at each stand was named after the species having the highest importance value (Hussain, 1989). Soil samples at 2 cm depth were collected from each quadrate in labeled polythene bags and transferred to the laboratory for chemical analyses. Soil texture and water holding capacity were determined by following the methods described in AOAC (1984). Electrical conductivity was measured using Consort-K520, digital conductivity meter. The ionic concentration (Na, K) of soil samples was noted with Flame Photometer (Corning M-410, UK) and phosphorus was recorded by Spectrophotometer (SPSO SANYO).

## Results

**Vegetation:** A total of 21 plant species were recorded (Table 1). Twelve species were recorded in the community dominated by *Capparis decidua. Prosopis cineraria* was most frequently found in this community followed by *Haloxylon recurvum* and *Aerva javanica*. Fifteen plant species were recorded in *Calligonum polygonoides* dominated vegetation types, with frequent *Haloxylon salicornicum* followed by *Leptadenia pyrotechnica* and *Dipterygium glaucum.* Fourteen species were found in the *Dipterygium glaucum* dominated vegetation types. *Aerva javanica, Haloxylon salicornicum* and *Dipterygium glaucum* were most frequently found followed by *Calligonum polygonoides* and *Capparis decidua*.

In *Aerva javanica* dominated vegetation types, a total of 15 plant species were recorded. *Haloxylon recurvum* was the species found most frequently, very closely followed by *Calligonum polygonoides, Dipterygium glaucum* and *Calotropis procera*. Thirteen species were recorded in the *Haloxylon salicornicum* dominated vegetation types. *Haloxylon recurvum* was the most frequently found followed by *Suaeda fruticosa* and *Capparis decidua*. In vegetation types dominated by *Suaeda fruticosa,* a total of 6 plant species were recorded. *Haloxylon salicornicum* and *Capparis decidua* were most frequently found, followed by *Ochthochloa compressa* and *Haloxylon recurvum*. Nine plant species were recorded in *Haloxylon recurvum* dominated vegetation types. *Haloxylon salicornicum* was the most frequent followed by *Capparis decidua*.

So far as the frequency occurrence is concerned, *Capparis decidua* and *Cymbopogon jwarancusa* were found in all the 7 vegetation types having 100% frequency occurrence. *Aerva javanica* and *Haloxylon recurvum* appeared in 6 vegetation types with 85.71% frequency occurrence. *Haloxylon salicornicum, Ochthochloa compressa* and *Lasiurus scindicus* were found in 5 vegetation types having 71.42% frequency occurrence. Upto 57.14% frequency occurrence was achieved by *Calligonum polygonoides, Dipterygium glaucum, Leptadenia pyrotechnica, Suaeda fruticosa, Aristida adscensionis* and *Eragrostis barrelieri* appearing in 4 vegetation types. *Crotalaria burhia, Prosopis cineraria, Salsola baryosma*, and *Tribulus longipetalus* recorded in 3 vegetation types with 42.86% frequency occurrence. *Euphorbia prostrata* and *Tamarix aphylla* were noted in 2 vegetation types having 28.57% frequency occurrence, while *Cenchrus ciliaris* was recorded only in one vegetation types having minimum frequency occurrence (14.29%).

**Salinity:** High electrical conductivity (10.70 dS $m^{-1}$) was recorded in vegetation types dominated by *Suaeda fruticosa* closely followed by *Haloxylon recurvum* (8.0 dS $m^{-1}$) (Fig. 1). These soils are considered as highly saline having extremely high conductivities. Minimum electric conductivity was recorded in the soil types dominated by *Dipterygium glaucum* vegetation types. Electrical conductivity ranged from 0.8 to 1.3 dS $m^{-1}$ in the soil types dominated by *Capparis decidua, Calligonum polygonoides, Dipterygium glaucum, Aerva javanica* and *Haloxylon salicornicum* vegetation types. These soils are less saline characterizing very low conductivities.

**Organic matter:** The percentage of organic matter recorded in various soil types dominated by various plant species in Lesser Cholistan was very low (Fig. 2). Maximum organic matter i.e., 0.45% was noted in the soil types dominated by *Aerva javanica* vegetation types closely followed by the soil types dominated by *Calligonum polygonoides* (0.32%). Organic matter recorded in the soil types dominated by *Haloxylon salicornicum* and *Dipterygium glaucum* was 0.30 and 0.24%, respectively. Very low concentration of organic matter was recorded in the soil types dominated by *Suaeda fruticosa, Haloxylon recurvum* and *Capparis decidua* ranging from 0.17 to 0.18%.

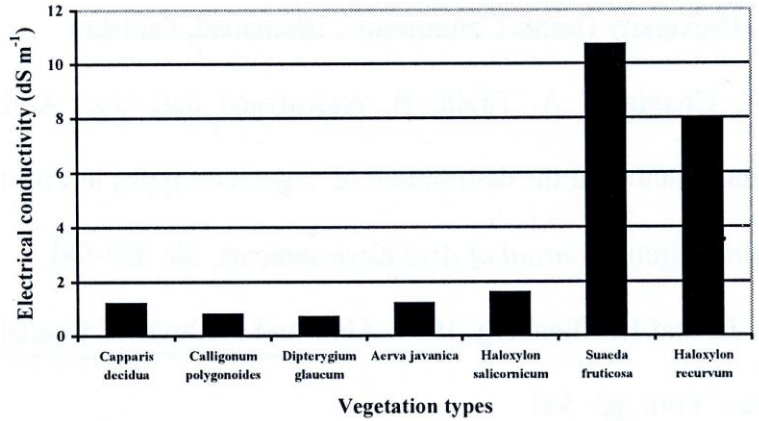


Fig. 1. Electrical conductivity of soil samples from different vegetation types.

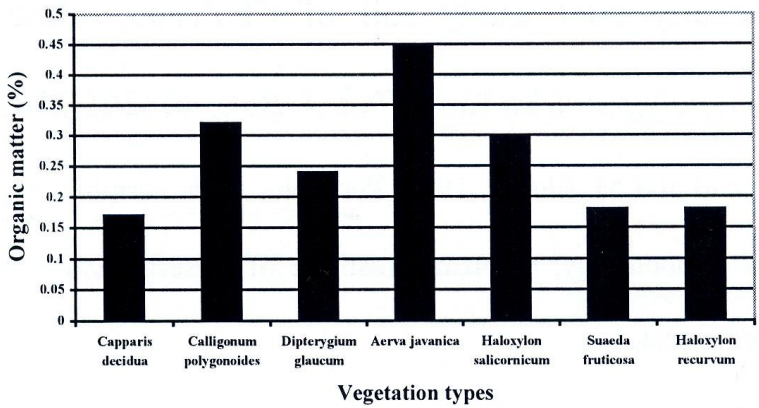


Fig. 2. Organic matter of soil samples from different vegetation types.

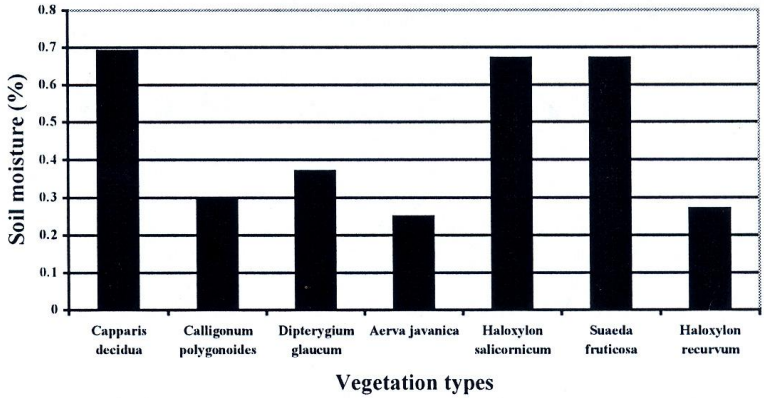


Fig. 3. Moisture content of soil samples from different vegetation types.

**Soil moisture:** Soil moisture recorded in various vegetation types, given in Fig. 3, showed that maximum soil moisture (0.69%) was recorded in the soil types dominated by *Capparis decidua*, very closely followed by the soil types dominated by *Haloxylon salicornicum* (0.67%) and *Suaeda fruticosa* (0.67%). Minimum soil moisture was recorded in the soil types dominated by *Aerva javanica* (0.25%). However, soil moisture ranged from 0.27% to 0.37% in the soil types dominated by *Haloxylon recurvum, Calligonum polygonoides* and *Dipterygium glaucum* vegetation types.

**Ionic concentration**

**Sodium:** Concentration of sodium in the soil types of Cholistan desert, dominated by different vegetation types, given in Fig. 4 showed that maximum sodium concentration i.e. 9.9 mg/100g was recorded in the soil types dominated by *Haloxylon recurvum* vegetation types. The soil types dominated by *Capparis decidua* vegetation types showed sodium concentration as 2.26 mg/100g. Concentration of sodium in the soil types dominated by *Haloxylon salicornicum* and *Calligonum polygonoides* was 1.22 and 1.02 mg/100g. However the concentration of sodium was very low in the soil types dominated by *Aerva javanica* vegetation types i.e., 0.54 mg/100g.

**Potassium:** Concentration of potassium in the soil of different vegetation types of Cholistan desert is given in Fig. 5. Higher concentration of potassium was recorded in all the soil types. Maximum potassium concentration (185 mg/100g) was recorded in the soil types dominated by *Dipterygium glaucum* vegetation types. The soil types dominated by *Haloxylon salicornicum, Haloxylonn recurvum, Capparis decidua, Aerva javanica* and *Suaeda fruticosa,* have the concentration of potassium recorded as 115, 120, 120, 125, 145 mg/100g, respectively. Minimum potassium concentration was noted in the soil types dominated by *Calligonum polygonoides* (105 mg/100g).

**Sodium/potassium ratio:** The sodium/potassium ratio in the soils dominated by different vegetation types is given in Fig. 6. Maximum Na/K ratio (0.0825 mg/100g) was recorded in the soil types dominated by *Haloxylon recurvum*, very closely followed by the soils dominated by *Capparis decidua* (0.0188 mg/100g). Minimum Na/K ratio was recorded in the soils dominated by *Dipterygium glaucum* vegetation types (0.0030 mg/100g). Ratio of Na/K recorded in the soils dominated by *Suaeda fruticosa, Aerva persica, Calligonum polygonoides* and *Haloxylon salicornicum* was 0.0040, 0.0043, 0.0097 and 0.010 mg/100g, respectively.

**Discussion**

The results of this study showed that the investigated plant species of Cholistan desert grow only on certain soils. The different vegetation types correspond clearly to certain soil salinity levels, soil moisture, organic matter and ionic concentration. The analyzed soil samples from different vegetation types showed their characteristic attributes and vegetation.

Vegetation types dominated by *Suaeda fruticosa* and *Haloxylon recurvum* are characterized by relatively high salinities whereas *Calligonum polygonoides, Dipterygium glaucum, Aerva javanica, Haloxylon salicornicum,* and *Prosopis cineraria* occurred on low saline soils. It is a well known fact that different plant species have different salt tolerance level. There is not much information available concerning the plant species studied and salinity in Cholistan desert. However the results are in conformity with the findings of Roshier *et al*., (1996); Boer (1996) and Boer & Sargeant (1998).

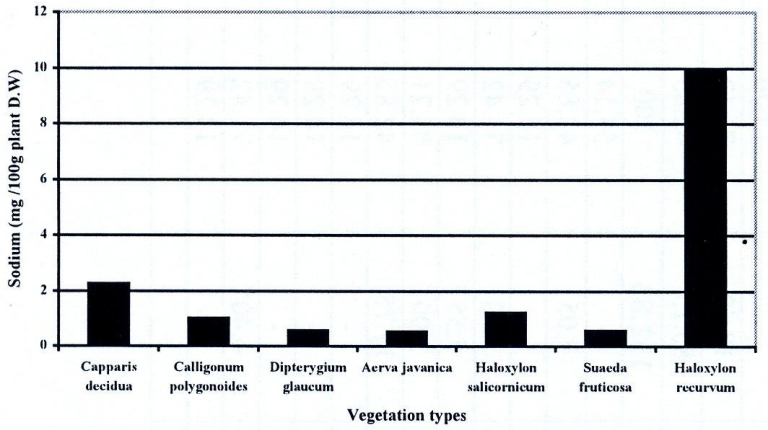


Fig. 4. Sodium concentration of soil samples from different vegetation types.

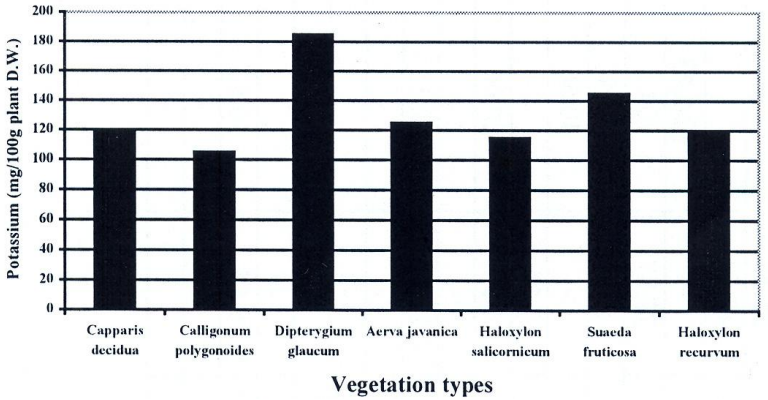


Fig. 5. Potassium concentration of soil samples from different vegetation types.

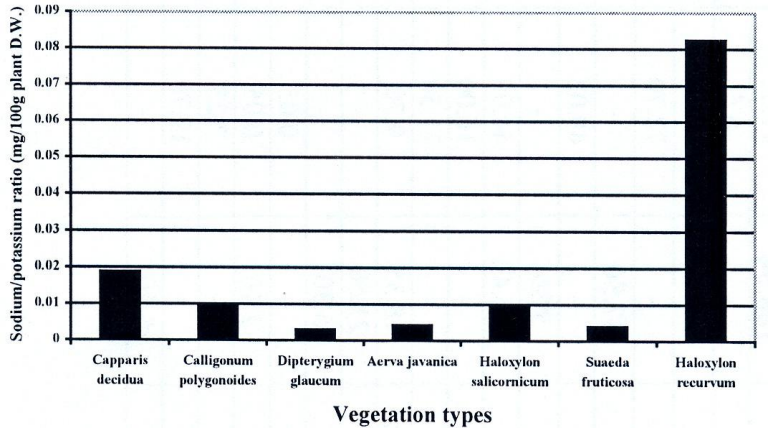


Fig. 6. Sodium/potassium ratio of soil samples from different vegetation types.

The vegetation types dominated by *Aerva javanica, Calligonum polygonoides* are characterized by relatively better organic matter and *Capparis decidua, Haloxylon recurvum, Suaeda fruticosa, Haloxylon salicornicum* vegetation types occurred on low organic matter soils. Percentage of organic matter in the soil of Cholistan desert is very low, which clearly indicate the aridity resulting in sparse vegetation cover (Rao *et al*., 1989). The vegetation types dominated by *Capparis decidua, Haloxylon salicornicum* and *Suaeda fruticosa* are characterized by relatively high soil moisture whereas *Aerva javanica, Calligonum polygonoides, Dipterygium glaucum* and *Haloxylon recurvum* occurred on soils having very low moisture percentage.

So far as the ionic concentration and vegetation distribution in Cholistan desert are concerned, the vegetation types dominated by *Haloxylon recurvum* appeared in the soil types having maximum sodium concentration, indicating its high salt tolerance. All the other vegetation types were noted in the soils with less or moderate sodium concentration. Analysis of various soil samples collected from different vegetation types of Cholistan desert showed that concentration of sodium is high in the soil types where salinity is high (Arshad, 2003). Vegetation types dominated by *Dipterygium glaucum* are characterized by relatively high potassium concentration, whereas rest of the vegetation types are characterized by moderate potassium concentration. The vegetation types dominated by *Aerva javanica* and *Haloxylon salicornicum* are characterized by relatively high phosphorus concentration whereas *Dipterygium glaucum, Calligonum polygonoides, Capparis decidua, Suaeda fruticosa* and *Haloxylon recurvum* occurred on soils with low phosphorus.

Based on the results of present study, the analysis of soil and vegetation assessment could be useful in identifying the suitable habitat manipulation techniques such as planting, top-soiling and irrigation techniques for the rehabilitation of degraded lands of Cholistan desert. The data is also important for the establishment of agro-systems. However, there are certainly a variety of additional soil properties, which may be responsible for the distribution of plants and a variety of additional vegetation types occur in the region. It is therefore, suggested that further studies be carried out on the relationship between plants and soils in Cholistan desert. Some of the important soil ecological parameters responsible for plant distribution in Cholistan desert seem to be salinity and ionic concentration.

**References**

Akbar, G., T.N. Khan and M. Arshad. 1996. Cholistan desert, Pakistan. *Rangelands*, 18: 124-128.

Akbar, G. and M. Arshad. 2000. Developing sustainable strategies for Cholistan desert: opportunities and perspectives. *Science Vision*, 5: 77-85.

Anonymous. 1993. *Pakistan–Cholistan Area Development Project*. Report No. 59/53 ADB-PAK 58 (Final version). Food and Agriculture Organization of the United Nations, Rome.

AOAC 1984. *Official Methods of Analysis*. 14th ed., Washington D.C.

Arshad, M. and A.R. Rao. 1995. *Phytogeographical divisions of Cholistan desert*. Proceedings of the sixth all Pakistan geographical conference (December 26-29, 1993). Department of Geography, Islamia University, Bahawalpur. pp. 55-61.

Arshad, M. 2003. Cholistan desert ecosystem monitoring for future management. Annual Technical Report of a project sponsored by WWF-Pakistan. (Unpublished)

Arshad, M. and A.R. Rao. 1994. Flora of Cholistan desert" (Systematic list of trees, shrubs and herbs). *Journal of Economic and Taxonomic Botany*, 18: 615-625.

Arshad, M. and G. Akbar. 2002. Benchmark of plant communities of Cholistan desert. *Pakistan Journal of Biological Sciences*, 5: 1110-1113.

Arshad, M., G. Akbar and S. Rashid. 2003. Wealth of medicinal plants of Cholistan desert, Pakistan: Conservational strategies. *Hamdarad Medicus*, 105: 25-34

Arshad, M., M. Ashraf and N. Arif. 2005. Morphological variability of *Prosopis cineraria* (L.) Druce, from the Cholistan desert, Pakistan. *Genetic Resources and Crop Evolution*, 53: 1589-1596.

Arshad, M., M.Y. Ashraf, M. Ahmad and F. Zaman. 2007. Morpho-genetic variability potential of *Cenchrus ciliarus* L., from Cholistan desert, Pakistan. *Pak. J. Bot*., 39: 1481-1488.

Baig, M.S., E.H. Khan, M.R. Zaheer and M. Ahmad. 1975. *Reconniassance soil survey of Cholistan*. Directorate of Soil Survey of Pakistan, Lahore, (Research Report), pp. 163.

Baig, M.S., M. Akram and M.A. Hassan. 1980. Possibilities for range development in Cholistan desert as reflected by its physiography and soils. *Pakistan Journal of Forestry*, 30: 61-71.

Boer, B. 1996. Plants as soil indicators along the Saudi coast of the Arabian Gulf. *Journal of Arid Environments*, 33: 417-423.

Boer, B. and D. Sargeant. 1998. Desert Perennials as soil indicators in Eastern Arabia. *Plant and Soil*, 199: 261-266.

Chaudhry, S.A. 1992. *The Cholistan desert. A TOKTEN Consultancy Report*. Cholistan Institute of Desert Studies, Islamia University, Bahawalpur. pp. 34.

El-Ghani, M.M.A. and W.M. Amer. 2003. Soil-vegetation relationships in a coastal desert plain of southern Sinai, Egypt. *Journal of Arid Environments*, 55: 607-628.

Hussain, F. 1989. *Field and Laboratory Manual of Plant Ecology*. National Academy of Higher Education, University Grants Commission, Islamabad, Pakistan.

Jafari, M., M.A.Z. Chahouki, A. Tavili, H. Azarnivand and G.Z. Amiri. 2004. Effective environmental factors in the distribution of vegetation types in Poshtkouh rangelands of Yazd Province (Iran). *Journal of Arid Environments*, 56: 627-641.

Mueller-Dombois, D. and H. Ellenberg. 1974. *Aims and methods of vegetation ecology*. Wiley & Sons, New York. pp. 547.

Noureen, S., M. Arshad, K. Mahmood and M.Y. Ashraf. 2008. Improvement in fertility of nutritionally poor sandy soil of Cholistan desert, Pakistan by *Calligonum polygonoides* Linn. *Pak. J. Bot*., 40: 265-274.

Rao, A.R., M. Arshad and M. Shafiq. 1989. *Perennial grass germplasm of Cholistan desert and their phytosociology*. Cholistan Institute of Desert Studies, Islamia University, Bahawalpur. pp. 84.

Roshier, D.A., B.B. Boer and P.E. Osbome. 1996. Vegetation of Abu Dhabi and a preliminary classifications. In: *Desert Ecology of Abu Dhabi*. (Ed.): P.E. Osbome. pp 50-65. Pisces Publications, Newbury. pp. 236.

(Received for publication 28 June 2008)