DETERMINING STATUS OF SOIL SALINITY FROM PLANT COMMUNITIES IN PESHAWAR VALLEY

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Abstract

Since the soil characteristics and invariably reflected in vegetation cover, an effort was made to identify, differentiate and discern plant communities as units indicating type and degree of salinity. An exploratory work was done in Peshawar basin, and several communities were marked specifying salinity status of land.

Introduction

Large tracts of assorted saline soils occur more in the alluvial plains of Pakistan, and likewise some areas have also developed in the pied-mont plains with the introduction of open canal irrigation system. Salinity, together with waterlogging, have hampered the productive potential of agricultural land in spite of emphasis on increasing various inputs to boost up the multifaceted economy of the country. Presently the development of land at places is beset with the cancealed salinity. The diagnostic and prognostic answer to this lies, to a considerable extent, in identifying plant communities depicting soil salinity conditions.

Combating water-logging and salinity involves multi-disciplinary approach. Before the problem can be attacked at its roots, a survey to know the extent of salinity status vis-a-vis soil conditions, and the identification of inhabiting vegetation units, are a pre-requisite. In the absence of a detailed soil survey, indicating vegetation can be an extent the relied upon on field basis. Moreover, at times the salinity parameters may not be satisfactorily generalized for large areas owing to unavoidable variation in soil site conditions. An alternate practical approach has since ages remained the necessary recourse to the understanding of natural vegetation, of which single species or for that matter plant communities, too, may be responding to provide an intuitive answer. The present study was, therefore, initiated to probe into the problem and gradually establish a scale in line with known principles for the identification of variation in type of salinity in order to find out an ameliorative approach suiting to conditions.

As for the study area, it lies in the main Peshawar valley, and includes pieces of land stretches of Yar Hussain (Mardan), Risalpur, Kheshgi (Nowshera), and Boobak (Charsadda). Risalpur saline area lies at Risalpur along and to the east of the Nowshera—Mardan Road. Yar Hussain saline area is situated north of the village on either side of the road, joining the village of Yar Hussain with the main Swabi-Mardan Road at village Adina. The Kheshgi-Boobak saline area, comprising the central part of the Peshawar valley, is found at 8 km to the north of the village Kheshgi Payan.

The study area falls within the limits of dry subtropical climate, receiving a mean annual rainfall of about 400 mm, mainly during the winter months.

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Review of Literature

Salinity tolerance is exhibited by plants in several ways; however, on economic basis for practical considerations it is the performance in terms of output. Halophytes invariably are the natural flora of such conditions and these persist owing to relatively much higher values of osmotic pressure of cell sap. (4) Not withstanding the intrinsic multifarious interacting factors of soil, plant and the environment on the behaviour of plant community and species in abnormally salt-infested soils, there is some regulating behaviour which can be discerned by an experiened keen observant eye from the indicator vegetation about the character of land. Nature reflects a lot provided there is a trained eye to catch and interpret the meanings. Folklore in all countries is rich with instances, some of which are still passed on to generations of farming communities where practical richness of land is more judged from the indicator vegetation. But salinity is a highly complicated affair, and negates the order of principles of interplay of nature.

Not only presence of plant species indicates a set of soil conditions, but some quantitative relationships have also been understood to bear upon the vigour of species. The limitations are owing to chances of errors in the approximation of reflection of soil conditions.(4)

Some efforts have been made to understand the natural indicator vegetation of saline and water-logged areas in the Indo-Pakistan sub-continent. Metha (6) reported that *Cynodon dactylon* and *Suaeda fruticosa* were used by the Punjab cultivators as a rough guide for the quality of soil. Smith and Anand (7) carried our qualitative and guantitative survey of plants, comprising the vegetation on water-logged area of Gujranwala; and compared the results of this survey with their findings in *partially* reclaimed areas. Chaudhri (3) stressed the importance of growing economic crops on water-logged areas, after removing salts from the sodic soils by growing halophytic species like *Suaeda fruticosa*. Baqar, et al. (1) reported the behaviour of plant communities and frequency of their occurrence of different soils in some districts of West Pakistan. Bodla et al. (2) attempted to correlate natural vegetation with type and extent of soil salinity in saline soils at the Punjab University New Campus, Lahore. Soils of Peshawar basin have been studies and classified, and salinity-infested soils demarcated. (8)

Hussain and Antoine (5) also specified the salt-affected soils of N. W. F. P. as calcareous containing low organic matter. They also stated that most of the soils in the Peshawar valley have high values of pH, E. S. P, and EC, associated with soda-sulphate type salinity, while the soils of D. I. Khan have SO_4, CI, CI-SO_4 dominating anions.

Material and Methods

The salinity-stricken area was surveyed to spot various plant communities. Vegetation was sampled and described following Braun-Blanquat. Plants were identified, according to Stewart.

Representative soil of associated plant community was sampled from the profile to depth of 60 cm, taking 5 samples, surface soil, 0-15 cm, 15-30 cm, 30-45 cm, and 45-60 cm, each bagged sample being composite of several lots. From the various habitats, the plant communities identified offered 17 soil profiles thus sampled as follows:-

Land habitat	Number of soil profiles sampled
Yar Hussain	6
Risalpur	6
Kheshgi	2
Boobak	3

Soil samples were air-dried, ground and 2 mm-seived. These were analysed following Richards. Saturation extract of soil was prepared and used in the determination of EC, Ca^{+2}, Mg^{+2}, Na^{+1}, CO^{-2}, HCO_3^{-1}, CI^{-1} and SO_4^{-2} pH was determined by Corning- Model-3 battery-operated pH-meter. EC was determined by Solubridge. Ca^{+2} and Mg^{+2} were determined by EDTA titration, Na^{+1} and K^{+1} by Spectroflame-photometry and SO_4^{-2} by difference method.

Results

The date of various plant communities and respective soil samples of representative soil profiles, depicting character of the land in relation to identified vegetation, was sorted out and presented for drawing some inferring relationships. Each plant community is being presented alongwith typical soil salinity parameters hereunder.

1. *Cynodon dactylon community*

This mono-specific vigorously growing community, covering 95%, occupies relatively flat sites with fine-textured internally well-drained soil. The site has a fluctuating high water table with sweet water, often rising within the top 15 cm profile layer and also receives casual surface washing. Since the soluble salts are regularly drained away, the profile is free from excess salts; however, the surface is slightly saline. Detailed picture of salts in the profile is given hereunder:-

Physical and chemical characteristics of soil profile under Cynodon community 95%

EC	pH	Na	CI	SAR	Ca	Mg	K	CO_3	HCO_3
6.5	7.5	42.9	28.0	33.4	1.50	1.80	0.1	Absent	1.0
1.8	7.8	10.7	10.0	12.4	0.65	0.85	0.0	"	1.0
1.4	7.8	7.1	10.0	7.6	0.78	0.97	0.0	"	0.8
1.1	7.6	3.6	10.0	3.6	0.85	1.10	0.0	"	0.8
0.4	7.6	3.6	7.0	4.0	0.78	0.82	0.0	"	0.7

Presently, the habitat supports a shallow-rooted bunch grass. The land may gradually take deep-rooted more economic species after the establishment of drainage system.

2. *Desmostachya bipinnata-Cynodon dactylon community*

This bispecific partially vigorously growing community, with *Desmostachya* more highly dominating the environment (60%) than *Cynodon* (10%), grows on a somewhat flat terrain with a fine-textured internally well-drained soil. Water table is fluctuating; the water is slightly brackish. There is an internal flushing of salts with water table more markedly staying within the 45-60 cm strata of the soil profile. Soil profile is generally free of excess soluble salts as also the surface. Slight salinity, however, develops in the 15-45 cm layer.

A picture of salt concentration in the profile is presented below:-

Physical and chemical characteristics of soil profile under Desmostacha-Cynodon community (60% + 10%)

EC	pH	Na	CI	SAR	Ca	Mg	K	CO_3	HCO_3
2.2	7.5	16.7	17.0	16.3	0.5	1.60	0.0	Absent	2.0
2.2	7.5	40.0	14.0	24.8	4.0	1.20	0.1	”	1.0
5.0	7.7	43.3	14.0	35.3	1.0	2.0	0.1	”	1.4
4.0	7.7	33.3	14.0	43.9	1.0	0.15	1.0	”	1.8
3.0	7.9	26.7	15.0	32.5	1.0	0.35	1.0	”	1.8

Of the two component species of the plant community, the shallow-rooted *Cynodon* is not so vigorous as it is influenced by soil conditions, especially light salinity in its root-zone (15-45 cm), affecting its nutrition. *Desmostachya* grass, with its deep root-system, however, can tolerate or probably avoid this saline layer and grows well. High water table has rendered it a waste-land.

The present vegetation only provides some sort of grazing. On reclamation, the area can be made to grow more economic deep-rooted plant species. *Desmostachya*, with its dense rhizomatous root-stock in the top layer, does not permit establishment of other vegetation unless its hold is softened.

3. *Cynodon dactylon-Desmostachya bipinnata community*

This bispecific community, with both the species equally highly dominant, inhabits a relatively flat habitat with a fine-textured but internally well-drained soil. The water table is much fluctuating and often rises upto and stays to cause slight salinity on the surface as well as in the top 15 cm layer. The surface salinity level is, however, kept low due to surface washing which also causes leaching down of salts. Since the soluble salts are regularly drained away, the profile in the subsoil level is over-all free from excess salts. A slightly saline layer, however, develops in the top 15 cm and in the 30-45 cm profile layers.

Detailed picture of salts in the soil profile is recorded hereunder:-

Physical and chemical characteristics of soil profile under Cynodon-Desmostachya community (60% + 40%)

EC	pH	Na	CI	SAR	Ca	Mg	K	CO_3	HCO_3
5.5	7.6	50.0	31.0	2.18	6.0	4.50	0.0	0.12	1.44
7.5	7.6	62.5	19.0	47.2	1.5	2.00	1.0	Absent	0.52
3.4	8.1	31.3	21.0	32.5	0.6	1.25	1.0	0.20	0.75
4.2	7.9	31.3	18.0	36.1	0.5	1.00	1.0	Absent	0.61
3.0	8.3	18.8	23.0	23.8	0.5	0.75	1.0	0.20	2.10

4. ***Salsola foetida community***

This mono-specific community grows sparsely and covers only 10%. It occupies raised but slightly slopy sites receiving casually slight surface flushing. The soil is finetextured but poorly drained. The water table lies deep. Soluble salts are fairly leached; and, being in excess, these increase with the depth of the profile. The upper 30 cm layer is slightly saline, the lower 30 cm layer is moderate; the surface is non-saline. Detailed salinity status of the profile is given below:–

Physical and chemical characteristics of soil profile under Sporobolus community (90%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
3.2	7.5	25.0	34.0	7.3	14.0	9.5	4.0	Absent	0.4
5.5	7.5	56.3	58.0	13.9	20.0	13.0	3.0	,,	0.3
6.0	7.4	56.3	69.0	13.4	28.0	27.5	1.0	,,	0.3
7.5	7.4	62.5	90.0	11.3	20.5	40.5	1.0	,,	0.3
8.0	7.3	81.3	103.0	13.9	32.0	36.0	1.0	,,	0.3

5. ***Aeluropus lagopoides community***

This monospecific semi-dense and partially vigorously growing community, covering 50%, occupies a slightly depressed site, receiving salt-rich surface flooding. The soil is fine-textured and water-logged with very brackish water. The water table is fluctuating, often rising upto the top 15 cm profile layer. There is a surface deposition of salts with strongly saline conditions and overall a moderate saline soil profile.

A detailed picture of salt concentration in the profile is as follows:–

Physical and chemical characteristics of soil profile under Aeluropus community (50%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
32.0	8.0	375.0	322.0	130.6	1.5	15.0	5.0	Absent	0.9
9.0	8.2	125.0	84.0	42.3	1.0	16.5	2.0	,,	0.9
11.0	8.1	125.0	106.0	42.9	1.5	15.5	1.0	,,	0.6
9.5	8.1	125.0	89.0	43.5	1.5	15.0	1.0	,,	0.6
11.0	7.8	150.0	98.0	52.2	2.5	14.0	1.0	,,	0.5

Elsewhere (figure 1, observation No. 5a), where the community covers 40%, the top and bottom layers, too, are rather strongly saline, instead of moderately so as in No. 5. Accordingly, the community has shrunk in coverage due to strong salinity in the absorbing root-zone in the top and bottom 15 cm layers. Detailed picture of salts in the soil profile is recorded hereunder:–

Physical and chemical characteristics of soil profile under Aeluropus community (40%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
34.0	7.4	400.0	428.0	90.0	20.0	19.5	4.0	Absent	0.5
13.0	7.6	160.0	149.0	54.8	1.5	17.0	2.0	,,	0.5
8.5	7.9	108.0	83.0	37.7	1.5	15.0	1.0	,,	0.8
8.0	8.0	100.0	73.0	35.4	1.5	14.5	1.0	,,	0.6
14.0	7.8	166.7	122.0	55.6	2.0	16.0	1.0	,,	0.6

6. *Salsola foetida-Halocharis sulphurea community*

This bispecific sparsely growing community, with ***Salsola*** more highly dominating the environment (15%) than ***Halocharis*** (5%), in-habits a slightly slopy terrain, receiving surface washing. The site has fine-textured soil, water-logged and poorly-drained; the ground water is very brackish. Salts rise in fine capillaries top 15 cm profile layer, causing high salinity throughout the profile and excess soluble salts on surface.

Details of the profile are given below:–

Physical and chemical characteristics of soil profile under Salsola-Halocharis community (15% + 5%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
17.0	7.4	180.0	186.0	54.1	45.5	8.0	10.0	Absent	0.4
18.0	8.0	281.3	194.0	61.5	34.5	7.3	6.0	,,	0.5
15.0	7.6	281.3	140.0	67.2	30.0	5.0	4.0	,,	0.4
14.0	7.5	200.0	122.0	43.1	34.0	9.0	3.0	,,	0.3
14.0	7.5	200.0	120.0	43.4	36.0	6.5	3.0	,,	0.3

7. *Sporobolus marginatus community*

This mono-specific vigorously growing community, covering 90%, occupies a slightly slopy terrain, receiving flash-floods. The soil is fine-textured, water-logged with a high fluctuating water table of slightly brackish water. The site is, however, internally partially fairly-drained. Soluble salts are quite leached down though high capillary rise and fair internal drainage set up a 45 cm mid-layer of profile. The soil surface remains desalinized as well as the profile below the saline-alkali layer.

A detailed picture of profile is presented below:–

Physical and chemical characteristics of soil profile under Sporobolus community (90%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
1.8	7.5	14.3	18.0	11.7	1.5	1.5	1.0	Absent	1.7
3.2	7.7	32.1	20.0	37.1	1.0	0.5	0.0	traces	2.2
15.0	8.2	210.7	162.0	89.9	2.5	8.5	1.0	1.6	3.3
6.5	8.7	78.6	53.0	111.2	1.0	–	0.5	4.6	3.7
5.0	8.7	64.4	44.0	75.9	0.5	0.25	1.0	2.6	3.8

In another phase of the community with 45% coverage (Figure 1, observation 7 a), the saline alkali conditions lie in the top 45 cm profile layer, being top 15 cm moderately and 15–45 cm slightly saline alkali layers and surface and bottom non-saline. Salinity picture of the profile is given below:–

Physical and chemical characteristics of soil profile under Sporobolus community (45%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
2.0	7.6	16.7	20.0	19.3	1.0	0.5	0.0	Absent	2.33
8.5	8.5	116.7	75.0	122.9	0.5	1.3	0.0	8.0	3.0
7.5	8.5	80.0	75.0	94.0	1.0	0.45	0.0	7.2	3.7
5.0	8.4	50.0	46.0	38.9	1.5	1.8	1.0	4.0	4.0
3.0	8.3	33.3	30.0	26.7	1.5	1.6	0.0	2.0	3.0

The study shows that a pure Sporobolus community indicates occurrence of a 45 cm saline alkali layer in the profile. It also equally appears to position of this horizon in the profile. When the community flourishes richly, the top 15 cm absorbing root-zone is free from excess soluble salts and the saline alkali layer lies deeper in the profile. On the other hand, when the community suffers shrinkage in coverage, it means that excess soluble salts have accumulated in this layer and the saline alkali layer occupies subsurface position.

8. *Suaeda fruticosa community*

This mono-specific vigorously growing community has 80% coverage, occupies a flat low-lying site, and receives saltrich surface suspended sediment from the surround. The site has fine-textured soil; it is water-logged and poorly drained, with watertable fluctuating and containing highly brackish water. Soil surface has high salt content. Leaching of salts is small. As a result, highly saline alkali conditions occur throughout the profile.

A detailed picture of salt status of profile is recorded hereunder :–

Physical and chemical characteristics of soil
profile under Suaeda community (80%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
70.0	8.9	625.0	857.0	221.0	1.0	15.0	12.0	8.3	2.0
32.0	8.7	375.0	343.0	134.7	1.5	14.0	4.0	2.2	1.1
26.0	8.6	175.0	264.0	59.2	2.5	15.0	3.0	1.0	1.2
18.5	8.7	125.0	121.0	45.6	1.5	13.5	2.0	1.4	1.0
13.0	8.5	75.0	43.0	26.1	1.0	15.5	1.0	0.2	0.7

9. *Eleocharis atropurpurea community*

This pure vigorously growing community has 80% coverage, occupies low-lying water-logged-submerged habitats. Soluble salts are maintained low in the profile; surface has somewhat high salt content. The top 45 cm soil profile is alkaline the surface is strongly saline-alkali, while the rest of the profile is non-saline.

Detailed salinity characteristics of profile are given below :–

Physical and chemical characteristics of soil
profile under Eleocharis community (80%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
15.0	8.8	262.5	211.0	130.0	1.7	6.45	1.0	13.2	4.0
4.0	8.6	62.5	44.0	32.3	1.7	3.8	1.0	1.8	1.7
3.0	8.6	37.5	31.0	19.6	1.29	5.05	0.5	1.02	1.59
2.8	8.6	31.3	27.0	15.8	1.25	6.65	0.0	0.8	1.3
2.0	8.3	18.8	20.0	9.5	1.25	6.65	0.0	0.2	1.2

10. *Desmostachya bipinnata-Sporobolus marginatus community*

This bispecific open community with component species respectively covering 25% and less than 1%, grows on depressed sites, patchily interpersed in the main Sporobolus marginatus community. The habitat receives salt-rich deposits from flash-floods, which gradually leach down in due course to lower soil profile layers. The soil is fine-textured and has a mixed pattern of drainage. It is water-logged and poorly drained below 45 cm profile layer, with slightly brackish water. The water table tends to rise even upto 15–30 cm profile layer in peak months, but drops down in rest of the period. The soil is fairly well-drained in the middle layers; as a result, excess soluble salts are regularly drained away. The profile has a top 30 cm saline-alkali layer, inclusive of a strongly saline-alkaline surface, a slightly saline profile below 45 cm profile layer, and a non-saline 30–45 cm layer.

A detailed picture of the salts is recorded below:–

Physical and chemical characteristics of soil profile under Desmostachya-Sporobolus community (25% + <1%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
15.0	8.7	189.3	172.0	267.8	0.8	0.7	1.0	20.0	5.5
10.0	8.6	114.3	116.0	208.6	0.5	1.0	1.0	12.4	8.3
4.0	8.4	42.9	40.0	42.9	1.0	1.0	1.0	2.0	4.0
2.0	8.0	17.9	19.0	17.9	0.5	1.5	0.0	0.2	2.4
5.0	8.2	46.4	29.0	41.5	1.0	1.5	0.0	0.2	3.9

From examination of the vegetation it emerges that both the species of the community are not growing vigorously. Growth of *Sporobolus* is held up due to moderately saline alkali conditions in its absorbing root-zone in the top 15 cm profile layer. The slight saline alkali conditions in the 15–30 cm layer do not appear to affect growth of *Sporobolus* adversely. Likewise, *Desmostachya* does not appear to withstand salinity below 45 cm depth.

The apparently Desmostachya-Sporobolus community, (10a) growing subdensely with component species respectively covering 38% and 2% occupies flat sites, actually abandoned fields, receiving salt-infested depositions. The soil is fine-textured; the water table is high and fluctuating and also slightly brackish; the water table invariably staying within the top 30–60 cm profile layer. In spite of fine texture of soil the land is internally fairly drained. Leaching down of salts is negligible. The soluble salts are regularly drained away; as a consequence, the profile is free from excess soluble salts and non-saline. The surface rich in salts, is, however, strongly saline-alkaline.

A picture of salt distribution in the profile is presented hereunder:–

Physical and chemical characteristics of soil profile under Desmostachya-Sporobolus community (38% + 2%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
13.5	8.6	160.7	190.0	207.4	1.0	0.2	0.0	26.0	8.5
2.6	8.2	17.9	26.0	23.6	0.5	0.65	0.0	0.8	2.8
1.4	7.8	7.1	16.0	8.3	0.5	0.95	0.0	0.08	2.16
1.4	7.8	7.1	13.0	5.3	2.25	1.4	0.0	Absent	1.5
1.0	7.8	7.1	13.0	12.0	0.5	2.0	0.0	,,	1.0

After desalinisation in the past, the land strip now under this community, had been under Desmostachya. Due to obstruction of salt-infested flash-floods, re-salinisation took place, by deposition of salts on the surface. The habitat continues to undergo change and with this its supporting vegetation.

Desmostachya-Sporobolus bearing profiles hitherto studied are widely different from each other. Accordingly, this community cannot be taken to be indicator of any specific conditions.

11. *Desmostachya bipinnata community*

This mono-specific subdense community, with a canopy coverage of 45 to 60%, grows on a variety of soils, ranging from non-saline to saline-alkali. It has many variants, and each one specific to a particular soil condition is being described hereunder.

One phase of the community (11a) has 45% coverage, and it grows on a flat terrain, receiving surface flash-flooding. The soil is fine-textured and internally well-drained. It has a fluctuating high water table, with slightly brackish water, often rising upto, and within the 30–45 cm profile layer. Due to the internal drainage, the soluble salts are regularly drained away. As a result, the profile is free from excess salts, and is non-saline, inclusive of the surface. Such sites are, however, rare in the area.

A detailed picture of salts in the profile is given below:–

Physical and chemical characteristics of soil profile under Desmostachya community (45%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
3.0	7.5	25.0	30.0	16.1	2.5	2.3	1.0	Absent	1.5
2.0	7.5	14.3	18.0	4.3	1.0	1.2	0.0	Traces	1.6
2.0	7.5	17.9	17.0	14.6	1.5	1.5	0.0	Absent	1.4
2.4	7.5	20.0	17.0	21.0	1.5	0.2	0.0	Absent	1.8
2.0	7.8	16.7	18.0	23.6	0.5	0.5	0.0	Absent	2.0

Another phase is a subdense community (11b), covering 60%, and with *Suaeda fruticosa* seedlings less than 1%, grows on a flat terrain, lying in a nallah bed. The site has fine-textured soil, waterlogged, poorly drained, and containing highly brackish water.

The land surface has high salt content, received from flash-flood sediment, and also from the capillary-rise on account of closer water table. The drainage in the upper soil profile is poor. Overall the top soil is strongly saline; the sub-soil layers are non-saline.

A detailed salt picture of soil profile is reproduced below :–

Physical and chemical characteristics of soil
profile under Desmostachya community (60)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
50.0	8.4	575.0	552.0	186.6	2.0	17.0	4.0	1.6	1.5
15.0	7.2	208.3	170.0	66.7	3.0	16.5	1.0	Absent	0.7
3.6	7.2	50.0	36.0	17.2	1.5	15.5	0.0	,,	0.5
3.4	7.2	41.7	30.0	14.1	1.15	16.0	0,0	,,	0.4
3.4	7.2	41.7	29.8	14.1	1.5	16.0	0.0	,,.	0.4

The situation overall is not yet stable. It deteriorates in the absence of any cultural practices. It ultimately turns saline-alkaline, accompained by a corresponding change in plant community.

In this complex, there is still another sub-dense community (11 c). It has a coverage of 50%; occurs on flat low-lying sites. The habitat has a fine-texture soil; it is water-logged and poorly drained. The water table is fluctuating. As a result of rich deposition of salts from flash-floods, the surface is extremely strongly saline alkaline. Leaching, too, concomitantly taking place which has made the top profile layer strongly saline alkaline. Due to fair drainage excess soluble salts are regularly removed away from the subsoil and the profile underneath is non-saline.

A detailed picture of salinity status of soil profile is recorded hereunder :—

Physical and chemical characteristics of soil
profile under Desmostachya community (50%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
130.0	8.3	975.0	1780.0	467.5	4.03	4.7	8.0	102.0	50.0
15.0	8.8	225.0	192.0	111.4	3.0	5.15	10.0	12.2	3.8
3.5	8.4	50.0	36.0	25.4	3.5	4.25	0.0	2.0	0.3
2.0	8.1	25.0	17.0	11.8	3.5	5.5	0.0	0.2	0.4
1.6	8.0	12.5	21.0	6.5	2.5	4.8	0.0	Absent	1.0

The community covers vast areas where water-logging and resultant salinity are of relatively recent development.

Still another phase of the community (11d), covering 50%, occupies flat low-lying areas with a hard salt crust on the surface. The site has a fine-texture, water-logged and poorly drained soil and a fluctuating high water table with very brackish water. It receives salt-rich flooding on the surface, and develops a hard salt crust thereon. Due to combined action of heavy leaching and high capillary rise of soluble salts, there is an accumulation of excess salts in the profile. As a result , a 45 cm saline-alkali layer develops in the upper part of the profile, inclusive of an extremely saline-alkaline surface. The profile thereunder, however, is non-saline.

A detailed picture of salinity status of the soil is given below:-

Physical and chemical characteristics of soil profile under Demostachya community (45%)

EC	pH	Na	Cl	SAR	Ca	Mg	K	CO_3	HCO_3
160.0	8.0	1250.0	2260.0	980.0	1.5	1.75	50.0	90.0	40.0
36.0	8.3	375.0	490.0	283.4	1.25	2.25	12.0	38.0	21.0
6.5	8.2	50.0	80.0	50.0	1.3	0.7	1.0	20.5	5.2
4.4	8.4	50.0	80.0	36.5	1.5	2.25	0.1	1.0	6.0
3.6	8.2	37.5	30.0	51.7	0.6	0.45	0.0	0.5	2.05

Discussion

Howsoever preliminary the study of plants as indicators of soil salinity may appear a suggestive type of indication can doubtlessly be drawn therefrom. A total of 11 plant communities have hitherto been delineated from the area. Of all the plant communities reported ***Demostachya*** community occupies vast stretches everywhere, while the others only occur locally as relatively small patches. Under undisturbed conditions, this species is known to exist as mono-specific as well as bi-specific communities, which all reflect the salinity status of soils, Quite often, however, the picture of the original natural vegetation is obliterated due to removal of indicating dominant/codominant species, through ploughing or for firewood. Being hardy, after such a treatment, it usually always re-establishes itself on its parent habitats and often without the formerly occurring codominant species. Thus, being derived from different plant communities, ***Desmostachya*** is not to be taken one community, as is evident from the very wide variation in the soils finding under various phases thereof in the present study (figure 1). As such it cannot be depended upon as indicator of specific soil conditions.

Desmostachya-Sporobolus community is another such case. Under undisturbed conditions, the community is at equillibrium with the edaphic environment and does indicate the relevant salinity status. Contrarily under disturbance the community or the soil salinity status or both are in a process of continuous change and the community , not being in equilibrium with the edaphic environment, cannot be taken to indicate specific salinity conditions. The study on the whole, however, does yield some useful information on the indicator value of plant communities recorded.

Most of the plant communities, hitherto recognized, are truly indicative, while the others may, for the time being, be considered only tentative. These do reflect the type, degree, extent and position of the toxic layer (s) in the profile. Some occur strictly on saline soils, other on saline-alkali, and still others on alkali soils. The various plant communities indicating salinity status of soils are as under:-

1. Cynodon dactylon community indicates a slightly saline surface, exclusive of a non-saline soil profile.

2. Demostachya bipinnata-Cynodon dactylon community reflects a slightly saline profile layer at a depth of 15–45 cm. exclusive of the non-saline surface.

3. Cynodon dactylon-Desmostachya bipinnata community is indicative of slightly saline top and third 15 cm profile layers, inclusive of the surface.

Comparison of the Cynodon-bearing soil profiles reveal that, while slight salinity on the surface does not appear to harm the species, it is not tolerant either of excess salts in its absorbing root-zone, at the depth of 0–30 - (45) cm either. Accordingly, even slight salinity development anywhere in its absorbing root-zone immediately disturbs its nutritive functions whereby the species tends to decrease in coverage. In this interpretation, the thicker the saline layer, the more shrunk is the canopy coverage.

4. Salsola foetida reflects a slightly saline top 30 cm profile layer exclusive of the surface and a moderately saline layer at a depth of 30–60 cm, and even below.

5. Aeluropus lagopoides community indicates a strongly saline surface and a top 60 cm moderately saline profile layer in case of a richly flourishing community. The species is sensitive to high salt concentration in its absorbing root-zone, i. e. in the top 15 cm. When a high degree salinity develops in this layer, as well as at a depth of 45–60 cm, the community shrinks in coverage.

6. Salsola foetide-Halocharis suplhurea community is indicative of a thoroughly strongly saline soil profile, inclusive of the surface.

7. Sporobolus marginatus community is indicative of a 45 cm wide moderately saline-alkali layer, between 0 and 60 cm in the soil profile, with a non-saline soil surface. It has been noticed that as long as saline alkali conditions lie below the top 15 cm layer, the community flourishes and grows vigorously. On the other hand, when the same also involves the top layer, the vigour of the community is adversely affected and it shrinks in coverage.

8. Suaeda fruticosa community is a reflection of presence of both water-logging and strongly saline-alkali conditions throughout the profile, inclusive of surface.

9. Eleocharis atropurpurea community indicates fully water-logged sites with a top 45 cm alkali profile and a strongly saline surface.

10. Desmostachya bipinnata-Sporobolus marginatus community at equilibrium with the existing soil conditions in its original natural habitat, indicates a strongly saline alkali surface with a moderately saline alkali top 15 cm layer and slightly saline 15–30 cm and 45–60 cm profile layers, Further development of both the component species is arrested by the existing static hostile edaphic environment. They have both low vigour and hence low coverage.

The other variant of the community (10a), on the way to development, is under a process of continuous change both in the community dynanism and in salinity status of the profile. Although the community apparently looks like No. 10, its soil profile is widely different from the former. In this, the profile is non-saline but has strongly saline-alkali surface.

Figure 1. Plant communities and salinity status of soils in Peshawar valley.

Observation No.	1	2	3	4	5	5a	6	7	7a	8	9	10	10a	11a	11b	11c	11d
Community	Cynodon dactylon community (95%)	Desmostachya bipinnata-Cynodon dactylon community (60% + 10%)	Cynodon dactylon-Desmostachya bipinnata community (60% + 40%)	Salsola foetida community (10%)	Aeluropus lagopoides community (50%)	Aeluropus lagopoides community (40%)	Salsola foetida-Halocharis sulphurea community (15% + 5%)	Sporobolus marginatus community (90%)	Sporobolus marginatus community (45%)	Suaeda fruticosa community (80%)	Eleocharis atropurpurea community (80%)	Desmostachya bipinnata-Sporobolus marginatus community (38% + 2%)	Desmostachya bipinnata-Sporobolus marginatus community (25% + ∠ 1%)	Desmostachya bipinnata community (45%)	Desmostachya bipinnata community (60%)	Desmostachya bipinnata community (50%)	Desmostachya bipinnata community (50%)
Surface	B	A	B	A	B	B	B	A	A	C	C	C	C	A	C	C	C
Top layer	A	A	B	B	B	B	B	A	C	C	D	A	C	A	B	C	C
Second Layer	A	B	A	B	B	B	B	C	C	C	D	A	C	A	A	A	C
Third layer	A	B	B	B	B	B	B	C	C	C	D	A	A	A	A	A	C
Fourth layer	A	A	A	B	B	B	B	C	A	C	A	A	B	A	A	A	A
Salinity status	Saline							Saline-alkali			Alkali	Mixed					

Legend:

- A — Non-saline
- B — Slightly saline
- B (shaded) — Moderately saline
- B (dark shaded) — Strongly saline
- C — Slightly saline-alkali
- C (shaded) — Moderately saline-alkali
- C (dark shaded) — Strongly saline-alkali
- D — Alkali

The low coverage of *Desmostachya* is due to its earlier extraction to bring land under cultivation. The species is now spreading again. Presence of Sporobolus in the community is only a recent development, following construction of road obliquely to its line of drainage. This caused deposition of salts from flood waters on the surface to make it saline-alkali, creating conditions for germination and establishment of *Sporobolus*. This is a young community in transition, and should in course of time develop to a stable community. Depending upon the physiography and the extent of salts which can be deposited through flooding from above and redistributed and finally balanced under the various physical processes, final mature community would be established. Conclusively, therefore, Desmostachya-Sporobolus community cannot be taken to indicate any specific salinity conditions.

Desmostachya is an arid zone species, occupying non-saline soils prior to soil salinization. It is, however, managing to tolerate, or avoid, salinity by virtue of its deep-feeding root-system. The vigour of *Desmostachya* is not much affected adversely by slightly saline conditions in the top 45 cm of non-absorbing root-zone nor by any type and degree of salinity in the top layer or on the surface. As soon as even slight salinity conditions develop in the absorbing root-zone in the profile below 45 cm, the vigour of species is immediately affected, whereby it shrinks in overage. The same is true for *Sporobolus*. It is a top layer feeder. On comparison with other Sporobolus-bearing soil profiles, it emerges that as soon as moderate saline-alkali conditions develop in its absorbing root-zone in the top 15 cm profile layer, the vigour of plant is adversely affected, and it is reflected in the reduction of canopy coverage.

II. Desmostachya bipinnata, being a complex community, is not indicative of any specific salinity conditions as it grows on all types of habitats, ranging from thoroughly non-saline to strongly saline alkali.

From the comparison of Desmostachya-included communities, it also emerges that when vigorously growing, whether in pure or mixed communities, *Desmostachya* indicates a non-saline soil profile below the top 45 cm layer. Now, whenever it starts shrinking in coverage, it indicates that salinity has developed in its root-zone below 45 cm in the profile.

Conclusion

In spite of the fact that the soil-plant relationships remain diffuse in many respects, they provide an insight into the essentials of the inter-acting physico-chemical systems of soil, reflecting their potential bearing on character of vegetation.Howsoever complex these relationships may be, the vegetation can be stratified into plant communities as reflecting the net result of interactions of various physical and chemical factors in salt-infested soils. Thus, they do indicate the type, the degree, the extent and the position of salinity in the rhizosphere, provided the supporting vegetation originally at equilibrium with the saline edaphic environment has not been redically altered. In such studies, both the species composition and their respective cover values are important in the assessment of salinity status of soils.

Cynodon, Cynodon-Desmostachya and Desmostachya-Cynodon communities indicate slight salinity; Salsola and Aeluropus communities reflect moderate salinity; while Salsola-Halocharis community is indicative of strong salinity. As to Sporobolus, Desmostachya-

Sporobolus and Suaeda communities, they are all reflection of saline-alkali conditions, while Eleocharis community is indicative of alkali soils. Desmostachya-sporobolus complex community as well as Desmostachya complex community the latter mostly being derived from bi-specific communities through selective removal of the other species, is rather a mixture of different communities, and as such it cannot be taken to indicate specific conditions. However, all Desmostachya-containing communities, mono-specific or bi-specific, indicate non-saline soil-profile below 45 cm depth. But as soon as the salinity develops below the above mentioned depth, it is reflected in simultaneous relative overall shrinkage of *Desmostachya* cover.

Cynodon alone indicates slight salinity, restricted only to the surface. Cynodon-Desmostachya reflects slight salinity in the surface, top 15 cm and 30–45 cm layers, with 15–30 cm clean soil zone. Desmostachya-Cynodon, however, shows salinity in the 15–45 cm soil layer. Salsola community reflects a top 30 cm slightly saline layer on a 30 cm moderately saline profile, exclusive of non-saline surface.

Aeluropus community is indicative of a top 60 cm moderately saline profile with a strongly saline surface. When a richly flourishing Aeluropus community starts shrinking in coverage, it indicates at least the top 15 cm layer turning strongly saline. Salsola-Halocharis community is reflective of surface inclusive thoroughly strongly saline soil profile. Similarly a densely growing Sporobolus community reflects a 45 cm mixed slightly to moderately strongly saline alkali layer below the top 15 cm non-saline layer inclusive of the surface. If the community shows a tendency of shrinkage in cover this means saline alkali conditions have developed also in the top 15 cm layer. Suaeda community is indicative of a waterlogged sub-soil and thoroughly strongly saline-alkali profile, inclusive of the surface. Eleocharis community is a reflection of a top 45 cm alkali but thoroughly water-saturated profile, inclusive of a strongly saline alkali surface.

The criterion of plant communities as reflection of the chemical environment in the rhizosphere can be used as a tool in identification, classification and delineation of saline soils in the field. The methodology is more sure than the mere soil analyses, and at times is even more economical as compared to the conventional procedures. The methodology, however requires a penetrating eye and demands minute observations in field as well as shifting of both tangible and intanglible data in analysis to arrive at discervible indicating parameters. With this approach, and of course a little more refined, it is possible to come up with thumb rules to be used as datum for effective management of salinised lands.

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