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Physico-chemical Analysis of Soils of Cholistan Desert

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Abstract

Soil samples from 3-6 inches depth were collected at 8 different locations from Cholistan desert during an expeditio November 1997. Physico-chemical analysis by standard methods revealed the following information as; electr conductivity as 211±25.63 μS/cm, pH as 8.72±0.09, total alkalinity as 5.36±1.63, bicarbonate content 91.44± MEq/L, chloride content 1.12±0.25 MEq/L, sulphate as 212.49±23.26 MEq/L, Na as 12.12±1.66 MEq/L, K 11.83±5.06 MEq/L, Ca as 0.62±0.097 MEq/L and Mg as 1.00±0.17 MEq/L. Carbonate and orthophosphate were detected by the employed methods. The amount of organic matter was 1.035±0.167 per cent with total nitrogen cont of 0.047±0.01 per cent. When soil samples were subjected to metal analysis by atomic absorption spectroscopy, s optimal levels of all four studied metals (in ppm) were found, i.e., Cu was 0.079±0.022, Fe was 1.808±0.316, Mn w 1.653±0.212 and Zn was 0.0363±0.007. These lower levels of essential metals indicate lower demands of these me by the desert vegetation.

Introduction

Cholistan is a vast sandy desert of 2.6 million hectares. It is 480 km in length with 32-192 km varying breadth. Its temperature during summer goes upto 50°C or more and in winter it varies around 15-25°C. Humidity is little and annual rainfall is uncertain and irregular, 125-250 mm. Most of the rainfall is received during summer, July-September. The soils of Cholistan desert are consisting of; dune land soils cover 44 per cent (pH 8-8.5); sandy soils constitute 37 per cent of the total area of Cholistan (pH 8-8.5); saline sodic-clay soils constitute 17 per cent of the total area of Cholistan desert (pH 8.6-10) and about 2 per cent of the total area is of loamy soils and their pH range is 8.0-8.5 (Akram *et al.*, 1995). The underground water is saline Due to high evaporation losses and low rainfall, these salts remain on the soil surface and these soils therefore are barren and bear poor vegetation (Rao *et al.*, 1989; Akram *et al.*, 1995).

Soils of an ecosystem provide water and anchorage to vegetation as well as regulate the availability of essential major elements like nitrogen, phosphorus, sulphur, potassium, calcium and magnesium and trace elements (like boron, copper, iron, manganese, molybdenum and zinc. It also acts as a sink for organic materials and for natural and pollution inputs from the atmosphere. The vegetation also influences the physico-chemical properties of the soils. Vegetation increases the release of hydrogen ions in the soils, and decaying vegetation causes leakage of organic leachates in the soil. The physico-chemical properties of the soils therefore reflect the nature and type of vegetaion of the given ecosystem (Cresser *et al.*, 1993).

Mineral analysis of several desert plant species have been carried out (Dhir *et al.*, 1985; Gopal *et al.*, 1989) but little work has been done on the physico-chemical analysis of soils of Cholistan desert (Rao *et al.*, 1989; Akram *et al.*, 1995). In the present work, soil samples have been collected from various locations of Cholistan for physi chemical analysis and the results indicate the sub-opti levels of essential metals with high salt and pH values. information thus obtained may be useful in demonstrat mechanisms to accelerate the germination and gro mechanisms of endangered flora of Cholistan desert.

Materials and Methods

Soil samples from 3-6 inches depth were collected a different locations from Cholistan desert during expedition in November 1997. Samples were subseque analyzed in 1998. Chemicals used were of Analytical gr Standard methods were used for the determination various parameters (Khan *et al.*, 1970; Allen *et al.*, 19 Flame photometer (Corning) was used for Na and estimations. pH meter (Hanna) was used for determination of pH of soils. Atomic absorpt spectrophotometer of Pye Unicam SP9 was used for analysis of Mn, Zn, Fe and Cu. The following conditi were set for the determination of these metals. Wavelen (nm): Cu (324.8), Fe (248.3), Mn (279.5), Zn (213. Maximum current used by hollow cathode lamp (mA): (5), Fe (15), Mn (12) and Zn (10); Acetylene gas pressu 10 lbs; Air pressure: 30 lbs. Computer programme Spa the attached computer was operated and key 'r commenced the sample feeding for metal estimations. 20g soil was taken in 40ml of reagent [3.93 Diethylenetriaminepentacetic acid (DTPA), 2.9404g calc chloride and 26.64g triethanol amine (TEA) were taken made volume upto 2L with double distilled water]. contents were shaken for 2 hours followed by filtera with Whatmann 42. Filtrate was used for the determina of metals. Stock solutions of Cu, Fe, Mn and Zn (prepa by dissolving pure metals in conc. HCl or HNO_3) w diluted to 0-10 ppm working strengths for the calibra curves. Each samples was analyzed in duplicates triplicates.

Results

Physico-chemical properties of desert soils: Table 1 indicates that pH values of these soil samples ranged from 8.43 to 9.20 with mean value of 8.53. Soil samples of Massu Wala (sample 4) and Bundri (sample 5) had higher pH values. However, when the electrical conductance was measured as an index of soluble salt contents, EC values ranged from 118 (sample 4) to 348 μS/cm (sample 6, Taraway Wala) with a mean value of 211 μS/cm.

When bicarbonate and carbonate levels were measured, with the employed methods, carbonate levels could not be detected. Several efforts were made and fresh solutions were used each time for the estimation of carbonate in the samples. However, bicarbonate levels were highest (116.3 MEq/L) in sample 5 (Bundri) and lowest (60.1 MEq/L) in sample 2 (Bijnote). Total alkalinity of soil samples ranged from 2.15 for sample 5 (Bundri) to 16.5 for sample 7 (Nawazay Wala) with a mean value of 5.36.

Chloride and sulphate ions are among the dominant anions present in soils. Minimum chloride was present in sample 8 (Wikrian Wali) and maximum levels were in sample 4 (Massu Wala II) and the mean value was 1.115 MEq/L. Sulphate was calculated by subtracting the sum of carbonate, bicarbonate and chloride from total anions MEq/L calculated from the conductivity reading. Sulphate ions, on the other hand, had much higher concentrations ranging from 146.2 for sample 7 (Nawazay Wala) to 342.5 for sample 6 (Taraway Wala) and the mean value was 212.8 MEq/L.

Levels of Ca, Mg, Na and K ions and organic matter in desert soils: Table 2 shows minimum Ca levels were in sample 1 (Dhori) with value of 0.06 MEq/L and higher levels (0.06) were seen in sample 7 (Nawazay Wala) with a mean value of 0.6 MEq/L. Similarly, Mg levels ranged from 0.38 (sample 7, Nawazay Wala) to 2.1 MEq/L for sample 4 (Massu Wala II). The mean Mg levels were 0.95, higher than the mean Ca levels. It is therefore observed that the mean Ca + Mg levels do not exceed 1.55 Meq/L. Na, K and Li levels were measured by flame photometer. Li was absent in the soil samples and varying levels of Na and K were found in 6 soil samples (Table 2). Na concentration ranged from 8 MEq/L (for samples 2 and 3) to 18.5 for sample 8 with mean value of 12.117 MEq/L. Similar profiles were observed for K ions wherein minimum value was 5 MEq/L for sample 3 and maximum value was 37 for sample 8, with mean value of 11.83 MEq/L.

Organic matter was determined by standard method and nitrogen contents were measured as (Nitrogen (%) = Organic matter x 0.05) (Khan *et al.*, 1970). Results are given in Table 2. Bijnote (sample 2) soils had minimum organic matter (0.258 percent) whilst soils of Bundri (sample 5) had maximum organic matter (1.71 percent), the mean value was 1.03 percent. When soil samples were digested for Kjeldhal estimation for total nitrogen, no nitrogen was found. However, by the formula given above, nitrogen contents varied from 0.004 percent for sample 7 (Nawazay Wala) to 0.085 percent for sample 5 (Bundri), with mean value of 0.047 per cent.

Trace metals in desert soils: Table 3 indicatesthat Cu levels ranged from 0.01 to 0.13 ppm for samples 3 (Massu Wala I) and 7 (Nawazay Wala), respectively. The mean value was 0.079 ppm. Fe levels were found maximal (3.97 ppm) in sample 5 (Bundri) and minimal (1.29 ppm) in samples 1 (Dhori) and 2 (Bijnote). Mn levels found were in the range from 1.1 ppm (for sample 3) to 2.71 ppm (for sample 4, Massu Wala II), with mean value of 1.653 ppm. Zn was found in the range 0.02 to 0.07 ppm in all samples with the mean value of 0.0363 ppm.

Discussion

Soil pH determines the acidic and basic behaviour of soils and also is responsible for the availability of nutrients to the plants which in turn effect the plant growth. The present study reports pH from 8.43 to 9.2, refluxing the alkaline nature of soils. Conductivity measurements of soils are index of soluble salt contents. Salt free soils exhibit upto 2 mS/cm value indicating 0.15 per cent salt concentrations. However, when salt concentration exceeds 0.65 per cent,

Table 1: Some physico-chemical properties of soils of Cholistan desert.[Carbonate contents were determined by standard method and value was found below the detectable limits!]

Area	E.C. μS/cm	pH	HCO_3 Meq/L	CO_3 Meq/L	Total Alkal.	Cl Meq/L	SO_4 Meq/L
Dhori	250	8.83	104.0	Nil	4.50	1.250	244.6
Bijnote	174	8.73	60.1	Nil	4.50	1.075	168.2
Massu Wala -I	158	8.77	73.5	Nil	3.80	1.170	153.3
Massu Wala -II	118	9.20	105.5	Nil	4.80	2.500	174.3
Bundri	242	9.04	116.3	Nil	2.15	0.425	239.0
Taraway Wala	348	8.43	77.5	Nil	4.15	0.825	342.5
Nawazay Wala	164	8.44	92.3	Nil	16.5	1.500	146.2
Wikrian Wali	234	8.53	102.3	Nil	2.50	0.175	231.8
Total contents ±SE	211.0 ± 25.7	8.75 ± 0.1	91.44 ± 6.80	Nil	5.363 ± 1.63	1.115 ± 0.3	212.5 ± 23.3

Table 2: Total nitrogen, organic matter and metal contents of soils of Cholistan desert. Ca, Mg, Na, K and Li expressed in MEq/L.

Area	Ca	Mg	Na	K	Li	Organic matter (%)	N (%)
Dhori	0.06	1.01	14.5	7.0	Nil	1.086	0.054
Bijnote	0.48	0.74	8.0	6.0	Nil	0.258	0.012
Massu Wala-I	0.50	0.52	8.0	5.0	Nil	1.340	0.067
Massu Wala-II	0.96	2.10	N.D.	N.D.	Nil	1.450	0.072
Bundri	0.47	0.77	13.0	8.0	Nil	1.710	0.085
Taraway Wala	0.77	1.05	N.D.	N.D.	Nil	0.630	0.032
Nawazay Wala	1.00	0.38	10.7	8.0	Nil	0.770	0.004
Wikrian Wali	0.58	1.02	18.5	37.0	Nil	1.034	0.052
Total contents	0.60±0.11	0.95±0.19	12.12±1.66	11.83±5.057	Nil	1.035±0.167	0.047±0.

Table 3: Trace metals in soils of Cholistan desert. Values are expressed in terms of ppm.

Area	Cu	Fe	Mn	Zn
Dhori	0.04	1.29	1.14	0.02
Bijnote	0.02	1.29	1.17	0.04
Massu Wala - I	0.01	1.42	1.10	0.02
Massu Wala - II	0.13	1.74	2.71	0.07
Bundri	0.17	3.97	1.45	0.02
Taraway Wala	0.02	1.69	2.34	0.06
Nawazay Wala	0.13	1.72	1.44	0.02
Wikrian Wali	0.11	1.34	1.87	0.04
Total contents	0.079	1.808	1.653	0.04
±SE	±0.022	±0.316	±0.212	±0.01

the E.C. value is >15mS/cm and soils are treated as strongly saline (Cresser *et al.*, 1993). Results presented in this report show E.C. values of 0.118 to 0.348 mS/cm, refluxing the saline nature of soils.

Bicarbonate is a normal constituent of soil-water extracts of saline soils. Carbonate, as well as bicarbonte, is often present in sodic (alkali) soils. It has been found that when carbonate is present in soil-water extracts in titratable amounts, pH of the extract is 8.5 or higher whilst the concentration of bicarbonate never exceeds 10 MEq/L in the absence of carbonate.

Total analysis for Ca and Mg is not very useful in characterizing a soil as a medium for plant growth but the analysis is very useful in characterizing a soil from a mineralogical standpoint. It has been seen that the concentration of Ca and Mg ions in soil-water extracts seldom exceeds 2 MEq/L at pH > 9.0. Therefore, Ca+Mg is low if carbonate is present in titratable amounts, and Ca+Mg is never high in the presence of high concentrations of bicarbonate. The data shows low levels of Ca and Mg and Ca+Mg ions.

Chloride is the principal anion in extracts of saline soils. Chloride is more toxic to plants when present as calcium chloride than sodium chloride. Results show minimum levels of 0.175 to the maximum of 2.50 MEq/L, with the mean value of 1.115 MEq/L. Sulphate is often determined as the difference between the sum of cations (Ca, Mg, Na, K ions) and the sum of anions (carbonate, bicarbonate and chloride). The reported results indicate 146.2 to 342.5 MEq/L levels with the average value of 212.5 MEq/L. contents in soils have been found to vary between 8 18.5 ppm. K contents in soils have been found to v between 5 to 37 ppm.

Soil organic matter plays a vital role in the establishment soil structure and helps in the regulation of soil pH or availability of minerals as nutrients to the grow vegetation. Minimum organic contents of just above 1 cent have been found in the desert soils though in so samples organic matter is 0.258 per cent. This va certainly reveals the low binding capacity of such san soils and hence wind blow results in shifting of sand du and so on. These low organic contents ultimately resul the low nitrogen contents in such soils. In the pres work, mean nitrogen levels of 0.0473 per cent have be found in the desert soils though some soil samples h higher nitrogen contents 0.085 per cent and other samp had minimum levels of 0.004 per cent. When the nitr contents of these soils were tested, both these ions w present. Nitrate contents varied from 2 to 26 mmole/g (preliminary data, not presented). Since the soils have b stored for 6 months before these determinatins, denitrification and nitrification processes had b operational during this period, the exact significance of determination of nitrate and nitrite had been obscu However, it is evident that nitrate and not the nitrite is major inorganic form of nitrogen present in desert s (Allen *et al.*, 1974).

The determination of metal contents in desert soils refle information about the mineral status of the plants. Cop contents in Cu deficient soils are 1-3 ppm and may re 200 ppm (Allen *et al.*, 1974). The need of Cu to plants very low and only 10 ppm of total plant dry weight is and excessive Cu is accumulated in plant roots. Cu lev in the desert soil have been found to be 0.079 ppm wit range of 0.01 to 0.17 ppm. Iron in soils occur as ferr and ferric states. In the present study, the iron contents 1.808 ppm have been found, ranging from 1.29 to 3 ppm. Again these iron levels are sub-optimal. Simila mean Mn levels of 1.653 ppm are found in Cholistani s with minimum levels of 1.1 and maximum levels of 2 ppm. Zn levels found are 0.0363 ppm with the range 0.02 to 0.07 ppm. Normal soil contains Zn from 10 to 3 ppm (Allen *et al.*, 1974). These studies reveal that Cholistan desert soils are dificient in these studied metals and similar profiles for other metals are also expected.

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