

Characterisation and classification of some soils of Ladakh region for land use

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Abstract

Twelve pedons occurring on different landforms of Ladakh region are studied. Soils are neutral to moderately alkaline with the exception of soils on terraces. The soils are low to high in organic carbon and variations are associated with altitude, landuse and soil texture. Mostly the soils are gravelly and the textural variations are due to the differences in the composition of parent materials as chemical weathering is very much restricted under frigid and arid pedo-environment. Side slopes are dominantly occupied by rock outcrops associated with Lithic/Typic Cryorthents. Fluvio-glacial valleys are mostly occupied by Typic Cryorthents and at places with Typic Cryochrepts. Valley and terrace lands have dominantly Typic/Mollic Cryofluvents, Fluventic Ustochrepts and Typic Ustipsamments. Valley floors are potential areas for agricultural development. Problems of cold and arid climate, erosion, high permeability, low AWC, coarse and gravelly texture, surface and subsurface stoniness and absence of irrigation facilities restrict the use and productivity of valley soils.

Additional keywords: Soil resource, landforms, soil characteristics and classification.

Introduction

Ladakh region of Jammu and Kashmir state occupies the high altitude ranges in north-western Himalayas. It is rocky and of rugged topography. Comprehensive information about the characteristics and classification of the soils of the cold desert is scarce (Gawande *et al.* 1979). Hence, the present study was undertaken to characterise and classify the soils of Ladakh region for landuse.

Materials and methods

Geographical setting

The study area of Ladakh region lies between 34°0' to 34°35'N latitudes and 76°0' to 77°32'E longitudes covering the part of Kargil and Leh districts. This region consists of the three large mountain ranges, viz. Zaskar, Ladakh, and their longitudinal valleys. The elevation of valleys ranges from 2000 to 4000 m above MSL and it rises to 4000 to 6000 m in mountain regions and 8000 m in the Karakoram ranges. Landforms such as summits and ridge tops, mountain and valley glaciers, side and reposed slopes, fluvio-glacial valleys, broad and narrow valleys, and terraces were delineated in the area. The region is drained by the river Indus and its main tributaries like Shyok, Shingar and Zaskar. The drainage patterns observed in the area are trellis, parallel, annular and centripetal type.

Geology

Crystalline rock of granite and gneiss of Archaeans occur in the Zaskar range and Ladakh. Slates, phyllites, schists, quartzites, crystalline limestone and dolomites are dominant in West Ladakh, North Hazara, Gilgit and Zaskar range.

Climate

The climate is dry and cold with warm summer. The mean annual temperature ranges from less than 1°C to 8°C. The mean summer temperature ranges from 10.2°C to 16.8°C and winter temperature from -8.4°C to 1°C. July is the warmest (17°C) and January is the coldest (-17°C) month of the year. The soil temperature regime is 'cryic'. The annual precipitation (mostly snowfall) ranges from 300 to 900 mm and received during November to March. The annual rainfall varies from 80 mm to 100 mm. The moisture control section is moist in some or in all parts in less than 90 consecutive days. Thus, the area qualifies for 'aridic' moisture regime. The cropping season commences from June and extends to October. The site characteristics and land use of representative pedons are given in table 1.

Table 1. Site characteristics

Pedon	Village/ District	Location	Elevation (m) above MSL	Parent material	Land use
Steep to very steep hill slopes					
P1	Stok, Leh	34°02'N; 77°32'E	3500	Granite	Barren
P2	Tumel, Kargil	34°33'N; 76°12'E	4000	Conglomerate	Barren
P3	Fotula, Kargil	34°17'N; 76°42'E	3600	Shale	Barren
P4	Chesore, Kargil	34°27'N; 77°07'E	3800	Sandstone	Barren
Fluvio-glacial valley					
P5	Nimugate, Leh	34°10; 77°21'E	3200	Moraine	Barren
P6	Bookharbu, Kargil	34°20N; 76°33'E	3400	Colluvium	Cultivated to wheat, barley and vegetables
P7	Bucha, Kargil	34°34'N; 76°13'E	3500	Moraine	Barren
Broad valley					
P8	Nimu, Leh	34°11'N; 77°23'E	3000	Alluvium	Grazing land
P9	Stok, Leh	34°04'N; 77°32'E	3000	Alluvium	Fodder crops
Narrow valley					
P10	Ashna, Kargil	34°26'N; 76°03'E	2500	Alluvium	Cultivated to wheat and barley
P11	Dengalthang, Kargil	34°25'N; 75°52'E	2300	Alluvium	Barley and wheat
Terrace					
P12	Gupufal, Leh	34°11'N; 77°23'E	3000	Alluvium	Wheat

Natural vegetation

Stunted cedars, willows and safadi are found in the moist strips. The dominant species in the pastures are *Medicago sativa*, *Medicago falcata* and *Microule tibetica*, *Poa spp.*, *Dactylis spp* and *Agropyron spp.*

Soil survey method

The landsat imagery (1:250,000) was interpreted and the landform delineations were transferred on Survey of India topographic base (1:250,000). They were used as the base maps. About 280 minipits and 30 profiles were studied on the different landform units and a soil-physiographic relationship (Fig. 1) was developed (Sehgal *et al.* 1989). Soil samples of representative pedons were analysed for various physical and chemical characteristics (Sarma *et al.* 1987). The soils were classified according to Keys to Soil Taxonomy (Soil Survey Staff 1990). An alternate landuse for the area has been suggested.

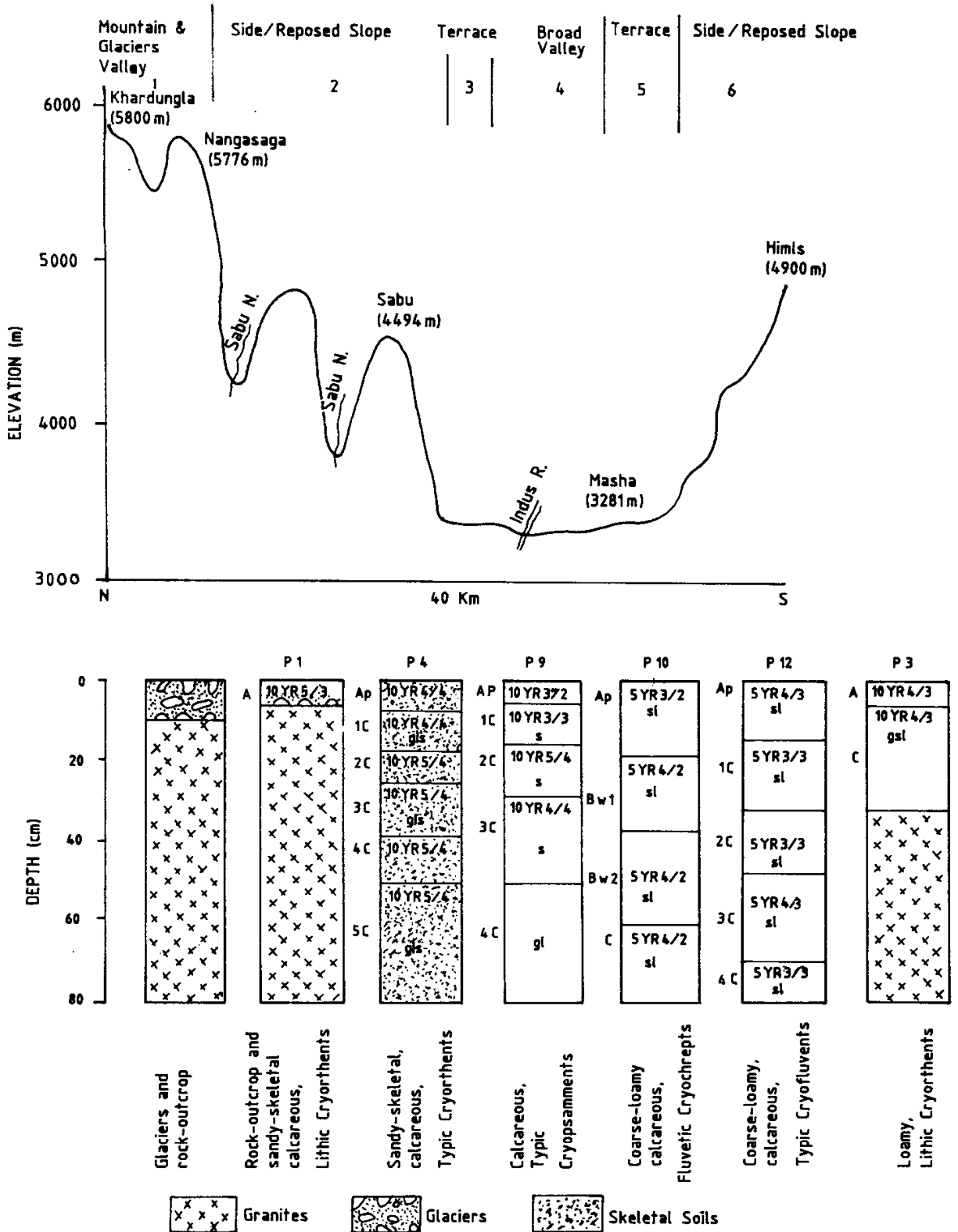


Fig. 1. Soil-physiography relationship.

Results and discussion

Soils under different physiographic units (Fig. 1) and their physical and chemical characteristics (Table 2) are described below:

Soils of steep to very steep hill slopes: This unit is located at an elevation of 3500-4000 m above MSL and is dominantly snow covered with considerable rock outcrops. However, at places extremely shallow to very shallow, skeletal soils (P1), occur on lower part of the unit and are classified as Lithic Cryorthents. These soils are nonarable due to shallow depth, stoniness, very steep slopes and severe erosion.

The side/reposed slopes of this unit occur at an elevation ranging from 3500 to 5000 m above MSL. Although it is also rocky, at places very shallow, excessively drained, gravelly loam sand to sandy clay loam, yellowish brown soils (P2 to P4) occur at places (Table 1). The soils are neutral to moderately alkaline, moderate to high in organic carbon (0.5 to 1.7 per cent) depending upon altitude. They are classified as Lithic or Typic Cryorthents. These soils remain mostly unutilised and at places cultivated to fruit crops. Rock outcrops, steep slopes, severe glacial erosion, low AWC restrict the use of these soils.

Soils of fluvio-glacial valley: The soils (P5 to P7) are formed from mixed moraine deposits of Pleistocene glaciation and occur at an elevation of ≥ 3000 m above MSL. These are moderately deep to deep, well drained to excessively drained, skeletal, calcareous soils (except P6) occurring on moderate slopes. The pH of the soils ranges from 8.0 to 8.3 as the result of free CaCO_3 . The organic carbon is low (0.16 per cent) in pedon 5 but it is high in other two soils. These soils are stratified, but pedon 7 show the development of structural B horizon. These soils have been classified as Typic Cryorthents and Typic Cryochrepts. Gawande *et al.* (1979) also found that the gravelliness and texture are the major limitations for their low productivity and agricultural use due to which they are grouped under land irrigability class 4 and 5. These are mostly barren and partly cultivated to upland rice, wheat, barley, lucerne and fruit crops such as apple, apricot and grapes. The major constraints of these soils are coarse and gravelly texture, surface stoniness, low AWC, high permeability and low fertility. Irrigation facility can bring more areas under cultivation.

Broad and narrow valleys: These soils are formed along the Indus, Drass and Zaskar rivers situated at an elevation of ≥ 3000 m above MSL. The soils (P8 and P9) of broad valleys occurring on gentle slopes, are deep, excessively drained, sand to sandy loam in texture, calcareous, neutral to slightly alkaline (pH 6.8 to 7.8) with wide variation in organic carbon depending on land use and parent material. These are prone to slight and moderate wind erosion and have slight surface stoniness. These soils are classified as Mollic Cryofluvents and Fluventic Cryochrepts. The soils are mostly cultivated to wheat, gram, mustard, fodder crops and pasture and partly lying as wastelands where no irrigation source is available.

Narrow valleys: They occur along the Zaskar river and are occupied dominantly by deep, somewhat excessively to excessively drained, loamy sand to sandy loam, stratified, soils occurring on gentle to moderate slopes. These soils (P10 and P11) are neutral to slightly alkaline (pH 7.4 to 8.3), medium to high in

Table 2. Physical and chemical properties of soils

Soil horizon	Depth (cm)	pH (1:2) Soil : Water	EC dS m ⁻¹ (1:2)	O.C.	CaCO ₃	Clay	Silt	Sand	Coarse fragments
-----%-----									
P1 – Sandy-skeletal (calcareous), Lithic Cryorthents									
A	0-8	7.0	0.15	0.27	2.47	5.3	5.2	89.5	21
R		-----Granite-----							
P2 – Coarse-loamy (calcareous), Typic Cryorthents									
A	0-8	6.8	0.15	1.77	7.74	5.8	16.8	77.4	22
AC	8-20	6.9	0.18	0.96	5.38	10.8	16.0	73.2	26
C	20-55	7.1	0.21	0.78	4.93	7.3	15.7	77.0	58
P3 – Loamy, Lithic Cryorthents									
A	0-5	7.7	0.25	0.51	--	27.5	13.9	58.6	18
C	5-35	7.7	0.39	0.25	--	23.0	11.8	65.2	35
P4 – Sandy-skeletal, Lithic Cryorthents									
A	0-8	7.6	0.42	0.84	--	9.2	4.1	82.7	40
1C	8-25	8.1	0.58	1.35	--	11.2	18.2	70.6	52
2C	25-41	8.2	0.49	0.90	--	12.3	17.2	70.5	72
P5 – Sandy-skeletal (calcareous), Typic Cryorthents									
A	0-26	8.2	0.03	0.16	3.25	5.0	13.8	81.2	36
1C	26-57	8.2	0.02	0.09	3.93	6.4	10.0	83.6	48
2C	57-100	8.2	0.02	0.13	3.58	7.2	12.4	80.4	62
P6 – Fine-loamy (calcareous), Typic Cryochrepts									
Ap	0-13	8.2	0.38	1.27	1.01	33.0	17.8	49.2	--
Bw1	13-38	8.2	0.43	0.70	0.67	19.8	37.8	42.2	--
Bw2	38-59	8.2	0.35	0.53	0.45	17.5	38.3	44.2	--
C	59-75	8.0	0.58	0.45	0.67	--	--	--	--
P7 – Loamy-skeletal (calcareous), Typic Cryorthents									
A	0-8	8.2	0.27	2.07	11.9	5.8	23.2	71.0	22
1C	8-25	8.3	0.32	1.46	11.7	9.5	33.6	56.9	44
2C	25-60	8.3	0.34	1.56	13.7	5.0	36.6	58.4	49
P8 – Coarse-loamy (calcareous), Mollic Cryofluvents									
Ap	0-17	7.6	0.05	0.95	3.03	7.5	27.0	65.5	4
1C	17-31	7.8	0.03	0.90	3.23	13.8	21.7	64.5	6
2C	31-47	7.7	0.04	0.51	2.53	6.8	36.8	56.4	8
3C	47-64	7.6	0.03	0.39	1.85	4.5	17.1	78.4	10
P9 – Coarse-loamy (calcareous), Fluventic Cryochrepts									
Ap	0-20	7.1	0.30	1.32	1.42	10.5	20.5	69.0	--
Bw1	20-37	7.2	0.27	1.02	1.42	12.0	24.5	63.5	--
Bw2	37-60	6.8	0.15	0.78	0.75	12.0	24.5	63.5	--
1C	60-91	6.8	0.11	0.96	0.68	12.0	24.5	63.5	--
2C	91-118	6.9	0.09	0.87	0.67	12.5	25.0	62.5	--
P10 – Typic Cryopsamments									
Ap	0-9	7.4	0.39	0.98	0.0	4.8	14.0	81.2	10
1C	9-28	7.5	0.22	0.64	0.0	4.5	15.2	80.3	12
2C	28-45	7.4	0.22	0.49	0.0	3.5	15.6	80.9	4
3C	45-105	7.6	0.19	0.41	0.0	4.5	8.9	88.5	8
P11 – Coarse-loamy, Typic Cryofluvents									
Ap	0-10	7.7	0.24	0.48	0.0	3.8	40.0	56.2	--
1C	10-32	8.3	0.39	0.33	0.0	12.8	24.8	62.4	--
2C	32-61	8.1	0.28	0.85	0.0	12.8	44.2	43.0	--
3C	61-86	8.0	0.48	1.22	0.0	12.1	40.2	47.7	---
4C	86-120	8.1	0.46	1.18	0.0	7.3	43.4	49.3	---
P12 – Coarse-loamy (calcareous), Typic Cryofluvents									
Ap	0-16	9.2	1.10	0.57	9.7	10.5	20.1	69.4	--
1C	16-34	8.5	1.00	0.33	9.7	11.4	22.1	66.5	---
2C	34-52	8.1	1.06	0.15	4.2	13.0	24.5	62.5	---
3C	52-70	8.1	1.04	0.06	7.2	16.1	18.6	65.3	--
4C	70+	8.0	1.02	0.15	8.9	10.2	16.8	73.0	--

* Mixed mineralogy is common to all soils

organic carbon (0.48 to 0.98 per cent). These soils are classified as Typic Cryosamments (P10) and Typic Cryofluvents. These soils are cultivated to rice, wheat, barley, vegetables, fodder and fruit crops. Slight to moderate erosion, coarse texture, poor fertility, occasional flooding due to overflow of rivers, and high permeability under irrigation are the main constraints due to which the agricultural use of these soils is restricted.

Terraces: These are found to occur in Leh valley of the Indus river. The soils (P12) of terraces are deep, somewhat excessively to excessively drained, light brown to brown, sandy loam, calcareous and occur on gentle to moderate slopes. They are strongly alkaline (pH 9.2), medium in organic carbon (0.57 per cent) and low in AWC. These soils are slightly to moderately eroded with slight to moderate surface stoniness and are classified as Typic Cryofluvents. Soils of these terraces are partly cultivated to wheat, barley and fodder crops and partly under grazing or lying as barren lands. Constraints such as sandy and gravelly texture, high content of CaCO₃, stoniness, erosion and non-availability of irrigation restrict the use of these soils.

Thus, the soils of Ladakh region are generally skeletal with A-C profile due to the effect of topography and frigid like aridic climate that restrict the chemical weathering. The soils are seldom subjected to leaching due to limited moisture supply (Sehgal *et al.* 1993). The profiles in valley and terraces at places exhibit the formation of weak structural horizons which appear to be the result of *in situ* weathering of primary minerals (Sehgal 1973). The lower parts of the sloping lands may be developed for tree plantation (*Rose macrophylla*, *Salix denticulata*; *Salix julacea*) and grasses. Soils of valley lands can be cultivated intensively, however, problems of coarse texture and gravelliness, erosion, stoniness, low fertility and droughtiness restrict their productivity. There is a need to develop a suitable technology for the management of such cold desert soils to make them productive.

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