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Resource characterization of foothill riverbed lands of north-western Himalayan region

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ABSTRACT : Conducive edaphoclimatic conditions are principal bases for the success of desired vegetation. However, in riverbed lands of north-western Himalayan region, the high gravel content (48.26% by volume) is the major constraint. The profile study indicated that there were high variability not only in soil : stone ratio but also in layers. Average workable top soil depth mixed with some gravels was less than even 24.45 cm. Among mechanical fractions, the silt and clay contents were very low and coarse sand alone was more than 50 percent, thereby the infiltration rate was very high (2.92 cm hr^{-1}) and water holding capacity was medium. The soil reaction was almost netural. Overall, fertility status of the soil was medium poor, particularly in lower horizons. The water table was shallow (2.5-3 m) during monsoon and deep during summer (6-7 m). Though, there was no definite pattern in genesis of riverbed land development but it was noticed that these lands are formed as a result of lateral migration or shifting course of torrents (seasonal river) and layered deposition of gravels/soils eroded from the adjoining hills. These torrents are originated from the hills and widen as they enter in the foothill plains. The heavy sediment load generated by the increasing erosive processes due to unscientific cultivation on the steep slopes, deforestation, open cast mining, uncontrolled grazing, construction of roads and houses on erosion prone sites etc. is carried out by the torrents and deposited in the valley lands, forming a large area unfit for crop cultivation. The area comes under humid subtropical climate receiving sufficient precipitation (1691 mm yr^{-1}). The maximum and minimum temperature ranges from 19 to 37°C and 3.6 to 24°C, respectively. The wind velocity was always observed below the erosive limit. Sunshine hour and solar radiation were moderate type. Evaporation was also not high. Overall weather is conducive to support variety of vegetation if site constratints are managed properly.

Key words : Gravel; Himalayan region; Riverbed; Torrent

Riverbed lands are very common along the torrents and in foot-hill areas of entire Hindukush Himalaya. Torrents cause the major land degradation problem. These lands are also known as gravelly in U.A., U.P., M.P., A.P., Maharashtra and Karnataka; bouldery in U.A., U.P., M.P. and Bihar; torrential in U.P., H.P. and J&K; riverine in U.P., M.P., Haryana and Rajasthan, *choe* bed in (Punjab and J&K), *Khala* bed in H.P.; *jhora* in Sikkim and West Bengal; *diara* in U.P. and Bihar; and *dongia* in Assam. So far no precise data is available on the area of riverbed lands in the country. As per estimate of National Commission on Agriculture (1976), 2.73 million has land is affected by torrents in India. However, Sharda and Patnaik (1995) reported that the area affected by the torrents in India is as high as 3.67 million ha. In Doon valley alone the area under torrent is about 35 percent, which is either lying vacant or occupied by uneconomical thin vegetal cover. Development of land under different situations and occurrence of parent material discontinuities or other disturbances are sometimes difficult to determine but the features can be more accurately characterized and distinguished from those due to pedogenesis (Sidhu *et al* 1998). At the same time, a sound knowledge of the kind, distribution and their characteristics is very essential for facilitating management techniques of any type of soil (Khan *et al* 1998). The initial study made by Bhardwaj and Singh (1981) described these soils under Bainkhala series having sandy skeletal typic ustifluvent taxonomy with gentle slope and rapid permeability. Patnaik (1985) analyzed the torrent bed material and developed a relationship between particle diameter and length, slope and width of torrent. The need of profile characterization for scientific utilization has also been earlier suggested in coal mining areas of Bihar, Aridosols in Chihsingshan mountain and Podzolic soils in Tamanshan mountain areas of northern Taiwan by Ghosh and Kundu (1991), Huang and Chen (1990) and Liu and Chen (1990), respectively. Therefore, before putting to a scientific landuse system, it is essential to know the intensive profile characteristics of these degraded riverbed lands and meteorological parameters prevailing in the locality.

MATERIALS AND METHODS

The investigation was carried out at Central Soil and Water Conservation Research and Training Institute, Research Farm, Selakui, Dehradun (Uttaranchal) during 1995-96. Geographically, the area is located at a latitude of 30°20' 4" N and longitude 72°52' 12" E and about 680 m above msl. The area was sparsely occupied by trees like *Dalbergia sissoo, Acacia catechu, Bombax ceiba, Albezzia lebbek, Leucaena*

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leucocephala etc. alongwith understorey vegetation like *Lantana camara, Zizyphus nummularia, Jasmine spp., Arundo donax* etc. In this study after removing the vegetation, 72 pits of 1 m^3 were dug out to expose the soil profile at an interval of 8 m apart to represent the large area. The profile study was conducted for all important characteristics. The infiltration rate and water holding capacity were also worked out. For determining gravelliness, 6 representative soil profiles were selected and gravels and boulders of different diameter (0.2-1.25, 1.25-2.50, 2.50-5.00, 5.00-7.50 and > 7.50 cm) and soil particles (< 0.2 cm) were sorted out through sieve analysis and weighed separately. The depth wise distribution of particles were also determined. For physico-chemical analysis, 54 profile samples were taken from three depths (0-30, 30-60 and 60-100 cm) and analyzed by standard methods (Jackson 1967). The meteorological parameters (rainfall, temperature, humidity, evaporation, wind velocity and sunshine hours) recorded at the Institute Observatory were used to analyse the month wise distribution of climatic parameters and long-term (1956-1995) behaviour of weather conditions in the locality.

RESULTS AND DISCUSSION

Mechanical compostion

The excavated materials from randomly selected six profiles (1 m^3) were classified into two major groups i.e. < 0.2 cm fractions (soil particles) and > 0.2 cm fractions (comprised of gravels, pebbles, boulders etc.). The particles > 0.2 cm diameter were further classified into different diameter classes i.e. 0.20 - 1.25, 1.25 - 2.50 , 2.50 - 5.0, 5.0 - 7.5 and > 7.5 cm. The results showed that riverbed land comprised of 48.36 per cent gravels by volume of different diameters and soil fractions (< 0.2 cm) was 51.7 per cent (Table 1). There was no definite pattern in the proportion of gravels of different diameter classes but it was found that the proportion of 2.50 - 5.00 cm diameter was maximum (12.6%) followed by > 7.5 cm (10.7%), 5.00 - 7.50 cm (8.7%), 1.25 - 2.50 cm (8.6%) and minimum of 0.20 - 1.25 cm (7.8%), though the differences among 0.20 - 1.25, 1.25 - 2.50 and 5.00 - 7.50 were non-significant.

There was not only variation in the proportion of different size of gravels but apparent variation was also observed in the gravelliness among different profiles. The results indicated that on weight basis soil : stone ratio of riverbed land was 31.3 : 68.7. The average top soil depth mixed with meagre of gravels was 24.45 cm which was formed as a result of layered deposition of lighter particles in the upper horizons. The depth of top soil determined the vegetal cover on the site, slope, velocity and runoff flow. The findings are in conformity with Puri and Gargya (1995) where they reported that in bouldery land of Doon valley, there was very little usable soil at the top while underneath it has gravels and boulders with coarse and fine sand filled in between the voids. The standard deviation (SD) and coefficient of variation (CV)for top soil depth were also high indicating the extent of variability of riverbed lands. Out of 72 profiles, there were 36 profiles having < 25 per cent soil, 29 profiles having 25-50 per cent soil, 3 profiles having 50-75 per cent soil, 4 profiles having no soils.

Particle size distrubution

There was no definite pattern of profile development but in general, a thin layer of top soil was found all over the area except in 4 profiles. In some profiles, either layer of soil or gravels/coarse sand were clearly distinguished whereas, in others, there was no clear-cut demarcation of different layers. In some cases, one or two thin layers of soil were also found in between them. In fact, formation of different layers comprised of either soil or gravels or both depending upon the type of deposition eroded from the adjoining hills in due coarse of time.

Table 1. *Graveliness of riverbed land.*

Particle size (cm)		Craveliness (% by volume)						Mean
		Profile-1	Profile-2	Profile-3	Profile-4	Profile-5	Profile-6	
A.	< 0.20	52.66	50.09	54.91	50.99	49.51	52.31	51.74
B.	i) 0.20-1.25	9.28	6.32	7.35	7.53	8.40	7.68	7.76
	ii) 1.25-2.50	7.20	9.90	9.36	8.46	7.94	8.57	8.57
	iii) 2.50-5.00	11.97	14.83	11.42	11.14	13.49	12.56	12.57
	iv) 5.00-7.50	8.36	9.31	8.37	8.15	8.96	8.84	8.67
	v) > 7.50	10.53	9.56	8.59	13.73	11.70	10.04	10.69
Total		47.34	49.91	45.9[illegible]	49.01	50.49	47.69	48.26
Total (A+B)		100.00	100.00	100.00	100.00	100.00	100.00	100.00
SEM+		-	-	-	-	-	-	0.616
CD (p=0.05)		-	-	-	-	-	-	1.796

Table 2. *Statistical summary of profile variation.*

Parameters	Values
Soil : stone ration (by weight)	31.34 : 68.66
Soil : stone ratio (by volume)	51.74 : 48.26
Average top soil depth (cm)	24.45
Number of pits having < 25% soil	36
Number of pits having 25-50% soil	29
Number of pits having 50-75% soil	3
Number of pits having > 75% soil	Nil
Number of pits without soil	4
SD ($\pm$) for top soil depth	13.79
CV (%) for top soil depth	54.46

Table 3. *Physico-chemical characterisitics of soil (< 2mm fraction).*

Parameter	Profile depth (cm)			Mean
A. *Mechanical Composition* (%)	0-30	30-60	60-100	
Coarse sand	32.08	51.60	51.73	51.73
Fine sand	35.72	28.20	16.28	26.73
Silt	18.40	9.40	3.40	10.40
Clay	13.80	10.80	8.80	11.13
B. *Chemical Characteristics*				
pH	6.9	7.2	7.4	7.2
O.C. (%)	0.80	0.57	0.21	0.52
Total N (%)	0.09	0.06	0.03	0.06
Available P_2O_5 (ppm)	11.34	11.47	10.54	11.13
Available K_2O (ppm)	94.92	43.43	20.42	52.92
Exchangeable Ca (%)	0.20	0.18	0.19	0.19
Exchangeable Mg (%)	0.17	0.15	0.11	0.14

The depthwise distribution of different particles is depicted in Fig. 1. It was found that the soil particles (< 0.2 cm) were more concentrated in 0-20 cm top horizons and decreased with increasing depth of soil. The high proportion of soil on upper horizons was more due to slow settling of lighter particles (< 2 mm) than those of sand or gravels. However, the trend was reverse with gravels and they increased with increasing depth of profiles. The larger particles (> 7.50 cm) were more concentrated in deeper depths (80-100 cm).

Physico-chemical properties

Better understanding of profile characteristics such as soil texture, permeability, water holding capacity, pH, organic matter content are very essential to determine the erodibility and utilization pattern of the land. In the present investigation, 54 soil samples (< 2 mm fraction) from three depths (0-30, 30-60 and 60-100 cm) were collected for mechanical and chemical analysis. Data presented in table 3 indicated that among mechanical fractions coarse sand alone was more than 50 per cent, while silt (10.4%) and clay (11.1%) content were very low. The fine sand found to the extent of 26.7 per cent was also more than double to either silt or clay. Overall soils were sandy loam in texture. The coarse sand content increased with increasing depth of soil though the differences between 30-60 cm and 60-100 cm were least. However, the fine sand, silt and clay content were decreased with increasing depth of profiles confirming the findings of Lal *et al* (1988). Moreover, due to high gravel content, the infiltration rate was very high (2.92 cm hr^{-1}) and water holding capacity was medium (33.4%).

The soil reaction was almost neutral (pH 7.2), though it was slightly acidic in upper horizons (0-30 cm). The content of almost all the major nutrients (N, P, K, Ca, Mg) decreased with increasing depth of soil. The similar trend with respect to fertility status was also reported by Khola and Saroj (1995) in another site of riverbed land. Moreover, the mean value of different nutrients revealed that the fertility status of the gravelly riverbed land was medium in surface layers which decreased with depth. Hence mixed type of vegetation is

Table 4. *Mean monthly meterological parameters at CSWCRTI, Research Farm, Selakui, Dehradun.*

Parameter	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Rainfall (mm)* 40 years (1956-95)	49.0	49.0	61.6	23.7	48.2	162.9	483.8	485.3	207.7	48.4	10.9	30.6
Max. Temperature (°C) 37 years (1959-95)	19.0	21.9	27.8	33.7	37.0	35.8	31.1	30.9	31.5	30.4	26.2	21.3
Min. Temperature (°C) 37 years (1959-95)	3.6	5.8	9.4	12.4	16.8	21.1	22.8	24.1	19.9	13.1	7.4	3.3
Wind velocity (km/hr) 39 years (1957-95)	1.3	1.7	2.6	2.3	2.5	2.6	2.0	1.4	1.1	0.9	0.9	1.2
Sunshine hours 34 years (1962-95)	7.2	7.5	8.1	9.2	9.9	7.8	5.3	5.1	7.3	9.3	8.7	7.2
Evaporation (mm) 34 years (1962-95)	1.4	2.2	3.7	6.2	8.3	6.7	3.4	2.7	3.1	2.8	1.9	1.3
Solar radiation (CAL cm^2) 18 years (1976-93)	274	348	433	516	533	470	372	349	408	411	433	260

* Average annual rainfall is 1691 mm.

suggested in such gravelly riverbed bouldery lands.

Meteorological parameters

The area comes under hill and mountain agro-ecosystem of north-western Himalayan rigion, popularly known as Doon Valley. The meteorological data (Table 4) indicated that the rainfall distribution was uneven, though, the average annual rainfall of the locality is quite sufficient (1691 mm) but out of total rainfall about 80 percent is received between June to September. Middle of April to middle of June are the dry months with high temperature (> 35°C) while December and January are the very cold months (< 5°C). Sunshine hours were maximum in hot summer (9.2 in April and 9.9 in May) while minimum in rainy season (July and August). Evaporation rate and solar radiation were directly proportional to temperature and thus high during summer and low during winter. The wind velocity was not severe and always less than erosive limit. Frost during winter and uncertain hailstorm are also limiting factors to agriculture.

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