

Infiltration Characteristics of Soils Under Different Soil Series of Jumar Nala Sub-watershed

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Abstract: Infiltration characteristics of Ultic Baleustalf, Ultic Paleustalf, Udic Haplastalf and Typic Haplaquent soils, falling under Nagri, Kokdro, Barhu and Bukru soil series, respectively of Jumar nala sub-watershed, Ranchi, were studied. The upland soil series, Nagri and Kokdro, exhibited higher infiltration rates (4.8 and 6.2 cm h⁻¹) as compared to that in Barhu (4.0 cm h⁻¹) and Bukru (2.8 cm h⁻¹) soil series representing midland and lowland topography, respectively. Cumulative infiltration also followed the similar trend among the series. Texture, bulk density and geometric mean diameter (GMD) of aggregates supported the above findings. The deviation between the observed and predicted values of cumulative infiltration was 0.824, 0.075, 0.865 and -0.639% in soil series Kokdro, Nagri, Barhu and Bukru, respectively.

Key words: Infiltration rate, cumulative infiltration, Ultic Baleustalf, Ultic Paleustalf, Udic Haplastalf, Typic Haplaquent, watershed.

The capacity of a soil to transmit water at a rate comparable to rainfall intensity is an important property that maintains adequate soil and water balance and erosion. Preparation of watershed management plan in relation to soil and water conservation, irrigation scheduling and management, drainage, solute movement and development of various hydrological models requires basic information on infiltration characteristics and physical properties of soil that influence this process (Singh and Bhargava, 1993; Mahendran and Mathan, 1994; Pagnish *et al.*, 1996). The major problems in the management of watershed in the plateau region of Jharkhand are soil and water conservation on undulating topography and torrential rains during the peak of rainy season (June to September). The present study was carried out to find the infiltration characteristics of important soil series of

Jumar nala sub-watershed, Ranchi, in relation to their physical properties.

Materials and Methods

Jumar nala sub-watershed (between N 23°25'20" and N 23°30'10", and E 85°18'20" and E85°20'15") is located in a typical plateau area, at an altitude 610 to 664 m above mean sea level. Climate is sub-humid subtropical, having mean annual rainfall of about 1400 mm with a well defined dry period from October to May. The mean maximum and minimum temperatures range from 22.3 to 40.9°C and 8.2 to 24.4°C, respectively.

Infiltration characteristics of four major soils (Haldar *et al.*, 1997), namely Nagri (Ultic Baleustalf), Kokdro (Ultic Paleustalf), Barhu (Udic Haplastalf) and Bukru (Typic Haplaquent), were studied at three locations

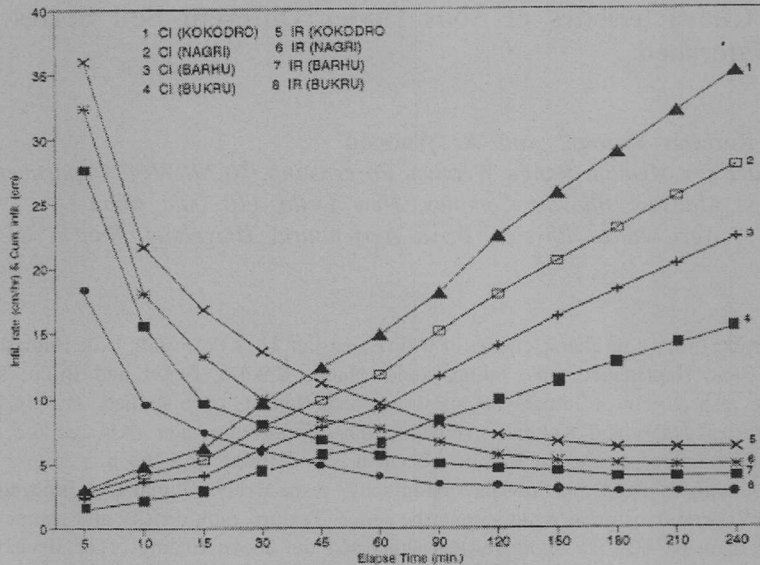


Fig. 1. Infiltration rate and cumulative infiltration of different soil series under *Jumar nala* sub-watershed.

in each series. The soils are lateritic, having mostly 'ochric' epipedon and Cambic and Argillic sub-surface. Three orders - Entisols, Inceptisols and Alfisols, shallow depth and 2 to 3% slope towards south, are the other characteristics.

The following methods were applied: *in situ* measurement of infiltration rate (IR) and cumulative infiltration (CI), using double ring infiltrometer with constant head device; organic carbon by Black's rapid titration method and mechanical analysis by Bouyoucos hydrometer method (Black, 1965); geometric mean diameter (GMD) on the basis of water-stable aggregates by wet sieving device (Yodder, 1936).⁸ The CI was predicted from the observed CI, using the empirical Kostikov's equations, modified by Michael (1978) as described below:

$$Y = a t^{\alpha}$$

$$Y = a t^{\alpha} + b \text{ when } t \neq 0$$

where,

Y is cumulative infiltration in time t, t is elapsed time and a, b and α are the characteristic constants.

Results and Discussion

The IR and CI values of different soil series (Table 1; Fig. 1) indicate that Kokdro and Nagri soil series on uplands have rapid (6.2 cm h^{-1}) and moderately rapid (4.8 cm h^{-1}) infiltration rates, respectively. Barhu soil series on midland topography exhibited moderate IR (4.0 cm h^{-1}), whereas lowland Bukru series exhibited very slow IR (2.8 cm h^{-1}). The curve for CI also gave similar trend. Higher content of sand 66.9%, in Kokdro and 58.7% in Nagri soil series and bulk density (1.62 Mg m^{-3} in Kokdro and 1.51 Mg m^{-3} in Nagri soil series) in coarse textured upland soils might be responsible for greater macroporosity and thus faster movement of water under saturated condition in the upland as compared to that in the

Table 1. Physico-chemical properties of soil series in Jumar nala sub-watershed

Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	Textural class	BD (Mg m ⁻³)	GMD	Organic carbon (%)	IR	CI	Initial moisture
Kokdro series (Ultic Baleustalf): Upland										
0-15	71.8	11.6	16.6	SL	1.66	0.555	0.40	6.2	35.1	9.42
15-30	65.5	12.4	22.1	SCL	1.62	0.612	0.33			
30-60	63.3	13.6	23.1	SCL	1.68	0.668	0.23			
Mean	66.9	12.5	20.6	SCL	1.62	0.612	0.32			
Nagri series (Ultic Paleustalf): Upland										
0-15	62.3	18.2	19.8	SL	1.56	0.582	0.41	4.8	27.8	10.50
15-30	58.5	18.8	22.7	SCL	1.50	0.642	0.32			
30-60	55.2	20.2	24.8	SCL	1.48	0.689	0.24			
Mean	58.7	19.1	22.4	SCL	1.51	0.638	0.33			
Barhu series (Udic Haplustalf): Midland										
0-15	52.2	21.5	26.3	SCL	1.48	0.738	0.55	4.0	22.2	11.00
15-30	49.0	24.3	26.7	SCL	1.45	0.773	0.45			
30-60	46.2	26.2	27.6	SCL	1.40	0.775	0.40			
Mean	49.1	24.0	26.9	SCL	1.44	0.762	0.47			
Bukru series (Udic Haplaquent): Lowland										
0-15	48.8	22.7	28.6	SCL	1.40	0.673	0.48	2.8	15.6	13.29
15-30	35.8	23.9	30.3	CL	1.35	0.677	0.42			
30-60	43.5	25.1	31.3	CL	1.32	0.716	0.36			
Mean	46.0	23.9	30.1	CL	1.36	0.689	0.42			

midland and lowland soil series. This is in agreement with findings of Mathan (1991), Prasad and Ali (1994) and Pagnish *et al.* (1996).

Upland soils were lower in organic carbon (around 0.33%) than the midland (0.47%) and lowland (0.42%) soils. The organic carbon content, together with finer soil particles, might have influenced the GMD of soil aggregates in all the series, giving rise to slightly higher value of GMD in midland (mean value 0.762 mm) soils. This might have influenced the IR in soil series. A positive correlation of organic carbon and water-stable aggregates with IR was reported by Lavit and Palival (1985) and Hirekurubar *et al.* (1993).

The CI values predicted with Kostiakov's equation were reasonably close to the observed values at 5 and 240 minutes of elapsed time. Equation for predicting the CI characteristics of various soil series are listed below:

$$\begin{aligned}
 \text{Kokdro} & : \text{CI} = 1.04 t^{0.64} + 0.29 \\
 \text{Nagri} & : \text{CI} = 0.91 t^{0.62} + 0.33 \\
 \text{Barhu} & : \text{CI} = 0.64 t^{0.64} + 0.59 \\
 \text{Bukru} & : \text{CI} = 0.47 t^{0.63} + 0.28
 \end{aligned}$$

A comparison of the observed and predicted CI values (Table 2) indicated mean deviation of 0.824, 0.075, 0.865 and -0.639% in Kokdro, Nagri, Barhu and Bukru soil series during the first five minutes

Table 2. Observed and predicted cumulative infiltration of different soil series in Jumar nala sub-watershed

Elap- sed time (min.)	Kokdro			Nagri			Barhu			Bukru		
	Obs. CI (cm)	Pred. CI (cm)	Devi- ation (%)	Obs. CI (cm)	Pred. CI (cm)	Devi- ation (%)	Obs. CI (cm)	Pred. CI (cm)	Devi- ation (%)	Obs. CI (cm)	Pred. CI (cm)	Devi- ation (%)
5	3.0	3.2	+6.667	2.7	2.8	+3.703	2.3	2.4	+4.348	1.5	1.6	+6.667
10	4.8	4.8	0	4.2	4.1	-2.381	3.6	3.4	-5.556	2.3	2.3	0
15	6.2	6.2	0	5.3	5.2	-1.887	4.1	4.2	+2.439	2.9	2.9	0
30	9.6	9.5	-1.042	7.8	7.8	0	6.1	6.2	+1.649	4.4	4.3	-2.273
45	12.4	12.2	-1.613	9.9	10.0	+1.010	7.8	7.9	+1.282	5.6	5.4	-3.571
60	14.8	14.6	-1.351	11.8	11.8	0	9.2	9.3	+1.087	6.6	6.5	-1.515
90	18.0	18.8	+4.444	15.1	15.1	0	11.7	12.0	+2.564	8.3	8.3	0
120	22.4	22.6	+0.893	17.9	18.0	+0.559	14.0	14.3	+2.143	9.9	9.9	0
150	25.7	26.0	+1.167	20.5	20.7	+0.976	16.2	16.4	+1.235	11.4	11.3	-0.877
180	28.9	29.1	+0.962	23.0	23.0	0	18.2	18.3	+0.549	12.8	12.7	-0.781
210	32.0	32.1	+0.313	25.4	25.5	0	20.2	20.2	0	14.2	13.9	-2.113
240	35.1	35.0	-0.286	27.8	27.5	-1.079	22.2	21.9	-1.351	15.6	15.1	-3.205
Av.			0.824			0.075			0.282			-0.639
'r' between obs. & cum. CI	0.999**			0.999**			0.999**			0.989**		

of infiltration, respectively. This may probably be due to relatively dry soil condition at the start of infiltration. Initial volumetric moisture content was 9.42% in Kokdro, 10.5% in Nagri, 11.0% in Barhu and 13.29% in Bukru. The movement of water through the air filled pores in the beginning is supposed to be responsible for a lower observed value than the predicted value of CI. Similar observations were also made by Sharma (1985).

Over time, the upland soil series (Kokdro and Nagri) had highest CI at all the observational intervals, than the midland (Barhu) and lowland (Bukru) soil series (Fig. 2), possibly due to the overall poor

physical condition of soil series on the upland than elsewhere. Poor physical condition of the upland soil series is also indicated by the value of bulk density, GMD (Table 1). However, aquic soil moisture regime might also have contributed to the gradual decrease in CI from upland to midland and lowland soil series.

Steady state infiltration and cumulative infiltration of upland sandy soils were double or even more than in clay soils, which suggest that infiltration characteristics of clay soils can be improved by mixing sandy soils and organic matter to improve macro-porosity and infiltration rates and to minimise the run-off loss.

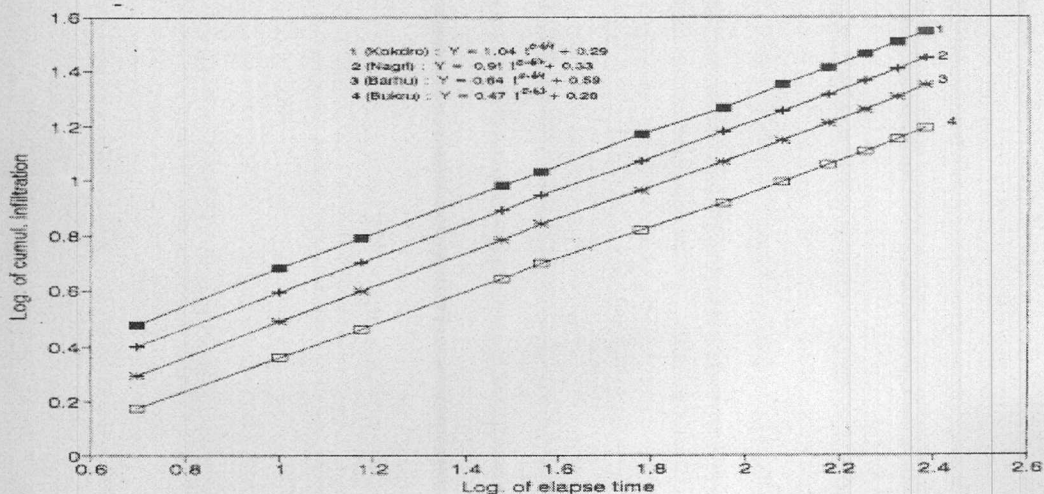


Fig. 2. Infiltration characteristics of various soil series under Jumar nala sub-watershed.

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