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RESEARCH ARTICLE

PHYSICO-CHEMICAL CHARACTERIZATION OF SOILS OF NAVANAGAR BLOCK OF BALLIA DISTRICT, UTTAR PRADESH

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ABSTRACT

The present investigation on charactirization of pedon was carried out to study the physico-chemical properties and nutrient status of soils from two representative pedons located in Gangkishor and Jamui villages of the Navanagar block in Ballia district, Uttar Pradesh. Soil samples were collected from surface to 15 cm intervals up to a vertical depth of 180 cm and analysed for soil pH (1:2.5), electrical conductivity (dSm^{-1}), bulk density ($Mg\ m^{-3}$), water holding capacity (%), organic carbon (%), available nitrogen ($kg\ ha^{-1}$), available phosphorus ($kg\ ha^{-1}$) and available sulphur ($mg\ kg^{-1}$). The results revealed that the soils were generally neutral to slightly alkaline in surface layers, becoming slightly acidic in deeper horizons, and were non-saline. Bulk density increased with depth, while organic carbon and nutrient status exhibited a decreasing trend down the profile. Available nitrogen was found to be low, whereas phosphorus and sulphur were in the medium to low range across both pedons.

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INTRODUCTION

Soil is the most important constituent to fulfilment of all the basic needs of human beings as well as organisms of earth. An eminent position in global cultivation of wheat, rice, jawar, pulse, sugarcane, vegetables and fruits etc., is occupied by Indian agriculture, and reason of physical, chemical condition of whatever land is indispensable for proper implementation of the other management practices. Thus, the physico- chemical study of soil is based on various parameters like- pH, EC, texture, temperature, moisture, soil organic matter, available nitrogen, phosphorous, and potassium. This knowledge will help to the people who are interested to work in agriculture field (Kekane *et al*. 2015). Soil is a dynamic natural resource that supports plant life by providing physical anchorage, water, and nutrients. A thorough characterization of soil's physico-chemical properties and nutrient status is essential for understanding its behaviour, classifying it taxonomically, and formulating sustainable land management practices (Sehgal, 2005). Soil profile is defined as the vertical section exposing a set of horizons in the wall of the pit dug 1m deep and about a meter wide. Soil profile descriptions are basic data in all soil surveys which provide major part of the information required for correlation and classification of the soils of an area and area essential for interpreting soils and for coordinating interpretations between soil survey areas. They also provide information for the evaluation of environmental and economic effects of proposed land uses through groupings or ratings of soils according to their limitations, suitability, and potentials for specified uses. (Ditzler *et al*. 2017). The fertility status of soil varies spatially and vertically depending on factors like parent material, climate, topography, and management practices. Ballia district, situated in the eastern part of Uttar Pradesh, is an agriculturally important region. However, systematic information on the detailed vertical distribution of soil properties and nutrients in specific blocks like Navanagar is often lacking. Therefore, a study was undertaken to characterize two representative soil profiles (pedons) from the Gangkishor and Jamui villages of the Navanagar block. The objective was to analyse the variations in key soil parameters with depth to assess the overall soil health and fertility status for informed agricultural decision-making.

MATERIALS AND METHODS

The study was conducted in the Navanagar block of Ballia district, Uttar Pradesh. Two representative soil profiles (pedons) were selected: one in Gangkishor village (Pedon-1) and one in Jamui village (Pedon-2). Pedons were excavated to a depth of 180 cm. Soil samples were collected from each horizon at 15 cm intervals (0-15, 15-30, 30- 165-180 cm). The samples were collected, air-dried, ground, and passed through a 2 mm sieve for subsequent laboratory analysis.

The soil samples were analyzed for the following parameters using standard analytical procedures. Soil pH determined by 1:2.5 soil-water suspension using a digital pH meter (Jackson, 1973) and EC determined by conductivity bridge and expressed as dSm^{-1} (Richards, 1954). BD measured by the core method and expressed as Mg m^{-3} (Blake and Hartge, 1986). WHC determined by the Keen box method. Organic carbon estimated by the Walkley and Black rapid titration method (Walkley and Black, 1934). Available N estimated by the alkaline potassium permanganate method (Subbiah and Asija, 1956). Available P extracted using 0.5 M $NaHCO_3$ (Olsen *et al.,* 1954). Available S extracted with 0.15% $CaCl_2$ solution and determined by the turbidimetric method (Chesnin and Yien, 1951).

RESULTS AND DISCUSSION

Soil pH (1:2.5): The soil pH value (table-1) of pedon-1 (Gangkishor) ranged from 6.28 to 7.34, while for pedon-2 (Jamui), it ranged from 6.07 to 7.74. In both pedons, the surface and subsurface layers (0-90 cm) exhibited neutral to slightly alkaline reactions. Below 90 cm, the pH decreased, indicating slightly acidic conditions. The decrease in soil pH with depth might be attributed to the leaching of basic cations from the surface to lower horizons or the presence of acidic parent material at depth (Gupta *et al.,* 2019).

Electrical conductivity (dSm^{-1}): The EC values for pedon-1 varied from 0.935 to 1.140 dSm^{-1}, and for pedon-2 from 0.848 to 0.996 dSm^{-1} (table-1). All recorded values were well below 1.5 dSm^{-1}, indicating that the soils are non-saline. The absence of soluble salt accumulation suggests no impediment to seed germination or plant growth due to salinity. The difference in EC at pedon-1 and pedon-2 may be ascribed to the lateral movement of water from the construction of earthen band on ground**.** The similar reports have been given by Mehta *et al.* (1996).

Bulk density (Mg m^{-3}): Bulk density has an indicator of soil compaction. In pedon-1, bulk density increased progressively from 1.36 Mg m^{-3} at the surface to 1.60 Mg m^{-3} at the deepest layer. Similarly, in pedon-2, bulk density increased from 1.48 Mg m^{-3} to 1.60 Mg m^{-3} with depth (table 1). The higher BD in the sub-surface layers (especially below 105 cm) might restrict root penetration and reduce water movement. In general soil bulk density was found to be lower in top soil than the lower depth. The increase in bulk density from upper to lower horizons of all pedon might be due to translocation of clay and other minerals and develop the compaction (Sharma *et al.* 2018).

Water holding capacity (%): The WHC of pedon-1 ranged from 30.32% to 36.31%, while for pedon-2, it ranged from 25.89% to 34.55% (table 1). There was great difference of water holding capacity in soils of both pedon Gangkishor and Jamui area of district Ballia. Water holding capacity decreased with increasing the horizon depth in the pedon 1 and 2. Due to variation in clay content and organic carbon concentration in the particular layer. Sharma *et al*. (2018) also reported the same pattern of water holding capacity.

Soil texture (%): The percentage of sand, silt and clay (table-1) varied from sand percentage 37.50 to 56.50%, silt percentage 10.50 to 14.50% and clay percentage 30 to 46%. However, in Pedon-2 result ranged from sand percentage 51.80 to 64.50% silt percentage 10.50 to 16.50% and clay percentage 23 to 33% for different soil depth. The textural class of these soils varied from loamy sand to silty loam (Pandey and Girish, 2007). The similar finding was given by Kar et al. (2017). Irrespective of the land use systems soil texture was finer in the sub-surface horizons than in the surface horizons and this might be due to the pedogenic process viz., clay accumulation and migration of sand and silt particles.

Organic carbon (%): Organic carbon content was low in both pedons and showed a distinct decreasing trend with depth (table-2). In pedon-1, OC decreased from 0.60% in the surface layer to 0.16% at 165-180 cm depth. In pedon-2, it decreased from 0.40% to 0.10% at the deepest layer. The maximum organic carbon was recorded in the uppermost soil layer and decreased with increasing of soil depth in both sites. Singh *et al*. (1981) and Shushma *et al*. (2023) also reported the same pattern of soil organic carbon. It might be due to low microbial activities, differences in organic carbon content of the soil and high rate of possible CO_2 evolution leads to low organic carbon.

Calcium carbonate (%): The maximum calcium carbonate content 1.55% at 0-15 cm soil depth and minimum calcium carbonate content 0.25% at 165-180 cm soil depth in pedon-1. In pedon-2 maximum calcium carbonate content 1.25% at 0-15 cm soil depth and minimum calcium carbonate content 0.32% at 165-180 cm soil depth. However, $CaCO_3$ content was found maximum in both the pedons which decreased with increasing soil depth. Marion *et al.* (1990) also reported the same pattern of calcium carbonate.

Available nitrogen (kg ha^{-1}): Available N status was low in both pedons, following the trend of organic carbon. In pedon-1, it ranged from 235.20 kg ha^{-1} at the surface to 104.62 kg ha^{-1} at depth. In pedon-2, it ranged from 219.52 kg ha^{-1} to 98.94 kg ha^{-1}. According to the ratings by Muhr *et al.* (1965), all values fall under the low category (<280 kg ha^{-1}). This might be due to the accumulation of natural vegetation, crop residues and organic materials at upper layer of soil and more microbial transformation due to moisture content. Verma *et al.* (2012) also reported the same pattern of available nitrogen. The available nitrogen in both the pedon's were in range medium to low. The similar result conferred with the finding Kumar *et al.* (2023).

Available phosphorus (kg ha^{-1}): Available P content also decreased with depth. In pedon-1, it varied from 14.81 to 7.26 kg ha^{-1}, and in pedon-2, from 13.76 to 5.71 kg ha^{-1} (table 2). The available phosphorous content follows a regular trend in both pedon. The content of higher available phosphorus in surface horizons might be due to supplementation of the depleted phosphorus through external sources and land use system i.e., fertilizers (Thangaswamy *et al*., 2005) and tillage opration also.

Available sulphur (mgkg^{-1}): The available sulphur content was low in both pedons. In pedon-1, it ranged from 10.35 mg kg^{-1} at the surface to 4.36 mg kg^{-1} at the bottom (table 2). In pedon-2, the range was 10.56 to 4.41 mg kg^{-1}. The higher amount of available sulphur was found in surface soil than in sub surface soil resulted from its recycling over the years by plant and subsequent organic matter accumulation (Bhatnagar et al. 2003). The similar finding was given by Trivedi *et al.* (1998).

Table 1. Status of soil pH, EC, BD and WHC of pedons soils at different depth

Soil Depth (cm)	Gangkishor (Pedon-1)							Jamui (Pedon-2)						
	pH (1:2.5)	EC (dSm^{-1})	BD (Mgm^{-3})	WHC (%)	Soil texture (%)			pH (1:2.5)	EC (dSm^{-1})	BD (Mgm^{-3})	WHC (%)	Soil texture (%)		
					Sand	Silt	Clay					Sand	Silt	Clay
0-15	7.34	0.935	1.36	32.07	56.50	13.50	30.00	7.51	0.996	1.48	34.26	60.80	15.20	24.00
15-30	7.29	0.941	1.40	31.26	53.50	14.50	32.00	7.74	0.848	1.52	34.55	62.60	14.40	23.00
30-45	7.01	1.018	1.40	30.32	53.60	12.40	34.00	7.67	0.896	1.52	32.58	63.50	12.50	24.00
45-60	7.31	1.140	1.40	30.82	53.50	10.50	36.00	7.57	0.975	1.54	31.21	64.50	10.50	25.00
60-75	7.19	1.132	1.44	35.41	50.50	13.50	36.00	7.66	0.996	1.52	29.68	60.70	12.30	27.00
75-90	7.33	1.020	1.48	36.07	50.50	12.50	37.00	7.61	0.981	1.56	29.69	60.60	13.40	26.00
90-105	6.71	0.983	1.52	36.31	48.60	12.40	39.00	7.21	0.941	1.56	30.28	58.50	14.50	27.00
105-120	6.86	0.991	1.52	36.08	43.60	14.40	42.00	6.78	0.956	1.60	30.20	55.60	14.40	30.00
120-135	6.49	1.021	1.52	36.27	45.50	13.50	41.00	6.12	0.942	1.60	29.68	53.70	16.30	30.00
135-150	6.71	0.987	1.56	34.99	43.50	14.50	42.00	6.07	0.906	1.60	27.41	55.50	15.50	29.00
150-165	6.67	0.981	1.58	32.03	41.50	14.50	44.00	6.26	0.964	1.56	26.88	52.50	16.50	31.00
165-180	6.28	0.970	1.60	31.39	37.50	16.50	46.00	6.23	0.986	1.60	25.89	51.80	15.20	33.00

Table 2. Status of Organic Carbon and available nitrogen, phosphorus and sulphur in pedons soils at different depth

Soil Depth (cm)	Gangkishor (Pedon-1)					Jamui (Pedon-2)				
	O C (%)	$CaCO_3$ (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available S (mg kg^{-1})	OC (%)	$CaCO_3$ (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available S (mg kg^{-1})
0-15	0.60	1.55	235.20	14.81	10.35	0.40	1.25	219.52	13.76	10.56
15-30	0.57	1.42	225.79	14.05	10.04	0.38	1.20	197.29	13.31	09.96
45-60	0.48	1.25	203.84	12.11	08.30	0.33	1.12	131.71	12.95	08.68
60-75	0.51	1.25	210.11	11.33	07.33	0.30	1.0	109.76	11.17	08.37
75-90	0.45	0.75	188.16	10.31	07.14	0.28	0.87	109.76	10.53	07.67
90-105	0.30	0.90	166.20	9.43	06.51	0.25	0.75	106.62	09.46	06.63
105-120	0.28	0.80	141.12	8.62	05.87	0.22	0.77	100.35	08.37	05.53
120-135	0.24	0.50	125.44	8.46	05.34	0.18	0.80	100.35	07.71	05.61
135-150	0.22	0.35	121.57	8.73	04.97	0.16	0.75	103.48	06.62	04.76
150-165	0.18	0.27	110.71	7.98	04.12	0.14	0.50	100.35	05.85	04.10
165-180	0.16	0.25	104.62	7.26	04.36	0.10	0.32	98.94	05.71	04.41

CONCLUSION

The soils exhibited neutral to slightly alkaline reaction in the surface and subsurface layers (0-90 cm), while becoming slightly acidic in the deeper horizons (below 90 cm). The electrical conductivity values were well within the safe limit, indicating the absence of any salinity hazard. Bulk density showed a progressive increase with soil depth, ranging from 1.36 to 1.60 Mg m^{-3} in Pedon-1 and 1.48 to 1.60 Mg m^{-3} in Pedon-2. This increase in bulk density corresponded with a decrease in water holding capacity in the subsurface layers, suggesting the presence of compacted zones that may impede root growth and water movement. Organic carbon content was low across both profiles, ranging from 0.60 to 0.16% in Pedon-1 and 0.40 to 0.10% in Pedon-2. Available nitrogen was uniformly low throughout both pedons, while available phosphorus was medium in surface layers but decreased to low levels in subsurface horizons. Available sulphur content was near the critical limit in surface layers but fell below the deficiency threshold in deeper layers.

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