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Depth-wise distribution of chemical properties of the soils from different sites of the Northern Hill Zone of C.G.

Sushma, Alok Tiwari, Neha Gawde, Rakesh Paul and Ipsita Pattanaik

Abstract
The current study, entitled "Vertical distribution of soil properties and diversity in permanent bench mark sites of the Northern Hill Zone of C.G.," was conducted in the year 2020-21 to assess the depth-wise distribution of physical properties of soils in different Permanent Benchmark Sites (PBMS). Analysis of soil pH, Electrical conductivity, Cation exchange capacity and Organic carbon revealed that all the chemical properties were increased with increasing soil depths in each series. The data on pH and EC followed the increasing trends with a decrease in depth along the series. The pH of soils in various series of *Inceptisols* ranged from slightly acidic to slightly alkaline, with the exception of the Jordo, Mahuli, and Kedali series, which ranged from slightly acidic to neutral. The pH of the series of *Alfisols* and *Entisols* ranged from moderately acidic to neutral. Whereas the value of EC has a normal range. The organic carbon content of the soil was higher at the surface than at deeper layers. The highest CEC value (25.6 $Cmol_c\ kg^{-1}$) was found in the Jordol series of *Inceptisols* and *Alfisols.* The lower CEC value of 9.3 $Cmol_c\ kg^{-1}$ was recorded in the Jordol.

Keywords: pH, EC, CEC, *Alfisols, Inceptisols and Entisols*

Introduction

Chhattisgarh is located in between 17° 46′ north to 24° 5′ north latitude and from 80° 15′ east to 84° 20′ east longitude in the central part of India and has a total area of 13.51 Mha and referred as the "rice bowl of India", where hundreds of varieties of rice are grown. Raipur is located near the centre of a large plain. There are 3 geographical zones *viz.* northern hills, central plains and Bastar plateau. The climate in general is different in these three zones. Northern hills area of this agroclimatic zone accounts for 21% of the total geographical area and extended in Koriya, Sarguja, Surajpur, Bal Rampur Jashpur, Raigarh and Korba of state. Chhattisgarh state has four major soils orders *i.e. Entisol, Inceptisol, Alfisol* and *Vertisol*

Vertical distribution of chemical properties in different horizons of soil profiles influence the inherent capacity of soil to supply nutrients to plants. Soils are characterized by a high degree of spatial variability due to the integrated effect of physical, chemical or biological processes, which operate with different intensities and at different scales (Goovaerts, 1998) [16]. The occurrence of the five soil forming factors: climate, organisms, relief, parent material, and time, results in variation in soil qualities (Jenny, 1961) [14]. Topography is the easiest of the five factors to analyse. Changes in the field topography influence the distribution of soil properties and crop productivity across the field. However, soil properties also vary largely through depth due to active soil-forming processes of eluviation-illuvation down the soil profile.

The vertical distribution of soils shows some variations due to duration and extent of weathering, geomorphic conditions and nature of parent rocks. It also varies from place to place. There is also some minute vertical variation within the section of a soil mass (Balasubramanian, 2017) [1].

Material and Methods

The soil samples were collected at eight soil series representative PBMS from the Northern Hill Zone of the C.G., and soil samples were collected from *Entisols, Inceptisols* and *Alfisols* from various PBMS at different depths (0-15, 15-30, 30-45, 45-60, 60-75 cm) from each of those places. All those soil samples were collected in groups of three at each soil series. A core sampler was used to collect soil samples. The total number of soil samples was 120.

pH and EC where determined by the method followed by Jackson (1973) [13]. Organic carbon content of the soil samples was estimated by wet digestion method as outlined by Walkley and Black (Jackson 1973) [13]. Cation exchange capacity of soil samples was determined by saturating a known weight of soil sample with 1 N sodium acetate (pH: 8.2) and the excess sodium acetate was washed out using 95 per cent ethanol.

Results and Discussions

Soil reaction

Chemical properties of the soil profiles are represented in Table 1.1. The pH values ranged from of 6.1–6.5 in Jordol soil series, 5.4-5.8 in Jordo soil series, 5.7-7.4 in Mahuli soil series, 5.3-7.4 in Kedali soil series, 5.0-6.9 in Pratappur soil series, 5.2-6.4 in Mayapur soil series, 5.1-6.1in Rampur soil series and 5.7-6.8 in Bogra soil series, of *Inceptisols* respectively. The pH values ranged from of 5.1-5.9 in Jordol soil series, 4.2–5.8, in Jordo soil series, 5.1–5.3in Mahuli soil series, 6.1–7.7in Kedali soil series, 6.5-7.6 in Pratappur soil series, 5.6–6.9, in Mayapur soil series, 5.9–7.4 in Rampur soil series and 6.3–7.4 in Bogra soil series, of *Alfisols* respectively. The pH values ranged from of 5.2-5.6 in Jordol soil series, 4.2-5.8 in Jordo soil series, 5.1-6.4 in Mahuli soil series, 4.7-6.3 in Kedali soil series, 4.8-6.1 in Pratappur soil series, 4.8-6.8 in Mayapur soil series, 4.5-5.2 in Rampur soil series and 4.4-5.9 in Bogra soil series, of *Entisols* soils respectively.

Similar findings were observed by Rajeswar *et al.* (2009). The increased pH with increasing depths of soil profiles was described to the deposition of exchangeable cations at lower depths of soil profiles due to heavy rainfall in the region during the rainy season (Balpande *et al*. 2007) [4].

Soil pH was found to increase with increasing depth. Similar results were given by Nagendran and Angayarkanni (2010) in the soils of Cumbum Valley also reported by Dadhwal (2009) [5], Tamil Nadu. Naik (2014) reported that pH gradually increased with increasing depth of the soil profile in mango-growing soils in Jharkhand. Mishra *et al*. (2015) [22] discovered that pH increases with decreasing height in the soils of the mid-Central Valley at Odisha zone in their studies. Khanday *et al*. (2017) [15] reported that the pH generally increased with increasing depth. The increase in pH with depth had been attributed to the leaching of bases and the decrease in organic matter accumulation with the extent of slope. According to Singh *et al*. (2017), the reason for the varying acidity may be due to increased precipitation, which results in base leaching losses from surface soils.

In addition, the soil acidity was increased by the addition of nitrogenous fertilizers and the decomposition of organic residues. Patangray *et al*. (2018) [23] also reported that pH showed a general trend of increasing down the profile in the soils of Yavatmal district, Maharashtra. Wani *et al.* (2017) [28] studied the soils of 36 spatially different pedons and reported that soil pH varied from slightly acidic to slightly alkaline, while soil pH increased significantly with soil depth. The *Alfisols* and *Entisols* of the Jordol Series, on the other hand, were slightly acidic to strongly acidic in all depths. Bhat (2010) [7] all reported similar findings.

Electrical conductivity

The soil Electrical conductivity increased with an increase in depth in all the soil series located in different areas of the Northern Hill Zone of the C.G. The EC ranged of the Jordol soil series of their *Inceptisols*, *Alfisols*, and *Entisols* varies with 0.15 to 0.21, 0.09 to 0.19 and 0.05 to 0.18 dSm^{-1}, as shown in Table 1.1. The EC of the Jordo soil series' *Inceptisols*, *Alfisols*, and *Entisols* ranges from 0.15 to 0.20, 0.07 to 0.16 and 0.05 to 0.16 dSm^{-1}, respectively. The EC of the Mahuli soil series of *Inceptisols*, *Alfisols* and *Entisols* varies with a statistical range ranging from 0.07 to 0.15, 0.06 to 0.21 and 0.08 to 0.21 dSm^{-1}. The EC of the Bogra soil series *Inceptisols*, *Alfisols* and *Entisols* ranges from 0.09 to 0.13, 0.07 to 0.15, and 0.08 to 0.19 dSm^{-1}, respectively.

The EC of the Pratappur soil series of *Inceptisols*, *Alfisols* and *Entisols* varies in different statistical ranges from 0.06 to 0.18, 0.07 to 0.16 and 0.05 to 0.14 dSm^{-1}. The EC of the Mayapur soil series of *Inceptisols*, *Alfisols* and *Entisols* varies within a statistical range of 0.03 to 0.07, 0.13 to 0.19 and 0.06 to 0.15 dSm^{-1}. The EC of the Rampur soil series of *Inceptisols*, *Alfisols* and *Entisols* varies statistically between 0.09 and 0.16 dSm^{-1}. The EC of the Kedali soil series of *Inceptisols*, *Alfisols* and *Entisols* varies with a statistical range ranging from 0.11 to 0.19, 0.10 to 0.19 and 0.02 to 0.09 dSm^{-1}. The EC value in all soil series ranged from increasing with depth to a low range with a neutral value.

The EC of all soil series varied from higher to lower values with depth. It was found to be within the normal range of EC in all soil series and all orders. The EC of all the pedons is much less than 1 dSm^{-1}, indicating no salinity hazards. EC values in the study area are in safe limits. EC increased with profile depth of profile, this might be due to the leaching of saline from the soil surface through profile depth because of the irrigation on the land (Durak *et al*. 2010) [6].

Cation exchange capacity

The data on cation exchange capacity (CEC) in all soil series and depths of 0-15, 15-30, 30-45, 45-60, and 60-75 cm in all three soils are tabulated in Table 1.1. The cation exchange capacity of the Jordol, jordo, Mahuli, Bogra, Pratappur, Mayapur, Rampur and Kedali series in *Inceptisols* was low and high ranging from 15.0–25.6, 11.6-20.5, 15.2-22.2, 9.6–19.5, 18.1–11.3, 19.4–13.9, 19.5–14.6 and 19.5–26.4 Cmol (p^+) kg^{-1}. Cation exchange capacities in *Alfisols* of all soil series ranged from 20.6-25.6, 16.6-18.2, 19.4-22.2, 9.6-19.5, 11.2-17.6, 12.5-16.2, 12.5-15.2 and 15.4-18.6 Cmol (p+) kg^{-1}.whereas, in *Entisols* of all soil series the cation exchange capacity were 9.3–18.2, 11.6–18.5, 14.9–24.5, 10.6–12.6, 16.9–18.4, 15.6-21.5, 17.5-21.3 and 12.–16.5 Cmol (p^+) kg^{-1}.

Cation exchange capacity showed increasing trends with depth within the all soil series in all three soils. Except for the Jordo series *Entisols* the Mahuli series *Alfisols* and Higher CEC and organic carbon recorded at the surface show the strong association between organic carbon and CEC (Chintala *et al*. 2013a) [11]. However, the lower CEC recorded at the subsoils could be due to the decrease in organic carbon and clay colloids to hold cations against leaching (Idoga & Azagaku 2005, Chintala *et al.* 2013a) [12, 11] From the surfaces.

Organic carbon

The data arranged in Table 1.1. Reveal that organic carbon values decreased with increasing depth in all soil series and in all the depths of 0–15, 15–30, 30-45, 45–60 and 60–75 cm in all three soil orders. Organic carbon in *Inceptisols* ranged from 0.29 to 0.74, 0.26-0.47, 0.36-0.64, 0.23-0.68, 0.30-0.61, 0.15-0.38, 0.26-0.36 and 0.19 to 0.32 for the Jordol, Jordo, Mahuli, Bogra, Pratappur, Mayapur, Rampur, and Kedali series.

Organic carbon range was found in a medium-to-low range with depth in the Jordol series, and lower organic carbon range was found in all depths in the other *Inceptisols* series. While in *Alfisols* of all soil series the organic carbon ranges were 0.59–0.77, 0.51-0.75, 0.11-0.86, 0.75-0.91, 0.36-0.90, 0.26-0.86, 0.71-0.93 and 0.38–0.56%. Medium-to-low ranges of organic carbon were found with depth in the Jordol, Jordo, and Kedali soil series of *Alfisols*. In Bogra, Mahuli, Mayapur, Rampur and Pratappur, the series showed a higher to medium range of organic carbon. In contrast, the organic carbon content of *Entisols* from all soil series was 0.11-0.15, 0.09-0.15, 0.20-0.30, 0.11-0.14, 0.11- 0.20, 0.11-0.21, 0.10-0.35 and 0.11-0.20%. Soil carbon content was lower at low and higher at high altitudes in all *Entisols* soil series, with a decreasing trend with increasing soil depth within the depth.

The lowest organic carbon was recorded in uncultivated soils and the highest in forest soils. This is because continuous cultivation increases the aeration of soil which enhances the decomposition of organic matter, leading to low organic content in cultivated soils. The decrease in organic carbon with depth was observed in all land-use systems. In forest soils that could be ascribed to the slower rate of decomposition of organic matter owing to lower temperatures at high altitudes which leads to accumulation of organic matter. (Chauhan *et al*. 2011, Celik 2005) [10, 9].

Organic carbon followed decreasing trend with depth in all five profiles. Low to medium organic carbon content was observed at the surface layer of the profiles. Organic matter acts as a major factor regulating the availability of organic forms of N, P, S and trace elements in the soils, as well as to improve soil structure, infiltration rate, nutrient retention and to reduce soil erosion (Smith and Elliott, 1990) [27]. Sankar and Dadhwal (2009) [5] observed decreasing trend of soil organic carbon with increasing depth in all pedons of red soils of Tamil Nadu. Observed that the organic carbon content was low and decreased with depth in pedons of all soils of Cumbum valley, Tamil Nadu.

Table 1: Chemical characteristics of different PBMS in Northern Hill Zone of C.G.

PBMS	**Soil order**	**Depth**	**Ph**	**EC**	**CEC**	**OC**
			(1:2.5)	**(dSm^{-1})**	**Cmol (p^{+}) kg^{-1}**	**(%)**
1. Jordol	*Inceptisols*	0-15	6.1	0.15	15.0	0.74
Series		15-30	6.9	0.18	19.2	0.62
		30-45	7.3	0.19	21.6	0.62
		45-60	7.6	0.19	22.1	0.41
		60-75	7.8	0.21	25.6	0.29
	Alfisols	0-15	5.9	0.09	20.6	0.77
		15-30	5.6	0.10	22.1	0.63
		30-45	5.3	0.12	23.6	0.62
		45-60	5.2	0.15	25.6	0.47
		60-75	5.1	0.19	25.6	0.59
	Entisols	0-15	5.2	0.05	9.3	0.15
		15-30	5.5	0.07	10.2	0.20
		30-45	5.5	0.09	12.2	0.11
		45-60	5.5	0.15	15.6	0.12
		60-75	5.6	0.18	18.2	0.11
2. Jordo	*Inceptisols*	0-15	5.4	0.15	11.6	0.47
Series		15-30	5.5	0.15	14.5	0.35
		30-45	5.7	0.17	16.2	0.30
		45-60	5.8	0.18	18.2	0.21
		60-75	5.8	0.20	20.5	0.26
	Alfisols	0-15	5.8	0.07	16.6	0.75
		15-30	5.8	0.09	17.5	0.71
		30-45	5.2	0.12	17.9	0.53
		45-60	5.0	0.14	16.2	0.57
		60-75	4.2	0.16	18.2	0.51
	Entisols	0-15	4.9	0.05	18.5	0.15
		15-30	5.5	0.07	17.2	0.12
		30-45	5.6	0.09	16.5	0.12
		45-60	5.8	0.11	14.2	0.11
		60-75	5.9	0.16	11.6	0.09
3. Mahuli	*Inceptisols*	0-15	6.9	0.07	15.2	0.64
Series		15-30	5.9	0.08	16.4	0.81
PBMS	Soil order	Depth	pH	EC	CEC	OC
			(1:2.5)	(dSm^{-1})	Cmol (p^{+}) kg^{-1}	(%)
		30-45	5.2	0.08	19.6	0.65
		45-60	5.1	0.12	20.4	0.54
		60-75	4.9	0.15	22.2	0.36
	Alfisols	0-15	5.3	0.06	16.4	0.86
		15-30	5.4	0.09	15.4	0.81
		30-45	5.5	0.15	16.9	0.59
		45-60	5.2	0.19	18.5	0.36

		60-75	5.1	0.21	19.4	0.11
	Entisols	0-15	5.1	0.08	24.5	0.30
		15-30	5.5	0.10	20.4	0.27
		30-45	5.9	0.14	19.5	0.32
		45-60	6.1	0.18	15.8	0.20
		60-75	6.4	0.21	14.9	0.20
4. Bogra	*Inceptisols*	0-15	5.3	0.09	9.6	0.68
Series		15-30	5.9	0.10	10.6	0.60
		30-45	6.1	0.11	11.5	0.47
		45-60	6.3	0.11	13.9	0.41
		60-75	6.2	0.13	19.5	0.23
	Alfisols	0-15	6.1	0.07	11.4	0.91
		15-30	6.6	0.07	12.6	0.88
		30-45	6.9	0.10	13.5	0.81
		45-60	7.3	0.11	15.5	0.77
		60-75	7.7	0.15	17.6	0.75
	Entisols	0-15	4.7	0.08	12.6	0.14
		15-30	5.4	0.09	12.0	0.12
		30-45	5.8	0.11	11.9	0.09
		45-60	5.9	0.16	11.2	0.09
		60-75	6.3	0.19	10.6	0.11
5. Pratappur	*Inceptisols*	0-15	5.0	0.06	18.1	0.61
Series		15-30	5.5	0.09	14.2	0.58
		30-45	5.9	0.10	13.5	0.51
		45-60	6.1	0.16	12.4	0.42
		60-75	6.3	0.18	11.3	0.30
	Alfisols	0-15	6.5	0.07	17.6	0.90
PBMS	Soil order	Depth	pH	EC	CEC	OC
			(1:2.5)	(dSm^{-1})	Cmol (p^+) kg^{-1}	(%)
		15-30	6.6	0.08	15.6	0.86
		30-45	6.9	0.10	15.4	0.63
		45-60	7.2	0.11	11.2	0.38
		60-75	7.6	0.16	11.2	0.36
	Entisols	0-15	4.8	0.05	16.9	0.20
		15-30	4.9	0.06	16.8	0.18
		30-45	5.4	0.09	15.4	0.15
		45-60	5.9	0.11	13.5	0.13
		60-75	6.1	0.14	18.4	0.11
6. Mayapur	*Inceptisols*	0-15	5.2	0.03	19.4	0.38
Series		15-30	5.5	0.05	18.4	0.32
		30-45	6.1	0.06	17.5	0.30
		45-60	6.1	0.07	15.4	0.21
		60-75	6.4	0.07	13.4	0.15
	Alfisols	0-15	5.6	0.13	16.2	0.86
		15-30	5.9	0.12	15.2	0.75
		30-45	6.1	0.16	14.6	0.66
		45-60	6.5	0.16	13.5	0.62
		60-75	6.9	0.19	12.5	0.26
	Entisols	0-15	4.8	0.06	21.5	0.21
		15-30	5.1	0.08	20.5	0.18
		30-45	5.8	0.09	19.4	0.15
		45-60	6.1	0.11	18.4	0.06
		60-75	6.8	0.15	15.6	0.11
7. Rampur	*Inceptisols*	0-15	5.1	0.09	19.5	0.36
Series		15-30	5.6	0.10	17.4	0.32
		30-45	5.9	0.12	16.4	0.30
		45-60	6.0	0.14	15.1	0.17
		60-75	6.1	0.16	14.6	0.26
	Alfisols	0-15	6.3	0.09	12.5	0.93
		15-30	6.5	0.11	12.9	0.90
		30-45	6.6	0.12	13.6	0.78
		45-60	6.9	0.16	14.3	0.75
		60-75	7.4	0.16	15.2	0.71
PBMS	Soil order	Depth	pH	EC	CEC	OC
			(1:2.5)	(dSm^{-1})	Cmol (p^+) kg^{-1}	(%)
	Entisols	0-15	4.5	0.07	21.3	0.35
		15-30	4.9	0.08	20.6	0.20

		30-45	4.9	0.08	19.4	0.18
		45-60	5.5	0.08	18.6	0.15
		60-75	5.2	0.10	17.5	0.10
8. Kedali	*Inceptisols*	0-15	5.7	0.11	19.5	0.3
Series		15-30	5.8	0.14	19.4	0.2
		30-45	6.4	0.16	21.6	0.2
		45-60	6.4	0.16	21.5	0.2
		60-75	6.8	0.19	26.4	0.1
	Alfisols	0-15	6.3	0.10	18.6	0.56
		15-30	6.5	0.11	18.9	0.45
		30-45	6.8	0.15	17.6	0.45
		45-60	6.8	0.16	16.8	0.42
		60-75	7.4	0.19	15.4	0.38
	Entisols	0-15	4.4	0.02	16.5	0.20
		15-30	4.6	0.04	15.2	0.18
		30-45	4.9	0.06	14.5	0.14
		45-60	5.2	0.08	13.4	0.11
		60-75	5.9	0.09	12.2	0.21

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