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Spatial Variability in Physico-Chemical Properties of Soils in Permanent Bench Mark Sites of Jabalpur in AESR-10.1 under Rice-wheat Cropping System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study aimed to found the spatial and vertical variability in physico-chemical properties of soils for regulating the nutrient availability under Rice-Wheat cropping system in permanent bench mark sites (PBMS) of Jabalpur in AESR-10.1 region. Rice wheat cropping system is dominant cropping system in AESR-10.1 Jabalpur region in Madhya Pradesh, India. pH, electrical conductivity (EC), cation exchange capacity (CEC), organic carbon (OC) and calcium carbonate ($CaCO_3$) have an justify role in the nutrient availability. pH affects nutrient availability by changing the nutrient form. Split plot design used to evaluate the vertical and spatial effect on site of Jabalpur district. Collected

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45 soil samples to examine the physico-chemical properties and results were interpreted. Three locations treated as main plot and five depths used as sub treatment for analysis the soils. pH, and EC vary with sites and depth but statistically not significant. Magarmuha soils has lowest OC and CEC values while soils of Khamaria showed significantly higher values of OC and CEC than Udna and Magarmuha. Soils of Udna were rich in $CaCO_3$ it was significantly higher than other sites. Across the depth it increases gradually. OC and $CaCO_3$ showed interaction effect of sites and depths. Nutrient availability governed by physico-chemical properties of soils. Rice wheat cropping system is dominant cropping system in AESR-10.1 Jabalpur region in Madhya Pradesh, India. Management of Soils in these areas were necessary for full potentially use of nutrient balance of these PBMS sites.

Keywords: Spatial variability; physico-chemical properties; AESR-10.1; rice-wheat cropping system; PBMS.

1. INTRODUCTION

Depending upon the soil, bioclimatic type and physiographic situations, the country has been grouped into 20 agro-eco regions (AER) and 60 agro-eco sub regions (AESR). Each agro- eco subregion has further been classified into agroeco unit at district level for developing long term land use strategies the study area comes into AESR 10.1 (Gajbhiye & Mandal, 2000). Madhya Pradesh has numerous agro-ecological systems, with diversity in crops and cropping systems, climate, agronomic and resource management inputs and socio-economic aspects. The profitable production of agronomic crops is nearly impossible without healthy soil. The reason for this is that all of the trademarks of a healthy soil viz. good soil organic matter levels, good water holding and infiltration capacity, earthworms and soil fauna, nutrient levels, and a proper pH level, which play into conditions that optimize crop production (Dar et al., 2017; Saha et al., 2000). Therefore, soil organic carbon concentrations reflect soil and ecosystem processes as well as past management practices for both agricultural and non-agricultural soils. Soil properties are interdependent and directly influence by key indicator of soil health which govern the availability of water and nutrients to plants and regulate crop growth and productivity (Collins et al., 2000). In view of these facts present study was undertaken to vertically characterize the physical properties of soils under rice-wheat cropping system in three permanent benchmark sites (PBMS) of Jabalpur district, Madhya Pradesh in India.

2. MATERIALS AND METHODS

The soils of PBMS of Jabalpur are medium black belonging to Kheri series of fine montmorillonitic hyperthermic family of Typic *Haplustert.* In the study total 45 undisturbed soil samples were collected from selected sites across three PBMS of Jabalpur district at 0-20, 20-40, 40-60, 60-80 and 80-100 cm depths procedures dried, processed and analysed for various physical and chemical properties by using standard analytical and the data thus obtained were analysed in split plot design taking sites as main plot and depth as sub-plot treatments. Following physico-chemical properties were analyzed by methods adopting respectively for study the soils in permanent bench mark sites of Jabalpur in AESR-10.1 under rice-wheat cropping system.

a) Soil pH: Piper (Piper, 1950)
b) Electrical Conductivity: Piper1950
c) CEC: Jackson, (Jackson, 1973)
d) Organic carbon: Walkley and Black (Walkley & Black, 1934)
e) CaCO3: Rapid titration method by Jackson 1973

3. RESULTS AND DISCUSSION

3.1 pH

Data pertains to effect of spatial and vertical variability on pH of soil has been given in Table.1. Data clearly indicated that spatial and vertical variation on pH of soils after rice –wheat cropping pattern was non- significant. Soils of Udna (7.60) have lowest and soils of Khamaria (7.72) have highest value of soil pH. it is evident from data Table 1 that soils of Khamaria were highly significant over soils of Udna and Khamaria, ph of soils of Udna and Khamaria were statistically at par. Further It is also evident from the data (Table 2) that soils pH at 0-20, 20-40, 40-60, 60-80 and 80-100 cm soil depths varied from 7.53 to 7.77. The results showed that soil pH was lowest under D_1 (0-20 cm) followed by D_2 (20-40 cm) and highest D_5 (80-100 cm)

Table 1. Effect of sites and soil depth on changes in pH, Electrical conductivity and cation exchange capacity of soils at permanent bench mark sites of Jabalpur districts

Main Plot (Benchmark sites)	pH	Electrical Conductivity (dSm^{-1})	Cation Exchange Capacity [Cmol (p^+) kg^{-1}]
S_1:Udna	7.60	0.13	54.03
S_2:Magarmuha	7.62	0.15	42.67
S_3:Khamaria	7.72	0.13	55.07
SEm±	**0.029**	**0.005**	**0.334**
CD(*p=0.05*)	**0.086**	**0.014**	**0.975**
Sub-Plot (Soil depth)			
D_1: 0-20 cm	7.53	0.14	46.44
D_2: 0.20-0.40 m	7.60	0.15	46.33
D_3: 0.40-0.60 m	7.64	0.13	50.17
D_4: 0.60-0.80 m	7.71	0.12	52.22
D_5: 0.80-1.0 m	7.77	0.13	54.44
SEm ±	**0.067**	**0.011**	**0.752**
CD(*p=0.05*)	**NS**	**NS**	**2.149**
Main x Sub treatment	**NS**	**NS**	**NS**

Table 2. Effect of sites and soil depth on changes in organic carbon (g kg^{-1}) in soils of permanent bench mark sites of Jabalpur districts

Soil depth (cm) → / Benchmark sites ↓	0-20 cm	20-40 cm	40-60 cm	60-80 cm	80-100 cm	Mean
S_1:Udna	4.83	3.93	2.93	1.67	0.90	2.85
S_2:Magarmuha	4.77	3.67	2.17	1.23	0.83	2.53
S_3:Khamaria	7.13	6.57	5.10	2.73	1.00	4.51
Mean	5.58	4.72	3.40	1.88	0.91	3.30
Comparison of main plot (Benchmark sites) treatments					SEm ±	0.096
					CD (*p=0.05*)	0.284
Comparison of sub-plot (Soil depth) treatments					SEm ±	0.095
					CD (*p=0.05*)	0.271
Comparison of main plots at the same level of sub-plot treatments					SEm ±	0.164
					CD (*p=0.05*)	0.470
Comparison of sub-plot plot at the same or different levels of main treatments					SEm ±	0.206
					CD (*p=0.05*)	0.589

Table 3. Effect of sites and soil depth on changes in calcium carbonate (g kg^{-1}) in soils of permanent bench mark sites of Jabalpur districts

Soil depth (cm) → / Benchmark sites ↓	0-20 cm	20-40 cm	40-60 cm	60-80 cm	80-100 cm	Mean
S_1:Udna	43.4	44.3	45.0	46.0	46.8	45.1
S_2:Magarmuha	41.9	42.2	44.6	45.5	46.7	44.2
S_3:Khamaria	38.4	43.1	44.6	45.9	47.7	44.0
Mean	41.2	43.2	44.7	45.8	47.1	44.4
Comparison of main plot (Benchmark sites) treatments					SEm ±	0.17
					CD (*p=0.05*)	0.50
Comparison of sub-plot (Soil depth) treatments					SEm ±	0.22
					CD (*p=0.05*)	0.63
Comparison of main plots at the same level of sub-plot treatments					SEm ±	0.39
					CD (*p=0.05*)	1.10
Comparison of sub-plot plot at the same or different levels of main treatments					SEm ±	0.43
					CD (*p=0.05*)	1.22

treatments. It was also found that irrespective of sites the soil pH increased with depth but with increase was statistically at par. The findings are well supported by those reported in literature indicating that Soil pH of Vertisol in permanent bench mark sites of Jabalpur in AESR-10.1 under rice-wheat cropping system was continuously decreasing with depth (Tripathi et al., 2018).

3.2 EC

Data pertains to effect of spatial and vertical variability on EC of soil studied under Rice – wheat cropping pattern has been given in Table 3. Data clearly indicated that spatial and vertical variability on EC of soils was non- significant. The values of soil EC varied from 0.13 (Udna and Khamaria) to 0.15 (Magarmuha) across the sites, while it ranged from 0.12 to 0.15 dSm^{-1} with depth. it is evident from data Table 1 that soils of Magarmua were highly significant over soils of Udna and Khamaria, soils of Udna and Magarmuha were statistically at par. It is also evident from the data (Table 2) that soil EC at 0-20, 20-40, 40-60, 60-80 and 80-100 cm soil depths varied from 0.14, 0.15, 0.13, 0.12 and 0.13 respectively. The results showed that soil EC was highest at 20-40 (0.15 dSm^{-1}) cm that was at par to those with 0-20 cm (0.14 dSm^{-1}) but significantly higher than remain 40-60 cm (0.13 dSm^{-1}), 60-80 cm (0.12 dSm^{-1}) and 80-100 cm (0.13 dSm^{-1}) which were at par among themselves Data clear cut showed that there were irregular trends in soil EC with depth. As results on Soil EC was showing that irregular pattern of soil EC at AESR-10.1 region specially cultivated soil (Mohanty et al., 2012).

3.3 CEC

Data pertains to spatial and vertical variability in the CEC of soil has been given in Table.3. Data clearly indicated that spatial and vertical variability on CEC of soils after rice –wheat cropping pattern was non- significant. The values of soil CEC varied minimum at Magarmuha (42.67 Cmol (p+) kg^{-1}) to highest at Khamaria (55.07 Cmol (p^{+}) kg^{-1}) across the sites, while it ranged minimum in 20-40 cm (46.33 Cmol (p^{+}) kg^{-1}) to maximum in 80-100 cm (54.44 Cmol (p+) kg^{-1}) with depth. it is evident from data Table1 that soils of Khamaria (55.07 Cmol (p+) kg^{-1}) were highly significant over soils of Udna (54.03 Cmol (p+) kg^{-1}) and Magarmua (54.03 Cmol (p+) kg^{-1}) soils it was further revealed from the data that soils of Udna [54.03 Cmol (p^{+}) kg^{-1}] significant over soils of Magarmuha (54.03 Cmol (p+) kg^{-1}). It is also evident from the data (Table 1) that CEC of soil was highest at 80-100 cm (54.44 Cmol (p+) kg^{-1}) cm which were significant over 0-20 cm (46.44 Cmol (p+) kg^{-1}), 20-40 cm (46.33 Cmol (p+) kg^{-1}), 40-60 cm (50.17 Cmol (p+) kg^{-1}) and 60-80 cm (52.22 Cmol (p+) kg^{-1}). It was further revealed that values of CEC at 20-40 cm (46.33 Cmol (p+) kg^{-1}) statistically at par with surface layer 0-20 cm (46.44 Cmol (p+) kg^{-1}). The value of soil CEC at 40-60 cm (50.17Cmol (p+) kg^{-1}) was also statistically at par with those at 60-80 cm (52.22 Cmol (p+) kg^{-1}). Data on Soil CEC also pointed that intraction among sites and depths were not significant. CEC of this ASER 10.1 region differ as site was changed and as the effect of input fertilizer or inert chemical substitute it may decrease at adjoin subsurface but after about 40 cm and above depth it was increased (Mohanti et al., 2000).

3.4 OC

Data pertains to spatial and vertical variability in the organic carbon (g kg^{-1}) of soil has been given in Table 2. Data clearly indicated that spatial and vertical variability on soils OC of Khamaria (4.51 g kg^{-1}) soils were highly significant over soils of Udna (2.85 g kg^{-1}) and Magarmuha (2.53 g kg^{-1}) soils. it is clear from the data that minimum OC was noticed in soils of Magarmuha (2.53 g kg^{-1}) which was also significant over soils of Udna (2.85 g kg^{-1}) cause?. It is also evident from the data (Table 2) that soil OC at 0-20, 20-40, 40-60, 60-80 and 80-100 cm depths varied from 5.58, 4.72, 3.40, 1.88 and 0.91 g kg^{-1} respectively. Data of Table 2 further showed that minimum OC was recorded at 80-100 cm (0.91 g kg^{-1}) and maximum at surface layer 0-20 cm (5.58 g kg^{-1}). There were significant difference among each depth and themselves. Interactive effect between sites and depth also significant in oc of soils. At the same depth at same sites OC of Khamaria soils were significant than soils of Udna and Magarmuha. It is further noticed that at surface layer of Khamaria soils were the highest oc (0.91 g kg^{-1}). Interaction effect between sites and depth on OC was significant in this study. Data further indicate that OC of Khamaria soils at same depth 0-20 cm (7.13 g kg^{-1}) was significantly higher than soils of Udna (4.83g kg^{-1}) and Magarmuha (4.77 g kg^{-1}) whereas they were statically at par. Khamaria soils were also found significant at 60-80 cm (2.73g kg^{-1}) depth with different depth at 40-60 cm (2.93g kg^{-1}) soils of Udna. Magarmuha soils were found always lowest in soils OC than soils of Udna and

Khamaria soils. As the results shows that soil oc were high in Khamaria soil that because of use of organic manures as the practices applied in this PBMS localized availability of this. Depth wise decrement of soil organic carbonwas (Ingle et al., 2018).

3.5 Calcium Carbonate ($CaCO_3$)

Data pertains to spatial and vertical variability in the calcium carbonate (g kg^{-1}) of soil has been given in Table 3 Data clearly indicated that spatial variability on soil $CaCO_3$ of:Udna (45.1 g kg^{-1}) soils were highly significant over soils of Khamaria (44.0 g kg^{-1}) and Magarmuha (44.2 g kg^{-1}) soils. Vertical distribution of calcium carbonate (g kg^{-1}) at 0-20, 20-40, 40-60, 60-80 and 80-100 cm depths varied from 41.2, 43.2, 44.7, 45.8, and 47.1 g kg^{-1} respectively. There also observed that significant increase in soil $CaCO_3$ with each depth. Soils of Khamaria found lowest (38.4 g kg^{-1}) $CaCO_3$ at 0-20 cm depth which was significantly lower than Udna (43.4 g kg^{-1}) and Magarmuha (41.9 g kg^{-1}) soils. In sub surface from 40-60 cm and onwards values of soil $CaCO_3$ sites were found statically at par values at same level of depth. It is also noticed that Interaction among sites and depth found significant with spatial and vertically. It was further found that at depth 0-20 cm soils of Magarmuha (41.9 g kg^{-1}) and Udna (43.4 g kg^{-1}) found statically at par with 20-40 cm depth of sites Udna (44.3 g kg^{-1}), Magarmuha (42.2 g kg^{-1}) and Khamaria (43.1 g kg^{-1}). The result on Calcium carbonate intrection effect among sites and depths and are altering (Chouhan et al., 2018; Ghodke et al., 2016; Jackson, 1967) and increase in $CaCO_3$ (Dwivedi et al., 2018; Wani et al., 2017).

4. CONCLUSION

Present study concludes that physico-chemical properties of soil like pH, EC and CEC could vary non significantly whereas OC and $CaCO_3$ in AESR 10.1 region could vary significantly (ρ=0.05) at vertical and spatial levels in Vertisols under rice-wheat cropping system. Therefore, greater attention to understand these physico-chemical l properties of Vertisols under rice-wheat cropping system is needed for potential agronomic management practices to enhance the inputs use efficiency.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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