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Characterization and Classification of Major Vegetables Growing Soils of Odisha Coastal System- A Case Study

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Abstract: Three representative pedons (P1, P2 and P3) of vegetable-growing soils in coastal Odisha were characterized and classified to understand the intrinsic pedogenic characteristics. Soil of P1 is very deep well-drained and has brown to dark reddish brown matrix, loamy A horizons to clay, argillic B horizons, slightly acidic (pH 5.5) to neutral (pH 6.9), non-saline, low organic carbon (OC), carbon exchange capacity (CEC) and base saturation status. Soil of P2 is moderately deep with somewhat poorly drained and dark yellowish brown to brown, sand to sandy clay loam in texture, neutral (pH 7.6) to moderately alkaline (pH 9.2) in reaction, non-saline, low OC, CEC and base saturation status. P3 soil is deep with moderately well drained, very dark grayish brown to dark grayish brown and entire profile is clay in texture, neutral to moderately alkaline (7.2 to 8.3) in reaction, non-saline, medium to low in OC content (0.63 to 0.23%) and CEC varied from 29.5 to 37.1 cmol (p^+) kg^{-1}) and base saturation from 76 to 92%. Among the exchangeable cations, calcium was found to be high in all soils, followed by magnesium, sodium and potassium. The soils were classified as *Typic Paleustalfs* (P1), *Typic Haplustepts* (P2) and *Typic Endoaquerts* (P3) sub-group level based on soil characteristics.

Key words: *Coastal, soil characterization, classification, vegetables*

Introduction

Coastal regions, home to a large and growing proportion of the world's population, are undergoing environmental deterioration through depletion of resources such as air, water and soil. The reasons for environmental decline are complex, but population factors play a significant role (Mitran *et al*. 2014). The coastal agro-ecosystem occupies 19.6 m ha (6.2%) area of land in India (Sehgal *et al*. 1992). About 14.2% of the population of India lives in coastal areas (Envis centre). In coastal agro-ecosystem, with the increasing human and animal population, the competition between various land uses has become intensive. Besides, unsuitable land is brought under cultivation and thereby causing physical and chemical degradation of land (Mini *et al*. 2007). Odisha coast line has extended from east to southern, about 445 km (Bandyopadhyay *et al.* 1984). Besides, there is narrow strip of land of few km in width along the sea coast which is saline (Chaudhary *et al.* 2008).

The coastal soils are formed mainly in the deltaic alluvium of the Subarnrekha, Brahmani, Baitarani, Mahanadi, Rushikulya and other minor rivers. These lands may be of low or high relief, sand bars running parallel to the coast and lacaustrine sediment of Chilka Lake. The soils of high relief are found on the slopes of hill range constituting sedimentary and igneous rocks and are often characterized by lateritic capping of uneven thickness. Soils of lacustrine sediment of Chilika Lake are affected by salt due to flooding of brackish water during monsoon and build up of sub-soil salinity due to high ground water table in low lying areas in dry season.

Growing vegetables requires soils that are rich in nutrients, good texture, neutral soil reaction and better water holding capacity (Cui *et al.* 2004). Therefore, soil type could influences the choice of vegetable to grow. The degraded soil and water quality together with climatic adversities like cyclone, heavy rains, flood and drought *etc*. contribute to the poor livelihood security and low agricultural productivity of the area (Swagatika *et al.* 2015). Therefore, farmers need to adapt greater agricultural diversification in coastal area. High-value crops (vegetable and fruit) can potentially increase farm income (Barghouti *et al.* 2005). An

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understanding of types of soils and their distribution, constraints and potential are important for proper management to increase productivity and crop yield. Keeping in view above, a case study has been attempted to characterize and to classifiy major vegetables growing soils in Ganjam block of Ganjam district, Odisha in coastal ecosystem.

Materials and Methods

A case study was conducted during 2014-15 in Ganjam block of Ganjam district, Odisha and is located (Fig. 1) in eastern part of the state, which come under agro- ecological zone (AEZ) of 18.4 and area covering 216.12 km^2. The mean annual rainfall is 1449 mm and more than 60-70% is received during south-west monsoon (June-September). The mean maximum summer temperature is 39°C and mean minimum winter temperature is 11.5°C. The soil temperature class is *hyperthermic* and moisture regime is "*ustic*" which is hot humid plain with Length of growing period (LGP) of 180-210days.

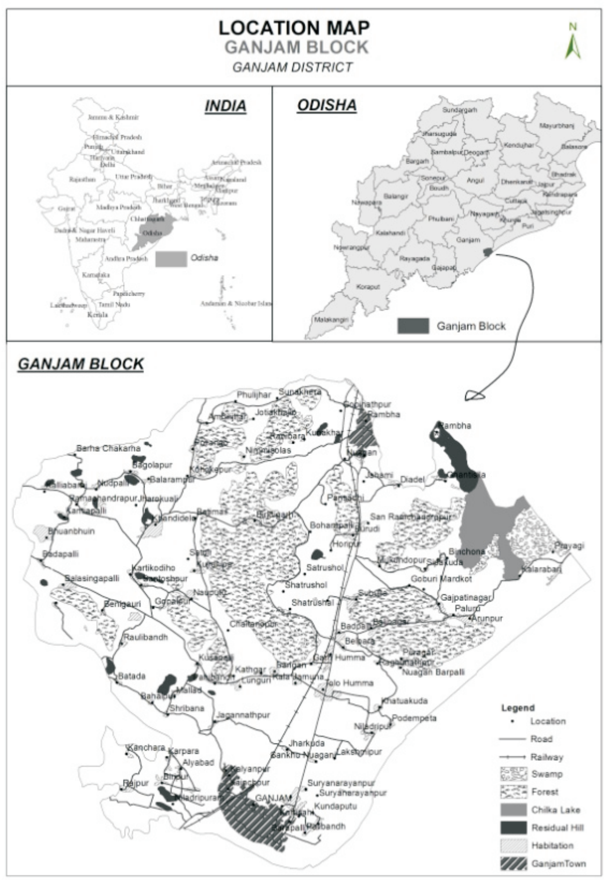

Fig. 1 Location of Study area

Detailed soil survey was carried out on 1: 10,000 scale by using base map prepared from remote sensing satellite data (1RS-P6 LISS IV) in conjunction with village cadastral map and survey of India (SOI) toposheets for physiographic delineation. Profile observations and auger samplings were done to cover all the major landform units under coastal ecosystem. Totally, 46 representative pedons were studied. After final correlation, three representative soils series (P1- Jahami, P2- Ranibara and P3-Madhuchua) were established under major vegetables growing zone (Table 1).

Table 1. Landscape characteristics of study area

Pedons	Series	Location	Land form	Slope (%)	Drainage	Land use
1	Jahami	19°29'49.19"N 85°5' 20. 46"E	Upland gently sloping	1-3	Well drained	cucurbit, tomato, chilli
2	Ranibara	19°30' 38.80"N 85°3' 37. 94"E	Valley	0-1	Somewhat poorly drained	cabbage, cauliflower
3	Madhuchua	19°28' 52.06"N 85°5'38. 85"E	Coastal plain very gently sloping	1-3	Moderately well drained	guards, cauliflower, tomato

Soil pits were excavated on each landform for describing morphological characteristics (Soil Survey Staff 2010). Major variables in site characteristics were slope, depth and soil colour. Soil colour was examined by using Munsell color chart. The collected soil samples were air dried ground and processed by sieving and labeled. The soil samples were analysed in the laboratory for physical and chemical parameters using standard procedures. The particle size analysis was done by International pipette method, soil pH in 1: 2.5 soil water ratio and in *1 N* KCl solution, organic carbon by Walkley and Black method (1934), CEC by *1 N* ammonium acetate at pH 7.0 (Page *et al.* 1982), whereas, base saturation was calculated as sum of bases divided by CEC and multiplied by 100. Exchangeable calcium (Ca) and magnesium (Mg) was determined by using Ethylene Ethylene diamine tetra acetic acid (EDTA) titration (Jackson 1973). These exchangeable acid cations were extracted using 1.0 *N* KCl and total exchangeable acidity was determined by titrating with standard alkali (NaOH) solution. Exchangeable Aluminium was determined by treating the titrated solution with excess potassium fluoride and then titrating with standard sulphuric acid until the pink colour disappears. Exchangeable hydrogen was calculated by difference (Sarma *et al.* 1987). Soil moisture-retention characteristics were determined by soaking disturbed soil samples for 48 h to allow complete saturation. The saturated soil samples were put in the pressure plate extractor and moisture at 0.03, 0.05, 0.1, and 1.5 MPa were measured. Available water capacity (AWC) was calculated as the water retained between suction 0.03 and 1.5 MPa (Klute 1986). The soils were classified as per guidelines given in Key to Soil Taxonomy (Soil Survey Staff 2010).

Results and Discussion

Morphological characteristics

The depth of soil varied from moderately deep (P2), deep (P3) and very deep (P1) (Table 2) depending on landform. P1 had brown colour in surface and reddish brown to dark reddish brown in sub soils. Whereas, in P2, surface soil colors were dark yellowish brown and brown in sub soil and in P3 had very dark grayish brown in surface and dark grayish brown in subsoils. The texture of P1 is coarse loamy over clay, where, after 80 cm depth, much more clay deposition was observed, where as P2 texture varied from sandy to sandy clay loam and P3 is very fine clay. The slope is level to nearly level with somewhat poorly drained to well drained. These soils possess good structure and consistency which is favorable for vegetables cultivation.

Physical characteristics

The detailed physical characteristics of the soils are presented in (Table 2). Granulometric data revealed that the clay content varied from 8.1 to 51.6%. The distribution of clay shows increase from top to lower horizons. P3 had maximum clay distribution. Silt content in P1 and P2 are less than 10% but P3 had high (29.8-33.9%). Sand distribution is maximum in P1 and P2 surface layers (70.1-81.4%). Soils of low land and valley (P2) had high clay. Rao *et al.* (2008) also reported similar findings. Further, higher clay also exhibited itself in higher water retention at 33 kPa, 1500 kPa and available water content which was higher in P3 (21 to 28%) than others, which is important for efficient use of limited water resources for optimization of vegetables productivity and proper land and water management (Ravender Singh *et al.* 2010).

Table 2. Morphological and physical characteristics of the soils

Depth (cm)	Horizon	Colour (Moist)	Sand (2.0-0.05)	Silt (0.05- 0.002)	Clay (<0.002)	Texture	AWC (%)	Structure	Consistency
			(mm)					S G T	D M W
Pedon P1: Jahami series									
0-22	A	7.5YR4/4	81.4	10.5	8.1	ls	8	vf 1 sbk	l vfr so/po
22-43	BA	5 YR 4/4	78.9	10.0	11.1	sl	11	vf 1 sbk	- vfr so/po
43-79	Bt1	5YR 4/6	59.7	6.6	33.7	scl		f 2 sbk	- fr ss/sp
79-113	Bt2	5 YR 4/6	45.3	9.5	45.2	c		m 2 sbk	- fr ss/sp
113-155	Bt3	5 YR 3/4	42.7	5.7	51.6	c		m 2 sbk	- fr ss/sp
Pedon P2: Ranibara series									
0-15	Ap	10 YR3/4	92.2	2.7	5.1	s	10	vf 1 sbk	sh fr so/po
15-30	Bw1	10 YR 4/6	80.2	4.6	15.2	sl	14	m 2 sbk	- fr so/po
30-57	Bw2	10 YR 4/6	75.9	6.3	17.8	sl		m 2 sbk	- fr so/po
57-90	Bw3	10 YR 4/3	57.2	17.2	25.6	scl		m 2 sbk	- fi ss/sp
Pedon P3: Madhuchua series									
0-14	Ap	10 YR3/2	7.7	31.2	61.1	c	21	f 2 sbk	sh fi s/p
14-46	Bss1	10 YR 3/2	7.3	31.5	61.2	c	28	m 3 sbk	- fi s/p
46-72	Bss2	2.5 Y 3/2	7.6	11.0	81.4	c		m 3 sbk	- fi s/p
72-97	Bss3	2.5 Y 4/2	11.9	20.3	67.8	c		m 2 sbk	- fi s/p
97-145	Bss4	2.5 Y 4/2	6.9	29.4	63.7	c		m 2 sbk	- fi s/p

Chemical characteristics

Chemical characteristics of the soils are shown in (Table 3). Soils of P1 were very slightly acidic to neutral (pH 5.5 to 6.9), whereas P2 and P3 were slightly alkaline to moderately alkaline (pH 8.3 to 9.2) in soil reaction and appear to be related with parent materials, rainfall and topography. Similar findings have been observed by (Mishra 2005). The KCl-pH values of P1 were lower than the water pH values, indicating the existence of net negative charge on colloidal particles. All the soils showed very low electrical conductivity values ranging from 0.1 to 0.58 dS m^{-1}, suggesting very low amount of soluble salts. OC content of the soils was low to medium (0.13 to 0.63%). The OC content decreased with the depth of the soils except P1. This could be attributed to the addition of plant residues and farmyard manure to surface horizons than in the lower horizons. The removal of surface soil containing high OC due to intensive vegetable cultivation was found to be a factor for lower OC content in the soils of the study area. Similar findings have been observed by (Nayak 2013). The exchangeable acidity with KCl extract in P1 was varied from 0.05 to 0.22 cmol (p^+) kg^{-1}. Low exchangeable acidity could allow, efficient recycling of basic cations facilitated by the soil to maintain a higher pH and low exchange acidity and aluminium (Patton *et al.* 2007). CEC and base saturation was more in P3 varied from 29.5 to 37.1 c mol (p^+) kg^{-1} and 76 to 92%, respectively, but in P1 and P2 CEC and base saturation varied from 1.9 to 20 cmol (p^+) kg^{-1} and 57 to 76%. Exchangeable bases in all pedons were in the order of Ca^{2+} > Mg^{2+} > Na^+ > K^+ on the exchange complex of soils. Exchangeable cations were low in P1 and P2, whereas in P3 was found higher in calcium and magnesium content.

Table 3. Chemical characteristics of the soils

Depth (cm)	Horizon	pH (1:2.5)		EC (dS m^{-1})	OC (%)	Exchangeable acidity	Exchangeable cations					CEC	BS (%)
		H_2O	1N KCl				Ca	Mg	Na	K	Sum of cations		
						cmol (p+) kg^{-1}	(*1 N* $NH_4$0Ac, pH 7.0)						
Pedon P1: Jahami series													
0-22	Ap	6.3	4.8	0.12	0.17	0.11	0.8	0.4	0.1	0.1	1.40	1.9	74
22-43	BA	6.9	4.6	0.10	0.14	0.05	1.1	0.6	0.1	0.1	1.90	2.5	76
43-79	Bt1	6.7	4.5	0.26	0.21	0.16	8.5	2.8	0.2	0.4	11.9	16.5	72
79-113	Bt2	5.6	4.5	0.12	0.18	0.11	7.0	3.2	0.2	0.4	10.8	18.7	58
113-155	Bt3	5.5	4.6	0.10	0.13	0.22	7.6	3.0	0.2	0.6	11.4	20.0	57
Pedon P2: Ranibara series													
0-15	Ap	7.6	-	0.18	0.48	-	1.3	0.5	0.3	0.1	2.20	3.4	65
15-30	Bw1	8.0	-	0.17	0.24	-	2.1	0.8	0.4	0.2	3.50	5.7	61
30-57	Bw2	8.5	-	0.19	0.15	-	2.6	0.9	0.2	0.3	4.00	6.2	65
57-90	Bw3	9.2	-	0.53	0.14	-	2.6	1.1	0.3	0.2	4.20	6.4	66
Pedon P3: Madhuchua series													
0-14	Ap	7.2	-	0.58	0.63	-	19.5	7.2	0.6	0.9	28.2	37.1	76
14-46	Bss1	8.1	-	0.26	0.40	-	20.2	7.5	0.4	0.9	29.0	36.2	80
46-72	Bss2	8.3	-	0.28	0.27	-	22.6	6.8	0.8	0.2	30.4	33.0	92
72-97	Bss3	8.3	-	0.23	0.24	-	20.2	6.2	0.9	0.2	27.5	30.4	90
97-145	Bss4	8.3	-	0.28	0.23	-	19.9	5.8	0.9	0.2	25.9	29.5	88

Soil classification

Based on morphological characteristics and soil properties of the pedons, the soils were classified upto the family level (Table 4) according to Keys to Soil Taxonomy (Soil Survey Staff, 2010). These soils were classified into the order of Inceptisols, Alfisols and Vertisols. The P1 showed the presence of argillic (Bt) sub-surface diagnostic horizon as evidenced by the fact that the illuvial horizon contained 1.2 times more clay than the eluvial horizon and also had base saturation more than 35% throughout the depth of the profile which was classified as Fine, Coarse-loamy over clay, mixed, hyperthermic, *Typic Paleustalfs*. P2, which has common horizon sequence of Inceptisols is an ochric epipedon over a cambic horizon (Bw), with or without an underlying fragipan and classified as Coarse-loamy, mixed, hyperthermic, *Typic Haplustepts* and P3 had Vertisols characteristics, wide cracks on surface of the soils and clay deposition in lower layer and presence of *slickensides* and CEC more than 35% and classified at family level as Very fine, mixed, hyperthermic, *Typic Endoaquerts*.

Table 4. Classification of coastal soils

Series	Soil Taxonomy				
	Order	Sub order	Great group	Sub group	Family
Jahami	Alfisols	Ustalfs	Paleustalfs	*Typic Paleustalfs*	Fine, Coarse-loamy over clay, mixed, hyperthermic, *Typic Paleustalfs*
Ranibara	Inceptisols	Ustepts	Haplustepts	*Typic Haplustepts*	Coarse- loamy, mixed, hyperthermic, *Typic Haplustepts*
Madhuchua	Vertisols	Aquerts	Endoaquerts	*Typic Endoaquerts*	Very fine, mixed, hyperthermic, *Typic Endoaquerts*

Conclusions

The study of morphological, physical and chemical analysis of soil samples revealed that the soils of coastal vegetable growing zone were slightly acidic to moderately alkaline in soil reaction, non-saline and low to medium in organic carbon content. The CEC and base saturation values were low except P3 and exchange complex was dominated by Ca^{2+} and Mg^{2+}. The soils were classified as *Typic Paleustalfs*, *Typic Haplustepts* and *Typic Endoaquerts* sub-group.

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