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Assessment of Soil and Water Salinity and Alkalinity in Coastal Odisha – A Case Study

R Srinivasan[1]*, SK Singh[3], DC Nayak[2] and S Dharumarajan[1]

[1]*ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, Hebbal, Bangaluru-560024, Odisha, India*
[2]*ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, Salt Lake, Kolkata-700091, West Bengal, India*
[3]*ICAR- National Bureau of Soil Survey and Land Use Planning, Amravati Road, Nagpur-440 033, Maharashtra, India*
**Corresponding author E-mail: srinivasan.surya@gmail.com*

Abstract

Soil development in Coastal Odisha is due to litteral deposits of estuarial intrusion of brackish tidal water from sea and lacustrine sediments of Chilika Lake. The present investigation aimed to assess the distribution of soil salinity and alkalinity in part of coastal Odisha with a view to effective management and adopting alternate cropping system. The study area was near to Bay of Bengal and Chilika lake, where frequently saltwater intrusion occurs to agricultural land. Study area is converted to different land management units (LMU); based on extent of fallow land and severity of salts. Soils were low in organic carbon (OC) content. Salt concentration (ECe) was varied from 6.94 to 16.86 dS m^{-1} and the highest was found in LMU 3. Soil cation exchange capacity (CEC) and base saturation (BS) were varied from 4.3 to 15.1 c mol (p+) kg^{-1} and 67 to 95%, respectively. Exchangeable bases in all LMU were in the order of Ca^{2+}> Mg^{2+}> Na^{+}> K^{+}. Results of soil fertility in different depths (0-15 and 15-30 cm) revealed that the available N, P and Zn were deficient and K, Fe, Mn and Cu were sufficient. Assessed soil and water salinity/alkalinity could able to suggest appropriate crop and land managements to each LMU.

Key words: Soil salinity, Alkalinity, Water quality, Land management unit, Soil cation exchange capacity, Coast line, Climate change

Introduction

Coastal agriculture is having a major portion of farmlands, occupies 19.6 m ha (6.2%) area in India (Sehgal *et al.,* 1992). About 14.2% of the population of India lives in coastal areas. Even though coastal land suffers with salt stress and shortage of freshwater which leads to poor crop production in different areas (FAO, 1998). Soil salinity is a major environmental constraint to crop production in irrigated land due to faulty irrigation practices and it is expected to contribute to global climate change (Rengasamy, 2010).

Odisha coast line is extended from east to south, about 445 km. Besides, there is narrow strip of land of few km in width along the sea coast which is saline (Chaudhary *et al.,* 2008). In coastal Odisha, rainfall occurs during middle of June to 1st week of October and remaining period is almost dry. Salinity increases with progress of the dry period (Bandyopadhyay, 1972; ORSAC, 1986). *Kharif* paddy followed by fallow is predominant cropping system because of excess water in monsoon and scarcity of irrigation water in during post-monsoon. In rainy seasons, salinity hazards are low due to dilution and flushing of soluble salts by heavy rains.

In coastal Odisha, soil salinity develop because of several factors viz. sea and lake water intrusion and reverse flowing of sea water in river during summer and utilization of reverse flow water for irrigation (Jha *et al.,* 2001; Mohanty *et al.,* 2012). Development of salinity, sodicity and toxicity problems in soils not only reduces crop productivity and also choice of choosing crops (Sethi *et al.,* 2002). Indiscriminate use of poor-quality waters in agricultural is risks to soil health and environment (Sharma and Minhas, 2005). The effects of salt stress on agricultural crops are very significant; crops exhibit slower growth rates, poor tillering and low production (Ray *et al.,* 2014). However, presences of high salt disperse the soil structure, reduces the infiltration and its causes the severe soil degradation, which makes the situation not favourable to plant growth (Agassi *et al.,* 1981; Tyagi and Minhas, 1998).

Micro-level assessment of soil and water-quality is a prerequisite to understanding the land's potential usage in coastal system. Appropriate land management promotes diversification and intensification in agriculture and thus cultivation of high-yielding and valuable cash crops (Burman *et al.,* 2015). Under these circumstances there is a need to introduce efficient techniques for land and water resources for better crop production. Keeping in view above, a study was conducted for assessing soil and water salinity in Ganjam block of Ganjam district, Odisha under three different land management units for improving crop productivity.

Materials and Methods

Selection of study area

Study area Ganjam block of Ganjam district, Odisha is located (Fig. 1) in eastern part of the state under agro-ecological sub region (AESR) 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 maximum elevation in the region is less than 10 m above the mean sea level. Three locations different in all respects but representing the neighborhood area of Chilika lake and Bay of Bengal sea were chosen for the study during 2015-16. The static water level varies from 1 to 5 m. The soils are formed mainly in the deltaic alluvium of rivers. Soils of lacustrine sediment of Chilika Lake are affected by salt due to flooding of brackish water during monsoon and buildup of sub-soil salinity due to high ground water table in low lying areas in dry season. The area is cultivated only for rice during the monsoon season (June-October). Site selection and soil samples

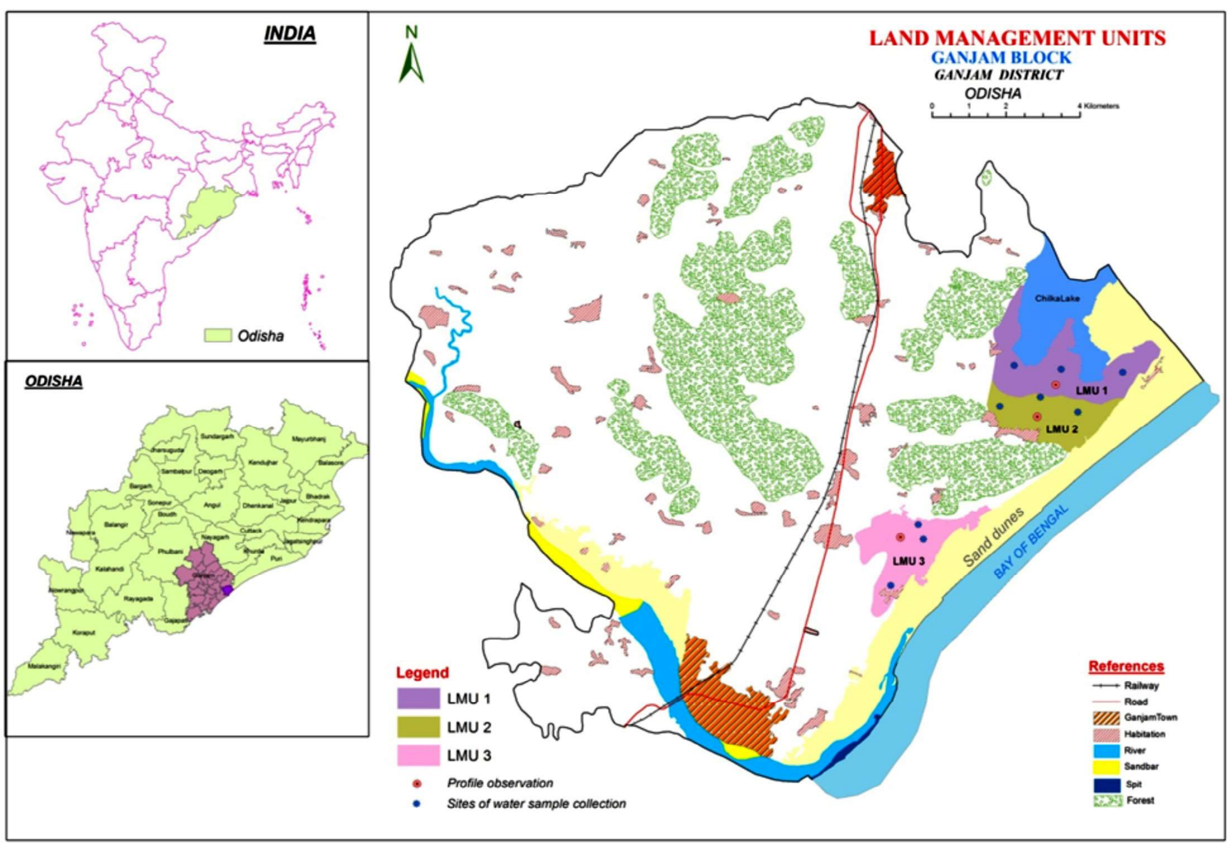

Fig. 1 Location of study area

Table 1. Land use and crop productivity in the Study area

LMU	Location	Area focused on (ha)	Land uses	Ground water depths (m)	Paddy production (kg ha^{-1}) (average)
1	19° 29′ 24″- 19° 24′ 44″ N 85° 07′ 13″- 85° 09′ 48″ E	546	Paddy-fallow	1-2	1593.7
2	19° 27′ 00″- 19° 26′ 54″ N 85° 07′ 08″- 85° 09′ 13″ E	352	Paddy-fallow	2-5	1875.0
3	19° 26′ 08″- 19° 24′ 28″ N 85° 05′ 02″- 85° 07′ 10″ E	421	Paddy-fallow	2-5	1312.5

collection (Table 1) were based on extent of fallow land and maximum salt stress in the root zone in pre-monsoon period (March-April).

Field studies

Soil and water characteristics were studied in each location with different land morphology (Soil Survey Staff, 2003) and distance of separation from the lagoon by carrying out soil profile study and irrigation water collection from bores or ponds. Soil profile was dug up to 1.5 m depths as per the varying slope characteristics of each LMU. Each LMU is covering five profiles study, which is after final soil correlation converted to single soil series and soil samples were collected from different horizons in each site. Composite water samples were collected from each land management unit in duplicate from three different sites for laboratory analysis. Soil samples were air dried, crushed, and passed through a 2-mm sieve, and physical and chemical characteristics were determined.

Soil analysis in laboratory

Particle-size distribution was determined by the international pipette method (Day, 1965). Soil pH and EC were determined using the procedures set forth by Page *et al.* (1982). Soil organic carbon was determined by the wet oxidation method of Walkey and Black (1934). Cation exchange capacity (CEC) was determined *1 N* ammonium acetate at pH 7.0 (Page *et al.,* 1982). Exchangeable calcium (Ca) and magnesium (Mg) was determined by using EDTA titration (Jackson, 1973). 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 pressure applied at 0.03, 0.05, 0.1, and 1.5 MPa suction until water ceased to drain out. The soil samples were weighed and oven dried at 105 ^{0}C for 24 h. Available water capacity (AWC) was calculated as the water retained between suction 0.03 and 1.5 Mpa (Klute, 1986). ESP is the sodium adsorbed on soil particles as a percentage of the Cation Exchange Capacity (CEC). The available nitrogen was estimated through alkaline pemanganate method as suggested by Subbiah and Asija (1956). Available phosphorus was determined by Olsen method (Olsen *et al.,* 1954) and available potassium was estimated by flame photometer after extraction with Neutral normal ammonium acetate solution (pH 7.0). The available micronutrients (Fe, Mn, Cu and Zn) were extracted using DTPA (Lindsay and Norvell, 1978) and their concentrations were determined using atomic absorption spectrophotometer.

Groundwater samples were collected from nine sites from different land management units spread over the area in the month of April-May, 2015-16 for analysis of water quality. The locations of water sample collection are shown in Fig. 1. Soon after collection, pH and EC of water samples were measured using portable pH and EC meters. The groundwater samples were also analyzed in the laboratory for Ca^{2+}, Mg^{2+}, Na^{+}, K, Fe^{2+}, Mn^{2+}, Cl^{-}, CO_3^{2-} and HCO_3^{-} by following standard methods (APHA, 1989; Richards, 1968). Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) of the water samples were calculated from standard formula (Richards, 1968; Sonon *et al.,* 2015). Water quality assessment for irrigation was carried out based on salt concentration (ppm), osmatic pressure (atm) and salt concentration (kg ha^{-1}) by using standard formula given in Tandon (2009).

Statistical analysis

The relationship between soil and water properties and different land management units were determined by Pearson's correlation matrix using SPSS Windows version 14.0 (SPSS Inc., Chicago, Ill).

Results and Discussion

Morphological and physical characteristics

Soil morphological and physical character-istics of the different land management units (LMU) are presented in Table 2. Soils were deep, somewhat poorly drained and colour of LMU 1 varied from gray (10YR 5/1) to light brownish gray (10YR 6/2) and mottle colour was yellowish brown (10YR 5/8) whereas, in LMU 2 showed brown (10YR 4/3) to dark grey (10YR 4/1) matrix colour with red (2.5YR 4/6) to yellowish brown (10YR 5/8) mottles after 41 cm of soil depths. Soil colour of LMU 3 was grayish brown (10YR 5/2) to dark grey (2.5Y 4/1). Mottles of yellowish brown (10YR 5/4) to brown (7.5YR 4/4) colour were present after 68 cm depth. Varying soil colour is influence of water movements in different depth and period and function of soil chemical and mineralogical composition (Walia and Rao, 1997). Mottles with Fe and Mn concretions were found in after 0.45 m depth of the soils, this indicated that soils are facing alternate oxidizing and reducing condition. The soils showed wide textural variations (clay to loamy sand). The wide textural variation might be due to stratification of soil layers by water in different periods. Soil textures play an important role in level of salinity build-up/leaching of salts from soils. The structure of the soils is sub-angular blocky to single grain. The blocky structure was attributed to the presence of higher quantities of clay fraction (Sharma *et al.,* 2004). The single grain structure of the soils (LMU 2) was due to inert nature of the parent material (sandy). The consistence of the soils is slightly hard (dry), very friable to friable (moist) and non-sticky to slightly sticky and non-plastic to slightly plastic (wet) condition.

Table 2. Morphological and physical characteristics of the soils

Depth (cm)	Horizon	Colour (moist)	Mottle colour	Sand	Silt (%)	Clay	Texture	Concentration (conir)	Structure	Consistence D	Consistence M	Consistence W
LMU-1												
0-16	Ap	10 YR 5/1	-	67.9	21.9	10.2	sl	-	paddled	sh	vfr	ss/sp
16-48	Bwn1	10 YR 5/1	10 YR 5/4	42.7	16.1	41.2	c	-	m2 sbk	-	fr	ss/sp
48-73	Bwn2	10 YR 5/2	10 YR 5/8	70.9	8.4	20.7	scl	C2di	m 2 sbk	-	fr	ss/sp
73-100	Bwn3	10 YR 5/1	10 YR 5/8	82.3	8.0	9.7	ls	C2di	f 1 sbk	-	vfr	so/po
100-135+	Bwn4	10 YR 6/1	-	75.7	3.8	20.5	scl	-	f 1 sbk	-	vfr	so/po
LMU- 2												
0-20	Ap	10 YR 4/3	-	29.4	34.0	36.6	cl	-	puddled	sh	fr	ss/sp
20-41	Bw1	10 YR 5/4	-	29.6	21.7	48.7	c	-	m 2 sbk	-	fr	ss/sp
41-73	Bw2	10 YR 5/1	7.5 YR 5/6	53.6	8.4	38.0	sc	C2pi	m 2 sbk	-	fr	ss/sp
73-104	Bw3	10 YR 4/1	2.5 YR 4/6	77.2	3.5	19.3	sl	C2pi	f 2 sg	-	vfr	so/po
104-140	Bwn4	10 YR 4/1	10 YR 5/8	68.5	18.9	12.6	sl	C2dt	s 2 sg	-	vfr	so/po
LMU- 3												
0-22	Ap	10 YR 5/2	-	22.5	45.6	31.9	cl	-	puddled	-	fr	ss/sp
22-46	Bwn1	10 YR 4/3	-	7.0	55.4	37.6	sicl	-	m 2 sbk	-	fr	ss/sp
46-68	Bwn2	10 YR 5/3	-	1.2	63.6	35.2	sicl		m 2 sbk	-	fr	ss/sp
68-97	Bwn3	10 YR 5/3	10 YR 5/4	2.1	65.5	32.4	sicl	C2fdi	m 2 sbk	-	fr	ss/sp
97-130	Bwn4	2.5 YR 4/1	7.5 YR 4/4	3.7	64.4	31.9	sicl	C2fdi	f 2 sbk	-	vfr	ss/sp

Texture: c - clay, cl- clay loam, sl- sandy loam, scl - sandy clay loam, sc - sandy clay, ls –loamy sand, sicl- silty clay loam.
Structure: Size (S) - vf - very fine, f - fine, m - medium, c - coarse; Grade (G) - 0 - structureless, 1- weak, 2 - moderate, 3 - strong; Type (T)- cr - crumb, sg - single grain, abk - angular blocky, sbk - sub-angular blocky.
Consistence: Dry: s - soft, 1- loose, sh - slightly hard, h – hard; Moist: 1- loose, fr - friable, fi - firm, vfi - very firm; Wet: so - non-sticky, ss - slightly sticky, s - sticky; po - non-plastic, ps – slightly plastic, p - plastic
Concentration: Quantity: f-few (<2%), c-common (2-20%), m-many (>20%); size: 1-fine (<2mm), 2-medium (2-<5); contrast: f-faint, d-distinct, p-prominent; shape: i-irregular, t-threads

Physico-chemical characteristics

The pH values ranged between moderately acidic to slightly alkaline (Table 3). The ECe values were high in LMU 3 (6.94-16.86 dS m^{-1}) and moderate to low in LMU 1 and 2 (1.37-7.32 and 1.38-7.27 dS m^{-1}). The ECe value increased with increasing depth of soils. The high salt content in subsurface layer may be ascribed to the lower topographic position that receives salts periodically through runoff and seepage movement and high-water table and secondary salinization were responsible for increasing sub-surface salinity in coastal soils during summer (Das *et al.,* 2010; Mohanty *et al.,* 2012). Organic carbon content of the soils was found to be low, ranging from 0.01 to 1.13 % but surface soils had more OC in LMU 2 than others. The organic carbon content decreased with depth in all the LMU. This is attributed to the addition of plant residues and farmyard manure to surface horizons. The CEC and base saturation (BS) were varied from 4.3 to 15.1 c mol (p+) kg^{-1} and 67 to 95% in soils which is directly influenced by clay, OC content and type of clay mineral present in soils. Exchangeable bases in all LMU were in the order of Ca^{2+}> Mg^{2+}> Na^{+}> K^{+} on the exchange complex and ESP values were low in surface soils and gradually increased with soil depths, maximum observed from LMU 1 and LMU 3 (9.3 to 22.9%).

Nutrient status and soil fertility

The available nitrogen (N) content in 0-15 cm and 15-30 cm depth of soils, varied from 130 to 231 and 90 to 118 kg ha^{-1} (Fig. 2). The available nitrogen content was found to be more in surface horizons and decreased with depth. Most of the coastal saline soils are deficient in nitrogen. This was mainly because of less use of N fertilizers and lower rate of mineralization of soil organic nitrogen under high soil salinity (Alam, 1999; Vijaya Kumar *et al.,* 2013).

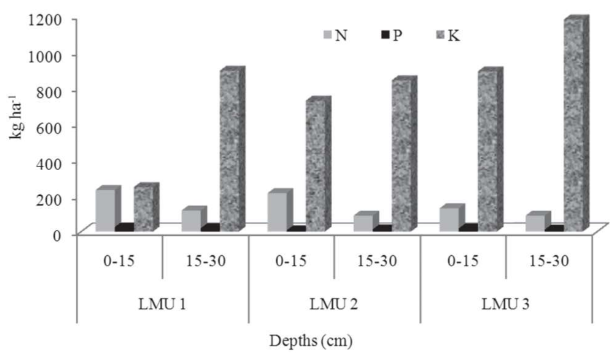

Fig. 2 Distribution of major nutrients in three land management units

Table 3. Physico-chemical characteristics of the soils

Units	Depth (cm)	pH (1:2.5)	ECe (dS m^{-1})	OC	AWC (%)	CEC	Exchangeable cations Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Sum (c mol kg^{-1})	BS (%)	ESP (%)
LMU- 1	0-16	5.4	1.37	0.46	14	4.3	1.6	0.5	0.4	0.1	2.9	67	9.30
	16-48	7.3	3.42	0.13	16	10.8	2.7	3.2	1.8	0.7	8.4	77	16.6
	48-73	7.0	5.09	0.04		9.9	3.5	2.9	1.5	0.4	8.3	83	15.2
	73-100	6.6	6.89	0.03		6.1	2.1	1.2	1.4	0.3	5.0	82	22.9
	$100-135^{+}$	5.7	7.32	0.01		8.1	3.1	1.5	1.4	0.3	6.3	77	17.2
LMU- 2	0-20	6.5	1.38	1.13	19	14.6	6.2	3.9	0.5	0.7	11.3	77	3.42
	20-41	8.1	1.55	0.21	16	15.1	7.8	4.6	0.8	0.7	13.9	92	5.29
	41-73	8.1	2.72	0.17		4.9	2.8	1.1	0.5	0.2	4.6	93	10.2
	73-104	8.0	6.67	0.12		4.9	2.7	1.0	0.8	0.2	4.7	95	16.3
	$104-140^{+}$	7.6	7.27	0.18		6.9	3.3	1.6	1.2	0.4	6.5	94	17.3
LMU- 3	0-22	6.7	6.94	0.65	13	13.0	5.5	3.4	1.6	0.4	10.9	83	12.3
	22-46	7.5	13.4	0.34	19	13.8	7.0	2.6	2.4	0.5	12.5	90	17.3
	46-68	7.8	14.02	0.34		11.8	6.0	2.4	2.2	0.4	11.0	93	18.6
	68-97	7.8	15.65	0.31		9.7	5.5	1.3	2.1	0.3	9.2	94	21.6
	$97-130^{+}$	6.2	16.86	0.87		13.5	6.7	2.0	2.7	0.5	11.9	88	20.0

The available phosphorus (P) content is in 0-15 and 15-30 cm depth of soils, varied from 5.4 to 24 and 9.6 to 18 kg ha^{-1}. The highest available P content was observed in the surface horizons. It might be due to the confinement of crop cultivation to the rhizosphere and supplementing the P by external sources. The lower phosphorus content in sub-surface (15-30 cm) horizons could be attributed to the fixation of released phosphorus by clay minerals and oxides of iron and aluminum. In other cases, a reduction in plant P concentration by salinity may result from the reduced activity of P in the soil solution due to the high ionic strength (Awad *et al.,* 1990). Available potassium (K) content of soils varied from 247 to 892 kg ha^{-1} in 0-15 cm and 843 to 1180 kg ha^{-1} in 15-30 cm of soil depths (Fig. 2). The highest available K content was observed in the subsurface horizons because of upward translocations of potassium from lower depths along with capillary raise of ground water. Coastal saline soils are rich in water soluble, exchangeable, non-exchangeable and available K (Bandyopadhyay, 1990).

The DTPA extractable available Fe in surface (0-15 cm) and subsurface (15-30 cm) were 89.8-172 and 7.06-58.9 mg kg^{-1}. Similarly, available Mn was in the range of 4.66-43.4 and 3.38-27.1 mg kg^{-1}, respectively in surface and subsurface soils. The higher concentration of Fe and Mn is recorded in surface soil than subsoil horizons. The high concentration is due to excess water stagnation in situ may contribute to availability through the formation of metallo-organic complexes with organic substances. This phenomenon may be attributed to the production of chelating agents from compost that generally keep the micronutrient elements soluble and consequently more available to plants (Subba Rao *et al.,* 2011). In case of DTPA extractable Zn ranged from 0.42 to 1.98 mg kg^{-1} in surface and 0.11 to 0.91 mg kg^{-1} in sub soils. All the soils were found to be sufficient in available copper (average more than 1.0 mg kg^{-1}) values were well above the critical limit of 0.2 mg kg^{-1} (Fig. 3) proposed by Lindsay and Norvell (1978). The available Cu content was more in surface soils than subsurface,

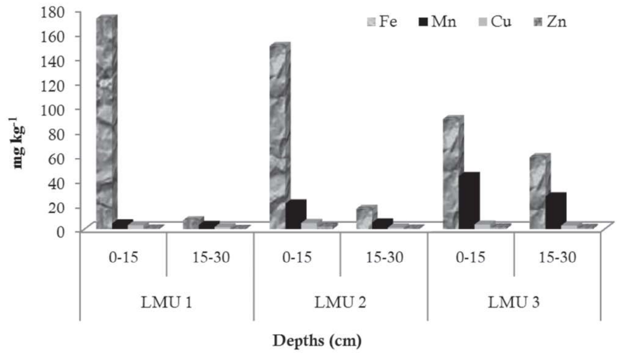

Fig. 3 Distribution of micro nutrients in three land management units

Hence, surface soils may be attributed to more micronutrients, where organic matter and more complexing with organic matter which resulted in chelation of micronutrient cations (Maji and Bandyopadhyay, 1991).

Water-quality and available water content

Water samples showed high EC (9.4 dS m^{-1}) from LMU 3 followed by LMU 1 and LMU 2 (Table 4). Sodium was the dominant cation varying in the range of 2.9-71.9 me L^{-1} in different LMU. Sum of cations, Cl^-, SAR and RSC were in the order of LMU 3>LMU 1>LMU 2. The available water content (AWC) of the soils in three different land management units was ranged from 13 to 19%. The varied AWC was recorded at plant root zone depths (0-15 and 15–30 cm). The moisture content in 0-15 cm soil depth (Fig. 4) were maximum at field capacity (0.03 MPa) ranged from 19 to 45%. In soil depth 15-30 cm more AWC were present compared to surface soils (Fig. 5). Maximum water content is presenting at field capacity (0.03 MPa) suction pressure and it has gradually decreased with increasing suction pressure of the soils with order of LMU 3 > LMU 1> LMU 2. Pearson's correlation matrix revealed strong significant correlations between anions and cations of the water samples (Table 5).

Salt concentration (EC) was positively correlated with sum of cations, Fe, Cl, SAR and RSC. Ca and Mg were significantly correlated with Na, K, HCO_3, Cl. SAR and RSC were also highly correlated with EC, Na, K, Fe, Cl. Soil clay negatively correlated with water pH (-0.695) and

Table 4. Ranges of water-quality in three land management units

Units	pH	EC	Ca^{2+}	Mg^{2+}	Na^+	K^+	Sum	Fe	Mn	CO_3^{2-}	HCO_3^-	Cl^-	SAR	RSC
LMU-1	7.5-8.2	2.3-3.2	0.210.31	0.10-0.50	9.50-11.74	0.1-0.5	10.7-12.2	0.8-1.1	34.2-36.8	0.9-1.2	2.4-3.6	12.0-15.9	15.8-29.9	2.7-4.5
	(0.4)*	(0.5)	(0.05)	(0.21)	(1.14)	(0.2)	(0.8)	(0.2)	(1.5)	(0.2)	(0.6)	(2.0)	(7.1)	(0.9)
	7.8	2.7	0.25	0.26	10.5	0.34	11.3	0.92	35.9	1.03	2.9	13.8	22.1	3.44
LMU-2	7.5-8.0	0.6-1.0	2.4-4.0	1.2-1.5	2.61-3.4	0.4-0.5	6.7-9.1	0.1-0.5	30-39	1.2-1.7	1.8-2.2	3.6-4.5	1.6-2.1(0.3)	0.1-2.5
	(0.3)*	(0.2)	(0.87)	(0.16)	(0.43)	(0.1)	(1.2)	(0.2)	(4.5)	(0.3)	(0.2)	(0.5)		(1.2)
	7.7	0.8	3.4	1.38	2.9	0.41	8.1	0.26	34.3	1.46	2.03	3.96	1.89	1.35
LMU-3	7.5-7.6	8.8-10.3	5.9-8.8	2.1-2.6	43.3-92.2	3.3-5.6	90.3-107	1.4-2.4	28.3-40.6	1.2-1.6	1.6-1.8	56.3-61.5	21.7-38.6	5.0-8.5
	(0.1)*	(0.8)	(1.53)	(0.28)	(25.48)	(1.2)	(8.7)	(0.5)	(6.8)	(0.2)	(0.1)	(2.6)	(9.7)	(1.8)
	7.5	9.4	7.0	2.4	71.9	4.26	97.2	1.75	32.8	1.4	1.6	58.9	32.8	6.35

*Standard Deviation (SD)

Table 5. Correlation of major water properties

Properties	pH	EC	Ca^{2+}	Mg^{2+}	Na^+	K^+	Sum	Fe	Mn	CO_3^{2-}	HCO_3^-	Cl^-	SAR	RSC
pH	1													
EC	NS	1												
Ca^{2+}	NS	0.707*	1											
Mg^{2+}	NS	0.675*	0.983**	1										
Na^+	NS	0.883**	0.821**	0.765*	1									
K^+	NS	0.927**	0.779*	0.781*	0.886**	1								
Sum	NS	0.962**	0.858**	0.819**	0.956**	0.934**	1							
Fe	NS	0.913**	NS	NS	NS	0.749*	0.794*	1						
Mn	NS	NS	NS	NS	NS	NS	NS	NS	1					
CO_3^{2-}	NS	NS	NS	NS	NS	NS	NS	NS	NS	1				
HCO_3^-	NS	NS	-0.793*	-0.872**	NS	NS	NS	NS	NS	NS	1			
Cl^-	NS	0.986**	0.772*	0.728*	0.933**	0.920**	0.988**	0.870**	NS	NS	NS	1		
SAR	NS	0.766*	NS	NS	0.824**	0.674*	0.741*	0.713*	NS	NS	NS	0.795*	1	
RSC	NS	0.806**	NS	NS	0.884**	0.684*	0.845**	0.684*	NS	NS	NS	0.865**	0.895**	1

* and ** significant at 5% and 1%, respectively (2-tailed).

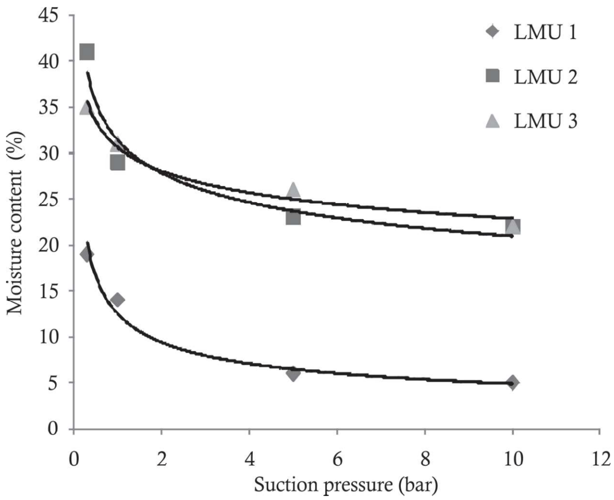

Fig. 4 Water retention curve of soils in three land management units (0-15cm)

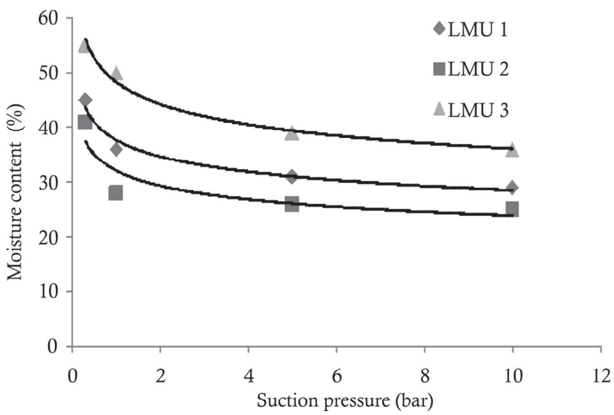

Fig. 5 Water retention curve of soils in three land management units (15-30 cm)

soil AWC is negatively correlated with water HCO_3 (-0.904), rest of the soil properties were non-significant (Table 6).

Suggested suitable land and crop management

After assessing the soil and water quality and land capability classification (LCC), land irrigability classification (LIC) based on that suitable land use viz. highly suitable (S1), moderately suitable (S2) and marginally suitable (S3) crops and management practices were prepared for each land management units (Table 7).

Conclusions

Result revealed that Ganjam block of Ganjam district in coastal Odisha had salinity problem. Soils are also of poor fetility. The ground water quality in two LMU out of three were saline with high RSC value. Judicious selection of crops that can produce satisfactory yields under saline conditions and the use of special management practices to minimize salinity may make the difference between success or failure. Thus, to achieve the potential productivity of a heterogeneous system, prioritizing constraints and their thorough understanding enable us to offer ways and means to exploit land capacity for promoting cropping in underproductive regions.

Table 6. Correlation between soil and water properties

Water parameters	Soil parameters					
	pH	ECe	Clay	OC	AWC	CEC
pH	NS	NS	-0.695*	NS	NS	-0.859**
EC	NS	0.984**	NS	NS	NS	0.800**
Ca^{2+}	NS	0.757*	NS	NS	NS	0.760*
Mg^{2+}	NS	0.750*	NS	NS	NS	0.755*
Na^{+}	NS	0.877**	NS	NS	NS	0.706*
K^{+}	NS	0.936**	NS	NS	NS	0.843**
Sum	NS	0.964**	NS	NS	NS	0.800**
CO_3^{2-}	NS	NS	NS	NS	NS	NS
HCO_3^{-}	-0.689*	NS	NS	NS	-0.904*	-0.751*
Cl^{-}	NS	0.972**	NS	NS	NS	0.770*
SAR	NS	0.677*	NS	NS	NS	NS
RSC	NS	0.743*	NS	NS	NS	NS

* and ** significant at 5% and 1%, respectively (2-tailed).

Table 7. Suitable crops management in different land management units

Units	Soil quality		LCC	LIC	Suitable crops			General Managements
					S1	S2	S3	
LMU-1	Surface Subsurface	Normal Saline-sodic	IVsw	3sd	Cotton, Tomato, Cluster bean	Paddy, Sesbania	Black gram, Ground nut, cow pea	1. Better Drainage & Leaching 2. Chemical treatment- addition of Gypsum 3. Incorporation of organic manures 4. Irrigation water treatments 5. Adopting salt Tolerance crops
LMU-2	Surface Subsurface	Normal Saline	IIIsw	2sd	Black gram, Ground nut, Cow pea, Cotton, Tomato, Cucumber, Paddy	Potato, Cabbage	Onion, Maize, Mung bean, Sunflower	
LMU-3	Surface Subsurface	Saline Saline-sodic	VIsw	5sd	Grasses and forestry	Paddy,S esbania	Cotton, Cluster bean, Tomato	

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