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Assessment of Soil Properties in Krishna Western Delta Ecosystem of Guntur district Andhra Pradesh

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Abstract: A study was conducted to assess the soil properties in Krishna western delta eco region in Guntur district of Andhra Pradesh. A total of 231 soil samples from 77 locations in three depths *viz.,* 0-15, 15-30 and 30-60 cm were collected for assessment. Soil properties *viz.,* texture, pH, EC_2, ECe, CEC, ESP, organic carbon, water soluble, exchangeable ion composition and available N, P and K were analyzed. Half of the soils of the study area are with clay loam texture. Soil reaction is mostly moderately alkaline, non-saline, none to slightly alkali hazard at all three depths of the soil. The organic carbon is low (<0.5%) with 42, 91 and 100 per cent samples at 0-15, 15-30 and 30-60 cm depth of soil respectively. Available nitrogen is low and available phosphorus is high at all the three depths of the soil. High available potassium was with the half of the soils at 0-15 and 15-30 cm depths of the study area. The study area consists of 87.01 per cent good soil, 9.09 per cent saline soil, 3.90 per cent saline alkali soil at 0-15 cm depth and 72.7 per cent good soil, 18.2 per cent saline soil, 9.09 per cent saline alkali soil at 15-30 and 30-60 cm depth of the soil for cultivation.

Keywords: Soil properties, Krishna western delta ecosystem, CEC, ECe, ESP

Krishna western delta ecosystem falls under eastern coastal plain, hot sub-humid to semi-arid eco region in Guntur district of Andhra Pradesh. The soils of the study area are covered with river borne alluvium and coastal sands in the area bordering to the coast. The thickness of alluvium varies from few meters to over 100m. The eco region is known for intensive cultivation of crops with the availability of good quality canal water. The soil resources are under severe stress due to lack of suitable management practices, indiscriminate use of input resources and also the salt laden winds and rains along the sea coasts carry oceanic salts in quantities sufficient to cause salinization in coastal areas. The coastal regions are also exposed to the risk of progressive salinization of land due to process like storms, cyclones, tidal surges, flooding (Rao et al 2014). In coastal areas of Andhra Pradesh, many farmers are practicing aquaculture by storing brackish water, drawn from the sea through creeks and drains, in big tanks for raising high value prawns this may leads soil degradation in adjacent agricultural soils. Hence, a study was conducted to assess the soil properties and their extent of degradation interms of salinity and alkalinity in Krishna western delta eco region.

MATERIAL AND METHODS

A total of 231 Soil samples were collected from 0-15 cm, 15-30 cm and 30-60 cm with geo-reference at 77 locations by taking location co-ordinates at Ponnur, Amarthalur, Tenali, Kolluru, Karlapalem, Duggirala, Nizampatnam and Bapatla mandals between 15.8577 and 16.2579 of Northern latitudes and 80.4727 and 80.8310 Eastern longitudes occupies northeastern part of Guntur district in Krishna western delta ecosystem in Andhra Pradesh. The collected samples were air dried under shade in room temperature. Roots and other debris present in soil samples were removed before grinding the soil samples using wooden pestle and mortar to pass through 2 mm sieve. Processed soil samples were analyzed for various physico-chemical and ionic compositions for characterization of salt affected soils. Saturation paste extract (1:1) was obtained by following standard procedure given by Gupta et al (2019) and same was used for analysis of water soluble ionic composition, pH in saturated paste extract and in 1: 2 soil water suspension was determined potentiometrically by using pH meter (Jackson 1973). Electrical conductivity was determined by using Conductivity Bridge (Willard et al 1974). Chlorides (Mohr's method), carbonates and bicarbonates (double indicator method) and calcium and magnesium (versenate method) were determined by adopting the procedures given by Richards (1954). Similarly the sodium and potassium were determined by using flame photometer (Richards 1954). Particle size analysis has been carried out through international pipette method (Piper 1966) using sodium hexametaphosphate as a dispersing agent. The textural class was determined by using USDA textural triangle. The cation exchange capacity (CEC) was determined by saturating a known weight of the soil with 1.0 N sodium acetate (pH 8.2), the excess sodium acetate was leached with 95% ethanol. The adsorbed sodium was displaced with 1.0 N neutral ammonium acetate. The concentration of the sodium in the lechate was determined by aspirating directly into the flame photometer. The CEC was calculated and was expressed in cmol (p^+) kg^{-1} soil (Bower et al 1952). The Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) were calculated by using the formulas given by Richards (1954) such as SAR = Na/ $((Ca^{2+}+Mg^{2+})/2)^{0.5}$ and RSC = $(CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$. The Na^+, Ca^{2+} and Mg^{2+} are in meq L^{-1}. RSC, CO_3^{2-}, HCO_3^-, Ca^{2+} and Mg^{2+} are in meq L^{-1}. The exchangeable sodium percentage (ESP) of soils was computed by the following equation (CSSRI 2004).

$$ESP = \frac{\text{Exchangeable sodium (cmol}(p^+)\text{ Kg}^{-1}\text{ soil)}}{\text{Cation exchange capacity (cmol}(p^+)\text{ Kg}^{-1}\text{ soil)}} \times 100$$

The soils are classified based on physicochemical properties into various salt affected soils (Richards 1954).

Statistical analysis: Research data were analyzed in SPSS 20.0 using Pearson correlation coefficient matrix to know significant variations between the soil physicochemical properties. Descriptive statistics were calculated using Microsoft Excel (Microsoft, WA, USA) spread sheet.

RESULTS AND DISCUSSION

Characteristics of Soils

Grouping of soils based on texture: The texture of the soil varied with depth and space in the study area (Table 1). The soils at 0-15 cm depth are mostly clay loam (50.0%), followed by loamy sand (22.7%), sandy clay loam (11.0%), sand (11.0%). At 15-30 cm depth the soils are mostly clay loam (50.6%), followed by loamy sand (23.4%), sand (14.3%) sandy clay loam (9.1.0%). At 30-60 cm depth 7 textural classes were identified; the dominant soils are clay loam (45.5%), followed by sand (14.3%), loamy sand (13.0%), sandy clay loam (9.1%), sandy loam (9.1%), sandy clay (5.2%) and loam (3.9%). The variation in soil texture with space and depth might be due to translocation and transportation of clay and sand materials (Purandar and Naidu 2020)

Grouping of soils based onsoil reaction: Based on soil reaction (pH) the soils at 0-15, 15-30 and 30-60 cm depth were mostly slightly to strongly alkaline in reaction, with increase in depth the alkalinity of soil was increased (Table 2). This might be due to variation in soil solution ionic composition (Gupta et al 2019).

Grouping of soils based on electrical Conductivity (ECe): Based on 1:1 Saturated soil water extract, the electrical conductivity (ECe) of the soils of the study area are grouped into 4 classes *viz.,* Non saline, Slightly saline, Moderately saline and Very strongly saline (Table 3) at all the three depths. The dominance of soluble ions *viz.,* Ca^{+2}, Mg^{+2}, Na^+ and Cl^- in soil may contribute higher salinity of soil at different depths (Mandal et al 2018).

Grouping of soils based on Exchangeable Sodium per cent (ESP): Based on exchangeable sodium percentage

Table 1. Textural class of soil in Krishna western delta region

Textural class	No. of samples	Per cent of samples	No. of samples	Per cent of samples	No. of samples	Per cent of samples
	0-15 cm		15-30 cm		30-60 cm	
Sandy clay loam	11	13.6	7	9.1	7	9.1
Sandy clay	0	0.0	0	0.0	4	5.2
Clay loam	39	50.0	39	50.6	35	45.5
Sand	11	13.6	11	14.3	11	14.3
Loamy sand	18	22.7	18	23.4	10	13.0
Sandy loam	0	0.0	0	0.0	7	9.1
Loam	0	0.0	2	2.6	3	3.9

Table 2. pH and the respective reaction of soils

Reaction class	pH range	No. of samples	Per cent	No. of samples	Per cent	No. of samples	Per cent
		0-15 cm		15-30 cm		30-60 cm	
Neutral	6.6-7.3	18	22.73	11	13.64	4	4.55
Slightly alkaline	7.4-7.8	11	13.64	11	13.64	14	18.18
Moderately alkaline	7.9-8.4	35	45.45	39	50.00	39	50.00
Strongly alkaline	8.5-9.0	14	18.18	14	18.18	18	22.73
Very strongly alkaline	9.1-10.6	0	0.0	4	4.55	4	4.55

(ESP) the soils (Table 4) of the study area are classified into none to slightly alkali hazard (ESP<15) and slight to moderate alkali hazard (ESP 15-30) at 0-15, 15-30 and 30-60 cm depth, no evidence of moderate, high and extremely high alkali hazard was noticed. Sodic soils are developed due to the presence of sodium on exchangeable complex of soil at very few parts of the study area. The higher sodicity may cause ill drainage of soil. The lesser sodicity of soil might be due to dominance of Ca^{+2}, Mg^{+2}, Na^{+} and Cl^{-} ions rather than HCO_3^{-} and CO_3^{-2} ions in coastal areas (Shahid et al 2018).

Physical, Physico-Chemical, Chemical Properties of Soils

Soil texture: Sand was dominant in all the depths of soil followed by clay and silt. The clay content of soil increased with the depth Table 5.

Soil reaction: The soil reaction (pH in 1: 2 soil water suspension) ranged from 6.6-8.8, 6.6-9.8 and 6.7-9.8 at 0-15, 15-30 and 30-60 cm respectively (Table 5). With increase in depth of the soil the pH of soil increased, this might be due to the presence of soil organic carbon at surface may lower the pH of the soil due to release of some organic acids during decomposition (Dutta et al 2021).

Electrical conductivity: Electrical conductivity (1:2 soil water suspension) ranged from 0.1-6.9, 0.1-6.1 and 0.09-5.8 dS m^{-1} and electrical conductivity (1:1 saturated soil water extract) ranged from 0.4-29.6, 0.3-40, and 0.5-31.0 dS m^{-1},at 0-15, 15-30 and 30-60 cm depths respectively (Table 5). The relationship between EC_2 and ECe of soil at 0-15, 15-30 and 30-60 cm presented in Figure 1-3, respectively indicated that ECe of soil was 4 times higher than EC_2 at 0-15, 15-30 cm depth of soil indicated that maximum conductivity is with the surface layers. At 30-60 cm depth the soil ECe is 3.72 times

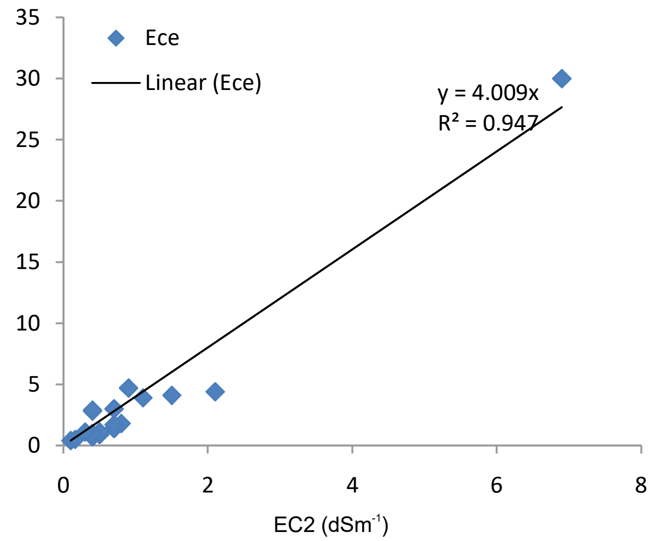

Fig. 1. Relationship between EC2 and ECe (0-15 cm)

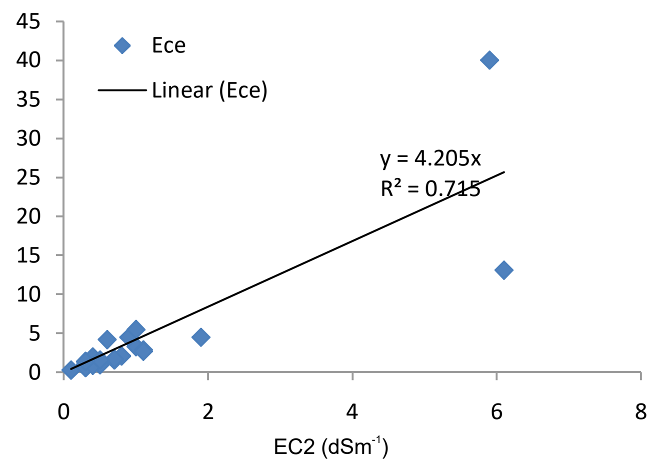

Fig. 2. Relationship between EC2 and ECe (15-30 cm)

Table 3. ECe (dSm^{-1}) and degree of salinity hazard in soils

Soil salinity class	Ece (dSm^{-1})	No. of samples	Per cent	No. of samples	Per cent	No. of samples	Per cent
		0-15 cm		15-30 cm		30-60 cm	
Non-saline	0-2	49	63.6	42	54.6	46	59.0
Slightly saline	2-4	14	18.2	14	18.2	11	13.6
Moderately saline	4-8	11	13.6	14	18.2	11	13.6
Strongly saline	8-16	0	0.0	4	4.6	7	9.0
Very strongly saline	>16	4	4.5	3	4.0	4	4.5

Table 4. ESP and degree of alkali hazard

Soil salinity class	Alkali hazard	No. of samples	Per cent	No. of samples	Per cent	No. of samples	Per cent
		0-15 cm		15-30 cm		30-60 cm	
Up to 15	None to slight	77	100	73	94.8	73	94.8
15-30	Slight to moderate	0	0.0	4	5.2	4	5.2

No evidence of moderate, high and extremely high alkali hazard at all the three depths of the study area higher than EC_2 indicate the lesser conductivity at lower depths. The salinity was decreased with the depth of the soils of the study area, this might be due to the capillary rise of salts at surface increased the conductivity of the soil at surface (Sharma and Chaudhari 2012).

Cation exchange capacity, ESP and organic carbon: Cation exchange capacity (CEC) ranged from 3.76-53.4, 3.28-58.3 and 2.13-60.66 cmol (p+) kg^{-1} soil. Exchangeable sodium percentage (ESP) ranged from 1.0-12.8, 1.12-16.87 and 0.95-16.95 and organic carbon ranged from 2.3 to 14.2, 2.2-5.8 and 1.9-4.8 g Kg^{-1} at 0-15, 15-30 and 30-60 cm depth of soil respectively (Table 5). The increased per cent of clay content might influence the cation exchange capacity of soil with the increased depth of the soil. ESP was increased with the depth. Soil organic carbon content was decreased with the depth of the soil.

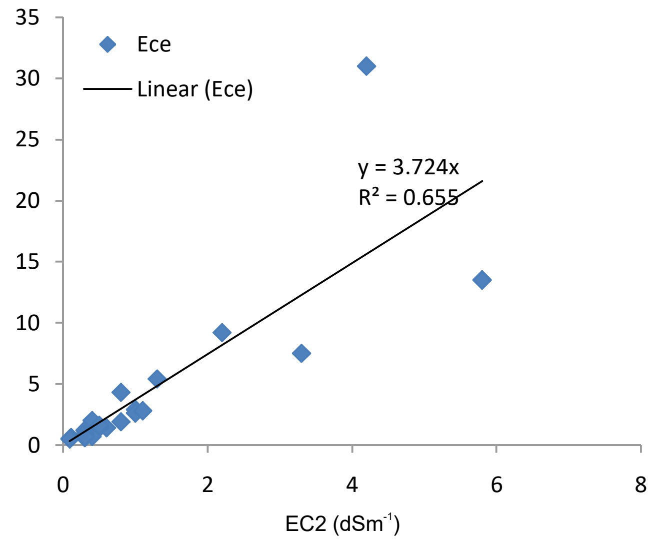

Fig. 3. Relationship between EC2 and ECe (30-60 cm)

Table 5. Physical, physico-chemical and chemical properties of soil

Parameter (me l^{-1})	0-15 cm Range	0-15 cm Mean	Standard deviation	Standard error	15-30 cm Range	15-30 cm Mean	Standard deviation	Standard error	30-60 cm Range	30-60 cm Mean	Standard deviation	Standard error
Sand (%)	34.64-90.64	56.8	21.5	2.45	36.64-90.64	56.5	22.11	2.52	36.64-90.64	56.74	21.7	2.47
Silt (%)	0-30.0	12.36	8.36	0.95	0.0-33.0	12.06	9.19	1.04	0.0-36.0	11.98	9.81	1.11
Clay (%)	9.36-59.4	30.82	16.79	1.91	9.36-58.36	31.34	17.33	1.97	9.36-59.36	31.2	17.15	1.95
pH_2	6.6-8.8	7.82	0.78	0.09	6.6-9.8	8.06	0.79	0.09	6.7-9.8	8.12	0.67	0.07
EC_2(dS m^{-1})	0.1-6.9	0.91	1.29	0.14	0.1-6.1	1.17	1.59	0.18	0.09-5.8	1.19	1.46	0.16
ECe (dS m^{-1})	0.4-29.6	3.08	5.62	0.64	0.3-40	4.27	7.75	0.88	0.5-31.0	4.16	6.35	0.72
CEC (cmol(p+) kg^{-1})	3.76-53.4	38.35	24.2	2.75	3.28-58.3	38.38	24.24	2.76	2.13-60.66	38.18	24.5	2.79
ESP	1.0-12.8	4.3	2.67	0.30	1.12-16.87	4.93	3.37	0.38	0.95-16.95	5.41	3.43	0.39
Organic carbon (%)	0.23-1.42	0.62	0.43	0.04	0.22-0.58	0.13	0.29	0.03	0.19-0.48	0.11	0.21	0.02
Water soluble ionic Composition (me L^{-1})												
CO_3^{2-}	0-0.6	0.05	0.17	0.01	0.0-0.4	0.01	0.07	0.01	0.0-0.0	0.0	0.0	0.0
HCO_3^-	0.4-6.6	2.56	1.59	0.18	0.0-4.4	1.78	1.03	0.11	0.0-6.0	1.74	1.22	0.13
Cl^-	1.6-301	22.75	57.65	6.57	0.8-298	31.13	62.19	7.08	1.2-334	31.9	65.2	7.43
Ca^{2+}	1.6-20.0	6.84	5.38	0.61	2.0-34.0	8.10	8.07	0.91	2.0-26.0	7.51	6.60	0.75
Mg^{2+}	0.8-24.4	4.32	4.85	0.55	1.2-46.0	7.07	11.03	1.25	0.4-33.2	6.66	8.58	0.97
Na^+	0.62-358	25.69	68.3	7.78	0.47-533	37.4	102	11.71	0.83-374	32.52	72.62	8.27
K^+	0.08-0.92	0.21	0.16	0.01	0.07-1.20	0.22	0.23	0.02	0.06-0.94	0.21	0.21	0.02
Exchangeable ionic composition (me/100 g soil)												
Ca^{2+}	1.6-21.6	11.4	7.0	0.79	0.8-24.4	11.8	7.55	0.86	1.2-25.6	11.76	7.68	0.87
Mg^{2+}	0.4-8.8	4.9	2.72	0.31	0.0-9.2	4.7	3.15	0.35	0.4-10.0	5.05	3.23	0.36
Na^+	0.2-4.02	1.41	1.21	0.13	0.17-4.30	1.61	1.35	0.15	0.15-5.97	1.79	1.54	0.17
K^+	0.03-1.26	0.46	0.36	0.04	0.03-1.01	0.35	0.27	0.03	0.02-0.95	0.33	0.27	0.03
Available major nutrients (kg ha^{-1})												
N	37.62-250	147	58.4	6.65	25.08-225	119	53.8	6.13	12.54-200	97.06	51.75	5.89
P	39.0-179	78.85	29.9	3.41	29.0-156	58.0	26.34	3.00	28.4-99.4	47.29	18.4	2.10
K	48.38-600	361	263	30.0	34.0-597	291	218	24.8	22.0-560	270	219	25.05

Table 6. Nutrient status of soil

Availability status	No. of samples	Per cent	No. of samples	Per cent	No. of samples	Per cent
	0-15 cm		15-30 cm		30-60 cm	
Organic carbon (g kg^{-1})						
Low	32	42	70	91	77	100
Medium	14	18	7	9	0	0
High	31	40	0	0	0	0
Available N						
Low	77	100	77	100	77	100
Available P						
High	77	100	77	100	77	100
Available K						
Low	13	17	23	30	20	26
Medium	23	30	14	18	25	32
High	41	53	40	52	32	42

Table 7. Soil types in salt affected areas of Krishna western delta region of Guntur district

Soil type	No. of samples	Per cent	No. of samples	Per cent	No. of samples	Per cent
	0-15 cm		15-30 cm		30-60 cm	
Good	67	87.01	56	72.7	56	72.7
Saline	7	9.09	14	18.2	14	18.2
Saline alkali	3	3.90	7	9.09	7	9.09

Water soluble ions: The dominance of Na^+ in water soluble ionic composition ranged 0.62-358, 0.47-533 and 0.83-374 meq L^{-1}, Cl^- ranged from 1.6-301, 0.8-298 and 1.2-334 meq L^{-1}, Mg^{+2} ranged from 0.8-24.4, 1.2-46.0, and 0.4-33.2 meq L^{-1}, Ca^{+2} ranged from 1.6-20.0, 2.0-34.0 and 2.0-26.0 meq L^{-1}, K+ ranged from 0.08-0.92, 0.07-1.20 and 0.06-0.94 meq L^{-1}, HCO_3^- ranged from 0.4-6.6, 0.0-4.4 and 0.0-6.0 meq L^{-1} and CO_3^{-2} ranged from 0.0-0.6, 0.0-0.4meq L^{-1} at 0-15, 15-30 and 30-60 cm depth of soil. Presence of Na^+, Mg^{+2} Ca^{+2}, Cl^- and HCO_3^- ions indicates the development of saline soils in the study area (Table 5). The salt laden winds and rains (sea sprays) along sea coasts carry oceanic salts along with them in quantities sufficient to cause salinization in coastal areas (Kumar and Sharma 2020).

Exchangeable ions: The exchangeable ions *viz.,* Ca^{+2} ranged from 1.6-21.6, 0.8-24.4 and 1.2-25.6 cmol (p+) kg^{-1}, Mg^{+2} ranged from 0.4-8.8, 0.0-9.2 and 0.4-10.0 cmol (p+) kg^{-1}, Na^+ ranged from 0.2-4.02 , 0.17-4.30 and 0.15- 5.97 cmol (p+) kg^{-1} and K^+ ranged from 0.03-1.26, 0.03-1.01 and 0.02-0.95 cmol (p+) kg^{-1} at 0-15, 15-30 and 30-60 cm depth of soil . The dominance of calcium and magnesium minimized the impact of sodium on exchangeable complex of soil (Table 5). Hence, very lesser area is occupied by sodic soils.

Available N, P and K: The available nitrogen ranged from 37.62-250, 25.08-225 and 12.54-200 kg ha^{-1}, Available P ranged from 39-179, 29-156 and 28.4-99.4 kg ha^{-1} and available K ranged from 43.38-600, 34.0-597 and 22.0-560 kg ha^{-1}. The lowest availability might be due to presence of sandy soils and highest might be due to clay loam soils of the study area (Table 5 & 6).

Soils of the study area: Based on the physico-chemical properties the soils are classified in to 3 categories (Table 6) *viz.,* good soil (87.01 %), saline (9.09 %) and saline alkali (3.90%) at 0-15 cm depth, good soil (72.7 %), saline (18.2 %) and saline alkali (9.09 %) at 15-30 and 30-60 cm depth (Table 7).

CONCLUSIONS

The Krishna western delta eco-region soils are under greater stress with lack of sufficient organic matter resulted low available nitrogen of soils. Around 40 per cent of the soils reporting slightly saline to very strongly saline in nature in all three depths of the soil. The alkali hazard is slight to moderate with 5.2 per cent at subsurface depth of soil, these soils are grouped in to saline and saline alkali. Hence, good agronomic management practices *viz.,* balanced fertilization, addition of organic and green manures, suitable reclamation, cereal-pulse crop rotation and selection suitable crops and varieties can sustain the long-term production of agri-ecosystem in the study area.

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