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Soil Properties and Land Use in Salt Affected Soils of Prakasam District, Andhra Pradesh, India

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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

A study was conducted to assess the soil properties, land use in salt affected areas of Prakasam district,Andhra Pradesh during 2021-22. A total of 240 soil samples in salt affected mandals were collected and were analysed for different physical, physico-chemical properties. The sandy clay loam texture is predominant (35.90%) followed by sandy loam (28.21%). pH_2 of soil varied from 7.2-11.0, ECe ranged from 0.3-58.0 dSm^{-1} ESP ranged from 0.9-57.0, CEC ranged from 3.5-56.6 c mol (p^+) kg^{-1}. The problem soils namely saline, saline alkali and alkali are present under various

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land use. A total of 460 farmers in salt affected areas and 460 farmers in non salt affected areaswere studied for livelihood options. The farmers are diversifying the livelihoods by practicing dairy, sheep and goat farming, Agroforestry, backyard poultry, orchards, products (leaf, trunk, fruits)of trees for various other purposes like coal preparation, firewood by utilizing predominant native vegetation in salt affected soils to secure their income for sustaining livelihoods.

Keywords: Salt affected soils; Prakasam district; ESP; livelihoods.

1. INTRODUCTION

"Prakasam district is located in Eastern coastal plain of hot sub humid to semiarid eco -region and lies in between 14^o 57' 00" and 16^o 17' 00" of Northern latitudes and 78^o 43'00" and 80^o 25' 00"Eastern longitudes occupies central part of Andhra Pradesh" (Fig. 1) [1]. "Prakasam has a total geographical area of 17,626 km^2. The district is bordered by Guntur district in North, east by Bay of Bengal with a coastal line of 102 km and on the South by Nellore and Kadapa districts, west by Kurnool district. The annual rainfall in the district is 798.6 mm through South-West and North-East monsoons. The maximum temperature varied 27.1^{0}C to 36.1^{o}C in summer. Minimum temperature varied 27.7^{0}C to 19.2^{0}C during winter. About 23.9 per cent of the total geographical area is covered by hills and forests. Another 8 per cent of the area has been put to non-agricultural uses. Sea water ingress is common along the coast, it increases salt content in coastal areas. 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 etc"., [2]. Many farmers in Andhra Pradesh's coastal regions engage in aquaculture, which involves holding brackish water—which is obtained from the sea through creeks and drains—in large tanks in order to raise premium prawns. Livelihoods of farmers mainly dependant on agriculture and allied components. Sharma and Choudhari [3] reported that "rural migration from salt affected soils will be minimized with alternate land use systems, Saline aquaculture, cultivation of salt tolerant crop varieties, agro forestry in coastal areas of India". Subbaiah et al. [4] reported that "salinity has a major impact on the livelihood of farmers". In this context a study was conducted to assess the soil properties, and livelihood options in salt affected soils of Prakasam district in Andhra Pradesh.

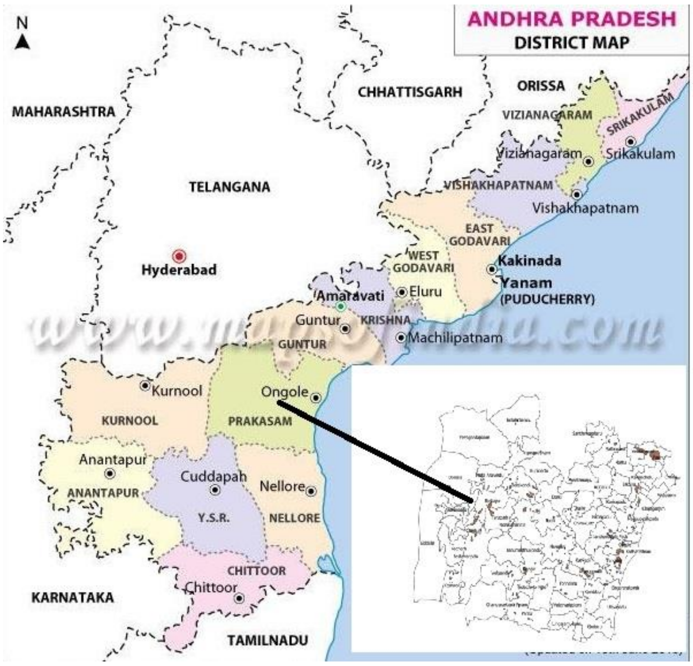

Fig. 1. District Location Map of Prakasam [1]

2. MATERIALS AND METHODS

A total of 240 Soil samples were collected from 0-30 cm with geo-reference by taking location co-ordinates at Kandukur, Martur, Ongole, Tangutur, Kothapatnam, Zarugumilli, Kanigiri, Santhanuthalapadu, Markapur, Donakonda, Ballikurava, Yeddanapudi, Parchur, Inkollu, Chinnaganjam, Nagaluppalapadu, Konakanamitta, Marripudi mandals (Fig. 2) of Prakasam district in Andhra Pradesh and 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 analysed 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. [5] 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 [6]. “Electrical conductivity was determined by using Conductivity Bridge” [7]. “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 [8]. “Similarly the sodium and potassium were determined by using flame photometer” [8]. “Particle size analysis has been carried out through international pipette method using sodium hexametaphosphate as a dispersing agent. The textural class was determined by USDA textural triangle” [9]. “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” [10].

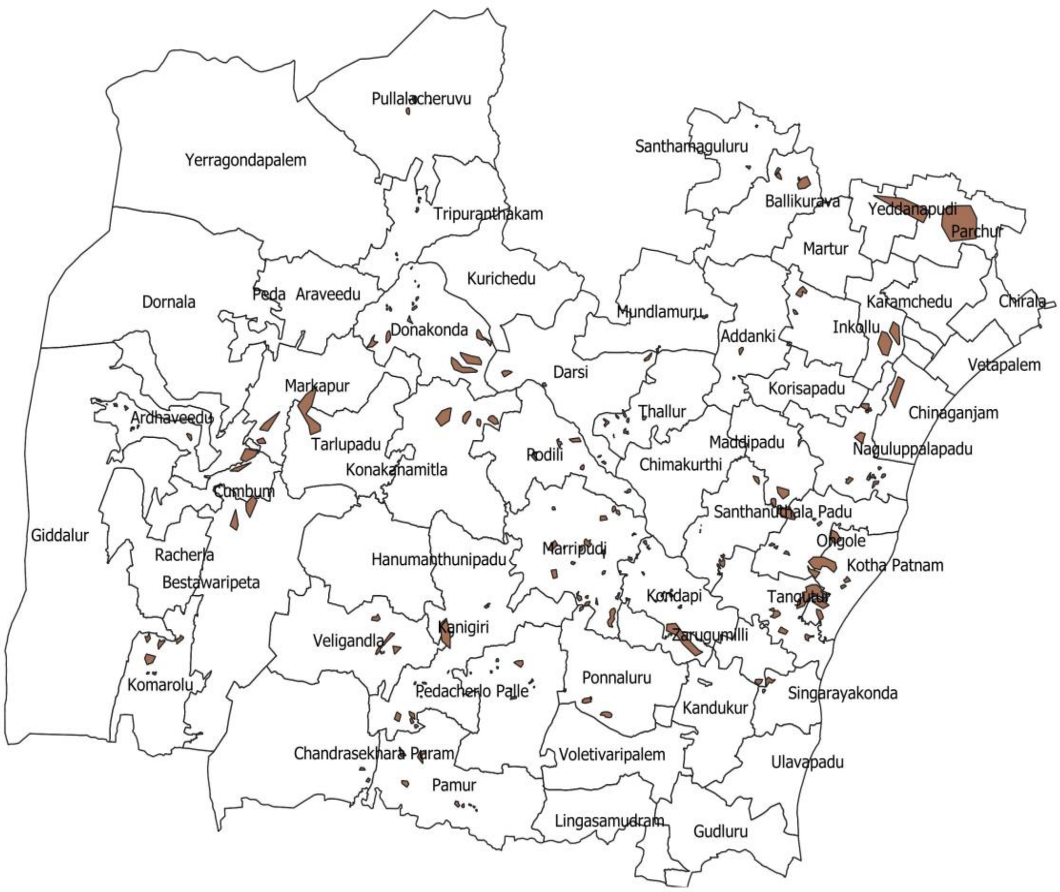

Fig. 2. Salinity points in Prakasam district

The Na^{+}, Ca^{2+}, Mg^{2+}, CO_3^{2-}, H CO_3^{-} are in meq L^{-1}. The exchangeable sodium percentage (ESP) of soils was computed by the following equation [11].

ESP= [Exchangeable sodium (cmol (p^{+}) Kg^{-1} soil)/Cation exchange capacity (cmol (p^{+}) kg^{-1} soil)]x 100

"The soils are classified based on physicochemical properties into various salt affected soils" [8]. "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" [9].

3. RESULTS AND DISCUSSION

3.1 Characteristics of Salt affected Surface soils

3.1.1 Texture

The soils of the study area (Table 1) are mostly sandy clay loam (35.90%), followed by Sandy loam (28.21%), Loam (17.95%), Clay loam (10.26%), Loamy sand (5.13%) and Sand (2.56%). Elevation of the study area differing at each and every location and hence, this might be the reason for distribution of different soils due to translocation and transport of clay and sand materials [12].

3.1.2 Soil reaction

Based on soil reaction (pH) the soils grouped into 5 classes (Table 2.) *viz.,* Neutral (2.56%), Slightly alkaline (7.69%), Moderately alkaline (38.46%), Strongly alkaline (12.82%) and very strongly alkaline (38.46%) this might be due to variation in soil solution ionic composition [5] due to variation in soil texture, composition and land use

3.1.3 Electrical conductivity

Based on Saturated soil water extract electrical conductivity (ECe) the soils of the study area are grouped into 5 classes (Table 3)*viz.,* Non saline (38.46%), Slightly saline (10.26%), Moderately saline (15.38%), Strongly saline (20.51%) andVery strongly saline (15.38%). More than half the soils of the study area are under moderate to severe salinity, this might be due to ingress of sea water along the coast increases salt content in coastal areas and capillary rise due to secondary salinization [2]. The dominance of soluble ions viz., Ca^{+2}, Mg^{+2}, Na^{+} and Cl^{-} in soil may contribute higher salinity [13]. The relationship between EC_2 (1:2 soil water suspension) and ECe (1:1 saturated soil water extract) was shown in Fig. 3 indicated that the ECe of soil is 3.041 times higher than the EC_2 of soil. Gupta et al. [5] reported that ECe should be more than 3 to 4 times higher than the EC_2 of soil. Subbaiah et al [14] also reported that ECe of the soil was 3.3 times higher than the EC2 in soils of YSR Kadapa region.

Table 1. Textural class of soil in salt affected Soils of Prakasam district

S.No.	Textural Class	No.of samples	Per cent of samples
1	Sandy loam	68	28.21
2	Loam	43	17.95
3	Sandy clay loam	86	35.90
4	Sand	6	2.56
5	Loamy sand	12	5.13
6	Clay loam	25	10.26

Table 2. pH and the respective reaction of soils

Reaction class	pH range	No. of samples	Per cent
Neutral	6.6-7.3	6	2.56
Slightly alkaline	7.4-7.8	18	7.69
Moderately alkaline	7.9-8.4	92	38.46
Strongly alkaline	8.5-9.0	31	12.82
Very strongly alkaline	9.1-10.6	92	38.46

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

Soil salinity class	ECe (dSm^{-1})	Surface soils (0-30 cm)	
		No. of samples	Per cent
Non-Saline	0-2	92	38.46
Slightly saline	2-4	25	10.26
Moderately saline	4-8	37	15.38
Strongly saline	8-16	49	20.51
Very strongly saline	>16	37	15.38

3.1.4 Physical, physico-chemical properties of soils

The physical and physico-chemical properties of soils of the study area are presented in Table 4. Sand was dominant (58.83%) ranged from 32.64-90.64 per cent, followed by Clay ranged from 9.4-42.4 per cent (22.40 %) and Silt ranged from 0-40.0 per cent (18.77%) in the soils. The soil reaction (pH in 1: 2 soil water suspension) ranged from 7.2-11.0, electrical conductivity (1:2 soil water suspension) ranged from 0.12-24.0 dS m^{-1} and, electrical conductivity (1:1 saturated soil water extract) ranged from 0.3-58.0 dS m^{-1}, Cation exchange capacity (CEC) ranged from 3.5-56.6 cmol (p+) kg^{-1} soil, Exchangeable sodium percentage (ESP) ranged from 0.9-57.0 and organic carbon ranged from 2.7 to 15.0 g Kg^{-1}. The dominance of Na^+ ranged 0.65-312 meq L^{-1} (67.67), Cl^- ranged from 0.8-900 meq L^{-1} (96.25) , Mg^{+2} ranged from 0.4-290 meq L^{-1} (19.41) Ca^{+2} ranged from 1.2-240 meq L^{-1} (29.16), HCO_3^-(2.16 meq L^{-1}) and CO_3^{-2} (0.56) ions were observed. Presence of Na^+, Mg^{+2} Ca^{+2}, Cl^- and HCO_3^- ions indicates the development of saline soils in the study area [15]. The salt laden winds and rains (sea sprays) along sea coasts carry oceanic salts along with them in quantities sufficient to cause salinisation in coastal area.

Table 4. Physical, physico-chemical properties of soil in salt affected areas of Prakasam District

Parameter	Surface (0-30 cm)		Standard deviation	Standard error
	Range	Mean		
Sand (%)	32.64-90.64	58.83	12.84	0.82
Silt (%)	0-40.00	18.77	8.72	0.56
Clay (%)	9.4-42.4	22.40	9.51	0.61
pH_2	7.2-11.0	8.79	0.95	0.06
EC_2(dS m^{-1})	0.12-24.0	3.09	4.83	0.31
ECe (dS m^{-1})	0.3-58.0	10.39	14.66	0.94
CEC (cmol(p+) kg^{-1})	3.5-56.6	24.2	14.14	0.91
ESP	0.9-57.0	9.15	13.05	0.84
Organic carbon(mg Kg^{-1})	0.27-1.5	0.51	0.40	0.02
Water soluble ionic Composition (me L^{-1})				
CO_3^{2-}	0-20.4	0.56	3.18	0.20
HCO_3^-	0-7.8	2.16	2.10	0.13
Cl^-	0.8-900	96.25	187	12.09
Ca^{2+}	1.2-240	29.16	56.02	3.61
Mg^{2+}	0.4-290	19.41	49.92	3.22
Na^+	0.65-312	67.67	86.93	5.61
K^+	0.1-0.9	0.37	0.20	0.01
Exchangeable ionic composition (me/100 g soil)				
Ca^{2+}	6.4-26.4	14.80	4.53	0.29
Mg^{2+}	0-12.00	3.15	3.03	0.19
Na^+	0.2-22.02	2.27	3.61	0.23
K^+	0.03-1.32	0.41	0.30	0.01
Available major nutrients (kg ha^{-1})				
N	25.4-539	95.53	89.17	6.22
P	24-155	66.00	29.78	1.9
K	80-500	211	203	13.11

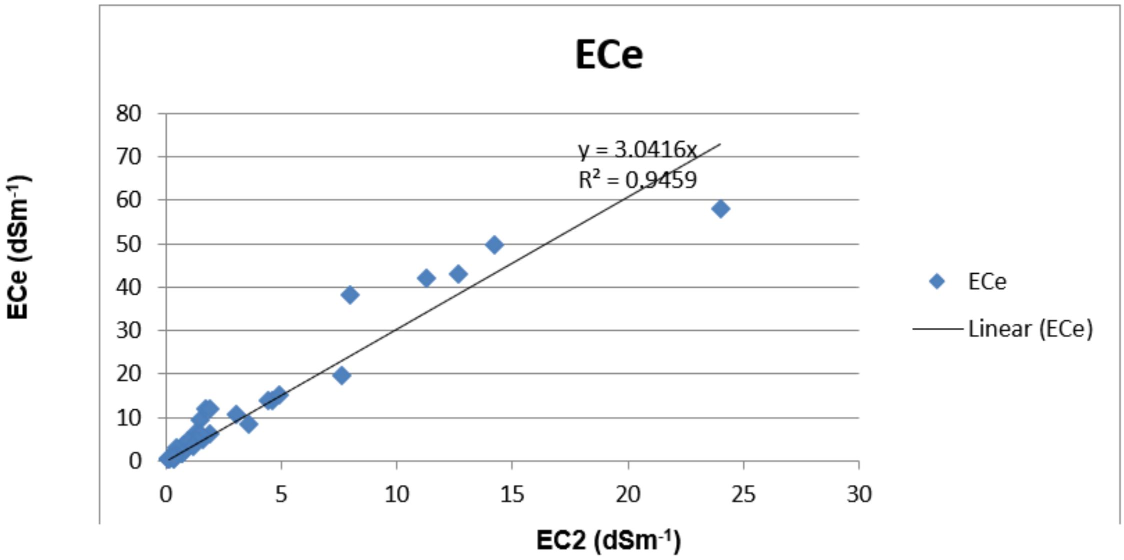

Fig. 3. Relationship between EC_2 and ECe

The exchangeable ions viz., Ca^{+2} ranged from 6.4-26.4 cmol (p+) kg^{-1}(14.80), Mg^{+2} ranged from 0-12.0 cmol (p+) kg^{-1} (3.15) , Na^{+} ranged from 0.2-22.02 cmol (p+) kg^{-1} (2.27) and K^{+} ranged from 0.03-1.32 cmol (p+) kg^{-1} (0.37). The dominance of calcium and magnesium minimized the impact of sodium in exchangeable complex of soil. Hence, very lesser area is occupied by sodic soils.

The available Nitrogen ranged from 25.4-539 kg ha^{-1}(95.53), Available P ranged from 24-155 kg ha^{-1} (66.0) and available K ranged from 80-500 kg ha^{-1} (211).

3.1.5 Exchangeable Sodium per cent (ESP)

Based on Exchangeable sodium percentage (ESP) the soils are grouped in to 5 classes (Table 5.) viz., none to slight alkali hazard (82.05%), Slight to moderate alkali hazard (10.26 %), Moderate to high alkali hazard (2.56 %), High to very high alkali hazard (5.13%). Sodic soils are developed due to the presence of sodium in exchangeable complex of soil at some 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 [5].

3.1.6 Soils of the Study area

Based on the physico-chemical properties of soil [5] the soils are classified in to 4 categories (Table 6) *viz.,*Good soil (46.15%), Saline (28.21%), Alkali (2.56%) and Saline alkali (23.08%). More than fifty per cent soils are problematic for cultivation in the study area of Prakasam district. Subbaiah et al. [4] reported that salinization has strong implications on socio –economic aspects, soil salinization decline the agricultural production and income of the farmers. Hence, Famer's are diversifying the livelihoods in problematic soil areas other than agriculture for sustainable income. "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" [14].

Table 5. ESP and degree of alkali hazard

Approximate ESP	Alkali hazard	No. of samples	Per cent
Up to 15	None to slight	197	82.05
15-30	Slight to moderate	25	10.26
30-50	Moderate to high	6	2.56
50-70	High to very high	12	5.13
>70	Extremely high	0.0	0.0

Table 6. Soil types in Salt affected areas of Prakasam district

S.No.	Problem soil	No.of samples	Per cent
1	Good	111	46.15
2	Saline	68	28.21
3	Alkali	6	2.56
4	Saline alkali	55	23.08

3.1.7 Land use

"Farmers in salt affected soils practiced sheep & goat rearing in addition to agriculture, followed by dairy, agroforestry plants, backyard poultry, orchards, Coal preparation, Fire wood, Tamarind leaf collection, Saline aquaculture, Products (toddy, leaf baskets, trunk and fruits) of Palmyra and sugar date palm. The livelihood diversification is more, this indicates that the farmers practiced alternate livelihood strategies to cope up with reduced crop returns" [4,16].

4. CONCLUSION

The soils are predominant with Na^{+}, Cl^{-}, Mg^{+2}, $Ca^{+2}$and HCO_3^{-} ions. This could be the reason for development of salt affected soils (54%). Salts are ruining the soils making them less productive and even non productive for many crops and in barren condition. The farmers' ability to diversify their sources of income is significantly impacted by the salinity. Nonetheless, in addition to farming with minimal or low input costs, some farmers are adopting coping techniques for livelihood stability by choosing other viable and alternate vocations within the current circumstances. Farmers could counteract the decreased or lost crop profits by diversifying. Farmers' migration to neighboring towns and cities is slowed down by these meager chances and their commitment to their home communities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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