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Characterization of salt affected soils of Vani Vilas Sagar command area, Hiriyur Taluk, Chitradurga district

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Abstract
Salt affected soils of Vani Vilas Sagar command area of Hiriyur taluk, Chitradurga district was investigated to Characterize based on different chemical properties for effective management to improve the soil health. The soils were found to be slightly to strongly alkaline in reaction with pHs ranging from 7.04 to 9.11. The soil salinity ECe ranged from 2.00 to 7.30 dS m^{-1} indicating strongly saline nature. Organic carbon content was low to medium ranging from 1.80 to 6.9 g kg^{-1}. Available nitrogen content was low to medium (188.16 to 480.2 kg ha^{-1}), available phosphorus content was medium in range from 26.94 to 48.97 kg ha^{-1}. The soils were high in available potash with values ranging from 287.64 to 519.32 kg ha^{-1} and available sulphur was above critical limit indicating higher sulphur availability 30.5 to 48.00 mg kg^{-1}, The contents of exchangeable cations were found to be in the order of Ca^{+2} >Mg^{+2} >Na^{+}. Thus exchangeable calcium was found to be dominant cation on exchange complex and it varied from 8.2 to 21.8 cmol (p^{+}) kg^{-1} followed by magnesium and sodium ranged from 2.73 to 7 cmol (p^{+}) kg^{-1} and 2.25 to 5.48 cmol (p^{+}) kg^{-1}, respectively. The free $CaCO_3$ content of surface soil samples were varied between 10.8 percent and 27 percent. While zinc was observed to be below the critical level, but the other micronutrients namely iron, copper, and manganese were found to have surpassed their critical limits in soils. Exchangeable sodium percentage of the soils ranged from 10.67 to 20.67 percent, when ESP more than ten in black soil it is sufficient to cause problem to soil. Sodium Adsorption Ratio (SAR) ranged between 7.97 to 17.37 $(meq/l)^{1/2}$ and RSC from 5.28 to 9.33 meq l^{-1}. Based on these parameters it was observed that 64.6 percent soil samples belongs to saline soil category, 19.5 percent soil samples under alkaline soil and 14.6 percent soil samples fall under normal to slightly saline soil category.

Keywords: Vani Vilas, pHs, ECe, ESP, SAR, RSC

Introduction
The key contributors to desertification worldwide are soil salinity and alkalinity. Improved soil structure and a dramatic decline in soil permeability to air are caused by an increase in Na^{+} concentration in the soil exchange complex. It also inhibits the processes that cause salt to be displaced by water and roots (US Salinity Laboratory Staff, 1954). They are most common in areas with precipitation-to-evaporation ratios of 0.75 or less, as well as in low, flat areas with high water tables that may be subject to seepage from higher elevations. The fundamental minerals in rocks and parent materials weather, and this process is where most of the soluble salts in soils come from. Calcium sulphate accumulations (gypsic horizon) may develop close to the surface in arid climates (annual precipitation of less than 25 cm), a saline environment may be created at the soil's surface by this moderately soluble mineral. However, most salts are transferred to a developing salt-affected soil as dissolved ions with water. From higher elevations to lower elevations, and from wetter soil zones to drier soil zones, the salt-containing water travels over a landscape. Evaporation eventually causes the water to disappear. The dissolved salts, however, are unable to evaporate and consequently, they are abandoned and allowed to build up in the soil of both irrigated and non-irrigated landscape (Brady and Weil, 2008) [2].

Salt-affected soils develop when dissolved minerals in water accumulate and change status as water is moved from the soil. Soluble salts are deposited in the soil when water evaporates and gradually accumulate with time to form saline soils. Sodic soils then develop when the soluble salts are leached and/or when divalent cations are precipitated out of the exchange complex followed by the corresponding increase in sodium ions. If leaching is insufficient, the salt-affected soils remain predominantly saline (FAO, 1984) and also develop as a consequence of

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changes in the local water balance, which are typically brought about by human activity through an increase in the input of salt-bearing water relative to drainage water output.
Nearly 147 million ha of land is subjected to soil degradation, including 94 million ha from water erosion, 23 million ha from salinity/alkalinity/acidification, 14 million ha from water-logging/flooding, 9 million ha from wind erosion and 7 million ha from a combination of factors due to different forces.
Out of 329 million hectares of total geographical area in India, the arid and semiarid zones occupy more than one-third of the area (127.4 m ha) and the total salt affected area is 6.74 m ha, saline soils occupy 44% (2.95 m ha) area covering 12 states and one Union Territory, while sodic soils occupy 47% (3.79 m ha) area in 11 states. The maximum salt affected soils are in Gujarat (2.22 m ha) followed by Uttar Pradesh (1.37 m ha).
A estimate states that salinization and/or alkalization, which are caused by poor drainage, ineffective use of the water resources available, and socio-political factors, harm 50% of the canal-irrigated regions. Vani Vilas sagar dam was constructed in Hiriyur taluk of Chitradurga district, Karnataka during 1906, to provide irrigation for parts of Hiriyur and Challakare taluks. During initial years the area was occupied by paddy and sugarcane and due to monsoon vagaries the storage capacity pattern also decreased and the cropping pattern also got changed. Due to alkaline nature of Vani Vilas sagar irrigation water, the soils which are irrigated have gradually become sodic and another reason is inadequate drainage. Around 50,000 ha of salt affected area is present in Chitradurga district out of which 30,000 ha is present in Hiriyur taluk alone (Chitradurga chapter IV). Hence, it was felt therefore necessary to study on Characterization of salt affected soils of Vani Vilas command area of Hiriyur taluk, Chitradurga district.

Materials and Method

The present investigation was carried out by identifying the salt affected soils of Hiriyur through survey. In order to characterize Vani Vilas Sagar command area soils, soil samples were collected from 30 villages at 0-15 cm depth on random basis. A total of 82 samples were analyzed for characterization. Hiriyur taluk is located at 13.95° N and 76.62° E and it has an altitude of 630 meters above mean sea level. It is located in the midst of the central dry zone IV of Karnataka.
The climate of the study area is tropical climate with maximum temperature of 38 °C in the month of April and minimum temperature of 19 °C in the month of December and annual average relative humidity in the study area is 85 percent. Rainy period commences from last week of May and continues up to the end of October. The average rainfall in the study area is 590 mm.
The collected soil samples were analysed for various chemical characteristics, as per the standard procedures for chemical properties such as Soil reaction (pHe), Electrical conductivity (ECe), Organic carbon (Walkley and Black, 1934) [19], available nitrogen by Subbaiah and Asija (1956) [20], available P_2O_5 in the soil was extracted by Olsen extractant (0.5 M $NaHCO_3$) as described by Jackson, 1973 [6] and the available K_2O was extracted by using neutral normal ammonium acetate and the content was determined by aspirating the extract into flame photometer (Jackson, 1973) [6], available sulphur (Black, 1965), Exchangeable Sodium Percentage (ESP), Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonates (RSC) (Jackson, 1973) [6] were also calculated.
The soils of the present investigation of Vani Vilas command area of Hiriyur taluk have classified according to the salinity and alkalinity indices (FAO/UNESCO 1974) (Table 1).

Results

The data on different chemical properties of salt affected soils of Vani Vilas Sagar command area was presented in table 2, 3, 4 and 5. The total soil samples were sorted into 3 groups based on ECe values i.e., soil samples having ECe 2 to 4 dS m^{-1}, 4 to 6 dS m^{-1} and above > 6 dS m^{-1}.

Soils having electrical conductivity 2 to 4 dS m^{-1}

The data on pHs varied from 7.04 to 9.11, ECe 2.0 to 3.9 dS m^{-1}, organic carbon 2.10 to 6.9 g kg^{-1}, available N, P_2O_5, K_2O varied from 206.32 to 480.2 kg ha^{-1}, 30.75 to 46.12 kg ha^{-1}, 364.24 to 517.44 kg ha^{-1} and available sulphur from 30.75 to 47.75 mg kg^{-1}, with mean values of pHs 7.87, ECe 3.11 dS m^{-1}, organic carbon 3.94 g kg^{-1}, available N 313.37 kg ha^{-1}, P_2O_5 38.12 kg ha^{-1}, K_2O 434.75 kg ha^{-1} and available sulphur 40.14 mg kg^{-1} (Table 2).
A perusal of data on exchangeable cations (Table 3) such as Ca^{+2}, Mg^{+2}, Na^{+} noticed on the exchangeable complex of soil with a range of 8.70 to 18.80, 3.0 to 7.0, 2.25 to 5.48 cmol (p^{+}) kg^{-1}. Free $CaCO_3$ content ranged from 10.8 percent to 13.8 percent. The mean values of exchangeable cations such as Ca^{+2}, Mg^{+2}, Na^{+} and free $CaCO_3$ were 14.36, 4.3, 3.66 cmol (p^{+}) kg^{-1} and 12.63 percent, respectively.
The results indicated that DTPA extractable Fe, Cu, Zn and Mn content ranged from 1.54 to 5.74, 0.69 to 4.45, 0.28 to 1.63 and 2.58 to 11.76 mg kg^{-1}, with mean values of 3.62, 2.3, 0.67, 5.62 mg kg^{-1} respectively (Table 4).
Water soluble cations like Na^{+} and sum of Ca^{2+} & Mg^{2+} were ranged from 2.37 to 9.19 me l^{-1} and 0.12 to 1.46 me l^{-1} with the mean values of 5.94 and 0.67 me l^{-1}, respectively. Anions like carbonates, bi-carbonates varied from Nil to 0.6 and 7.68 to 8.86 me l^{-1}, with mean values of 0.03, 8.15 me L^{-1}, respectively (Table 5). SAR ranged from 8.71 to 16.28 $(meq/l)^{1/2}$, ESP ranged from 11.56 to 19.63 percent and RSC from 6.96 to 9.32 me l^{-1} with the mean values of 10.79 $(meq/l)^{1/2}$, 13.87 percent and 7.51 me l^{-1}, respectively.

Soils having electrical conductivity 4 to 6 dS m^{-1}

The data on pHs varied from 7.15 to 8.98, ECe 4.0 to 5.9 dS m^{-1}, organic carbon 1.9 to 6.6 g kg^{-1}, available N, P_2O_5, K_2O varied from 206.32 to 439.04 kg ha^{-1}, 28.75 to 48.97 kg ha^{-1}, 287.64 to 519.32 kg ha^{-1} and available sulphur from 30.5 to 48 mg kg^{-1}, with mean values of pHs 8.00, ECe 4.98 dS m^{-1}, organic carbon 3.98 g kg^{-1}, available N 315.44 kg ha^{-1}, P_2O_5 39.16 kg ha^{-1}, K_2O 422.59 kg ha^{-1} and available sulphur 39.63 mg kg^{-1} (Table 2).
A perusal of data on exchangeable cations (Table 3) such as Ca^{+2}, Mg^{+2}, Na^{+} noticed on the exchangeable complex of soil with a range of 8.2 to 20.80, 2.73 to 5.7, 2.32 to 5.12 cmol (p^{+}) kg^{-1}. Free $CaCO_3$ content ranged from 11 percent to 27 percent. The mean values of exchangeable cations such as Ca^{+2}, Mg^{+2}, Na^{+} and free $CaCO_3$ were 14.18, 4.27, 3.67 cmol (p^{+}) kg^{-1} and 14.28 percent, respectively.
The results indicated that DTPA extractable Fe, Cu, Zn and Mn content ranged from 1.37 to 7.25, 0.69 to 4.87, 0.33 to 1.72 and 2.98 to 14.46 mg kg^{-1}, with mean values of 4.07, 2.8,

0.78, 5.97 mg kg^{-1} respectively (Table 4).

Water soluble cations like Na^+ and sum of Ca^{2+} & Mg^{2+} were ranged from 1.95 to 9.27 me l^{-1} and 0.12 to 1.37 me l^{-1} with the mean values of 6.01 and 0.67 me l^{-1}, respectively. Anions like carbonates, bi-carbonates varied from Nil to 1.2 and 5.97 to 9.76 me l^{-1}, with mean values of 0.06, 7.98 me L^{-1}, respectively (Table 5). SAR ranged from 7.97 to 16.58 $(meq/l)^{1/2}$, ESP ranged from 10.67 to 19.92 percent and RSC from 5.28 to 9.33 me l^{-1} with the mean values of 10.77 $(meq/l)^{1/2}$, 13.88 percent and 7.38 me l^{-1}, respectively.

Soils having electrical conductivity >6 dS m^{-1}

The data on pHs varied from 7.22 to 8.87, ECe 6.0 to 7.3 dS m^{-1}, organic carbon 1.80 to 6.60 g kg^{-1}, available N, P_2O_5, K_2O varied from 188.16 to 427.2 kg ha^{-1}, 26.94 to 47.26 kg ha^{-1}, 298.62 to 510.45 kg ha^{-1} and available sulphur from 30.75 to 45.5 mg kg^{-1}, with mean values of pHs 8.19, ECe 6.45 dS m^{-1}, organic carbon 3.86 g kg^{-1}, available N 305.16 kg ha^{-1}, P_2O_5 35.30 kg ha^{-1}, K_2O 412.46 kg ha^{-1} and available sulphur 38.34 mg kg^{-1} (Table 2).

A perusal of data on exchangeable cations (Table 3) such as Ca^{+2}, Mg^{+2}, Na^+ noticed on the exchangeable complex of soil with a range of 9.86 to 21.80, 3.3 to 5.8, 2.82 to 4.94 cmol (p^+) kg^{-1}. Free $CaCO_3$ content ranged from 11 percent to 18.4 percent. The mean values of exchangeable cations such as Ca^{+2}, Mg^{+2}, Na^+ and free $CaCO_3$ were 15.26, 4.45, 3.98 cmol (p^+) kg^{-1} and 15.64 percent, respectively.

The results indicated that DTPA extractable Fe, Cu, Zn and Mn content ranged from 0.96 to 5.66, 0.79 to 5.34, 0.18 to 1.21 and 2.07 to 12.6 mg kg^{-1}, with mean values of 3.39, 2.45, 0.70, 5.51 mg kg^{-1} respectively (Table 4).

Water soluble cations like Na^+ and sum of Ca^{2+} & Mg^{2+} were ranged from 3.30 to 9.04 me l^{-1} and 0.23 to 1.25 me l^{-1} with the mean values of 6.29 and 0.66 me l^{-1}, respectively. Anions like carbonates, bi-carbonates varied from Nil to 1.20 and 7.74 to 9.15 me l^{-1}, with mean values of 0.06, 8.23 me L^{-1}, respectively (Table 5). SAR ranged from 9.40 to 17.37 $(meq/l)^{1/2}$, ESP ranged from 12.36 to 20.67 percent and RSC from 6.80 to 9.22 me l^{-1} with the mean values of 11.10 $(meq/l)^{1/2}$, 14.23 percent and 7.63 me l^{-1}, respectively.

Based on these parameters it was observed that 64.6 percent soil samples belongs to saline soil category, 19.5 percent soil samples under alkaline soil and 14.6 percent soil samples fall under normal to slightly saline soil category (Fig. 1).

Discussion

Soil reaction (pHs)

Majority of the soil samples tested had pH_s that ranged from slightly alkaline to alkaline. In general, the possible reason for the high pH_s value in this command area might be accredited to the relative abundance of exchangeable bases such as calcium, magnesium and sodium gave a preponderance of hydroxyl ions over hydrogen ions. In addition to this, the areas have higher evapotranspiration than rainfall, the reason for the accumulation of basic cation at surface soil and its result for higher soil reaction. Alkalinity occurs in soils due to salt accumulation spurred upon with poor drainage. These results were in agreement with Singh *et al*. (2020) [18] reported in salt-affected soils of Nagaur district in Rajasthan and Daba *et al*. (2021) [3] in salt affected soils of Afar regional states of Ethiopia.

Electrical conductivity (EC_e)

Higher salinity in samples may be due to the presence of higher chlorides which contribute to higher ECe values. Higher evaporation during summer months also brings the soluble salts to the surface by capillary rise coupled with lack of natural drainage to leach down salts from the plant rooting zone resulted in the development of salt affected soils. Similar results were reported by Singh *et al*. (2020) [18] in salt-affected soils of Nagaur district in Rajasthan and Daba *et al*. (2021) [3] salt affected soils of Afar regional states of Ethiopia.

Organic carbon (OC)

The low OC can be attributed to continuous cultivation, removal of crops residues without return, effects of water and wind erosion which preferentially remove the soil colloids including the humidified organic fractions (Pharande and Kale 2019) [12]. The reason for low organic carbon content in these soils may be due to the prevalence of arid condition, where the degradation of organic matter occur at a faster rate coupled with little or no addition of organic manures and low vegetative cover on the fields, thereby leaving less chances of accumulation of organic carbon in the soils. Majority of the soils studied fall in the category of lower organic matter indicating poor soil fertility status. Similar findings were reported by Manimalika *et al*. (2017) [10] under salt affected soils of Srikalahasthi division of Chittoor district and Reddy *et al*. (2021) [15] in Nagarjuna Sagar left bank command area.

Available Nitrogen

Majority of soil samples showed medium status of available nitrogen which could be due to low amount of organic carbon as similar findings reported by Manimalika *et al*. (2017) [10] under salt affected soils of Srikalahasthi division of Chittoor district. The poor available nitrogen status of salt-affected soils is due to poor vegetative cover and high decomposition rate of organic matter, reported by Mahale *et al*. (2019) [9] in soils of Kal amba command area of Konkan region of Maharashtra. Nitrogen is the most limiting nutrient in black soils as its availability decreases due to fixation and volatilization losses, Reddy *et al*. (2021) [15].

Available phosphorus

Majority of soil samples showed medium status of available phosphorous which may be due to continuous application of phosphatic fertilizers to crops which resulted in build-up of phosphorus as efficiency of applied P is very low and it comes in available form very slowly, mainly due to the fixation as Ca-phosphate. The similar results are reported by Rezapour and Kalashypour (2019) [16] in saline-sodic soils of Urmia area and Reddy *et al*. (2021) [15] in soils of Nagarjuna Sagar command area.

Available potassium

Majority of soil samples showed higher status of available potassium. The higher content may be due to the predominance of potash rich micaceous and feldspar minerals present in parent rocks and the similar findings were reported by Reddy *et al*. (2021) [15] and Manimalika *et al*. (2017). Surface soil samples have high available potassium content which could be due to more intense weathering, release of K from organic residues, application of K fertilizers and upward translocation of potassium from lower depth along with capillary rise of ground water. (Pharande and Kale 2019) [12].

Available sulphur

Majority of the soil samples showed higher content of available sulphur which may be due to the presence of soluble salts present in the soil and addition of S through fertilizers like single super phosphate to meet the requirement of the growing plants. Similar results were reported by Manimalika *et al*. (2017) [10] in salt affected soils of Chittoor district of Andhra Pradesh, Singh and Prasad (2020) [18].

Exchangeable calcium, magnesium and sodium

The results further revealed that in all soil, the contents of exchangeable cations were found to be in the order of Ca^{+2} >Mg^{+2} >Na^{+}. Thus exchangeable calcium was found to be dominant cation on exchange complex. Usually calcium dominate the exchange complex in soils of semiarid regions due to greater adsorption strength of calcium on soil compared to other cations (Singh and Prasad 2020) [18]. Similar results were observed by Reddy *et al.* (2021) [15] in soils of Nagarjuna Sagar command area.

The exchangeable magnesium is the second dominant cation next to exchangeable calcium but higher than exchangeable sodium.

The low values of monovalents compared to divalents were due to dominance of parent materials like schist minerals rich in calcium and magnesium and also the monovalents are leached out easily than divalents because divalents are immobile compared to monovalents (Singh and Prasad 2020) [18].

Free $CaCO_3$

Accumulation of bases, especially Ca^{2+} and Mg^{2+} in semi-arid climates is known to favour calcification process leading to accumulation of free lime in soil reported by Pharande and Kale (2019) [12] in salt-affected soils of Mula Command Area.

DTPA extractable iron

The increase in pHs of the soil has lead to reduction in iron availability which may be due to oxidation of divalent cation to higher valent forms. At higher pH, iron may get precipitated as insoluble $Fe(OH)_2$. Similar findings were reported by Karajanagi *et al.* (2016) [7] in soils of Malaprabha command area and Reddy *et al*. (2021) [15] Nagarjuna Sagar command area.

DTPA extractable copper

The higher copper content of soils may be due to manuring, application of copper fungicides and release from parent materials reported by Rahul *et al*. (2019) [14] and Reddy *et al.* (2021) [15].

DTPA extractable zinc

The soils which are alkaline in reaction and rich in $CaCO_3$, zinc might be precipitated as hydroxides and carbonates under alkaline pH range. Therefore, their solubility and mobility may be decreased resulting in reduced availability similar results were reported by Ilavarasi *et al.* (2019) [5] and Reddy *et al*. (2021) [15].

DTPA extractable manganese

The irrigated cropping system, medium and heavy nature of the soils might have contributed for the accumulation of reducible and soluble forms of manganese in the surface layers and these results are in accordance with the findings of Karajanagi *et al.* (2016) [7] and Reddy *et al*. (2021) [15].

Water soluble cations and anions

Sodium was the dominant cation among all the soluble cations, as reported by Paulraj (2016) [11] in salt affected soils of Israna, Haryana and Qadir *et al*. (2006) [13] that is plants growing in sodic soils are associated with impaired uptake of Ca^{2+} as result of high concentrations of Na^{+} in soil solution.

Salts are brought along with the seepage water by lateral movement from the main canal situated at higher level. There was a marked difference in content of the carbonates and bi-carbonates with decrease in organic matter content which could be attributed to poor vegetation and rapid decomposition and mineralization under prevailing tropical and sub-tropical climatic condition as reported by Rezapour and Kalashypour (2019) [16] and Singh *et al*. (2020) [18].

Exchangeable Sodium Percentage (ESP)

The increase in sodium content and decrease in calcium and magnesium content due to precipitation, such a reaction is enhanced under semi-arid climatic condition with low partial pressure of CO_2 and low content of organic matter in soil might be the reason for high ESP values as reported by Daba *et al*. (2020) [22]. The relatively medium and heavier texture of the soils, soil erosion and low-lying area with poor drainage could be attributed as probable reasons for the higher ESP Zhao *et al*. (2018) [21].

Sodium Adsorption Ratio (SAR)

Impoundment of water in the weir causes shallow water table conditions and congestion of drainage, which has lead to evaporative concentration of salts in the area. As a result, high values of SAR have been obtained due to precipitation of Ca and Mg. Similar findings were reported by Lakshmi *et al.* (2019) [8] and Singh and Prasad (2020) [18].

Residual Sodium Carbonate (RSC)

Accumulation of sodium and total carbonates in the surface soil could be due to their higher solubility. It may also be due to high capillary evapo-transpiration rates in deep clayey soils as reported by Hailu *et al*. (2020) [4] in soils of irrigated lands at Raya Alamata district, northern Ethiopia and Lakshmi *et al.* (2019) [8].

Table 1: Classes of salt-affected soils (FAO/UNESCO 1974)

Factors affecting use	Degree of limitation			
	Slight (1) (Normal soils)	Moderate (2) (Saline soils)	Severe (3) (Sodic soils)	Extreme (4) (Saline-Sodic soils)
ECe	<4	≥4	<4	≥4
pHs	<8.5	<8.5	≥8.5	<8.5
SAR	<13	<13	≥13	≥13

Table 2: Soil pH, EC, organic carbon, avail. N, P_2O_5, K_2O and avail. sulphur content in soils of Vani Vilas Sagar command area, Hiriyur taluk, Chitradurga district

Soil Samples having EC_e		pH_s	EC_e	O.C	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. S
			dS m^{-1}	g kg^{-1}	Kg ha^{-1}			mg kg^{-1}
2 to 4 dS m^{-1}	Range	7.04 – 9.11	2.00 – 3.90	2.10 – 6.90	206.32 - 480.20	30.75 - 46.12	364.24 - 517.44	30.75 - 47.75
	Mean	7.87	3.11	3.94	313.37	38.12	434.75	40.14
	SD	0.61	0.76	1.32	76.75	4.37	50.13	4.44
4 to 6 dS m^{-1}	Range	7.15 – 8.98	4.00 – 5.90	1.90 – 6.60	206.32 - 439.04	28.75 - 48.97	287.64 - 519.32	30.50 - 48.00
	Mean	8.00	4.98	3.98	315.44	39.16	422.59	39.63
	SD	0.44	0.61	1.23	61.84	5.17	61.21	4.40
> 6 dS m^{-1}	Range	7.22 – 8.87	6.00 – 7.30	1.80 – 6.60	188.16 - 427.20	26.94 - 47.26	298.62 - 510.45	30.75 - 45.50
	Mean	8.19	6.45	3.86	305.16	35.30	412.46	38.34
	SD	0.47	0.39	1.36	78.70	5.61	67.10	4.28

Table 3: Exchangeable Ca, Mg, Na and free $CaCO_3$ content in soils of Vani Vilas Sagar command area, Hiriyur taluk, Chitradurga district

Soil Samples having EC_e		Exch. Ca	Exch. Mg	Exch. Na	$CaCO_3$
		cmol(p^+)/kg			%
2 to 4 dS m^{-1}	Range	8.70 – 18.80	3.00 – 7.00	2.25 – 5.48	10.80 – 13.80
	Mean	14.36	4.30	3.66	12.63
	SD	3.48	1.08	0.89	2.09
4 to 6 dS m^{-1}	Range	8.20– 20.80	2.73 – 5.70	2.32 – 5.12	11.00 – 27.00
	Mean	14.18	4.27	3.67	14.28
	SD	3.51	0.85	0.74	6.01
> 6 dS m^{-1}	Range	9.86 – 21.80	3.30 – 5.80	2.82 – 4.94	11.00 – 18.4
	Mean	15.26	4.45	3.98	15.64
	SD	3.39	0.66	0.60	4.56

Table 4: Micronutrient status in soils of Vani Vilas Sagar command area, Hiriyur taluk, Chitradurga district

Soil Samples having EC_e		Fe	Cu	Zn	Mn
		mg kg^{-1}			
2 to 4 dS m^{-1}	Range	1.54 – 5.74	0.69 – 4.45	0.28 – 1.63	2.58 – 11.76
	Mean	3.62	2.30	0.67	5.62
	SD	1.01	0.75	0.29	2.71
4 to 6 dS m^{-1}	Range	1.37 – 7.25	0.69 – 4.87	0.33 – 1.72	2.98 – 14.46
	Mean	4.06	2.80	0.78	5.97
	SD	1.30	0.88	0.28	2.37
> 6 dS m^{-1}	Range	0.96 – 5.66	0.79 – 5.34	0.18 – 1.21	2.07 – 12.60
	Mean	3.39	2.45	0.70	5.51
	SD	1.43	1.09	0.29	2.49

Table 5: Water soluble cations (Na^+ & $Ca^{2+} + Mg^{2+}$), anions (CO_3 & HCO_3), SAR, ESP and RSC content in soils of Vani Vilas Sagar command area, Hiriyur taluk, Chitradurga district

Soil Samples having EC_e		Na^+	$Ca^{2+} + Mg^{2+}$	CO_3	HCO_3	RSC	ESP	SAR
		meq/l					%	$(meq/l)^{1/2}$
2 to 4 dS m^{-1}	Range	2.37 – 9.19	0.12 – 1.46	0.00 – 0.60	7.68 – 8.86	6.96 – 9.32	11.56 – 19.63	8.71 – 16.28
	Mean	5.94	0.67	0.03	8.15	7.51	13.87	10.79
	SD	2.29	0.42	0.13	0.33	0.59	2.21	2.06
4 to 6 dS m^{-1}	Range	1.95 – 9.27	0.12 – 1.37	0.00 – 1.2	5.97 – 9.76	5.28 – 9.33	10.67 – 19.92	7.97 – 16.58
	Mean	6.01	0.67	0.06	7.98	7.38	13.88	10.77
	SD	1.71	0.31	0.23	0.76	0.88	1.75	1.62
> 6 dS m^{-1}	Range	3.30 – 9.04	0.23 – 1.25	0.00 – 1.20	7.74 – 9.15	6.80 – 9.22	12.36 – 20.67	9.40 – 17.37
	Mean	6.29	0.66	0.06	8.23	7.63	14.23	11.10
	SD	1.46	0.24	0.28	0.41	0.60	2.02	1.92

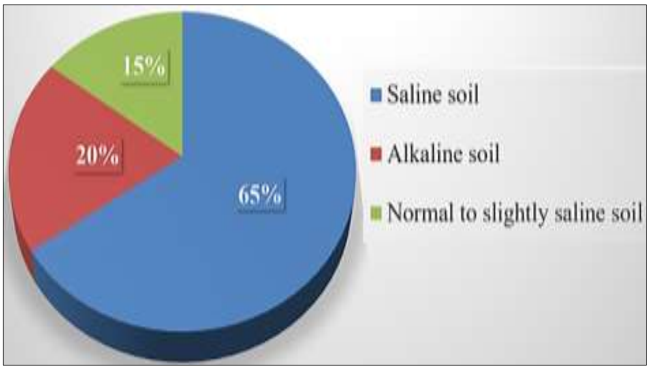

Fig 1: Proportion of soil samples in different salinity classes

Conclusion

The study of chemical properties of Vani Vilas Sagar command area Chitradurga soils revealed that the soil pHs indicated that majority of the samples were in the range of moderate to strongly alkalinity. Similarly the organic carbon content was low in majority of the soil samples indicating low fertility status. The available nutrient status revealed that nitrogen availability was low to medium, phosphorous was medium and potassium is higher in range. The Exchangeable sodium percentage of soils is good indicator of alkalinity and it ranged from 10.67 to 20.67 percent. Majority of the soils were alkaline in nature reflecting the necessity of reclamation measures to improve the soil health.

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