

Characterization of Salt Affected Soils of Visweswaraiah Canal Tract of Cauvery Command Area in Southern Dry Zone of Karnataka

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Abstract

Six pedons from Visweswaraiah canal command were sampled and analyzed for soluble and exchangeable cations and anions, cation exchange capacity (CEC), exchangeable sodium percentage (ESP), pH, EC and CaCO₃. Based on the results, the cationic composition of soil profiles was of the order Na⁺ > Ca²⁺ > Mg²⁺ > K⁺ and the anionic composition of soil profile was of the order HCO₃⁻ > Cl⁻ > SO₄⁼ > CO₃⁼. Exchangeable sodium was dominant (ESP>60) cation in the profiles of ZARS, Mandya and Muttanahalli. All the profiles of Malavalli taluk contained higher exchangeable calcium. The CEC increased in second depth in all the profiles and higher CEC was observed in all the profiles of Malavalli due to higher clay content. The ESP was maximum in Muttanahalli profiles followed by ZARS profile of Mandya and all other profiles were sodic in nature with more than 15 ESP. Malavalli profiles were calcareous alkali soils with high calcium carbonate content ranging from 63 to 128 g/kg. Textural class remains sandy clay loam in all the three depths indicating less clay content and hence less ESP.

Key words : Cauvery command, Alkali soils, Exchangeable cations and anions, CaCO₃, pH.

Excessive use of irrigation water and poor water management practices are the chief causes for salt build up in the soil. The southern dry zone of Karnataka has a net work of canal system, which provides a net irrigation to nearly 193,452 ha and the command area is known as Cauvery command area. Visweswaraiah canal which runs for a distance of 229 km, is the left bank high level canal of Krishnarajasagar Canal System. It irrigates an area of 77,200 ha covering the taluks of Pandvapura, Srirangapatna, Mandya, Maddur and Malavalli (1). In the middle and lower reaches of Visweswaraiah canal, the productivity is less due to increasing problems of alkalinity. In Karnataka state 4 lakh hectare of soils are salt affected and cauvery command area of the state is not exceptional, with an estimated area of over 17,000 ha under salt affliction. To decrease the alkalinity and to increase the yield of the crops identification of the nature of alkalinity is important and helpful in reclamation of problematic soils. Therefore, study was conducted to investigate the nature of salt affliction in the soil bodies of Vishewaraish canal tract of Cauvery command area.

Methods

Soil samples from six profiles were collected from the first three horizons, during 1998, and subjected for characterization. One profile was from the middle reaches of V. C. tract falling in Mandya taluk and other profiles from the lower reaches falling in Maddur and Malavalli taluks. One profile in Mandya taluk was at Zonal Agricultural Research Station (ZARS), V. C. Farm. The other five profiles were at Muttanahalli and Doddarasinakers villages of Maddur taluk, Gowdagere, Megalapura and Hadli villages of Malavalli taluk. The soil samples collected from different depths in these profiles were processed and analyzed for water soluble cations and anions, cation exchange capacity, exchangeable cations, pH, EC, calcium carbonate and exchangeable sodium percentage (2) and particle size distribution (3).

The water soluble calcium and magnesium were determined by versanate titration method. Sodium and potassium were determined in the soil water extracts by using flame photometer (4). Soluble carbonates, bicarbonates and chlorides in the water extract of the

Table 1. Particle size distribution (physical properties) of the problem soils bodies of Visweshwaraiah canal tract of Mandya. SCL : Sandy clay loam ; CL : Clay loam ; C : Clay.

Profile	Depth (cm)	Sand g/kg	Silt g/kg	Clay g/kg	Textural class
1. ZARS, Mandya	0—15	520	175	305	SCL
	15—45	456	182	362	CL
	>45	431	183	386	CL
2. Muttanahali Maddur	0—15	458	155	391	CL
	15—40	414	147	439	C
	40—60	422	163	415	C
3. Doddarasinakere, Maddur	0—15	506	198	296	SCL
	15—40	681	139	180	SCL
	40—75	520	166	314	SCL
4. Gowdagere, Malavalli	0—25	489	197	314	SCL
	25—40	431	214	355	CL
	40—75	420	220	360	CL
5. Megalapura, Malavalli	0—25	498	201	301	SCL
	25—50	457	210	333	CL
	50—80	464	207	329	CL
6. Hadli, Malavalli	0—22	506	174	320	SCL
	22—40	461	168	371	CL
	40—75	543	180	367	CL

Table 2. The pH , EC and CaCO₃ of the problem soil bodies of visweshwaraiah canal tract, Mandya.

Profile	Depth (cm)	pH (1:2)	E.Cw ds/m	CaCO ₃ g/kg
1. ZARS, Mandya	0—15	10.1	1.5	18
	15—45	9.8	1.20	30
	>45	9.3	0.75	32
2. Muttanahali Maddur	0—15	9.7	1.35	12
	15—40	9.0	0.70	25
	40—60	8.7	0.45	28
3. Doddarasinakere Maddur	0—15	8.9	0.65	28
	15—40	8.7	0.28	16
	40—75	8.4	0.47	25
4. Gowdagere Malavalli	0—25	9.0	0.62	97
	25—40	9.1	1.74	100
	40—75	9.5	1.02	122
3. Megalapura Malavalli	0—25	8.6	1.25	105
	25—50	9.1	1.40	128
	50—80	8.9	1.33	120
6. Hadli Malavalli	0—22	8.5	1.10	75
	22—40	9.1	1.30	63
	40—75	9.3	1.40	64

soil were determined titrimetrically (2). The water soluble sulfates was determined turbidometrically by precipitating sulfate as barium sulfate (5). The cation exchange capacity of soil was determined by leaching the soil with sodium acetate buffered to 8.5 and then replacing sodium saturated soil with ammonium by leaching with ammonium acetate. The exchangeable sodium in the leachate was determined by flame photometer (2), exchangeable cations were determined by extracting the soil with neutral normal ammonium acetate solution. The exchangeable sodium and potassium was determined by flame photometer. The sum of exchangeable calcium and magnesium was computed by taking the difference of CEC exchangeable sodium plus potassium. The exchangeable sodium percentage was calculated by using exchangeable sodium and cation exchange capacity values (2).

Results and Discussion

Six soil profiles, representing one from Mandya, two from Maddur and three from Malavalli taluk were characterized for their physico-chemical properties. The results on each of these characters are presented and discussed.

Particles Size Distribution

The sand fraction decreased with depth in all the

profiles except in Doddarasinakere of Maddur taluk where the second depth had higher sand content (Table 1). The decrease in sand fraction was from 520 to 431 g/kg at ZARS, Mandya, 489 to 420 at Gowdagere, Malavalli 498 to 464 at Megalapura, Malavalli and from 506 to 453 g/kg at Hadli, Malavalli.

The silt, fraction did not show much variation with the depth. The least values of silt fraction were observed in Muttanahalli of Maddur taluk, which ranged from 147 to 163 g/kg. The Malavalli taluk profiles generally contained higher silt fractions when compared to Maddur and Mandya taluk profiles. The silt fraction varied from 197 to 220, 201 to 210 and 168 to 180 g/kg in Gowdagere, Megalapura and Hadli profiles of Malavalli taluk respectively.

The clay content increased with depth in all the profiles studied. The clay content decreased at second depth from 296 to 180 g/kg in Doddarasinakere profile of Maddur taluk, but again increased at third depth, to 314 g/kg. Addition of sand as a layer to improve drainage could be the cause for a sandy sub-surface in this profile.

From the particle size distribution data it can be stated that the textural class of ZARS, Mandya is clay loam to sand clay loam, Muttanahalli Maddur taluk is clay to clay loam, Doddarasinakere of Maddur taluk is sandy clay loam, Gowdagere, Megalapura and

Table 3. Water soluble cations in the problem soil bodies of Visweshwaraiah canal tract, Mandya.

Profile	Depth (cm)	Water soluble cations me/liter			
		Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺
1. ZARS, Mandya	0—15	0.4	0.2	18.8	0.30
	15—45	0.3	0.1	19.6	0.32
	>45	0.3	0.1	14.4	0.21
2. Muttanahalli, Maddur	0—15	0.8	0.4	15.2	0.09
	15—40	1.0	0.4	8.3	0.07
	40—60	0.8	0.4	6.2	0.01
3. Doddarasinakere, Maddur	0—15	1.2	0.8	8.7	0.02
	15—40	0.6	0.4	1.9	0.02
	40—75	1.0	0.6	3.8	0.01
4. Gowdagere, Malavalli	0—25	0.8	0.4	8.2	0.14
	25—40	1.0	0.4	9.6	0.15
	40—75	1.2	0.4	10.7	0.13
5. Megalapura,	0—25	0.8	0.4	13.4	0.03
	25—50	1.2	0.8	12.9	0.05
	50—80	0.8	0.4	17.4	0.08
6. Hadli, Malavalli	0—22	1.2	0.6	12.0	0.07
	22—40	1.0	0.6	15.1	0.07
	40—75	0.8	0.6	16.5	0.02

Table 4. Water soluble anions in the problem soil bodies of Visweshwaraiah canal tract, Mandya.

Profile	Depth (cm)	Water soluble Anions me/liter			
		CO ₃ ⁼	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁼
1. ZARS, Mandya	0—15	1.2	12.6	4.8	2.0
	15—45	1.6	13.2	4.2	1.8
	>45	1.8	10.8	3.0	1.2
2. Muttanahalli, Maddur	0—15	1.2	9.5	2.8	2.1
	15—40	0.8	5.7	2.0	1.0
	40—60	0.6	3.8	1.8	1.2
3. Doddarasinakere, Maddur	0—15	0.3	4.6	1.8	1.0
	15—40	tr	0.6	2.0	0.4
	40—75	tr	2.8	1.6	0.8
4. Gowdagere, Malavalli	0—25	0.6	5.4	2.0	1.6
	25—40	0.6	6.8	2.2	1.4
	40—75	1.2	8.5	2.0	1.0
5. Megalapura, Malavalli	0—25	0.6	7.6	3.8	2.4
	25—50	1.2	8.2	3.2	2.2
	50—80	1.2	12.4	2.8	2.2
6. Hadli, Malavalli	0—22	0.2	5.8	4.4	2.8
	22—40	1.2	9.4	3.2	2.8
	40—75	1.8	11.6	2.8	1.6

Hadli, Malavalli taluk is clay loam to sandy clay loam (Table 1).

The pH of the Soil Profiles

The soil pH in the profiles showed variation with depth (Table 2). In ZARS, Mandya and both the profiles of Maddur taluk the soil pH decreased with depth, while in Malavalli profiles the soil pH increased with depth. This may be due to decrease in the carbonate content of the profiles of Mandya and Maddur with depth and an increase in the carbonate and bicarbonate contents from the surface to lower depths in the profiles of Malavalli taluk. Similar observations were made by Somani (6) who reported that the domination of carbonates and bicarbonates of sodium in soil solution increased the pH (>8.2) in alkali soils. The results of high pH in surface soils and decrease with depth are in conformity with the findings of Landey and Murthy (7) who observed domination of carbonates and bicarbonates at surface.

The soluble salt content as determined by the electrical conductivity of the soil water extracts (EC_w) showed exactly the same trend as that of soil pH (Table 2). The soluble salts decreased with increasing depth in Mandya and Maddur profiles, whereas in Malavalli profiles, it increased with depth. Thus, soluble salts

were more when pH was also more. Since sodium is the dominant cation and bicarbonates, chlorides and sulfates are the anions, with increasing pH, more of sodium salts with neutral chlorides and sulfates and sparingly soluble bicarbonates could be present in soil solution resulting in more conductivity values. Similar observations were made by Landey and Murthy (7) who reported that the electrical conductivity of the jougu soils increased with increasing pH. They reported high ESP values at the surface resulted in high pH and salts in the surface soil.

The profiles of Malavalli taluk contained higher lime content throughout their profile (Table 2), which contributed higher exchangeable calcium in the profiles. The profiles of Maddur and ZARS, Mandya contained less calcium carbonates and therefore showed high pH and contained higher sodium content on the exchange complex. The reasons for the lime accumulation in Malavalli profiles could be the climate, with less rainfall favoring accumulation of calcium carbonates. Richards (2) reported that owing to low rainfall and limited leaching, alkaline earth carbonates are usually a constituent of soil of arid and dry regions.

Water Soluble Cations

The soluble sodium content decreased with

Table 5. Cation exchange capacity and exchangeable cations in the problem soil bodies of V. C. tract, Mandya.

Profile	Depth (cm)	CEC mol. (P ⁺)/kg	Exchangeable cations C. mol (P ⁺)/kg				ESP
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	
1. ZARS, Mandya	0—15	16.5	3.3	1.8	10.9	0.3	64.8
	15—45	16.2	2.4	1.6	11.6	0.4	71.6
	>45	16.8	3.8	1.1	10.2	0.4	61.1
2. Muttanahalli, Maddur	0—15	18.5	2.4	1.2	14.6	0.2	78.9
	15—40	23.0	5.6	2.4	14.8	0.2	64.3
	40—60	22.1	5.2	2.0	14.6	0.1	66.4
3. Doddarasinakere, Maddur	0—15	12.3	6.8	2.4	3.1	0.1	25.2
	15—40	7.8	3.8	1.6	2.3	0.1	29.4
	40—75	13.7	7.2	2.8	3.6	0.1	26.2
4. Gowdagere, Malavalli	0—25	26.8	17.6	2.2	6.9	0.1	25.7
	25—40	31.4	20.6	2.2	8.6	0.1	27.4
	40—75	29.2	18.0	2.0	9.1	0.1	31.2
5. Megalapura, Malavalli	0—25	25.7	18.6	2.0	4.9	0.2	19.0
	25—50	28.0	19.4	2.2	6.4	0.3	22.5
	50—80	26.9	19.8	1.8	5.1	0.2	19.0
6. Hadli, Malavalli	0—22	22.8	17.0	1.8	3.8	0.2	16.7
	22—40	24.6	16.8	2.0	5.5	0.3	22.4
	40—75	24.1	16.4	1.6	5.8	0.3	24.0

depth in Mandya and Maddur taluk profiles while it increased with depth in Malavalli taluk profiles (Table 3).

The soluble calcium and magnesium contents did not vary much in most of the profiles at different depths. Soluble calcium content ranged from 0.3 to 1.2 me/liter and soluble magnesium from 0.1 to 0.8 me/liter.

Sodium was the dominant cation in all the soil profiles. The soluble sodium was high in RRS, Mandya profile and therefore, alkalinity was also high. The profiles of Malavalli also showed higher soluble sodium in spite of higher lime content in these profiles. The ionic composition of all the profiles was of the order Na⁺ > Ca⁺⁺ > Mg⁺⁺ > K⁺ cationic type, and HCO₃⁻ > Cl⁻ > SO₄⁼ > CO₃⁼ anionic type. The composition of bicarbonates was invariably high in all the profiles, followed by chlorides and sulfates (Table 4).

Visweshwaraiah canal tract with a rainfall of 600—700 mm is showing the soil profiles with the domination of bicarbonates followed by chlorides and sulfates. The quality of irrigation water, dominated by bicarbonate ions could be the factor, which contributes bicarbonates in water (HCO₃⁻—2.9 me/liter). The results are in line with the observations of Singh et al. (8) who reported that carbonate and bicarbonate are dominating anions around 750 mm rainfall.

Exchangeable Cations

Exchangeable sodium was the dominant cation in profiles of ZARS, Mandya and Muttanahalli of Maddur taluk. All profiles of Malavalli taluk contained higher exchangeable calcium. The ZARS, Mandya and Muttanahalli profiles were highly alkaline because of their high exchangeable sodium content and hence having high ESP values (Table 5). The profiles of Malavalli were alkaline in spite of appreciable calcium content, because the ESP values are more than 15. Krishnamurthy and Govindarajan (9) who studied the exchangeable cations in a typical alkali soil profile of Andrapradesh showed that the order of dominance was Ca > Na > Mg > K. They reported that in spite of dominance of calcium, the ESP of the soil is more than 15, and may be due to heavier texture of soil, it makes the soil to behave as alkali soils.

The exchangeable sodium percentage (ESP) was maximum in Muttanahalli profile of Maddur taluk with a range of 64.3 to 78.9% closely followed by ZARS profile of Mandya taluk with a range of 61.1 to 71.6%. In the profiles of Malavalli taluk, the ESP ranged from 25.7 to 31.2, 19.0 to 22.5 and 16.7 to 24.0%, respectively in Gowdagere, Megalapura and Hadli profiles. The ESP of Doddarasinakere profile of Maddur taluk ranged from 25.2 to 29.4%. All the profiles were sodic

with an ESP of more than 15 (Table 5).

The high ESP values in Mandya and Maddur profiles were due to high exchangeable sodium content of these soils. The profiles of Malavali taluk contained appreciable amounts of calcium due to calcium carbonate content and hence the ESP values were comparatively lesser, but the values were more than 15, making these soils to be termed alkali soil. The profile sample of Doddarasinakere of Maddur is having least alkaline earth carbonates and the ESP values are more than 25, in making it necessary to be termed as non-saline alkali soil. Bhumbla (10) reasoned that alternate wet and dry condition seems to be the contributing factor for sodic soil formation. Bhargava (11) reported that alkali soils of south India have high ESP values coupled with heavy soil texture with clay content of 35—40%. Krishnamurthy and Govindarajan (9) reported that the alkali soils of Andhra Pradesh in spite of dominance of calcium, had ESP values of more than 15 and due to heavier texture of soil having higher clay (28 to 49%), it makes these soils to behave as alkali soils.

The soils of ZARS, Mandya falling in mid-reach are distinctly alkaline with high pH and ESP, when compared to soils of Maddur and Malavalli coming under lower reaches. This is because of the high calcium carbonate content in the profiles of the lower reaches.

Cation Exchange Capacity (CEC)

The cation exchange capacity (CEC) increased with depth in all the profiles (Table 5). Least CEC values from 7.8 to 13.7 C.mol (P⁺)/kg was observed in Doddarasinakere profile of Maddur taluk. The CEC values ranged from 16.2 to 16.8 for RRS, Mandya profile and from 18.5 to 22.1 C.mol (P⁺)/kg for Muttanahalli, Maddur taluk profile. The profiles of Malavali taluk showed higher CEC values ranging from 26.8 to 31.4 for Gowdagere profile, from 25.7 to 28 for Magalapura profile and from 22.8 to 24.6 C.mo (P⁺)/kg for Hadli profile. The CEC decreased at second depth in Doddarasinakere profile of Maddur taluk. The cation exchange capacity (CEC) increased in all the profile in the second depth when compared to surface layer

(Table 5). Increased CEC in the lower depths is due to increase in the clay content of the soil layers down the profile. Higher values of CEC were observed in all the profiles of Malavalli. This is due to higher clay content and calcareous nature of the soil. Richards (2) has reported that alkaline earth carbonates influence the texture of the soil when present in appreciable amounts. The presence of this fine alkaline carbonate particles, improves the physical condition of the soils and cation exchange capacity.

The study reveals that soil profiles from ZARS, Mandya and Muttanahalli, Maddur taluk are non-calcareous alkali soils with high ESP, while Malavalli taluk profiles were calcareous alkali soils with high calcium carbonate content ranging from 63—128 g/kg and ESP values ranging from 16.7 to 27.4. Higher CEC was observed in all the profiles of Malavalli due to higher clay content.

References

1. Anonymous. 1993. National agricultural research project. Status Rep. ZARS, V. C. Farm, Mandya, India.
2. Richards L. A. 1954. Diagnosis and improvement of saline and alkali soils. Hand Book No. 60 USDA, Washington DC, USA.
3. Piper K. 1956. Soil and plant analysis. University Adelaide, Australia.
4. Jackson M. L. 1973. Soil chemical analysis. Prentice Hall India Pvt. Ltd., New Delhi, India.
5. Black C. A. 1965. Methods of soil analysis, part 1 and 2. Agron. Mon. No. 9. Am. Soc. Agron., Inc. Madison, Wisconsin, USA.
6. Somani. 1990. Alkali soils, their reclamation and management. Divya Jyothi prakashan, Jodhpur, India.
7. Landey R. J. and R. S. Murthy. 1967. Investigation on the quality of irrigation waters in the Tungabhadra watershed, Hadagali, Bellary district, Mysore state. Indian J. Agron. 12 : 84—96.
8. Singh S. B., R. Chhabra and I. P. Abrol. 1980. Effect of soil sodicity on the yields and chemical composition of cowpea grown for fodder. Indian J. Agric. Sci. 50 : 852—856.
9. Krishnamoorthy P. and S. V. Govindarajan. 1977. Genesis and classification of associated red black soils under Rajollibunda division irrigation scheme (AP). J. Indian Soc. Soil Sci. 25 : 239—246.
10. Bhumbla D. R. 1977. Alkali and saline soils of India. Proc. Indo-Hungarian Sem. on management of salt affected soils, CSSRI, Karnal, India, pp. 14—19.
11. Bhargava G. P. 1979. Soil and water quality surveys in a decade of research. CSSRI, Karnal, India.