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Characterization of soils of Ghataprabha Left Bank Canal command area of north Karnataka for salinity and sodicity

Mallikarjuna Lingappa* and V. B. Kuligod

Department of Soil Science and Agricultural Chemistry,
University of Agricultural Science, Dharwad-580 005, India.
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ABSTRACT

A study was conducted to characterize soil salinity and sodicity of Ghataprabha Left Bank Canal command area of Mudhol *taluk* (Bagalkot District). Bulk Electrical conductivity of salt affected soils was determined by using electromagnetic induction (EM 38). The pHs of surface and sub-surface soil layers ranged from 7.4 to 8.7 and 7.7 to 8.6, respectively. Electrical conductivity of saturated extract of surface and sub-surface soils ranged from 4.2 to 59.9 dSm^{-1} and 4.2 to 57.0 dSm^{-1}. Majority of soil samples were found to be saline as sodium absorption ratio (SAR) ranged between 0.3 to 10.8 and 0.5 to 10.9 for surface and sub-surface soil, respectively. Among the analysed surface soil samples, 26 per cent were saline, 18 per cent sodic and 56 per cent were saline-sodic. On the other hand, 26, 20 and 54 per cent of soils were categorized into saline, sodic and saline-sodic, respectively. Among the water soluble cations, Na^+ (10.9 to 73.4 cmol (P^+) kg^{-1}) pre-dominated in surface and sub-surface horizons (10.9 to 65.2 cmol (P^+) kg^{-1}). Among water soluble anions, Cl^- dominated both in surface (2.0 to 60 me L^{-1}) and sub-surface (2.0 to 59.0 me L^{-1}).

Key words: Bulk electrical conductivity, Electromagnetic induction, SAR, Soil, Salinity, Sodicity.

INTRODUCTION

Continued irrigation (ground and surface water) coupled with the agriculture intensification in the command area of Ghataprabha is the major cause of soil degradation through secondary soil salinity and sodicity development. The problem of salinization is aggravated by restricted land drainage in most part of the command. Deep black soils characterized by very high swell-shrink clay content significantly reduces internal drainage. This facilitates accumulation of soluble salts over a period of irrigation. Further, semi-arid climate keeps salts in surface layers and adversely affects crop growth.

Sodicity signifies the predominance of exchangeable sodium (Na^+) in the soil. Sodicity in soils has a strong impact on the soil structure. Dispersion occurs when the clay particles swell strongly and separate from each other on wetting. On drying, the soil becomes dense and hard cloddy and without defined structure form (Charters, 1993; Ford *et al*., 1993; Sumner *et al*., 1998). Sodic soils have a pH > 8.4 and a preponderance of carbonate and sodium by bicarbonate (Richards, 1954).

Salinity refers to the amount of neutral soluble salt in soil, such as sulphates (SO_4), and chlorides (Cl). Strongly saline soils often exhibit a whitish surface crust when dry. The solubility of calcium sulphate, also called gypsum ($CaSO_4$), is used as the standard for comparing salinity levels. It occurs in areas where saline ground waters are very close to or at the ground surface, and evaporation exceeds precipitation (Dehaan and Taylor, 2002). In irrigated lands, salinity occurs when salts are concentrated in soils by the evaporation of free-standing irrigation water. The major causes are a combination of poor land management and crude irrigation practices. These practices cause changes in soil and vegetation cover and ultimately loss of vegetation, soil fertility and agricultural productivity. Soil salinity could be measured by ground-based geophysics, measurements of soil electrical conductivity (EC) using soil pastes, and water extracts. Saline soils have an ECe > 4 dS m^{-1} at 25°C (Richards, 1954).

Realising when, where and how salinity and sodicity may occur is very important to the sustainable development of any irrigated production system (Al-Khaier, 2003). Corrective actions require reliable information to help set priorities and to choose the type of action that is most appropriate in each situation (Metternicht and Zinck, 2003). Ground-based electromagnetic measurements of soil EC are generally accepted as the most effective method for quantification of soil salinity (Norman *et al*., 1989; Dehaan and Taylor, 2002).

Most saline soils cause yield reduction in crop plants by reducing osmotic potential of soil water. This makes lesser availability of water from soil. Therefore, crops suffer from water stress and result in physiological wilt. Soil water gets predominated by Cl^- and SO_4^{--} and these ionic species

*Corresponding author's e-mail: mallu.maski@gmail.com

become toxic and hinder uptake of other nutrients, thereby causing nutrient imbalance.

It is essential that soils need to be characterized chemically to adopt appropriate agronomic practice for profitable crop production.

MATERIALS AND METHODS

One hundred surface and sub-surface soil samples were collected at two depths (0-20 & 20-40 cm) in different locations of Mudhol taluk (Bagalkot District). Care was taken to represent sampling sites to larger area of the command. The GPS was used to locate sampling sites. The study area lied between 16° 17’ 12.8" to 16° 18’ 54.9" N latitudes and 75° 18’ 57.4" to 75° 20’ 59.3" E longitudes. The annual average rainfall is 482 mm and an average elevation is 542 m above MSL (Fig.1). The area is categorized into water deficit (precipitation lower than evaporation).

The pHs and ECe were determined using potentiometer and electrical conductivity bridge by following standard procedure. Bulk salinity of the soils was determined by using electromagnetic induction (EM 38). Soil organic carbon was determined by Walkley and Black’s wet oxidation method using potassium dichromate and sulphuric acid. (Jackson, 1973).

Soluble sodium per cent (SSP) was calculated using the following formula

$$\mathrm{SSP} = \frac{(\mathrm{Na}^{+}) \times 100}{\mathrm{Ca}^{2+} + \mathrm{Mg}^{2+} + \mathrm{Na}^{+} + \mathrm{K}^{+}}$$

Water soluble cations and anions like calcium and magnesium were estimated by versanate titration using Eriochrome Black-T indicator (Black, 1965a). Sodium and potassium was estimated using flame photometer. Carbonates and bicarbonates were estimated immediately after extraction from soil by titrating against standard H_2SO_4 using phenolphthalein and methyl orange indicators respectively (Richards, 1954).

RESULTS AND DISCUSSIONS

The details of soil salinity in GLBC command area are presented in Table 1. The pHs of surface and sub-surface soils ranged from 7.4 to 8.7 with mean value of 7.94 and 7.7 to 8.6 with mean value of 7.98, respectively. The data revealed tendency of slight increase with depth. Soil reaction was found to be slightly to moderately alkaline as the soils studied were under arid to semi-arid region and hence not subjected to leaching losses of cations. Similar values were reported by Binita *et al*. (2009) and Ashok (1996) in black soils of the GLBC area. The ECe of the surface and sub-surface soils ranged from 4.2 to 59.9 dSm^{-1} with mean value

Table 1: Statistical summary of salinity parameters of salt affected soils of Ghataprabha Left Bank Canal command area.

Depth	0-20 cm				20-40 cm			
Parameters	**Range**	**Mean**	**SEm±**	**CV%**	**Range**	**Mean**	**SEm±**	**CV%**
pHs	7.4-8.7	7.94	0.18	2.28	7.7-8.6	7.98	0.14	1.74
ECe (dSm^{-1})	4.2-59.9	27.8	10.29	37.08	4.2-57.0	23.1	8.85	38.27
SAR	0.3-10.8	4.6	1.98	43.17	0.5-10.9	4.7	2.14	46.09
SSP (%)	28.7-95.0	51.5	10.65	20.66	29.0 - 96.2	56.7	10.91	19.24
ESP (%)	2.9-36.9	23.1	7.57	32.74	4.2-39.9	23.4	7.63	32.68
RSC	-86.6 to -34.4	-59.14	9.29	-15.71	-79.6 to -34.7	-55.94	7.89	-14.11
OC (%)	0.2-1.0	0.5	0.13	25.34	0.2-0.9	0.4	0.13	29.27

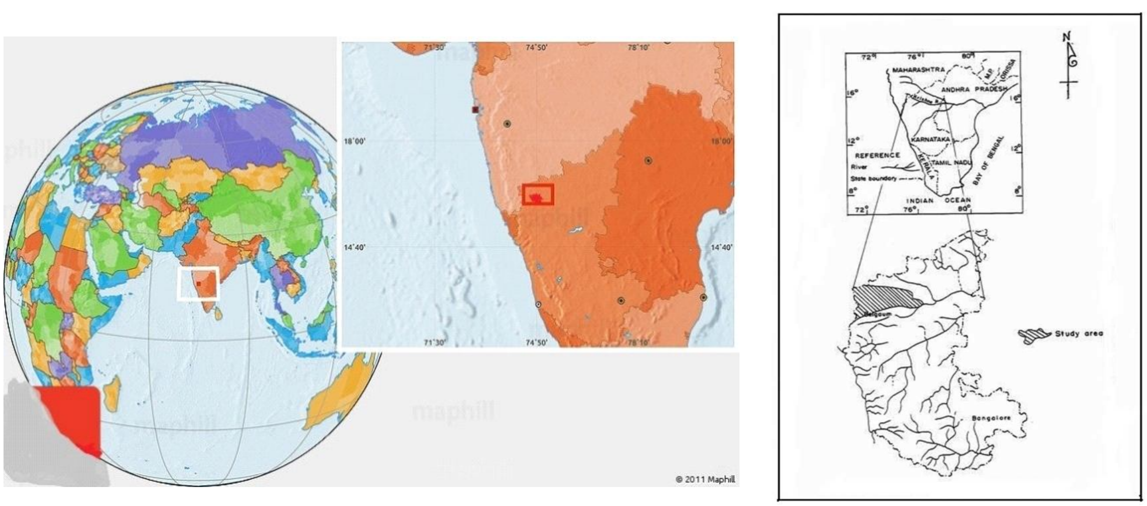

Fig 1: Index map of the Study Area

of 27.8 dSm^{-1} and 4.2 to 57.0 dSm^{-1} with mean value of 23.1 dSm^{-1}, respectively. Groundwater being highly saline both during pre-monsoon and post-monsoon, the lands are bound to be saline. However, the soil salinity is confined to certain patches of the study area particularly in parts of Gokak and Biligi taluks. Excessive salinity zones are also reported from Mudhol and Jamkhandi taluks (Varadarajan *et al.*, 2010).

The degree of sodium hazard and its solubility was revealed through sodium adsorption ratio (SAR) and soluble sodium per cent (SSP). The SAR of surface and sub-surface soils ranged from 0.3 to 10.8 with mean value of 4.6 and 0.5 to 10.9 with mean value of 4.7, respectively. The SSP ranged from 28.7 to 95 per cent with mean value of 51.5 per cent and 29.0 to 96.2 per cent with mean value of 56.7 per cent for surface and sub-surface soil samples respectively. Irrigation water with > 60 per cent of soluble sodium is hazardous if such water is used for irrigation. It would cause accumulation of sodium in soils which disperse the soil aggregates finally destroying the soil structure.

Exchangeable sodium per cent of surface soils ranged from 2.9 to 36.9 per cent with mean of 23.1 per cent and in sub-surface the values varied between 4.2 to 39.9 per cent with mean of 23.4 per cent. These values were found to be more than critical limit (15%) for the clay rich fine textured soil. As the soils are calcareous in nature the residual sodium carbonate (RSC) values are negative. The RSC of surface soils varied between -86.6 to -34.4 and in sub-surface varied between -79.6 to -34.7. Most of the surface and sub-surface soil samples analysed were low in organic carbon content. The soil organic carbon content ranged from 0.2 to 1.0 per cent with mean value of 0.5 per cent in surface and 0.2 to 0.9 per cent with mean value of 0.4 per cent in subsurface layer.

Among the surface soil samples analysed 26 per cent were saline, 18 per cent sodic and 56 per cent soil samples were saline-sodic. Whereas sub-surface soil samples are concerned 26, 20 and 54 per cent were saline, sodic and saline-sodic, respectively. Therefore, salt affected soils of the study area (representing GLBC) were predominantly (> 50 per cent) saline sodic in nature. Therefore, these soil need reclamations measures that aim at soluble salt leaching and reducing exchangeable sodium.

Bulk salinity was determined by using electromagnetic induction (EM 38) at different locations of the salt affected areas of GLBC command (Table 2). Both vertical and horizontal readings were recorded from EM 38 after standardising the instrument. The distribution of soil salinity along the soil depth, greater salt concentration was found at surface soil than at sub-surface indicating the salt accumulation occurs by the arid conditions. Because of larger salt concentration at effective crop root zone most of the crops of that area were affected.

Soil water cationic composition, (Table 3) in contrast to exchangeable ionic composition, was dominated by Na^+ (10.9 to 73.4 cmol (P^+) kg^{-1}) in surface soil samples and (10.9 to 65.2 cmol (P^+) kg^{-1}) in sub-surface soil samples, which might be due to divalent cation preference of 2:1 clays.

However, concentration of water soluble Ca^{2+} remained next to that of Na^+ both at surface and sub-surface soil samples. Among the anions, chlorides were the dominant, in both surface (2.0 to 60 me L^{-1}) and sub-surface (2.0 to 59.0 me L^{-1}) soil samples followed by sulphates (1.9 to 38.1 me L^{-1}in surface soils and 1.9 to 38.8 me L^{-1}in sub-surface soils), indicating the chloride-sulphate type of soil salinity. Because of highly calcareous nature of soils, bicarbonates (1 to 4 me L^{-1} in both surface and sub-surface soils) were found be in small amounts, while concentration of carbonates was negligible (Anonymous 1981).

Table 2: Bulk salinity of salt affected soils of Ghataprabha Left Bank Canal command area determined by using electromagnetic induction.

	Bulk EC (dSm^{-1})*			
Depth (cm)	0-15	15-30	30-60	60-90
Range	4.4-18.4	3.4-10.7	1.9-8.2	2.2-7.8
Mean	9.7	6.5	5.0	5.8
SEm±	2.1	1.3	1.0	1.1
CV%	21.3	19.3	19.2	18.6

*Determined by electromagnetic induction (EM 38)

Table 3: Saturation extract properties of salt affected soils of Ghataprabha Left Bank Canal command area.

Depth	**0 – 10 cm**				**20 – 40 cm**			
Water soluble ions (cmol (p^+) kg^{-1})	**Range**	**Mean**	**SEm±**	**CV%**	**Range**	**Mean**	**SEm±**	**CV%**
Ca^{2+} (cmol (p^+) kg^{-1})	1.2-31.2	20.7	5.1	24.6	0.9-26.9	14.3	4.1	28.9
Mg^{2+} (cmol (p^+) kg^{-1})	0.7-18.8	11.0	3.0	27.3	0.7-16.7	7.9	2.3	29.4
K^+ (cmol (p^+) kg^{-1})	0.03-0.17	0.09	0.04	37.5	0.01-0.13	0.07	0.02	36.0
Na^+ (cmol (p^+) kg^{-1})	10.9-73.4	34.6	11.1	32.0	10.9-65.2	30.5	8.7	28.5
CO_3^{2-} (me L^{-1})	-	-			-	-		
HCO_3^- (me L^{-1})	1.0-4.0	2.02	0.54	26.7	1.0-4.0	2.34	0.59	25.4
Cl^- (me L^{-1})	2.0-60	23.8	11.3	47.3	2.0-59.0	24.7	11.3	45.6
SO_4^{2-} (me L^{-1})	1.9-38.1	19.1	8.4	43.8	1.9-38.8	19.6	8.5	43.3

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