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Assessment of Soil Quality of Taluka Thari Mirwah, District Khairpur, Sindh, Pakistan

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Abstract: Soil salinity is an increasing threat for agriculture. The knowledge of physical and chemical properties of the soil is vital for the assessment of the capacity of soil for better plant productivity and improvement through management practices. We assessed the soil of ten union councils of Taulka Thari Mirwah, district Khairpur. The soil was evaluated for pH, EC, organic matter and salt contents through standardized methods. The overall soil was found to be slightly alkaline (pH 8 ± 0.6 SD), with a varied texture among the sites. The soil EC (10 ± 7.9 SD dS/m) was recorded to be comparatively higher than the surrounding districts. The study did not find any significant variation in various salt contents in the area. The organic contents were lower than the advised extent. However, the management practices were suggested to improve the health of soil for better productivity.

Keywords: Soil salinity, soil pH, agriculture, soil salt contents, organic matter, Thari Mir wah.

Introduction

Soil salinity is a prominent threat for agriculture, affecting about 3% land around the world (Zhu, 2001; Zhang et al., 2007). It has become the foremost risk for dry land areas, which depend on canal systems for crop production, resulting in reduced crop yield (FAO, 2002; Brady and Well, 2008). Salts may deposit in the agricultural fields with irrigation water, the excess water evaporates leaving behind the salts in the top layers of the soil (Tischbein et al., 2012). The other reasons that add to salinity may include the dispersion of soil aggregates, decrease in soil organic matter and a rise of groundwater table etc. (Lal et al., 2007; Egamberdiev et al., 2012).

The presence of salts in the soil decreases accessibility of water to plants. This is due to osmotic pressure of the soil solution, which increases with the increase in salt quantity, resulting in reduced availability of water for plant absorption. Moreover, the increased level of certain ions may cause a threat to plants, for example the high amount of chloride (Cl^{-1}) may be lethal for most of the plants like citrus and grapes. Nevertheless, various management practices play an important role to enhance crop production via crop breeding advances or appropriate soil and water management practices (Ayers and Westcot, 1985). Numerous management practices are suggested to decrease the water evaporation loss (Rhoades et al., 1992; Rhoades, 1999), seed management before cultivation, better cultivation skills (Egamberdiev, 2007; Bakker et al., 2010), improved seed rates (Minhas, 1996), use of appropriate fertilizers such as nitrogen and potassium fertilizers (Tanji and Kielen, 2002), mulching the soil surface with crop residues (Egamberdiev, 2007; Bezborodov et al., 2010).

Soil salinity is increasing in Pakistan. About 24% of the soil of Pakistan was reported saline in the year 2006 (SMO, 2006; Azhar, 2010). The farmers lose up to $1.2 billion every year in crop losses in the country, in addition to the cost of the agricultural land that turns unproductive (World Bank, 2006; Corbishley and Pearce, 2007). The salinity problem in Pakistan requires prompt attention from all stakeholders to stop further destruction of the soil and reduce the crop losses. In this study we assessed and report the quality and condition of soil in agriculture use at taluka Thari Mirwah. Most of the population of these areas is dependent on agriculture.

Materials and Methods

Study Area

The study was conducted in taluka Thari Mirwah, stretched over 15910 km^2. This is one of the eight talukas of district Khairpur with a total population of more than 1.5 million people. Diverse weather conditions prevail in the area with an average temperature of 14 and 40 ^{0}C in winter and summer respectively. The weather permits the growth of various cereals and vegetable crops including wheat, cabbages, water melons, turnips, lady fingers, cucumbers, carrots, banana, tomato, onion and potato etc.

Table 1. Global Positioning System (GPS) coordinates of sampling locations, Mirwa taluka.

Locations	Longitude	Latitude	Location	Longitude	Latitude
Thari	27004"05N	068039"46E	Mandan	27008"20N	068031"30E
Thari	27004"22N	068037"01E	Mandan	270 03"42N	068037"30E
Thari	27004"21N	068037"04E	Mandan	27003"47N	068037"24E
MeharVeesar	27006"31N	068034'‘05E	Bozdar Wada	27010"O4N	068037"37E
MeharVeesar	27006"29N	068034"18E	Bozdar Wada	270 09"50N	068.037"43E
MeharVeesar	27006"25N	068033"58E	Bozdar Wada	27009”55N	068037"41E
Mohsin Shah	27008"25N	068031"27E	Baki Khan	27001"32N	068030"56E
Mohsin Shah	27008"24N	068031"26E	Baki Khan	270 01"29N	068030"57E
Mohsin Shah	27008"05N	068032"06E	Baki Khan	27001"29N	068030"55E
Setharja	27011"37N	068029"26E	Sabar Rind	27008"49N	068038"54E
Setharja	27011"33N	068029"25E	Sabar Rind	270 08"45N	068038"41E
Setharja	27011"35N	068029"23E	Sabar Rind	27008"43N	068038"44E
Tando Mir Ali	27005"15N	068028"02E	Hindyari	27006"42N	068035"40E
Tando Mir Ali	27005"17N	068028"03E	Hindyari	27006"40N	068035"40E
Tando Mir Ali	27005"13N	068028"01E	Hindyari	27006"40N	068035"38E

Sample Collection and Processing

A total of 30 samples were collected from ten Union Councils (UC) of taluka Thari Mirwah in the year 2015, with the help of auger at the depth of 15 cm, 30 cm and 45 cm. The samples were taken in triplicate at random positions. The coordinates were recorded for each location (Table 1). The samples were transported to and processed in the soil laboratory, Department of Botany, Shah Abdul Latif University Khairpur. The samples were first dried with the help of oven at 110 ^{0}C. and then further analyzed for the soil parameters like pH, EC and salt contents.

Twenty grams of soil sample were added to 100 mL double distilled water (deionized), the mixture was shaken in shaker machine for ten minutes. The shaken mixture was placed for about 30 minutes for settling down of residues at the bottom of the container and filtered through Whatmann#42. Direct measurement of EC and pH of soil samples was performed from the extract. 1:1 (V/V) of soil/water mixture was used to measure pH of soil which was composed of ten gm NCR-13 volumetric soil scoop and ten ml distilled or de-ionized water. All samples were stirred before as well as after a 15 minutes' equilibration phase. Before taking the reading, pH-meter was calibrated by using buffer solutions of 4, 7 and 10 respectively (Ayers and Westcot,1985; Rhoades, 1999).

Measurement of Soil Parameters

Parameters such as potential of hydrogen (pH), electrical conductivity (EC), chloride (Cl^{-1}), sodium (Na^+), calcium (Ca^{+2}), magnesium (Mg^{+2}) soil texture (ST) and organic matter (OM) were measured by standard protocol (Jones, 2017). The pH was measured by pH-meter, EC with conductivity meter by dipping their electrodes directly into the prepared extract, Cl^{-1} was determined by argentometric titration by using chrome indicator, Na^+ was analyzed by flame photometer. For calibrating the instrument standard solutions were prepared whereas, Na^+ contents were measured from calibration curve. Ca^{+2} and Mg^{+2} were measured with the help of complexometric titration by using EDTA as standard solution in the presence of ammonium perpetrate and Eriochrome Black-T as indicators respectively, soil texture (ST) was detected by hydrometer method (Jones, 2017).

For the statistical analysis, the data were first checked for normality using Shapiro–Wilk and Kolmogorov–Smirnov test using SPSS 20 for windows (IBM Corp., 2010). Data were shown to be normally distributed, parametric tests, e.g. mean, One-way ANOVA, were used otherwise non-parametric tests were selected to identify the variations (Fowler et al., 1998).

Table 2. Descriptive statistics for various soil parameters observed in all taluka Thari Mirwah sites.

Parameters	Max.	Min.	Mean	SD
pH	9.7	6.5	8.0	0.6
EC (dS/m)	26.0	1.0	10.0	7.9
Cl (Meq/L)	371.0	17.3	125.8	97.5
OM (%)	3.2	0.6	1.5	0.6
Na^{+1} (Meq/L)	253.0	95.0	188.5	46.2
Ca^{+2} (Meq/L)	225.0	11.3	36.1	41.6
Mg^{+2} (Meq/L)	93.8	4.7	15.0	17.3

Results and Discussion

Soil Texture

Soil texture regulates various phyico-chemical processes in the soil for example, the water holding capacity, root penetration, internal drainage, soil erosion through wind and water, nutrients availability etc. (Hamarshid et al., 2010). The soil texture was found to vary significantly among the sites (ANOVA, df =9, F=59.4, p <0.001). Comparatively higher proportion of sand and limited clay and silt in Bodar Wada, area was found therefore the soil is classified as sandy loam (Fig. 1) whereas the soil at Thari and Hindyari contained almost equal amount of silt and clay, which appeared to be sandy clay loam. On the contrary, soil at Baki Khan and Mandan were identified with least amount of sand and identified as clay loam. Ghafoor et al., (2004) and Dahar et al., (2014) reported a high percentage of clay particles around Tando Jam and the lower Indus plain. In contrast, a high percentage of sand particles were found in the area under study. This could be explained by the presence of sandy deserts in the nearby zones. A similar texture of the soil has been reported in Chakwal and Layyah districts in Punjab province. (Rashid, 1993; Ashraf et al., 2015).

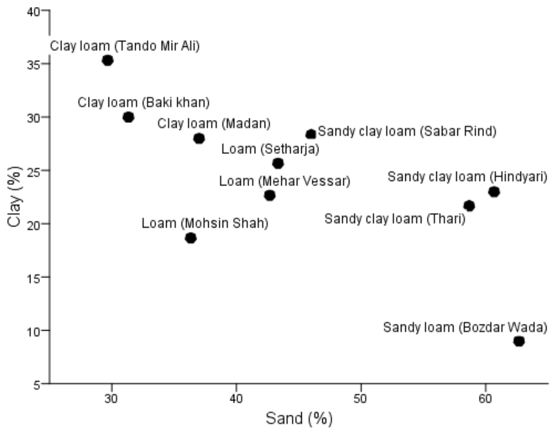

Fig. 1 Assessment of soil texture at different sites of taluka Thari Mirwah. Average contents of sand and clay particles are plotted in the scattered chart with identified soil type and locations shown in brackets.

Soil pH

The soil pH plays an important role in the growth of plants. It affects the availability of soil nutrients to the plants by controlling reactions between nutrients, consequently affecting the growth of plants. The overall soil in the study area was recorded moderately alkaline with an average mean 8.0 ± 0.6 SD (Table 2). This is slightly higher than the ideal range (5.2 – 7.5) of pH for the growth of a wide range of plants. The study found a significance difference in the pH of the recorded locations (one-way ANOVA, F=4.59, p<0.05). This difference was due to higher pH of soil at Tando Mir Ali form Meharvessar (mean difference 1.43 ± 0.3 SE, p=0.01), Mohsin Shah (mean difference 2 ± 0.3 SE, p=0.00), Baqi Khan (mean difference 1.5 ± 0.3 SE, p=0.07), Bozdar Wada (mean difference 1.3 ± 0.3 SE, p=0.02), and Hindyari (mean difference 1.2 ± 0.3 SE, p=0.4) (Fig. 2 a). About 50% of the samples were recorded with a pH less than eight. A slightly alkaline soil recorded (range between 8-9) at Hindyari, Bozdar Wada and Setharja, may disturb the absorption of some plant nutrients to the crops. However, the soil at Tando Mir Ali was not found suitable for many crops due to high levels of pH. A similar range of pH has also been recorded in various areas of Pakistan, i.e. Jhat Pat, Hafizabad, Pindorian, Shahdra etc. (Imtiaz et al., 2010). The alkaline soil reduces the availability of cobalt, phosphorus and zinc, causing reduced yield of crops. Additional management practices are therefore, suggested to cope with this issue in these areas.

Soil EC

The soil EC varies with soil properties i.e. soil particles, texture and water holding capacity. The EC varied in soil samples with a mean EC 10 ±7.9 SD dS/m (Table 2). This is comparatively higher than recorded in the agricultural lands around Tando Jam, Sindh (Dahar et al., 2014), Lahore, Faisalabad, Sargodha, Rawalpindi and Gujranwala divisions (Mehdi et al., 2013). About 40% of our samples were recorded up to normal range (up to 4 dSm). The EC measured at different locations were found to be significantly different (Kruskal Wallis test, df = 9, X^2 = 17.0, p = 0.05). There was a huge variation in EC observed in soil samples of Tando Mir Ali, whereas EC at Mehar Vessar, Mohsin Shah and Sehtarja were found to be relatively higher than in other areas (Fig. 2b).

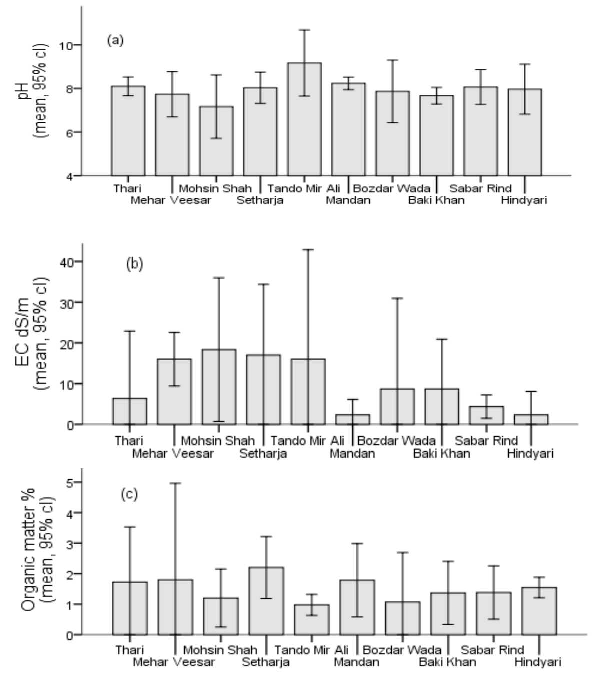

Fig. 2 Soil parameters, (a) soil pH, (b) electrical conductivity (EC) and (c) organic matter (OM) contents in the soil of Thari Mir Wah.

Soil Organic Matter (SOM)

The nitrogen fertilizer is usually advised after the evidences of organic contents in the soil (Cooke, 1982). Organic matter improves the health of plants by providing nutrients and enhances water holding capacity of the soil (Zia, 1993). The percentage organic matter slightly varied among the soil samples, with a mean 1.5 ± 0.6 SD (Table 2). This is

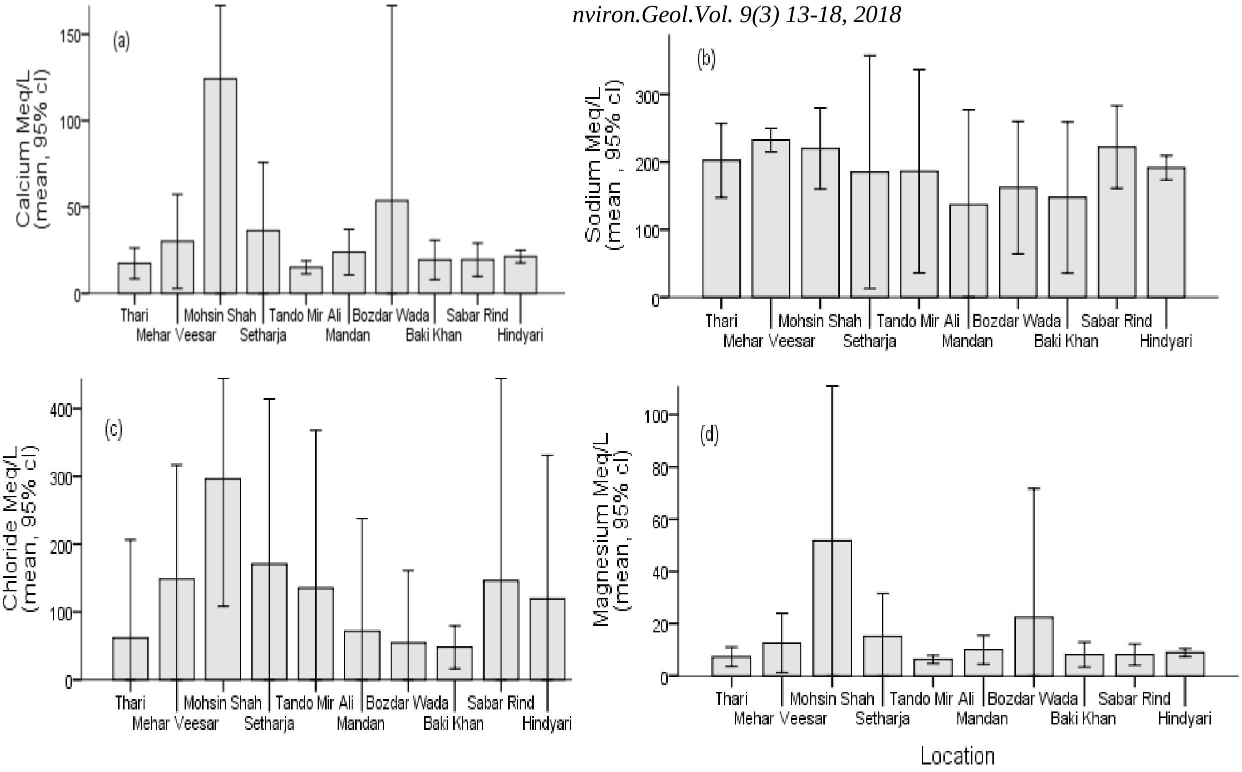

Fig. 3 Dissolved salts in the soil of Thari Mirah (a) calcium, (b) sodium, (c) chloride and (d) magnesium.

comparatively higher than the same reported in Chakwal (0.2-1.3%) by Rashid et al. (1994) and other areas. The average OM contents of soil recorded in Punjab were lower than one percent (Azam, 1988). The study sites did not vary significantly in organic matter contents (one-way ANOVA, F=1.2, p=0.32). The organic matter contents of the soil under study were found to be adequate (more than 1.29 %, as described by Malik et al. (1984), except in two samples from Bozdar Wada, which were found to be poor in organic contents (Fig. 2c). There are certain environmental factors, such as high temperature in the region, which reduces the organic matter through faster decomposition. Nevertheless, this would be managed through management practices i.e. adding farmyard and other manure.

Salts Contents

However, the chloride (mean 125.8 Meq/L) and sodium (mean 188.5 Meq/L) contents varied among the samples (Table 2, Fig. 3), both chloride (Kruskal Wallis test, df =9, X^2 = 14.1, p=0.12) and sodium (one-way ANOVA, F=1.8, p=0.1) contents did not vary significantly among the sites. A similar variation and level of chloride and sodium contents have also been reported in the soil of Tando Bago, district Badin Sindh (Chanio et al., 2010). On the contrary, the difference in calcium (Kruskal Wallis test, df = 9, X^2 = 16.0, p=0.055) and magnesium (Kruskal Wallis test, df =9, X^2 = 16.6, p=0.055) contents among the sites were found to be marginally significant (Fig. 3). Further, there was a significant correlation between sodium (Na^+) and chlorides (Cl^{-1}), EC with magnesium (Mg^{2+}) and calcium (Ca^{2+}), and magnesium (Mg^{2+}) with calcium (Ca^{2+}) (Fig. 4). The amount of total dissolved salts generally strengthens the electric conductance. The calcium and magnesium salts are reported correlating with each other and with electric conductance (Agarwal et al., 2014).

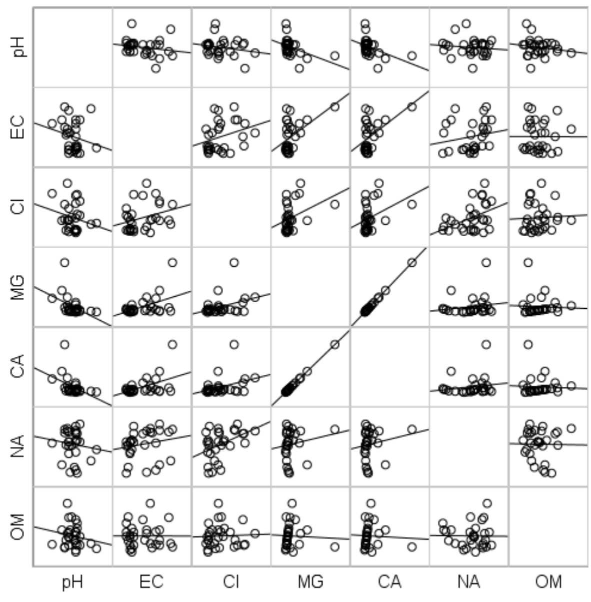

Fig. 4 Relationship among the soil parameters analyzed in the study area. A significant correlation between sodium (Na^+) and chlorides (Cl^{-1}) (Pearson correlation, r =0.19, p<0.01), EC with magnesium (Mg^{+2}) and calcium (Ca^{+2}) (Pearson correlation, r = 0.48, p<0.01), and magnesium (Mg^{+2}) with calcium (Ca^{+2}) (Pearson correlation, r = 1.0, P<0.01).

Conclusion

The soil of the area under study contained high concentration of sand particles. The higher concentration of sodium contents and calcium in some parts characterized the soil as slightly alkaline in nature, which is suitable for salt tolerant crops. However, the health of soil could be improved through management practices. It is recommended that the appropriate type and amount of fertilizer may be applied for maximum crop production in saline soil. The farmyard and poultry manure could be used to improve the soil quality. In addition, the use of canal water may be used to trickle down the salts from the soil.

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