Progressive Agriculture 30 (2): 157-164, 2019 ISSN: 1017 - 8139

Progressive Agriculture
Journal homepage:http://www.banglajol.info/index.php/PA

Seasonal study on soil salinity and its relation to other properties at Satkhira district in Bangladesh

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Abstract

The study was conducted at Shyamnagar and Talaupazila of Satkhira district in Bangladesh to know about the soil salinity and its relation to other properties of soil in both dry and wet season and comparison the present status of soil between two upazilas. Electrical Conductivity (EC) value of the study area showed that yield of many crops can be restricted in dry season due to salinity. Mean EC was slightly saline (5.93 dsm^{-1}) in dry season and non- saline (0.61 dsm^{-1}) in wet season. Ranges of pH were slightly acidic to slightly alkaline (6.2 to 7.5) in dry season and slightly acidic to neutral (5.7 to 6.9) in wet season. pH values indicate it was suitable for crop production. Mean Organic Matter (OM) status was low in both seasons (1.5 % in dry season and 1.6 % in wet season). Mean total N status was very low (0.08 %) in dry season and low (0.10 %) in wet season. Mean status of P in the study areas was low (8.08 μgg^{-1} soil) in dry season and very low (4.98 μgg^{-1} soil) in wet season. Mean status of K, Ca, Mg, S and Zn were very high in both season of study area and this was may be due to excessive fertilizer use and inherent properties of soil in the agricultural land. Mean status of B was high in Tala in both season and in Shyamnagar was high in dry season and optimum in wet season. To test the significance of the pair of parameters p-value has been measured. Pearson's correlations among the different parameters were done to identify the highly correlated and interrelated soil quality parameters. EC showed significant and positive correlation with Potassium, Sulphur and Zinc in dry season. Although chemical properties of soil at Shyamnagar and Talaupazila was not found similar and optimum level but it was found that the chemical properties of soil of wet season more suitable than the dry season because of soil salinity.

Key words: Soil salinity, agriculture, soil pH, electrical conductivity, organic matter

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Introduction

Bangladesh lies in the northeast of the Indian subcontinent on the Bay of Bengal. It is a predominantly low-lying country with several major rivers located mainly in the large delta formed by the Brahmaputra and Ganges Rivers. Bangladesh has a tropical climate; it is humid and warm throughout the year with a year round average temperature of 25°C. Rainfall is moderate to high across the country and ranges from 1400mm along the eastern border to 5100 mm in the northeast which directly affect the crop growth and production (Asaduzzaman *et al.*, 2010; Hossain and Deb, 2011; Rokonuzzaman *et al.*, 2018). Bangladesh has 710 km coastal line. Tidal and estuarine floodplains cover almost 98% of the coastal area. Small areas (2%) with river floodplains and peat basins are found in the northern part of the coastal area

(Haque, 2006). Karim *et al.* (1982) investigate that, coastal saline area lies about 1.5 to 11.8 meters above the mean sea level. The Ganges river meander floodplain systems are standing higher than the adjoining tidal lands. The tidal floodplain has a distinctive, almost level landscape crossed by innumerable interconnecting tidal rivers and creeks. The estuarine islands are constantly changing shape and position as a result of river erosion and new alluvial deposition. Peat basins are located in some of the low-lying areas between the Ganges river floodplains and tidal floodplains occurring in the western part of Khulna. Agricultural land in the coastal area is limited to wet season cropping because soil salinity is high in the dry season. Medium-high land dominates the coastal area, followed by highland, medium lowland and lowland. At present, coastal regions contribute approximately 16 percent of the total rice production of the country. In coastal districts monsoon paddy is the dominant crop, covering about 70 percent of the total paddy-cropped area. About 60 percent of the paddy-cropped area is planted with local varieties adapted to poor water management that results in water logging and salinity. The coastal zone produces a relatively high proportion of pulses, oilseeds, betel nuts and leaves, winter vegetables and potatoes (BCAS, 2010). The concentrations of soil nutrients (e.g., organic C, N, P, and K) are good indicators of soil quality and productivity because of their favorable effects on the physical, chemical, and biological properties of soil (Cao *et al.*, 2011). Saline soils vary widely in their physical and chemical properties as well as hydrology (Ikehashi and Ponnamperuma, 1978). Salinity problem is often intensified when high spring tides inundate low-lying coastal areas, especially when they are associated with cyclonic storm surges. Many of the crop varieties, especially those of food grain varieties, are not salinity tolerant. As a result, a large area in the coastal districts is virtually unsuitable for a number of crops, while the production of a few other crops is lesser under saline conditions. (Habibullah *et al*., 1999). The total area affected by salinity has increased to about 0.1056 million hectares from 0.833 million hectares in the last four decades. In 2009, the size of the salinity-affected land was nearly 0.1056 million hectares (SRDI, 2010). Soil mapping based on zones also showed the affected area in Bangladesh (Islam *et al.*, 2017). The worst salinity conditions are reported from the Khulna, Bagerhat, Satkhira and Patuakhali districts. (Rashid *et al.,* 2004; Ashraf *et al*., 2002). Therefore, the specific objectives of this study were to assess the changes of physic-chemical properties of soil component (P^H, OM,¸salinity, nutrients etc.) in dry and wet season, to find out the impacts of soil salinity on soil properties and to find out the relation of soil salinity with others soil properties.

Materials and Methods

Satkhira district is located in AEZ 11 and AEZ 13, those are known as High Ganges river floodplain and Ganges Tidal floodplain. The study was carried out in Tala and Shyamnagar upazila under Satkhira district of Bangladesh for one year.

***Data collection*:** The composite soil samples were collected in April, 2015 (dry season) and August, 2015 (wet season) from the same location. Three samples were collected from Hybadpur(S1), Nakipur (S2) and Dadpur (S3) of Symnagar upazila (P1) and the rest three were collected from Tetulia (S1), Mohondir bill (S2) and Horischandrakati (S3) of Tala upazila (P1) in dry season and the same way in wet season. Samples were collected from surface soil. The study area was divided according to its soil characteristics of flooding and also its texture, structure, color.

***Data analysis*:** Ground samples were screened to pass through a 2mm stainless steel sieve. The sieved samples were further grind and screened to pass through a 0.5mm sieve. The sieved samples were mixed thoroughly for making composite samples. The following analyses were done in the laboratory for the collected soil samples: Soil pH was determined by digital pH meter and EC of soil was determined by EC meter. The organic matter of the soil sample was determined by Walkley and Black's wet oxidation method (Imam and Didar, 2005). Total Nitrogen of soil samples were determined by Semi-micro Kjeldahl method (Satter and Rahman, 1987). Available Potassium in soil was determined by ammonium acetate extraction method (Satter and Rahman, 1987). The Calcium and Magnesium of the soil sample was also determined by ammonium acetate extraction method (SRDI, 2001). Available Phosphorus of soil was determined by using the Olsen method /sodium bicarbonate method (Satter and Rahman, 1987). The available Sulphur in soil was determined by calcium chloride extraction method (Satter and Rahman., 1987). Boron was determined by Hot-water extraction method using a dilute calcium chloride solution (Wolf, 1971). Zinc of the soil sample was determined by 0.1 N HCl (hydrochloric acid) extraction methods (Huq and Alam, 2005). The chemical data were interpreted and put in Table.

Results and Discussion

***Electrical conductivity (EC)*:** In dry season the highest salinity slightly saline (7.69 ds/m) soil was found in station 3 under point 1 and the lowest salinity non-saline (1.46 dsm^{-1}) was found in station 2 under point 1. But in dry season soil salinity of all points was found non-saline (Table 1). This variation was found mainly for seasonal rainfall and flood. Mean EC indicates in dry season was slightly saline (5.93dsm^{-1}) and in wet season was non-saline (0.61 dsm^{-1}). Mean EC value of Shyamnagar (P1) and Tala (P2) showed that yields of many crops can be restricted in dry season but in wet season salinity effects are mostly negligible. Soil EC values ranges from 0-2 ds/m indicates non-saline soil (SRDI, 2010). Khalilnagar which located in Talaupazila of Satkhira district, is very close to study area (sampling point 2) and in 2009, EC was found 3.8 dsm^{-1} in here which indicates salinity effects are mostly negligible except for the most sensitive plants (SRDI, 2010).

***pH*:** In dry season, pH ranges in P1 was slightly acidic to slightly alkaline (6.5-7.5) and in P2 was slightly acidic to neutral (6.2-7.2). Mean pH was neutral (6.83). In wet season, pH ranges in P1 was slightly acidic (5.7-6.4) and in P2 was slightly acidic to neutral (6.4-6.9). Mean pH was slightly acidic (6.4) (Table 1). It indicates pH of the study area soil was more or less neutral condition which was suitable for agricultural crop production. Soil pH ranges from 6.6-7.3 can be categorized as neutral soil (BARC, 2018).In 2009, pH was found 7.8 in Khalilnagar of Tala upazila, which was close to study area (S2) (SRDI, 2010) which indicates slightly alkaline soil. In most cases, pH range of 6.0-7.5 is optimum for the adequate availability of nutrients in the soil (BARC, 2012).

***Organic matter (OM)*:** In dry season, OM ranges were found very low to low (0.49 to 1.61percentages) but it was low (1.22 to 1.88 percentages) in dry season in both P1 and P2. Mean OM status in dry and wet season was low (1.16 and 1.56 percentages) respectively (Table 1). High (>3.4%) soil organic matter status indicates suitable for agricultural crop production (BARC, 2018).

***Total nitrogen (N)*:** In dry season, N status ranges were found very low (0.047 to 0.071 %) in P1 and very low to low (0.047 to 0.155 %) in P2. But in wet season it was found low (0.098 to 0.121 %) in P1 and very low to low (0.074 to 0.135 percentages) in P2. Mean N status was very low (0.08 %) in dry season but low (0.10%) in wet season (Table 1). All the N status indicates that both seasons were lower than the optimum (0.271 to 0.36 %) level (BARC, 2018).

***Available phosphorus (P)*:** In dry season, P status ranges were found very low to low (1.65 to 11.15 $\mu g g^{-1}$ soil) in P1 and very low to medium (3.09 to 17.37 $\mu g\ g^{-1}$soil) in P2. But in wet season it was found very low (0.88 to 7.11$\mu g\ g^{-1}$soil) in P1 andvery low to low (0.72 to 8.98 $\mu g\ g^{-1}$soil) in P2. Mean P status was low (8.09 $\mu g\ g^{-1}$soil) in dry season but very low (4.98 $\mu g\ g^{-1}$soil) in wet season (Table 1).

Table 1. Status of the soil properties in and around the study area.

Parameters	Seasons	Sampling Points (P1)			Sampling Points (P2)			Mean	Optimum
Sampling Stations		S1	S2	S3	S1	S2	S3		
EC (ds/m)	Dry	3.92	4.46	7.69	6.13	6.89	6.46	5.93	<2
	Status*	VSS	SS	SS	SS	SS	SS	SS	NS
	Wet	0.63	0.41	0.8	0.59	0.63	0.57	0.61	<2
	Status*	NS	NS	NS	NS	NS	NS	NS	NS
pH	Dry	6.7	7.5	6.5	6.2	6.9	7.2	6.83	6.6-7.3
	Status*	N	SAL	SA	SA	N	N	N	N
	Wet	5.7	6.4	6.1	6.7	6.9	6.5	6.4	6.6-7.3
	Status*	SA	SA	SA	N	N	SA	SA	N
OM (%)	Dry	0.94	1.41	1.41	1.61	1.09	0.49	1.16	>3.4
	Status*	VL	L	L	L	L	VL	L	H
	Wet	1.22	1.88	1.42	1.68	1.69	1.48	1.56	>3.4
	Status*	L	L	L	L	L	L	L	H
Total N (%)	Dry	0.047	0.071	0.071	0.081	0.155	0.047	0.08	>0.271
	Status*	VL	VL	VL	VL	L	VL	VL	O
	Wet	0.111	0.098	0.121	0.084	0.135	0.074	0.10	>0.271
	Status*	L	L	L	VL	L	VL	L	O
P (µg/g soil)	Dry	1.65	9.45	11.15	5.80	3.09	17.37	8.09	>22.51
	Status*	VL	L	L	VL	VL	M	L	O
	Wet	3.87	0.88	7.11	8.32	0.72	8.98	4.98	>18.1
	Status*	VL	VL	VL	L	VL	L	VL	O
K (meq/100 g soil)	Dry	0.34	0.31	0.72	0.52	0.82	0.31	0.50	>0.271
	Status*	O	O	VH	VH	VH	O	VH	O
	Wet	0.44	0.26	0.6	0.25	1.4	0.23	0.53	>0.226
	Status*	H	O	VH	O	VH	O	VH	O
S (µg/g soil)	Dry	23.52	22.57	171.23	106.5	317.7	54.14	115.9	>22.51
	Status*	O	O	VH	VH	VH	VH	VH	O
	Wet	40.36	22.38	80.63	21.4	429.1	43.18	106.2	>27.1
	Status*	H	M	VH	M	VH	H	VH	O
Ca (meq/100 g soil)	Dry	20.25	31.65	10.62	18.96	20.89	22.17	20.76	>4.51
	Status*	VH	VH	VH	VH	VH	VH	VH	O
	Wet	11.37	9.90	5.70	12.55	13.6	14.77	11.32	>4.51
	Status*	VH	VH	O	VH	VH	VH	VH	O
Mg (meq/100 g soil)	Dry	5.42	5.54	2.10	6.58	8.17	1.93	4.96	>1.126
	Status*	VH	VH	VH	VH	VH	VH	VH	O
	Wet	2.15	1.76	1.67	2.72	2.9	2.24	2.24	>1.126
	Status*	VH	H	H	VH	VH	VH	VH	O
Zn (µg/g soil)	Dry	3.38	3.20	5.64	4.39	4.94	4.42	4.33	>1.351
	Status*	VH	VH	VH	VH	VH	VH	VH	O
	Wet	4.35	2.78	5.02	5.08	7.79	6.52	5.26	>1.351
	Status*	VH	VH	VH	VH	VH	VH	VH	O
B (µg/g soil)	Dry	0.63	0.27	0.93	0.96	0.89	0.52	0.70	>0.451
	Status*	H	L	VH	VH	VH	O	H	O
	Wet	0.64	0.33	0.6	0.26	1.2	0.43	0.58	>0.451
	Status*	H	M	O	L	VH	M	O	O

Note:*Status: NS= Non-saline; VSS= Very slightly saline; SS= Slightly saline; SA= Slightly acidic; N= Neutral; SAL= Slightly alkaline; VL= Very low; L= Low; M= Medium; O= Optimum; H= High; VH= Very high.

All the P status indicates that both seasons were lower than the optimum (22.51 and 18.1 μg g^{-1}soil) level (BARC, 2018).

Potassium (K): In dry and wet season, K status ranges were found optimum to very high (0.26 to 1.4meq/100 g soil) in both P1 and P2. Mean P status was very high (0.50 and 0.53meq/100 g soil) in both seasons (Table 1). Mean K status indicates that both seasons were higher than the optimum (0.271 and 0.226meq/100 g soil) level (BARC, 2018).

Available sulphur (S): In dry season, S status ranges were found optimum to very high (22.57 to 171.23 μg g^{-1}soil) in P1 and very high (54.14 to 317.7 μg g^{-1}soil) in P2. But in wet season it was found medium to very high (21.4 to 429.1μg g^{-1}soil) in both P1 and P2. Mean S status was very high (115.9 and 106.2 μg g^{-1}soil) in both dry and wet seasons (Table 1). Mean S status indicates that both seasons were higher than the optimum (22.51 and 27.1 μg g^{-1}soil) level (BARC, 2012).

Total calcium (Ca): In dry and wet season, Ca status ranges were found very high (10.62 to 31.65 meq/100 g soil) in both P1 and P2 except S2. It was optimum (5.70meq/100 g soil). Mean Ca status was very high (20.76 and 11.32meq/100 g soil) in both seasons (Table 1). Mean Ca status indicates that both seasons were higher than the optimum (4.51 meq/100 g soil) level (BARC, 2012).

Total magnesium (Mg): In dry season, Mg status ranges were found very high (2.10 to 5.54 meq/100 g soil) in both P1 and P2. In wet season, it was high to very high (1.67 to 2.15 meq/100 g soil) in P1 and very high (2.24 to 2.72meq/100 g soil) in P2. Mean Mg status was very high (4.96 and 2.24meq/100 g soil) in both seasons (Table 1). Mean Mg status indicates that both seasons were higher than the optimum (1.126meq/100 g soil) level (BARC, 2018).

Zinc (Zn): In dry and wet season, Zn status ranges were found very high (2.78 to 7.79 μg g^{-1} soil) in both P1 and P2. Mean Zn status was also very high (4.33 and 5.26 μg g^{-1} soil) in both dry and wet seasons (Table 1). All the Zn status indicates that both seasons were higher than the optimum (1.351 μg g^{-1} soil) level (BARC, 2018).

Boron (B): In dry season, B status ranges were found low to very high (0.27 to 0.93 μg g^{-1} soil) in P1 and optimum to very high (0.52 to 0.96 μg g^{-1} soil) in P2. But in wet season it was found medium to high (0.33 to 0.64 μg g^{-1} soil) in P1 and low to very high (0.26 to 1.2μg g^{-1} soil) in P2. Mean B status was high (0.70μg g^{-1} soil) in dry season and optimum (0.58μg g^{-1} soil) in wet season (Table 1). Mean B status indicates that both seasons were higher than the optimum (0.451μg g^{-1} soil) level (BARC, 2018).

Correlation among different soil parameters with EC: The EC showed significant and positive correlation with K, S and Zn ($p<0.05$) in dry season. pH shows a positive and significant correlation ($p<0.05$) with Cain dry season and OM showed a positive and significant correlation ($p<0.05$) with N in wet season and K, S and B in both season. N showed a positive and significant correlation ($p<0.05$) with OM in wet season and with K, S and B in both season. K showed a positive and significant correlation ($p<0.05$) with OM, N, S and B in both season. Ca showed a positive and significant correlation ($p<0.05$) with pH in dry season and negative and significant correlation ($p<0.05$) with EC and Zn in dry season. S showed a positive and significant correlation ($p<0.05$) with OM, N, K and B in both season and with EC and Zn in dry season. B showed a positive and significant correlation ($p<0.05$) with OM, N, K and S in both season. Zn showed a positive and significant correlation ($p<0.05$) with EC and S in dry season and negative and significant correlation ($p<0.05$) with Ca in dry season (Table 2 and Table 3).

Table 2. Pearson correlations among the different parameters of dry season soil at Satkhira district.

	EC	pH	OM	N	K	Ca	Mg	P	S	B	Zn
EC	1	-0.77*	0.53	0.53	0.89*	-0.83	0.17	-0.34	0.77*	0.62	0.81*
pH		1	-0.06	-0.06	-0.49	0.78*	-0.11	0.38	-0.26	-0.18	-0.47
OM			1	1*	0.78*	-0.02	0.7	-0.44	0.9*	0.95*	0.39
N				1	0.78*	-0.02	0.7	-0.44	0.9*	0.95*	0.39
K					1	-0.53	0.41	-0.47	0.88*	0.78*	0.67
Ca						1	0.33	0.017	-0.4	-0.21	-0.8*
Mg							1	-0.81*	0.4	0.61	-0.26
P								1	-0.27	-0.46	0.23
S									1	0.94*	0.72*
B										1	0.48
***. Correlation is significant at 0.05 level.**											

Table 3. Pearson correlations among the different parameters of wet season soil at Satkhira district.

	EC	pH	OM	N	K	Ca	Mg	P	S	B	Zn
EC	1	-0.26	0.52	0.47	0.36	-0.44	-0.03	0.38	0.25	0.37	0.4
pH		1	-0.07	-0.07	0.37	0.5	0.66	-0.07	0.47	-0.2	0.55
OM			1	0.99*	0.85*	-0.37	0.08	-0.58	0.78*	0.84*	0.28
N				1	0.84*	-0.38	0.06	-0.62	0.77*	0.83*	0.24
K					1	0.08	0.48	-0.54	0.99*	0.96*	0.67
Ca						1	0.74	0.03	0.19	0.13	0.52
Mg							1	-0.03	0.55	0.43	0.69
P								1	-0.55	-0.52	0.13
S									1	0.95*	0.7
B										1	0.67
***. Correlation is significant at 0.05 level.**											

Conclusion

The present study revealed that mean EC value of P1 and P2 can be restricted the yield of many crops in dry season due to excessive salinity but in wet season salinity effects are mostly negligible. The mean status of pH atP1 indicates neutral soil in dry season and slightly acidic soil in wet season and mean pH in P2 indicates neutral condition of soil which is suitable for agricultural production. In P1 and P2 status of OM in dry and wet season was low in soil which was not suitable for agricultural production and was lower than optimum level. Mean status of N in P1 and P2 were lower than the optimum value. Mean status of K, Ca, Mg and S were very high in both season in P1 and P2 this might be due to inherent properties of soil and excessive use of fertilizer in the agricultural land of the study area. Mean status of P in P1 and P2 were low which means the study area was P deficient. Mean status of B was high in P2 in both season and in P1 it was high in dry season and optimum in wet season. Mean status of Zn in P1 and P2 was very high than the optimum value. The correlation analysis on the soil quality parameters revealed that all parameters are more or less correlated with each other. It is observed that some of the parameters do not have significant correlation. Expanding research, monitoring, knowledge management and development and transfer of technology, especially on saline-resistant crop varieties, special management and access to freshwater are needed to manage climate change and its impacts in the study area.

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