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Original Article

Spatial variability of some chemical properties of soil at Taltali Upazila of Barguna district, Bangladesh

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ABSTRACT

Soil is a suitable place for vegetation and plant growth while this valuable investment is not preserved, shortage of food, and erosion and damage natural resources will be respected. Soil is a heterogeneous, diverse and dynamic system and investigation of its temporal and spatial changes are essential. Salt accumulation in soils, affecting agricultural productivity, environmental health, and the economy of the coastal farmers. The present study was undertaken to evaluate the salinity level in different soil layer and to provide better understanding of spatial variability of soil salinity and some nutrients during dry period, in south coastal region of Bangladesh. Soil samples were collected from 30 different locations of Taltali Upazila in Barguna district. From each spot, soil samples were collected from two soil depths (0–5 cm and 5–10 cm.). The results revealed that in the 0–5 cm and 5–10 cm soil depth the EC value varied from 1.62 to 8.44 dS/m and 0.09 to 3.15 dS/m with mean value of 4.69 and 1.52 dS/m, respectively. Soil salinity is, therefore, developed within a very thin top layer of the soil, below which the salinity level is comfortable for crop growth. The top soil layer pH value was very low and strongly acidic (4.18 in 0–5 cm soil depth and 4.62 in 5–10 cm soil depth) indicating acidic nature of the soil. Phosphorus content was found higher in subsurface soil (5–10 cm soil depth) whereas sulfur content was higher in surface soil (0–5 cm soil depth). The sodium, potassium, HCO_3^- and Cl^- ion content was found higher in surface soil than subsurface soil. The sodium content was found several folds higher than the potassium content. The results are, therefore, clearly evidenced that top soil is very much sensitive to salt stress. The shallow rooted crops are more susceptible with this salinity. Deep rooted crops are may be suitable for growing in the coastal saline soils which contribute in agricultural management and ecological restoration in southern coastal region of Bangladesh.

Keywords: Chemical properties, salinity and soil, spatial variability

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INTRODUCTION

Soils as a natural bodies are inherently heterogeneous in nature because of the many factors that contribute to their formation and the complex interactions of these factors.[1] Soils are diverse, and dynamic system.[2] Soil heterogeneities may arise from management activities[3] and can occur from land use and management strategies.[4] Heterogeneity of soil properties is a general characteristics in arid and semi-arid ecosystem.[5,6] Soils characterized by high degree of variability due to the interplay of physical, chemical, biological, and anthropogenic processes that operate with different intensities and at different scales and acting simultaneously.[7,8] The differences in their characteristics associated with landscape position are usually contributed to the differences in the runoff, erosion, and deposition which effect soil gneisses.[9] These characteristics can be a direct result of soil forming factors and their interactions.[10]

Soil spatial variability is an important determinant of efficiency of farm inputs and yield[11] as well as crop management and design and effectiveness of field research trials.[12] These variations differed among soil properties and may reflect the impacts of plant, soil fauna, precipitation, and management practices adopted in the area.[13] Consequently, soils can exhibit marked spatial variability at the macro-scale and micro-scale.[14] High variability of soil properties might be related to variability of properties of flood sediments and controlled by primarily the

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depositional environment where high energy systems deposit materials with high spatial variability.[15] These processes and causes create pattern of nested variability or heterogeneity, this means that, soil properties may display spatial /or temporal patterns only over certain distances and not others.[16]

The characterization of spatial variability of soil attributes is essential to achieve a better understanding of the complex relations between soil properties and environmental factors.[17] Moreover, knowledge of spatial variability and relationships among properties is important for the evaluation of agricultural management practices[18] and the variability of physical and chemical properties of soil is unavoidable.[14] Moreover, understanding the distribution of soil properties in the field is essential in refining agricultural management practices.[19] Understanding the magnitude and pattern in spatial variability of soil properties is necessary for improved management options application and strategies for sampling and design for field research trials,[12] such information is needed for enhancing agricultural production and provides as a base for further research by scientists.

Estimating spatial variability of soil properties is significant for evaluating environment and prerequisite for soil and crop specific management[20] and provides the factors and processes controlling potential in agriculture production.[19] Spatial variability should be studied in every field and understanding this variability has important application in agriculture, environment, hydrology, and earth sciences.[21] For seeing the importance of spatial variability, and because of limited or little information available for description of spatial variability of soil chemical properties of Ganges floodplain, this study was directed to characterize and evaluates the spatial variability of chemical properties of soil.

MATERIALS AND METHODS

Location of the Study

The study was conducted at Taltoli Upazila of Barguna district, Bangladesh. It is one of the most cyclones prone salt affected coastal Upazila in Southern Bangladesh. It lays between 22°0.0876′North latitude and between 90°0.177′East longitude. Five villages adjacent to sea-beach were selected for soil sample collection. From five villages total thirty sampling locations were selected randomly. From each location soil samples were collected from two different soil depths: 0–5 cm and 5–10 cm.

Collection and Preparation of Soil Samples

Soil samples were collected from each location by means of an auger. The collected soil samples were carried to the laboratory, air dried, broken down large macro aggregates, and passed through a 2-mm sieve to remove weeds and stubbles from the soil. Samples are preserved in plastic bottles for subsequent laboratory analysis according to different soil depth (0–5 cm and 5–10 cm).

Climate

The climate of the study area is typically monsoon with a warm and dry season from March to May followed by a rainy season from June to October and a cool period from November to February. The mean annual rainfall in south western region is about 2000 mm of which about 70% occur during the monsoon season. The distribution of rainfall usually varies in a northwest (minimum 1500 mm) to southeast direction (maximum 2900 mm).

Agro-ecological Region

The experimental area belongs to the Agro-Ecological Zone of AEZ–13 (Ganges Tidal FloodPlain).

Data Management and Analysis

The data were analyzed by Microsoft Office Excel 10. Results were expressed as frequencies and percentages (%).

RESULTS AND DISCUSSION

Soil Reaction (pH)

Soil reaction (pH) considerably influenced by soil depth [Table 1]. Considering 30 soil sample data the range of pH at 0–5 cm soil depth was 3.73 in Koroibaria-3 to 5.72 in Moddhokochupatra-8 with mean value of 4.18. At 5–10 cm soil depth highest pH was found in Moddhokochupatra-8 (5.88) and the lowest was in Alirbondor-3 (4.01). The mean pH value in this soil depth was 4.62.

The results clearly evidenced that with the increase of the soil depth pH value progressively increased. Previously the highest pH value of 7.45 was found in 5–10 cm soil depth by Islam *et al.*[22] Higher soil acidity (lower pH values) favors the availability of cations in soil.[23] In the study most of the soils was found strongly acidic in nature. When soil depth effect in different villages was considered at 0–5 cm soil depth, the 2nd, 3rd, 4th, and 5th highest rank was recorded at Koroibaria-1 (4.74), Moddhokochupatra-10 (4.58), Alirbondor-6 (4.56), and Moddhokochupatra-6 (4.46), respectively.

Electrical Conductivity of Soil

Electrical conductivity ($EC_{1:5}$) of soil was highly influenced by soil depth. In the 0–5 cm soil depth, the mean $EC_{1:5}$ value was 4.69dS/m with a wide range of 1.62–8.44 dS/m. In this soil, depth lowest and highest $EC_{1:5}$ were found at Alirbondor-4 and Kochupatra-2, respectively [Table 1]. At 5–10 cm soil depth the mean $EC_{1:5}$ values found as 1.52 dS/m. In this depth, $EC_{1:5}$ varied from 0.09 to 3.15 dS/m over the sampling locations. Table 1 clearly evidenced that soil salinity developed in the top layer of the soil, below which the salinity levels comfortable for crop growth.

Table 1: Soil pH and soil electrical conductivity (EC1:5) as influenced by soil depths and locations

Location	Soil pH value			Soil EC1:5 (dS/m)		
	0–5 cm	5–10 cm	Mean	0–5 cm	5–10 cm	Mean
Kochupatra-1	4.34	5.18	4.76	2.26	0.85	1.56
Kochupatra-2	4.01	4.05	4.03	8.44	2.85	5.65
Kochupatra-3	3.96	4.64	4.30	3.81	1.04	2.43
Moddhokochupatra-1	3.96	5.25	4.61	4.62	1.14	2.88
Moddhokochupatra-2	4.60	5.36	4.98	2.96	0.09	1.53
Moddhokochupatra-3	3.87	4.49	4.18	4.11	1.36	2.74
Moddhokochupatra-4	3.89	4.46	4.18	3.92	1.19	2.56
Moddhokochupatra-5	3.98	4.08	4.03	6.51	2.46	4.49
Moddhokochupatra-6	4.46	4.62	4.54	6.48	1.35	3.92
Moddhokochupatra-7	3.93	4.20	4.07	2.77	1.81	2.29
Moddhokochupatra-8	5.72	5.88	5.80	5.55	1.96	3.76
Moddhokochupatra-9	4.35	4.96	4.66	1.96	0.44	1.20
Moddhokochupatra-10	4.58	5.12	4.85	5.35	1.41	3.38
Nolbunia-1	4.47	4.82	4.65	4.56	1.35	2.96
Nolbunia-2	4.03	4.95	4.49	6.03	2.06	4.05
Nolbunia-3	4.24	4.49	4.37	7.84	3.15	5.50
Nolbunia-4	4.29	4.25	4.27	4.45	2.51	3.48
Nolbunia-5	4.00	4.38	4.19	4.12	1.28	2.70
Koroibaria-1	4.74	5.00	4.87	8.03	1.03	4.53
Koroibaria-2	4.16	4.58	4.37	6.61	2.51	4.56
Koroibaria-3	3.73	4.48	4.11	3.78	1.09	2.44
Koroibaria-4	3.96	4.25	4.11	6.00	1.79	3.90
Koroibaria-5	3.87	4.53	4.20	4.62	1.24	2.93
Koroibaria-6	3.99	4.41	4.20	5.58	1.04	3.31
Alirbondor-1	3.87	4.58	4.23	3.68	1.09	2.39
Alirbondor-2	4.04	4.61	4.33	5.57	1.67	3.62
Alirbondor-3	3.93	4.01	3.97	4.51	2.24	3.38
Alirbondor-4	3.98	4.38	4.18	1.62	1.01	1.32
Alirbondor-5	3.99	4.11	4.05	2.39	1.52	1.96
Alirbondor-6	4.56	4.45	4.51	2.48	0.95	1.72
Average	4.18	4.62	4.40	4.69	1.52	3.10
Minimum	3.73	4.01	3.97	1.62	0.09	1.20
Maximum	5.72	5.88	5.80	8.44	3.15	5.65
Standard deviation	0.39	0.43	0.38	1.81	0.70	1.16

The data presented in Table 1 are interpreted with standard values. In Bangladesh, salt affected soils are classified into five groups according to EC value as non-saline (0–2 dS/m), slightly saline (2–4 dS/m), moderately saline (4–8 dS/m), saline (8–12 dS/m), and highly saline (>12 dS/m). It is showed in Table 1 that over the locations the soils at 0–5 cm soil depth was moderately saline. However, there was found a big variation among the samples. Out of 30 samples at 0–5 cm soil depth, only four were non-saline, three slightly saline, 12 moderately saline, eight saline, and four were highly saline. When soil depth effect is considered between different villages it was found that in 0–5 cm soil depth highest of 8.44 dS/m was recorded in Kochupatra-2 location which was followed by Koroibaria-1 (8.03 dS/m), Nolbunia-3 (7.84 dS/m), Moddhokochupatra-5 (6.58 dS/m), and Moddhokochupatra-6 (6.48 dS/m) village. Over the villages both lowest (0.44 dS/m) and highest (8.44 dS/m) salinity found in which indicates extreme variability in soil salinity, in agreement with salinization patterns observed under oak plantations with groundwater at 5 cm of depth.[24] This salinity decrease with the increase of soil depth could be expected if anoxic conditions, driven by the shallow water-table, and hinder groundwater consumption (and salt accumulation) by crops.[25]

Available Phosphorus Content in Soil

The highest available P content (29.6 ppm) at Moddhokochupatra-10 and lowest available P content (1.8 ppm) at Koroibaria-2 was recorded in 0–5 cm soil depth [Table 2] which was considerably different with other soil depth. In 5–10 cm soil depth, the highest available P content (30.0 ppm) was found at Nolbunia-3 and lowest available P content (2.5ppm) was at Koroibaria-3. Table 2 indicates that P content found in all the soil depths was very low which indicates the acute deficiency of P over the soil column in the study areas.

Considering 30 soil sample data in 0–5 cm soil depth, the 2nd, 3rd, 4th, and 5th rank was recorded at Alirbondor-6 (29.2 ppm),

Table 2: Soil available phosphorus and sulfur content (ppm) as influenced by different soil depths and locations

Location	Available P content (ppm)			Available S content (ppm)		
	0–5 cm	5–10 cm	Mean	0–5 cm	5–10 cm	Mean
Kochupatra-1	10.8	15.2	13.0	42.0	40.0	41.0
Kochupatra-2	16.1	19.0	17.6	70.0	20.1	45.1
Kochupatra-3	10.4	12.4	11.4	53.0	34.1	43.5
Moddhokochupatra-1	8.6	11.5	10.1	148.1	5.1	76.6
Moddhokochupatra-2	9.8	10.5	10.2	73.0	26.0	49.5
Moddhokochupatra-3	14.0	24.0	19.0	81.1	33.1	57.1
Moddhokochupatra-4	20.5	19.1	19.8	87.1	47.0	67.1
Moddhokochupatra-5	11.8	11.4	11.6	99.0	4.1	51.6
Moddhokochupatra-6	18.9	14.5	16.7	19.1	8.1	13.6
Moddhokochupatra-7	20.7	14.6	17.7	74.0	54.9	64.5
Moddhokochupatra-8	12.5	19.0	15.7	22.0	22.1	22.1
Moddhokochupatra-9	6.4	11.5	9.0	49.0	8.1	28.5
Moddhokochupatra-10	29.6	23.8	26.7	31.1	25.0	28.1
Nolbunia-1	17.1	18.2	17.6	50.1	14.1	32.1
Nolbunia-2	24.0	16.4	20.2	142.7	36.0	89.4
Nolbunia-3	12.4	30.0	21.2	57.0	39.0	48.0
Nolbunia-4	17.5	18.6	18.0	51.0	49.0	50.0
Nolbunia-5	15.7	14.7	15.2	52.0	30.0	41.0
Koroibaria-1	5.1	10.6	7.8	56.0	20.0	38.0
Koroibaria-2	1.8	10.3	6.0	111.6	98.1	104.8
Koroibaria-3	3.3	2.5	2.9	66.0	28.1	47.0
Koroibaria-4	13.9	18.5	16.2	86.0	51.1	68.5
Koroibaria-5	15.6	27.8	21.7	29.0	30.0	29.5
Koroibaria-6	21.3	13.1	17.2	86.0	25.1	55.5
Alirbondor-1	17.8	18.3	18.0	86.0	52.1	69.0
Alirbondor-2	20.2	13.7	17.0	82.0	76.0	79.0
Alirbondor-3	18.6	20.2	19.4	96.0	20.1	58.0
Alirbondor-4	18.5	23.0	20.7	225.6	10.1	117.8
Alirbondor-5	25.7	28.2	26.9	40.0	15.1	27.5
Alirbondor-6	29.2	18.5	23.9	52.0	36.0	44.0
Average	15.6	17.0	16.3	73.9	31.9	52.9
Minimum	1.8	2.5	2.9	19.1	4.1	11.6
Maximum	29.6	30.0	26.9	225.6	98.1	117.8
Standard deviation	7.0	6.1	5.7	42.4	20.9	23.9

Alirbondor-5 (25.7 ppm), Nolbunia-2 (24.0 ppm), and Koroibaria-6 (21.3), respectively. P content determined in the present study was lower than the optimum level. Factors such as weathering, leaching, soil water retention, soil water discharge, and soil reaction may give variations in P content with huge irregularity in soil at different depth.

Available Sulfur Content in Soil

Available sulfur(S) content was extremely influenced by soil depth. In 0–5 cm soil depth, the highest available S content of 225.6 ppm was found at Alirbondor-4 and lowest available S content of 19.1 ppm was recorded at Moddhokochupatra-6 [Table 2]. In 5–10 cm soil depth, the highest available S content of 98.1 ppm was found at Koroibaria-2 and lowest available S content of 4.1ppm was at Modhokochupatra-5. Based on the mean value of 30 samples, the available S content of 73.9 and 31.9 ppm was found at 0–5 and 5–10 cm soil depth, respectively. Table 2 shows that available S content was found higher at 0–5 cm soil depth compare to 5–10 cm soil depth in all the sampling locations.

Considering 30 soil sample data the 2nd, 3rd, 4th, and 5th highest rank at 0–5 cm soil depth was recorded at Modhokochupatra-1 (148.1 ppm), Nolbunia-2 (142.7 ppm), Koroibaria-2 (111.6 ppm), and Modhokochupatra-5 (99.0 ppm), respectively. The optimum S content in coastal soil was 16-32 ppm for agriculture. S content determined in the present study was higher than the optimum level. Factors such as weathering, leaching, soil water retention, soil water discharge, and soil reaction may give variations in S content with huge irregularity in soil at different depth. The most uncertain cause of nutrient fluctuation is weathering. Weathering is a source of dissolved inorganic S in soil. Key factors that control chemical weathering processes in the field are litho logy, runoff, temperature, physical erosion, morphology, soil, ecosystems, land use as well as tectonic activity.[26] These are the major causes behind the S content variations in soil from surface to subsurface.

Exchangeable K Content in Soil

Based on the mean value of 30 sample data, the exchangeable K content in 0–5 cm soil depth was 0.31 meq/100 g soil and at 5–10 cm soil depth it was 0.27 meq/100 g soil [Table 3]. The results clearly evidenced that with the increasing of soil depth exchangeable K content was gradually increased. It was probably occurred due to leaching of K from surface soil and accumulation in the sub-surface layer of the soil. The exchangeable K content at 0–5 cm and 5–10 cm was ranged from 0.21 meq/100 g soil to 0.57 meq/100 g soil, and 0.12 meq/100 g soil to 0.42 meq/100 g soil, respectively. When the exchangeable K content data were interpreted, it was found that all the depth mean data were very high with some variation. Sedimentation, river bank infiltration, flooding, weathering, soil retention, nutrient release by organic or inorganic fertilizer use, rhizospheric nutrient deposition, etc., influences K content in crop fields from sea to in-stream.[27]

Exchangeable K content was also varied among the villages. The lowest exchangeable K content was found in the village Nolbunia-4 (0.21 meq/100 g soil) which was very closer with the sample Moddhokochupatra-1 (0.22 meq/100 g soil), Moddhokochupatra-7 (0.23 meq/100 g soil), and Koroibaria-2 (0.23 meq/100 g soil).

Exchangeable Na Content in Soil

Among the 30 sample data exchangeable Na content in 0–5 and 5–10 cm soil depth ranged from 6.2 to 55.7 and 4.8 to 110.7 meq/100 g soil, respectively [Table 3]. When mean of 30 samples was considered the 0–5 and 5–10 cm depth had Na content of 26.7 and 20.6 meq/100g soil, respectively. Table 3 indicated that with the increase of the soil depth Na content reduced by 23%, which means that in the coastal region surface soil is more saline than subsurface soil.

At 0–5 cm soil depth highest Na content was found in Kochupatra-2 location (55.7 meq/100 g soil); 2nd and 3rd being in Nolbunia-3 (44.0 meq/100 g soil) and Koroibaria-4 location (39.21 meq/100 g soil), respectively. The lowest Na content was found in Alirbondor-4 location (4.82 meq/100 g soil).

Available Bicarbonate (HCO_3^-) Content of Soil

Available bicarbonate (HCO_3^-) content was highly influenced by soil depth. The highest available HCO_3^- content (1.01 %) was found at Moddhokochupatra-8 and lowest available HCO_3^- content (0.02%) at Nolbunia-2 was recorded in 0-5 cm soil depth [Table 4]. The 2nd, 3rd, 4th, 5th, and 6th rank was recorded at Kochupatra-2 (0.85%), Nolbunia-5 and Alirbondor-5 (0.65%), Moddhokochupatra-10 (0.45%), and Alirbondor-3 and Koroibaria-6 (0.35%), respectively. In 5–10 cm soil depth, the highest available HCO_3^- content (0.65%) was at Kochupatra-1 and lowest available HCO_3^- content was at Nolbunia-1 and Koroibaria-2 (0.01%). Based on the mean value, the HCO_3^- ion content was 0.31 and 0.16 % at 0–5 and 5–10 cm soil depth, respectively. The optimum HCO_3^- content in coastal soil is 16–32 ppm for agriculture. HCO_3^- content determined in the present study was much higher than the optimum level. Factors such as weathering, leaching, soil water retention, soil water discharge, and soil reaction may give variations in HCO_3^- content with huge irregularity in soil at different depth.

Available Chloride (Cl-) Content of Soil

Available chloride (Cl^-) content was also considerably influenced by soil depth. At 0–5 cm soil depth the available chloride ion concentration of soil ranged from 0.02 to 0.46 % with average value was 0.14% [Table 4]. In this soil depth

Table 3: Soil exchangeable K and Na content (meq/100 g soil) as influenced by soil depths and locations

Location	Exchangeable K content			Exchangeable Na content		
	0–5 cm	5–10 cm	Mean	0–5 cm	5–10 cm	Mean
Kochupatra-1	0.31	0.30	0.31	31.7	31.0	31.3
Kochupatra-2	0.32	0.31	0.32	55.7	17.2	36.5
Kochupatra-3	0.31	0.32	0.32	23.4	23.4	23.4
Moddhokochupatra-1	0.22	0.19	0.21	33.7	27.5	30.6
Moddhokochupatra-2	0.29	0.28	0.29	31.0	10.3	20.6
Moddhokochupatra-3	0.27	0.27	0.27	32.3	9.6	21.0
Moddhokochupatra-4	0.27	0.25	0.26	28.2	9.6	18.9
Moddhokochupatra-5	0.35	0.37	0.36	25.5	18.6	22.0
Moddhokochupatra-6	0.35	0.12	0.24	24.8	6.2	15.5
Moddhokochupatra-7	0.23	0.26	0.25	23.4	10.3	16.9
Moddhokochupatra-8	0.29	0.22	0.26	23.4	5.1	14.2
Moddhokochupatra-9	0.24	0.20	0.22	11.1	9.6	10.4
Moddhokochupatra-10	0.36	0.31	0.34	24.1	110.7	67.4
Nolbunia-1	0.34	0.22	0.28	20.0	110.7	65.3
Nolbunia-2	0.28	0.26	0.27	28.2	11.0	19.6
Nolbunia-3	0.26	0.32	0.29	44.0	24.1	34.1
Nolbunia-4	0.21	0.23	0.22	20.6	9.6	15.1
Nolbunia-5	0.31	0.20	0.26	31.7	19.3	25.5
Koroibaria-1	0.30	0.26	0.28	39.2	9.6	24.4
Koroibaria-2	0.23	0.24	0.24	29.6	18.6	24.1
Koroibaria-3	0.39	0.31	0.35	32.3	16.5	24.4
Koroibaria-4	0.33	0.33	0.33	39.2	18.6	28.9
Koroibaria-5	0.30	0.22	0.26	27.5	15.8	21.7
Koroibaria-6	0.57	0.42	0.50	20.6	20.6	20.6
Alirbondor-1	0.28	0.25	0.27	13.1	5.1	9.1
Alirbondor-2	0.32	0.33	0.33	18.6	10.3	14.4
Alirbondor-3	0.40	0.37	0.39	25.5	9.6	17.5
Alirbondor-4	0.32	0.26	0.29	6.2	4.8	5.5
Alirbondor-5	0.38	0.30	0.34	20.6	15.1	17.9
Alirbondor-6	0.25	0.22	0.24	15.8	11.0	13.4
Average	0.31	0.27	0.29	26.7	20.6	23.7
Minimum	0.21	0.12	0.21	6.2	4.8	5.5
Maximum	0.57	0.42	0.50	55.7	110.7	67.4
Standard deviation	0.07	0.06	0.06	10.0	25.4	13.6

the highest and lowest Cl^- content was found in Nolbunia-4 and Koroibaria-4, respectively. Similarly at 5–10 cm soil depth the Cl^-ion content varied from 0.02 to 0.32 % over the sampling locations. The average Cl^- ion concentration was found as 0.10%. In this soil depth, the highest and lowest Cl^- ion content was obtained in Nolbunia-4 and Alirbondor-5, respectively. Based on the average value found in 0–5 (0.14%) and 5–10 cm (0.10%) soil depth it could be declared that with the increase of the soil depth the Cl^- ion concentration in soil gradually decreased.

In the experiment, there also have some variation in of Cl^- ion concentration among the villages and sampling locations. Factors such as weathering, leaching, soil water retention, soil water discharge, and soil reaction may give variations in Cl^- content with huge irregularity in soil at different depth.

Table 4: Soil HCO3- (%) and Cl- (%) ion concentration as influenced by soil depths and locations

Location	Soil HCO3- content (%)			Soil Cl- content (%)		
	0–5 cm	5–10 cm	Mean	0–5 cm	5–10 cm	Mean
Kochupatra-1	0.70	0.65	0.68	0.12	0.06	0.09
Kochupatra-2	0.85	0.45	0.65	0.18	0.16	0.17
Kochupatra-3	0.35	0.25	0.30	0.10	0.12	0.11
Moddhokochupatra-1	0.04	0.05	0.05	0.06	0.10	0.08
Moddhokochupatra-2	0.35	0.05	0.20	0.10	0.08	0.09
Moddhokochupatra-3	0.15	0.25	0.20	0.02	0.06	0.04
Moddhokochupatra-4	0.25	0.01	0.13	0.02	0.06	0.04
Moddhokochupatra-5	0.30	0.25	0.28	0.16	0.10	0.13
Moddhokochupatra-6	0.65	0.05	0.35	0.12	0.04	0.08
Moddhokochupatra-7	0.25	0.15	0.20	0.14	0.10	0.12
Moddhokochupatra-8	1.01	0.25	0.63	0.12	0.14	0.13
Moddhokochupatra-9	0.25	0.25	0.25	0.12	0.02	0.07
Moddhokochupatra-10	0.45	0.25	0.35	0.10	0.06	0.08
Nolbunia-1	0.25	0.01	0.13	0.04	0.06	0.05
Nolbunia-2	0.02	0.03	0.03	0.04	0.02	0.03
Nolbunia-3	0.05	0.05	0.05	0.12	0.08	0.10
Nolbunia-4	0.03	0.01	0.02	0.02	0.02	0.02
Nolbunia-5	0.65	0.06	0.36	0.16	0.06	0.11
Koroibaria-1	0.06	0.35	0.21	0.08	0.06	0.07
Koroibaria-2	0.25	0.01	0.13	0.18	0.16	0.17
Koroibaria-3	0.25	0.03	0.14	0.06	0.12	0.09
Koroibaria-4	0.05	0.35	0.20	0.46	0.16	0.31
Koroibaria-5	0.25	0.08	0.17	0.16	0.16	0.16
Koroibaria-6	0.35	0.25	0.30	0.22	0.06	0.14
Alirbondor-1	0.30	0.35	0.33	0.12	0.06	0.09
Alirbondor-2	0.05	0.04	0.05	0.06	0.12	0.09
Alirbondor-3	0.35	0.25	0.30	0.32	0.10	0.21
Alirbondor-4	0.03	0.04	0.04	0.12	0.12	0.12
Alirbondor-5	0.65	0.05	0.35	0.34	0.32	0.33
Alirbondor-6	0.04	0.05	0.05	0.30	0.26	0.28
Average	0.31	0.16	0.24	0.14	0.10	0.12
Minimum	0.02	0.01	0.02	0.02	0.02	0.02
Maximum	1.01	0.65	0.68	0.46	0.32	0.33
Standard deviation	0.26	0.16	0.18	0.10	0.07	0.08

CONCLUSION

Bangladesh is one of the most vulnerable countries facing the adverse impacts of climate change. Salinization is one of the major natural hazards hampering crop production. The coastal area in Bangladesh constitutes 20% of the country of which about 53% are affected by different degrees of salinity. Soil salinity, water salinity, and some plant essential nutrient imbalance are great limitation for successful crop production in Taltali Upazila of Barguna district when monsoon cases that in dry period salinity start to rise. In November-January, the crops are less affected by salinity where the salinity level was low. The highest crop damage occurs in February to April due to higher EC values of soil. The soil under the study area was suffering heavy salinization and high salinity generally appeared in the topsoil during dry period due to high evaporation. The spatial distribution pattern of soil salinity of the 0–5 cm depth was more sophisticated than the 5–10 cm soil depths. The spatial distribution of soil salinity resulted from the comprehensive effects of anthropogenic activities and some natural factors. The findings of this study are expected to contribute to agricultural management and ecological restoration in southwest coastal region of Bangladesh. High salinity and the nutritional imbalance are generally appeared in the top soil during dry period due to high evaporation. Salinity develops within a very thin top soil layers below which salinity level is comfortable for plant growth. Shallow rooted crops are more susceptible with this salinity. Deep rooted crops are recommended to cultivate in the south coastal saline soils of Bangladesh.

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REFERENCES

1. Maniyunda B, Raji A, Gwari MG. Variability of some soil physicochemical properties lithosequence in Funtua, North-Western Nigeria. Int J Sci Res 2013;2:174-80.
2. Kavianpoor H, Ouri AE, Jeloudar ZJ, Kavian A. Spatial variability of some chemical and physical soil properties in Nesho mountainous rangelands. Am J Environ Eng 2012;2:34-44.
3. Sivarajan S, Nagarajan M, Sivasamy R. Spatial variability analysis of soil properties using raster based GIS techniques. Asian J Appl Sci 2013;6:6878.
4. Yasrebi J, Saffari M, Fathi H, Kaimian N, Emadi M, Baghemejad M. Spatial variability of soil fertility properties for precision agriculture in Southern Iran. J Appl Sci 2008;8:1642-50.
5. Schlesinger WH, Raikes JA, Hartley AE, Cross AF. The spatial pattern of soil nutrients in desert eco-systems. Ecology 1996;77:364-74.
6. Liu X, Shi C, Liang W, Jiang Y, Jiang D, Steinberger Y. Spatial variability of soil properties related to salinity and alkalinity in meliorated grasslands of Horqin Sand Land, Northeast China. Agric J 2007;2:564-9.
7. Ghartey EO, Dowuona GN, Nartey EK, Adjadeh TA, Lawson YD. Assessment of variability in the quality of an acrisol under different land use systems in Ghana. Open J Soil Sci 2012;2:33-43.
8. Shahidian SS, da Silva JM. Spatial and temporal patterns of apparent electrical conductivity: DUALEM vs. veris sensors for monitoring soil properties. Sensors 2014;14:10024-41.
9. Akhtaruzzaman M, Haque ME, Osman KT. Morphological, physical and chemical characteristics of hill forest soils at Chittagong University, Bangladesh. Open J Soil Sci 2014;4:26-35.
10. Mann KK, Schumann AW, Obreza TA, Harris WG, Shukla S. Spatial variability of soil physical properties affecting Florida citrus production. Soil Sci Plant Nutr 2010;175:487-99.
11. Saglam M, Ozturk MH, Ersahin S, Ozkan AI. Spatial variation of soil physical properties in adjacent alluvial and colluvial soils under Ustic moisture regime, Hydrol. Earth Syst Sci Discuss 2011;8:4261-80.
12. Khan MJ, Rashid M, Ali S, Khattak I, Naveed S, Hanif Z. Mapping of variability in major and micro nutrients for site-specific nutrient management. Int J Plant Soil Sci 2014;3:303-29.
13. Jafari M, Asgari HM, Tahmoures M, Biniaz M. Assessment of soil property spatial variation based on the geostatistical simulation. Desert 2011;16:87-101.
14. Fathi H, Fathi H, Moradi H. Spatial variability of soil characteristic for evaluation of agricultural potential in Iran. Merit Res J Agric Sci Soil Sci 2014;2:24-31.
15. Moss RE, Hollenback JC, Ng J. Spatial Variability of Levees as Measured Using the CPT, 2nd International Symposium on Cone Penetration Testing, Huntington Beach, CA, USA; 2010.
16. Douaik A. Application of Statistical Methods and GIS for Downscaling and Mapping Crop Statistics using Hypertemporal Remote Sensing. Rabat, Morocco: Research Unit on Environment and Conservation of Natural Resources, National Institute of Agricultural Research; 2011.
17. Goovaerts P. Geostatistical tools for characterizing the spatial variability of microbiological and physico-chemical soil properties. Biol Fertile Soils 1998;27:315-34.
18. Huang E, Skidmore L, Tibhz G. Spatial Variability of Soil Properties along a Transect of CRP and Continuously Cropped Land; 1999. p. 641-7.
19. Akbas F. Spatial variability of soil color parameters and soil properties in an alluvial soil. Afr J Agric Res 2014;9:1025-35.
20. Inigo A, Alonso-Martirena JI, Marín A, Jiménez-Ballesta R. Soil property variability in a humid natural Mediterranean environment: LaRioja, Spain. Spanish J Soil Sci 2012;2:38-54.
21. Biswas A, Paul AK, Physico-chemical analysis of saline soils of solarsalterns and isolation of moderately halophilic bacteria for poly (3-hydroxybutyric acid) production. Int Res J Microbiol 2012;2:227-36.
22. Islam MS, Ahmed MK, Al-Mamun MH, Masunaga S. Trace metals in soil and vegetables and associated health risk assessment. Environ Monit Assess 2014;186:8727-39.
23. Adeniyi A, Yusuf A, Okedeyi KO. Assessment of the exposure of two fish species to metalspollution in the Ogun river catchments, Kettu, Lagos, Nigeria. Environ Monit Assess 2008;137:451-8.
24. Nosetto MD, Jobbagy EG, Toth T, Di-Bella CM. The effects of tree establishment on water and salts dynamics in naturally salt-affected grasslands. Oecologia 2007;152:695-705.
25. Ayars JE, Christen EW, Soppe RW, Meyer WS. The resource potential of *in-situ* shallow ground water use in irrigated agriculture: A review. Irrig Sci 2006;24:147-60.
26. Hartmann J, Moosdorf N. Chemical weathering rates of silicate-dominated lithological classes and associated liberation rates of phosphorus on the Japanese archipelago implications for global scale analysis. Chem Geol 2011;287:125-57.
27. Blair NE, Leithold EL, Aller RC. The evolution of particulate organic carbon across coupled watershed-continental margin systems. Mar Chem 2004;92:141-56.