International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(1): 1257-1261

Received: 17-11-2018
Accepted: 21-12-2018

Tonmoy Sengupta
Department of Agricultural Chemistry and Soil Science, Institute of Agricultural Science, University of Calcutta, Kolkata, West Bengal, India

BK Bandyopadhyay
Emeritus Scientist, ICAR, ICAR- Central Soil Salinity Research Institute, Regional Research Station, Canning Town, West Bengal, India

Sudipta Tripathi
Department of Agricultural Chemistry and Soil Science, Institute of Agricultural Science, University of Calcutta, Kolkata, West Bengal, India

Correspondence
Tonmoy Sengupta
Department of Agricultural Chemistry and Soil Science, Institute of Agricultural Science, University of Calcutta, Kolkata, West Bengal, India

Changes in soil properties due to raising of elevation of lowland rice fields through land shaping in coastal saline soils of Sundarbans, West Bengal

Tonmoy Sengupta, BK Bandyopadhyay and Sudipta Tripathi

Abstract
Soil samples were collected from upland developed through land shaping (done more than ten years ago) and adjacent original lowland rice fields located at Canning and Basanti Blocks in coastal region of Sundarbans in South 24 Parganas District of West Bengal, India. The elevated land (uplands) followed vegetable – vegetable/ field crop or perennial orchard cropping pattern, while original lowlands followed rice – fallow cropping pattern. The results indicated that there was a considerable change in physical and chemical properties of soil due to conversion of lowlands into uplands along with change in cropping pattern. The soil salinity of uplands showed remarkable decrease compared to original lowlands. The bulk density of upland soil reduced while porosity increased compared to original lowland soil. Phosphorus availability also increased to a great extent in upland soil.

Keywords: Coastal saline soil, lowland rice fields, land shaping, soil physical and chemical properties

1. Introduction

Numbers of environmental issues and soil problems are hindering the agricultural production in coastal regions (Hossain *et al*., 2015) [10] of Sundarbans which spreads over West Bengal (India) and Bangladesh in the Ganges delta. Of the soil problems salinity is one of the most important hindrances for higher crop productivity of coastal saline lands (Amanullah, 2008) [2] of Sundarbans. Along with soil salinity others soil physico-chemical properties of soil e.g. high bulk density, higher clay content, lower porosity and deficiency of major nutrients affect crop production (Worku and Bedadi, 2016 and Hossain *et al*., 2015) [17, 10]. Besides soil and water salinity other major obstacles are poor drainage condition, lack of good quality water, heavy texture and poor aeration of soil (Bandyopadhyay *et al*., 1988) [4]. Bandyopadhyay *et al*. (2009, 2011) [5, 6] observed that raising land elevation of lowland rice fields by proper land shaping enhanced crop productivity of coastal saline lowlands considerably. Mandal *et al*. (2013) [13] revealed that rise in land elevation through land shaping reduced water logging / drainage congestion problems and the lands could be used for vegetable cultivation throughout the year instead of rice (paddy) in *Kharif* (monsoon) season only. The lowlands thus converted into uplands became suitable for higher economic return. However, changes in soil properties due to land shaping had poorly studied. The present study was aimed at investigating the changes occurred in soil properties due to increase in elevation of lowland rice fields along with associated change in cropping pattern.

2. Materials and Method

2.1 Experimental site

The study was conducted in Basanti and Canning Blocks of Sundarbans region in the districts of South 24 Parganas, West Bengal, India. The study area lies between 88º 2′ 14″ and 89º4′ 34″ E latitude and 21º 31′51 ″N and 23º13′ 3″ N longitude and falls under coastal agro-eco-region of 18.5. The area falls under sub-humid region with monsoon climate having mean annual rainfall of about 1800 mm and mean annual temperature varies from 12.6 (winter) to 35.9 (summer) centigrade. The cultivable lands in the region were heavy textured (silty clay/ clay loam/ clay) low-lying with brackish ground water table at shallow depth. Due to high monsoon rainfall (about 80% of annual rainfall occurs during monsoon season from June-July to September- October), flat topography, heavy texture and presence of ground water at shallow depth, drainage condition of the land is very poor (Bandyopadhyay *et al*. 1988) [4]. In the land shaping technique followed for the present experimental plots, a portion (80%) of lowland was raised by about 0.75- 1.0 meter through dug out soil obtained from making a pond (approx. 10 ft.depth)/ channel on the remaining portion (20%) of land. In this process of land shaping the surface 0-30 cm soils of raised land maintained same as that of original lowland. The raised land followed cropping pattern of vegetable- vegetable/ field crop while, the original lowland followed its original cropping pattern of rice (*Kharif*)-fallow. The details of land shaping technique have been described elsewhere (Bandyopadhyay *et al*, 2009) [5].

2.2 Experimental design

Soil samples were collected from 8 different field locations in Basanti and Canning Blocks. Land shaping work was done on these fields more than 10 to 12 years ago. Samples were collected simultaneously from uplands (denoted as 'U') and adjacent lowlands (denoted as 'L') for each location. Soil samples from Basanti Block were: 1U, 1L; 2U, 2L; 3U, 3L; 4U, 4L; 5U, 5L and those from Canning Block were: 6U, 6L; 7U, 7L and 8U, 8L. Soil samples were collected from 0-10, 10-20 and 20-30 cm soil depth for two years in summer season (lowland remained submerged during rainy and early winter seasons). For analysis of soil physical properties composite soil samples were collected from 0-30 cm soil depth.

2.3 Cultural practice

The original lowlands followed rice - fallow (rice in *Kharif* only) crop rotation. While the raised/ uplands land (except 5U) followed vegetables- vegetables- vegetables / field crop rotation. Land location 5U was an orchard with guava plants.

2.4 Soil analysis

Soil physical properties like bulk density, porosity and texture was analysed through standard methods as described by Pal (2013) [14]. Peizometer was installed to determine the depth of ground water table. Salinity of soil (ECe) was measured in saturated soil paste extract with conductivity meter. Other soil properties like pH, available N, P, K and soil organic carbon was estimated by standard methods as described by Tandon (1998) [16]. Statistical analysis was done by using SPSS ver. 22. Duncan's multiple range test at 0.05 P was used for determining the differences between upland and lowland soil for various soil properties.

3. Results and Discussion

3.1 Physical properties

Bulk density (BD) of soils in different plots varied considerably (Table 1). For all the field locations BD was significantly ($P < 0.05$) lower in upland soils (average 1.26 g/cm^3) than lowland soils (average 1.43 g/cm^3) (Table1). Overall average decrease in BD was about 0.17 (g/cm^3) in upland soil compared to lowland soil. Aubertin and Kardos (1965) [1] reported that potential root restriction occurring at BD $\geq$ 1.4 g/cm^3 for clay dominated soils. Reduced BD indicated improvement in plant growth condition in raised lands. Decrease in bulk density of soil (upland) may be due to increase in elevation of lowlands along with associated changes in cropping pattern and land management practices. Hugar and Soraganvi (2014) [11] also reported change in bulk density of soil with change in cropping pattern. Porosity percentage of 0-30 cm soil layer of upland soils (47.9%) increased significantly compared to lowland soils (45.9%). Average porosity in upland soils of Basanti and Canning blocks increased by about 2.08 and 1.93% respectively. It was also observed that moisture percentage in 0-30 cm soil depth of lowlands soil was higher than in uplands. In lowlands, groundwater table (brackish) was present at shallow depth (at about 30cm soil depth) which facilitated easy upward movement of groundwater and increased moisture content of lowland soils (Table 2). While the groundwater table in uplands were present at about 100 cm soil depth. The soil moisture content in upland was higher in surface soil (0-10cm) compare to soil depth up to 50 cm with decrease with increasing soil depth. Higher moisture percentage in surface 0-10 cm soil of upland may be due to application of irrigation for crop cultivation during the season (summer).

The results indicated that the soils of upland fields became loose after the conversion of lowlands

into uplands (Table1). Low bulk density, high porosity and high air filled pore space indicated better aeration favouring root penetration. Bhavya *et al*. (2018) [8] reported that the "ideal" soil would hold sufficient air and water to meet the needs of plants with enough pore space for easy root penetration. Textural analysis revealed that both upland and lowland soils were silty clay loam in Basanti Block and clay loam in Canning Block.

Table 1: Bulk density and porosity of soil at different field locations.

Soil Properties	Land situation	Field location								
		1	2	3	4	5	6	7	8	Mean
BD (g/cm^3)	U	1.24	1.25	1.38	1.25	1.31	1.23	1.21	1.22	1.26a
	L	1.36	1.36	1.59	1.56	1.56	1.38	1.32	1.34	1.43b
Porosity (%)	U	48	46.7	47.9	46.9	47.6	46.1	50	49.9	47.9b
	L	42.9	44.3	46.3	46.6	46.6	45	45.8	49.4	45.9a
Textural class		Silty clay loam					Clay loam			

Figures denoted by same alphabets are statistically similar at 5% probability level by DMRT

Table 2: Moisture content (percentage) of soil at different soil depth in upland and lowland situation (samples collected in the first week of April)

Land situation	Soil depth cm)			Depth to water table (cm)
	0--10	10--20	20--30	
U	23.0	22.0	18.5	95.3
L	29.1	30.9	33.8	32.2

3.2 Chemical properties

3.2.1 Soil pH

pH of soils varied considerably (Fig.1) in different field locations. Mean pH of soil was higher in upland (6.7) than in lowland soils (6.4) (Table 3). A depth wise variation in pH was noticed, especially for lowland soils. For lowland soils average soil pH varied from 5.5 in surface soil (0-10 cm) to 7.1 at 20- 30 cm soil depth, whereas in upland soils the variation for the same depths were from 6.4 to 6.9 (Fig. 2). High variations of pH in lowland soils (Table 3) might be due to possible oxidation-reduction cycles in lowlands (lands remained submerged during monsoon and dry during summer seasons).

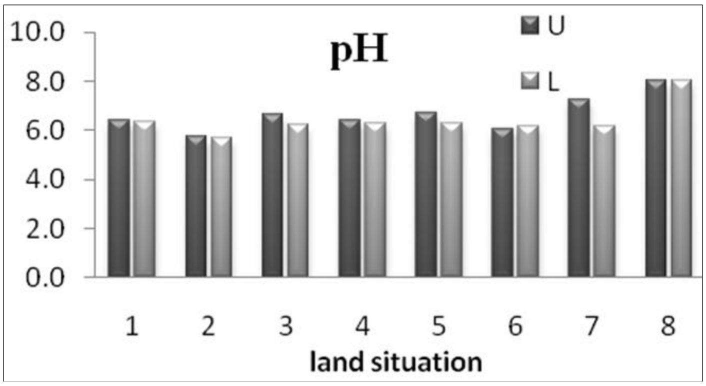

Fig 1: Mean soil pH in different field location

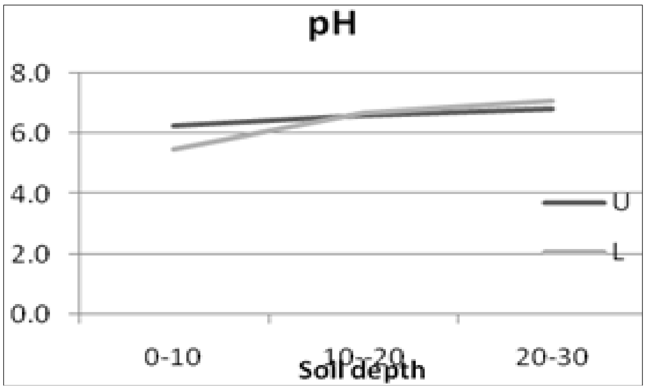

Fig 2: Mean pH in different soil depths

3.2.2 Soil Salinity

The average soil salinity (ECe) was much higher in lowland soils (7.6 dS m^{-1}) than upland soils (3.7 dS m^{-1}) (Table 3). Mean soil salinity at different land situations are presented in fig. no. 3. In uplands average soil salinity was 5.1 dS m^{-1} in surface layer (0-10 cm) and it decreased with increasing soil depth from 10-20 (3.6 dS m^{-1}) cm to 20-30cm (2.7 dS m^{-1}) (Fig. 4). Similarly in lowland soils, salinity also decreased with increasing soil depth. Thus soil salinity build up in these lands was due to upward capillary flow of brackish ground water towards drier surface soil. Thus the gradually decrease in soil salinity with increasing soil depth was quite reasonable. Similar observation also recorded by Bandyopadhyay *et al*. (2003) [7] and Biswas *et al*. (1990) [9]. Comparably low soil salinity of uplands was possibly due to increase distance of surface soil from brackish ground water table (Table 2).

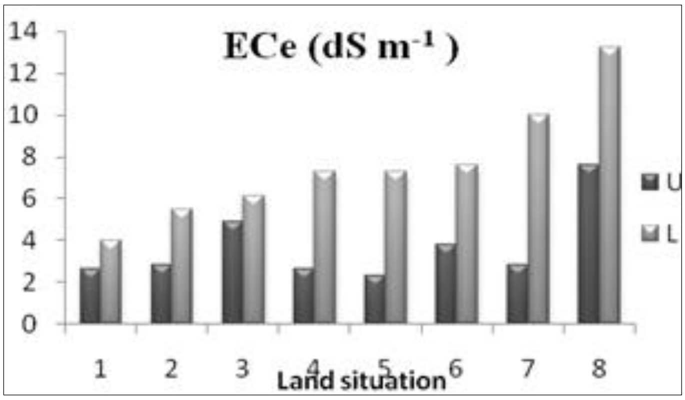

Fig 3: Mean ECE (DSM-1) in Different Field Location

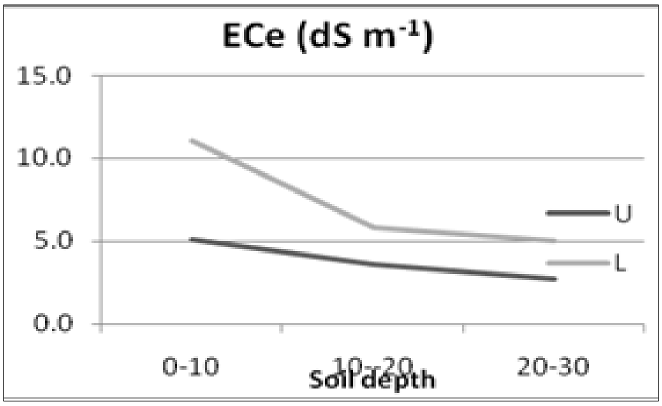

Fig 4: Mean ECe (dS m) in different soil depth

3.2.3 Soil organic carbon

Soil organic carbon was different in different field locations. Soil organic carbon in all field locations was significantly higher in lowlands than uplands (except plot no 5) (Fig. 5). Organic carbon percentage was higher in upland soil at plot no. 5. This might be due to the fact that intact plot no. 5 was under orchard cultivation with guava plant. Continuous falling from orchard plantation might have enriched organic carbon content in surface soil of the upland plot. Kantola *et al*. (2017) [12] observed higher organic carbon in orchard plantation than in seasonal crop fields and it was higher in 0-10 cm soil depth. For both upland and lowland soils organic carbon was higher in surface soil (17.3g C kg $soil^{-1}$ in 0-10 cm soil depth) than lower soil depth (11.4g C kg $soil^{-1}$ in 10-20 cm soil depth and 8.5g C kg $soil^{-1}$ in 20-30 cm soil depth) (Fig.6). High organic carbon in lowland might be due to lower rate of decomposition of organic matter in lowlands which remained waterlogged/water saturated during major part of a year. Sahrawat (2004) [15] also reported that the organic carbon content was higher in waterlogged soil because of lower rate of decomposition of organic matter.

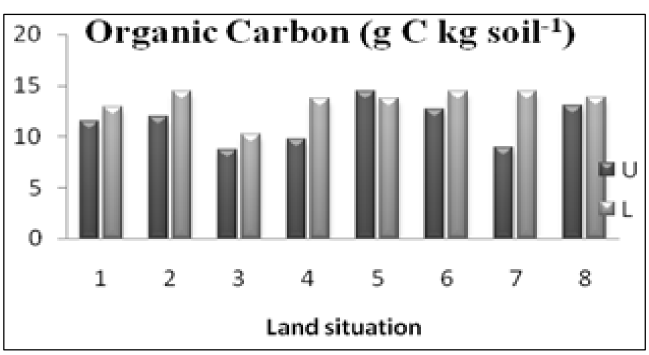

Fig 5: Mean OC (%) in soil at different field locations

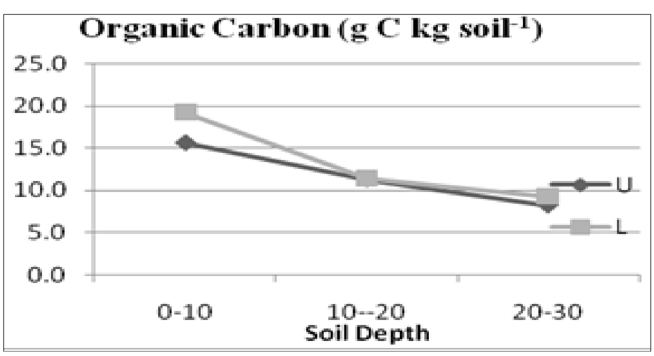

Fig 6: Mean OC(%) in different soil depths

3.2.4 Major plant nutrients
Available nitrogen content also varied from soil to soil (Fig. 7) but there were no significant differences in available nitrogen content between upland and lowland soils. Available nitrogen was considerably lower in all the soils. Bandyopadhyay *et al*. (1985) [3] also reported that the available nitrogen was low in coastal saline soils of Sundarbans area. For all the land situations (uplands and lowlands) available nitrogen decreased with increasing soil depth (Fig. 8). There was a drastic change in phosphorus availability of soil with conversion of lowland to upland. The average phosphorus availability increased more than two times in upland soils (15 kg ha^{-1}) compared lowlands (4.6 kg ha^{-1}) (Table 3). Available phosphorus content in upland soils varied from 8.9 kg ha^{-1} to 22.6 kg ha^{-1} (Fig. 9), whereas in lowland soils it varies from 3.0 kg ha^{-1} to 6.9 kg ha^{-1}. Available phosphorus was higher in surface soil and it decrease considerably with increasing soil depth (Fig. 10). Available potassium in soil at all field locations was high and varied from 590 -1038 kg ha^{-1} but it did not follow any distinct trend in soil profile. For all the locations potassium availability was high in both upland and lowland soils.

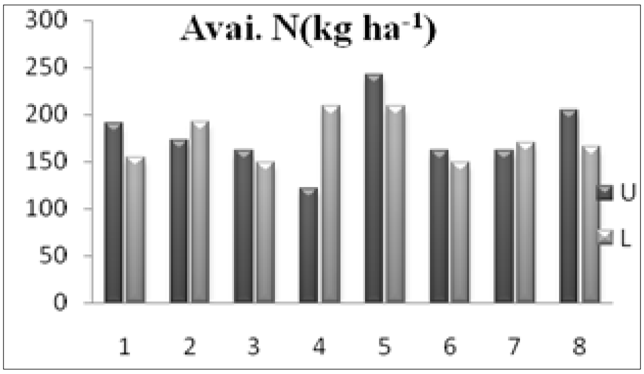

Fig 7: Mean avail. N (kg ha^{-1}) in different field location

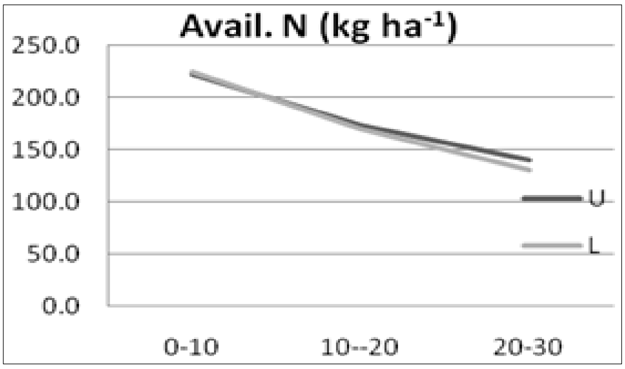

Fig 8: Mean avail. N (kg ha^{-1}) in different soil depth

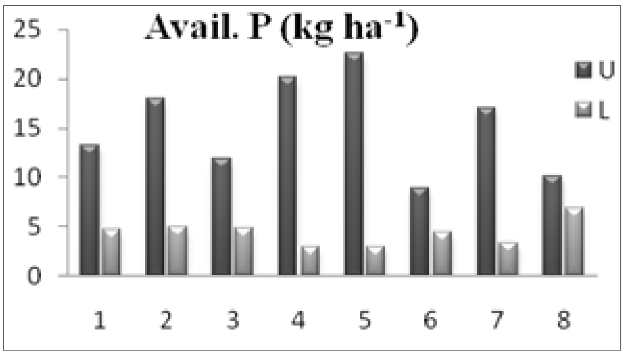

Fig 9: Mean avail. P(kg ha^{-1}) in different field location

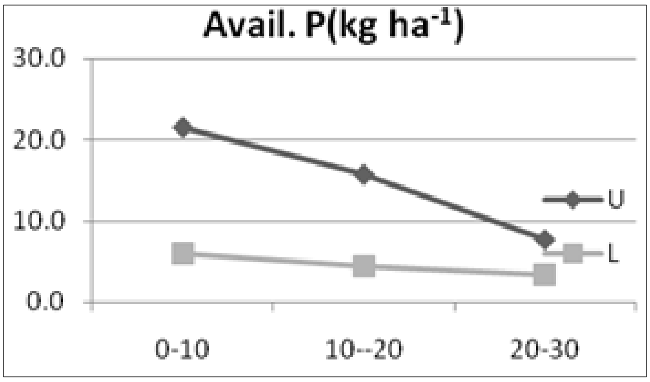

Fig 10: Mean avail. P (kg ha^{-1}) in diff. soil depths depth

Table 3: Mean soil properties at upland and lowland situations at different soil depth.

Soil Parameters	Soil depth	U	L	Mean
pH	0-10	6.4	5.5	5.9a
	10—20	6.7	6.7	6.7b
	20-30	6.9	7.1	7.0c
	Mean	6.7a	6.4a	
ECe (dS m^{-1})	0-10	4.9	11.3	8.1c
	10—20	3.5	6.3	4.9b
	20-30	2.6	5.4	4.0a
	Mean	3.7b	7.6a	
OC (g C kg $soil^{-1}$)	0-10	15.2	19.4	17.3a
	10—20	10.9	11.8	11.4b
	20-30	8.0	9.1	8.5c
	Mean	11.4b	13.4a	
Avail. N(kg ha^{-1})	0-10	220.9	225.3	223.1a
	10—20	169.8	167.5	168.6b
	20-30	139.4	131.0	135.2c
	Mean	176.7a	174.6a	
Avail. P(kg ha^{-1})	0-10	22.4	5.7	14.0a
	10—20	15.3	4.3	9.8b
	20-30	8.1	3.3	5.7c
	Mean	15.3a	4.4b	

Figures denoted by same alphabets are statistically similar at 5% probability level by DMRT

4. Conclusion
The study revealed that increase in elevation of lowlands reduced salinity in coastal saline lands considerably. Conversion of coastal lowlands into uplands leads to improvement of phosphorus availability in soil to a great extent. The increase in elevation of lowlands along with associated changes in cropping pattern also improved drainage/ aeration condition of poorly drained rhizosphere soil as indicated by lower soil moisture content in 0-30 cm soil depth, decreased bulk density and increased soil porosity in uplands. All these changes can greatly contribute to enhancement of productivity of low productive coastal saline lands.

5. Acknowledgement
The authors are grateful to the Indian Council of Agricultural Research, New Delhi, for financial support for continuing the work under Emeritus Scientist Scheme. The authors also grateful to the Director, ICAR- Central Soil Salinity Research Institute, Karnal and the Head, ICAR- Central Soil Salinity Research Institute Regional Research Station, Canning Town for providing all necessary facilities for the work. The authors are also highly thankful to the Director, Institute of Agricultural Science, University of Calcutta for extending laboratory facilities at Baruipur Farm.

6. References

1. Aubertin GM, Kardos LT. Root growth through porous media under controlled conditions: Effect of pore size and rigidity. Soil Science of America Proceedings. 1965; 29:290-293.
2. Amanullah MM. Response of lowland rice varieties to reclamation practices in coastal saline soils. Journal of Applied Sciences Research. 2008; 4:871-874.
3. Bandyopadhyay BK, Bandyopadhyay AK, Bhagava GP. Characterization of soil potassium and quality intensity relationship of potassium in some coastal soils. Journal of Indian Society of Soil Science. 1985; 3:548-554.
4. Bandyopadhyay AK, Bhargava GP, Rao KVGK, Sen HS, Sinha TS, Bandyopadhyay BK, *et al*. Coastal saline soils of India and their management. Bulletin no. 13. ICAR-Central Soil Salinity Research Institute Regional Research Station, Canning town, 1988, 1-158.
5. Bandyopadhyay BK, Burman D, Sarangi SK, Mandal S, Bal AR. Land shaping techniques to alleviate salinity and waterlogging problems of mono-cropped coastal land for multi-crop cultivation. Journal of the Indian Society of Coastal Agricultural Research, 2009; 27:13-17.
6. Bandyopadhyay BK, Burman D, Mandal S. Improving Agricultural Productivity in Degraded Coastal Land of India – Experiences gained and Lessons Learned. Journal of Indian Society of Coastal Agricultural Research. 2011; 29:1-9.
7. Bandyopadhyay BK, Maji B, Sen HS, Tyagi NK. Coastal soils of West Bengal - their nature, distribution and characteristics. Bulletin No. Central Soil Salinity Research Institute, Regional Research Station, Canning Town, West Bengal, India, 2003, 1-62.
8. Bhavya VP, Kumar SA, Alur A, Shivanna M, Shivakumar KM. Changes in soil physical properties as a result of different land use systems with depth. International Journal of Current Microbiology and Applied Sciences. 2018; 7:323-327.
9. Biswas CR, Chattopadhyay GN, Bandyopadhyay AK, Ghosh A, Chakraborty PK. Journal of the Indian Society of Coastal Agricultural Research. 1990; 8:37-41.
10. Hossain N, Muhibbullah M, Ali KB, Molla MH. Relationship between soil salinity and physico-chemical properties of paddy field soils of Jhilwanja Union, Cox's bazar, Bangladesh. Journal of Agricultural Science. 2015; 7:166-180.
11. Hugar GM, Soraganvi VS. Impact of soil organic carbon on bulk density and plasticity index of arid soils of Raichur, India. International Research Journal of Environment Sciences. 2014; 3:48-58.
12. Kantola IB, Masters MD, DeLucia EH. Soil particulate organic matter increases under perennial bio energy crop agriculture. Soil Biology & Biochemistry. 2017; 113: 184-191
13. Mandal S, Sarangi SK, Burman D, Bandyopadhyay BK, Majhi B, Mandal UK, Sharma DK. Land shaping models for enhancing agricultural productivity in salt affected coastal areas of West Bengal – an economic analysis. Indian Journal of Agricultural Economics. 2013; 68:389-401.
14. Pal SK. Soil sampling and method of analysis. New India publishing agency. New Delhi, 2013.
15. Sahrawat KL. Organic matter accumulation in submerged soils. Advances in Agronomy. 2004; 81:169-201.
16. Tandon HLS. Methods of analysis of soils, plants, waters and fertilizer. Fertilizers development and consultation organisation, New Delhi, India, 1998, 1-144.
17. Worku A, Bedadi B. Studies on soil physical properties of salt affected soil in Amibara area, central rift valley of Ethiopia. International Journal of Agricultural Sciences and Natural Resources. 2016; 3:8-17.