RECENT STUDY ON SOIL SALINITY STATUS OF COASTAL AREA IN KHULNA DISTRICT OF BANGLADESH

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CERTIFICATE

*This is to certify that the thesis entitled **"RECENT STUDY ON SOIL SALINITY STATUS OF COASTAL AREA IN KHULNA DISTRICT OF BANGLADESH"** submitted to the Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGROFORESTRY AND ENVIRONMENTAL SCIENCE,** embodies the result of a piece of bona fide research work carried out by **FARZANA YASMIN,** Registration No. **13-05294** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been fully acknowledged.

Dated: June, 2020
Dhaka, Bangladesh

Dr. Ferzana Islam
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THIS THESIS IS LOVINGLY DEDICATED TO MY PARENTS

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-Author

RECENT STUDY ON SOIL SALINITY STATUS OF COASTAL AREA IN KHULNA DISTRICT OF BANGLADESH

ABSTRACT

Soil salinity is one of the major problems in the coastal zone of Bangladesh. About 53% of the coastal areas are affected by salinity which is causing decline in soil productivity and crop yield which results in severe degradation of environment. Our present study was conducted to determine soil salinity status in Dacope upazilla of Khulna District. To fulfill the objectives of our study soil sampling was done by random sampling method at 0-15cm depth and samples were collected from agricultural, riverbed and embankment site. These locations are in Dhaki, Vodra and Chunkuri in Dacope upazilla. Salinity has a detrimental effect on soil physical and chemical properties in Dacope upazilla. Soils pH was found higher which expresses moderately alkaline. Electrical Conductivity (EC) of soils varied from 510.67µs cm^{1-}to 834 µs cm^{-1} expressing moderate to high salinity. Organic matter content is pretty low to medium (0.23 to 1.96) %. Nutrient deficiencies for total nitrogen were quite dominant in the study area. Total Phosporus, potassium and Sulfur contents were in medium to low level and the amount of accumulated salt was found high. The findings of the research showed that the salinity in study areas is increasing day by day which were affecting crops and vegetation depending on degree of salinity. So the present study suggests to imply necessary management plan to reduce salinity in Dacope upazilla of Khulna district.

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LIST OF ABBREVIATIONS

ABBREVIATIONS	ELABORATIONS
%	Percentage
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CV%	Percentage of Coefficient of Variance
et al.	and others
FAO	Food And Agriculture Organization of United Nations
LSD	Least Significant Difference
Ppm	Parts Per Million
SAU	Sher-e- Bangla Agricultural University
EC	Electrical Conductivity
N	Nitrogen
P	Phosphorus
S	Sulfur
SD	Standard Deviation
NS	Non Significant
OM	Organic Matter
SRDI	Soil Resources Development Institute
USDA	United Nations Department of Agriculture
pH	Negative Logarithm of Hydrogen ion Concentration
µs cm^{-1}	Microsimen Per Centimeter
mol kg^{-1}	Mol Per Kg
OC	Organic Carbon

CHAPTER 1

INTRODUCTION

Bangladesh is one of the most densely populated countries in the world. It's population is 152.5 million and annual growth rate is 1.37 (BBS, 2011). The total area of Bangladesh is 147,570 km^2. The area of coastal region of Bangladesh is about 47,201 km^2 which extending along the Bay of Bengal. Now this region covers 19 coastal districts facing or in proximity to the Bay of Bengal (Islam *et al.*, 2006). The coastal zone covers 20% of the area and 28% of the population of Bangladesh (Islam, 2004).

Salinity is the most important chemical attribute in coastal area. There are some confusion persists of what 'salinity' means and how to measure it. Salinity is best defined as the sum total of all ion concentrations. Ideally salinities should be expressed on a mass per mass basis and as ppt (parts per thousand). Direct measurements of salinity can only be derived from full ionic analyses and indirect measurements can be derived by determinations of density, conductivity, freezing point depression and total dissolved solids or matter (Williams and Sherwad, 2004) Salinity is considered as one of the most serious threats to the environment. It's impacts on food security, agriculture, fisheries, human health, biodiversity, water and other natural resources are considered negative. Salinity degraded the productive land, caused loss in firm production, diminished farm production, and damage the infrastructure (SRDI, 2010). Salinization is one of the major natural hazards in Bangladesh and it adversely hampers crop production. The coastal saline are lies about 1.5 to 11.8 meters above the mean sea level. The Ganges River meander flood plain systems are considered higher than the adjoining tidal lands. The tidal flood plain has a distinctive, almost level landscape which are crossed by innumerable interconnecting tidal rivers and estuaries. The estuarine islands are continually changing shape and position as result of river erosion and new alluvial deposition. The lands of coastal area become saline because it comes in contact with sea water by gradual inundation during high tides and entrance of sea water through crack,cleft and sometimes cyclone caused storm surge. The intensity and severity of salinity is increasing in the coastal area during winter season with the drying of soil (Naher *et al.,* 2011). Soil salinity is a global problem and it affects approximately 20 % of irrigated land and also reduces crop yields significantly (Qadir *et al*., 2014).

Agriculture is affected severely for salinity in all over the world. (Charman and Murphy, 2000). As Bangladesh belongs to one of the seaside countries the adverse impact of salinity intrusion is serious here. Land and water in the coastal areas are mainly affected by salinity (Mahmuduzzaman *et al.,* 2014). The cultivable areas in coastal districts are affected adversely by varying degrees of soil salinity. It has been recognized that 8,142 km^2 (5.5% of the country) land in the coastal zone is salt affected and it is increasing at the rate of 146 km2 per year (SRDI, 2001). The rate of salinity intrusion in coastal areas of Bangladesh has increased over the last decades (SRDI, 2003). A comparative study of the salt affected area from 1973 to 2009 emerged that about 0.223 million ha (26.7%) new land was affected by various degrees of salinity during about the last four decades. It was also showed that from 2000 to 2009 about 35,440 hectares (3.5%) of new land is affected by various degrees of salinity during last 9 years only (SRDI, 2010). Salinity severely affect the bio environment and there is a significant reduction in vegetation in the salt affected areas (Dutta and Iftekhar, 2004). The severity of salinity problem in Bangladesh increases with the desiccation of the soil. It affects crops which depends on different degrees of salinity at the critical stages of growth, which reduces yield and in severe cases total yield is lost. Soil reaction values (pH) in coastal regions range from 6.0-8.4 (Haque, 2006).

The dominant land use in coastal region of Bangladesh is mainly for agriculture. The gross area in the coastal zone of Bangladesh is 144,085 and the net cropped area is 83,416 hector (Islam, 2004). Soil salinity is making the environment non-conductive for tree growth (FAO, 2003). Although in coastal area fruit and timber production are the main source of income in homestead areas but increased salinity hinders growth and survivability of trees in this region. Salinity causes unfavorable environment and hydrological status which restricts the normal growth and crop production throughout the year (Haque, 2006). In the coastal regions crop production of the salt affected areas differs considerably from non-saline areas. It has been found that because of Salinity, special environmental and hydrological situation exists that restricts the normal crop production intensity in the area (Rahman and Ahsan, 2001). It is considered as the main obstacle for intensification of crop throughout the year. In the recent year, the degree of salinity of some areas are changing due to intrusion of saline water, and for this situation normal crop production becomes very risky. Cropping intensity, crop yield, production levels in agriculture and people's quality of livelihood are much inferior than that in other parts of the country (BBS, 2001).

It is estimated that a net reduction of 0.5 million of rice production would take place due to 0.3 m sea level rise in coastal areas of Bangladesh (World Bank, 2000). Along with other factors shrimp cultivation plays a major role to increase soil salinity particularly in southwestern coastal areas (SRDI, 2003). At the beginning of shrimp culture, lands and bushes are cleared and forest is cut down. On the other hand, when shrimp cultivation started tree species and vegetations started to disappeared fastly due to excess salinity and inundation. In the farm areas most of the tree species and vegetations are completely cleared. Sometimes trees on the duke and embankment are excluded but due to seepage and leakage of saline water the trees disappear subsequently (Portch and Islam ,2004).Water logging can have negative effect on the growth of vegetation and trees. Salinity along with water logging severely affected the vegetations. Different species of shrubs and herbs or grass that are used for fuel or other domestic uses are lost gradually due to higher saline level in water logged areas (karim, 2004).

Salinity affect vegetation diversity in terms of plant growth and yields of plants by general osmotic effect and specific ion effect. To ensure the effect of salinity intrusion on tree and crop species soil salinity is believed to be mainly responsible for low land use and reduction of cropping intensity in the coastal area (Rahman and Ahsan, 2001). The crop production in the coastal areas are mainly reduced for seasonally high content of salts which are found seasonally in the root zone of the soil. Due to drainage congestion, the area remains waterlogged, increasing the salinity (Abedin, 2010).

N and P nutrient deficiencies are quite dominant in saline soils. Micro-nutrients, such as Cu and Zn are widespread in saline soils. The severity of salinity is reduced during the wet monsoon due to dilution of the salt in the root-zone of the standing crop (Qureshi, 2008).Salinity distributions in the coastal region of Bangladesh vary location to location. Research on Determination of soil salinity status in coastal area of Khulna district under Bangladesh conditions is limited till date. In practice, the most relevant benefits that persuade decision-makers have proven to be (1) the reduction of climate and disaster risks; (2) the reduction of loss of life (3) strengthening of the adaptive capacity of natural systems and human; and (4) the demonstration of cost-effectiveness"

Hence the designed case study aims to contribute to the existing pool of knowledge in general, and to bridge some of the remaining gaps in regard to the present salinity status of agricultural soil, riverbed side soil, embankment of riverside soil and embankment countryside soil in Khulna district. It thus intends to documents the present findings of our research work and explore how and where private and public benefits potentially align. Based on these the exploratory study aims to address the following research objectives:

- To determine soil salinity content in different location of Dacope upazilla in Khulna district
- To identify the impact of salinity on the chemical properties of soil.

CHAPTER 2

REVIEW OF LITERATURE

The purpose of this chapter is to review the past research works that are related to the present study Soil salinity is a worldwide problem. Bangladesh is no exception to it. In Bangladesh salinization is one of the major natural hazards hampering crop production. According to SRDI soil and water salinity is a common hazard in many parts of the coastal zone. All soils contain some water soluble salts. Plants absorb essential plant nutrients in the form of soluble salts, but excessive accumulation of soluble salts, called soil salinity, suppresses plant growth. Many studies have been conducted on soil salinity but no study has yet been conducted on determining soil salinity status of, riverbed side, embankment riverside and embankment countryside soil of Dacope upazilla in Khulna district. However the review of some related studies on soil salinity have been furnished below under the following sections:

2.1. Soil salinity

Hasan *et al.* (2018) reported that the coastal zone of Bangladesh covers about 20% of total land of the country and over 30% of the cultivable lands. According to the National Adaptation Program of Action (NAPA), water related hazards due to climate change are likely to become a critical issue for Bangladesh. Salinity in surface water, ground water and soil has become a dominant hazard in Bangladesh coastal zone. The results show that western region is very high saline zone and eastern region is low saline zone in terms of soil salinity. This study tries to find out the saline affected area from 1973 to 2009 and also tries to give a salinity risk map in the southern part of Bangladesh. Amount of saline affected area is considered as the parameter and by normalizing the amount of affected areas the salinity risk maps are prepared. About 0.223 million ha (26.7%) new land is affected by various degrees of salinity during the last four decades. The maximum saline affected area is found at Galachipara Upazila in Patuakhali District while the minimum saline affected area is found at Maladi Upazila in Barisal district. The saline affected areas are increased in Khulna, Bagerhat, Satkhira, Patuakhali districts. From the risk map it is identified that the lower middle and the corner of the southern part of Bangladesh fall at the zone of high and very high risk.

Aslam *et al.* (2017) revealed that salinity whether primary or secondary, is among the most destructive abiotic stresses that disturb the plants from germination to physiological maturity. This problem is more severe in arid areas that get low yearly rainfall and are prone to high evapo-transpiration. Land under salinity stress is increasing on daily basis and it is thought that about half of the fertile land would become saline by the year 2050. The effects of salinity are highly diverse and depends on large number of factors like amount, intensity and duration of salinity and crop growth stages. Increased uptake of toxic ions couples with limited uptake of essential minerals resulting in significant reduction in enzymatic activity and disturbance in cell metabolism.

Payo *et al.* (2017) stated that understanding the dynamics of salt movement in the soil is a prerequisite for devising appropriate management strategies for land productivity of coastal regions, especially low-lying delta regions, which support many millions of farmers around the world. In this research, we develop a novel holistic approach to simulate soil salinization comprising an emulator-based soil salt and water balance calculated at daily time steps. The method is demonstrated for the agriculture areas of coastal Bangladesh (∼20,000 km2). This shows that we can reproduce the dynamics of soil salinity under multiple land uses, including rice crops, combined shrimp and rice farming, as well as non-rice crops. The model also reproduced well the observed spatial soil salinity for the year 2009. Using this approach, we have projected the soil salinity for three different climate ensembles, including relative sea-level rise for the year 2050. Projected soil salinity changes are significantly smaller than other reported projections. The results suggest that inter-season weather variability is a key driver of salinization of agriculture soils at coastal Bangladesh.

Saha (2017) reported that households in the coastal areas of Bangladesh undertake various adaptation and coping measures to minimize their vulnerability to cyclone hazards and salinity intrusion, these autonomous measures have received little attention in the past. However, the Government of Bangladesh has recently emphasized the importance of understanding these measures so that necessary interventions to make households more resilient to natural hazards and the adverse impacts of climate change can be introduced. This paper, based on secondary sources, explores adaptation and coping measures that households in the coastal areas of Bangladesh undertake to minimize their vulnerability to cyclone hazards and salinity intrusion. This paper shows that many of the adaptation and coping measures contribute to making households less vulnerable and more resilient to cyclone hazards and salinity intrusion, although some coping measures do the opposite as they reduce households' adaptive capacities instead of improving them. The adaptation and coping measures that contribute to reducing households' vulnerability to natural hazards need to be supported and guided by the government and NGOs to make them more effective.

Khanom (2016) studied local people's experience with salinity intrusion in interior coast of SW region. Along with semi-structured & open ended questionnaire five focus group discussions and eight interviews were conducted to outlines the relationship between food security and salinity intrusion in regards of crop production and examines the impact of salinity on the crop production. The analysis found salinity in both soil and water is favorable for rice cultivation, although yield loss in every year has increased. Community shifted from native to high yield rice varieties to increase production and cope with soil salinity, in turn, the activity increase fertilizer and pesticides usage. Additionally oil seed, sugarcane and jute cultivation has discontinued for twelve years due to inability to cope with current salinity level. Some other reasons put forward for saline intrusion includes lack of fresh water in the dry season, and saline encroachment from sea through downstream rivers. Through identification of salinity in the study area, the study suggests to measure impacts rigorously and imply necessary adaptation even though the saline level is favorable for rice, to protect interior coast from suffering like exterior coastal districts.

Dasgupta *et al.* (2015) carried out a study which estimates location-specific soil salinity in coastal Bangladesh for 2050. The analysis was conducted in two stages: First, changes in soil salinity for the period 2001–2009 were assessed using information recorded at 41 soil monitoring stations by the Soil Research Development Institute. Using these data, a spatial econometric model was estimated linking soil salinity with the salinity of nearby rivers, land elevation, temperature, and rainfall. Second, future soil salinity for 69 coastal sub-districts was projected from climate-induced changes in river salinity and projections of rainfall and temperature based on time trends for 20 Bangladesh Meteorological Department weather stations in the coastal region. The findings indicate that climate change poses a major soil salinization risk in coastal Bangladesh. Across 41 monitoring stations, the annual median projected change in soil salinity is 39 % by 2050. Above the median, 25 % of all stations have projected changes of 51 % or higher.

Gupta *et al*. (2014) mentioned that salinity is a major abiotic stress limiting growth and productivity of plants in many areas of the world due to increasing use of poor quality of water for irrigation and soil salinization. Plant adaptation or tolerance to salinity stress involves complex physiological traits, metabolic pathways, and molecular or gene networks. A comprehensive understanding on how plants respond to salinity stress at different levels and an integrated approach of combining molecular tools with physiological and biochemical techniques are imperative for the development of salt-tolerant varieties of plants in salt-affected areas. Recent research has identified various adaptive responses to salinity stress at molecular, cellular, metabolic, and physiological levels, although mechanisms underlying salinity tolerance are far from being completely understood.

Habiba *et al.* (2014) reported that salinity is one of the major problems in the coastal region of Bangladesh that contributes to 20% of the total land area. About 53% of the coastal region is affected by different degrees of salinity. Salinity intrusion in this area is mainly derived through climate change as well as anthropogenic factors that make this region more vulnerable. Hence, salinity intrusion has adverse effects on water, soils, agriculture, fisheries, ecosystem, and livelihoods of this region. To ensure the availability of food as well as drinking water, this chapter highlights how individual and community people have endeavored several adaptation measures to minimize salinity effects.

Moreover, it further discloses governmental and other development organizations' actions toward salinity to reduce its impacts.

Mahmuduzzaman *et al.* (2014) stated that water salinity in the coastal zone highly depends on the ice melting of the Himalayas and the discharge of Ganga, Brahmaputra and Meghna rivers. The annual average discharge of these rivers is 1.5 million cases which are generally characterized by seasonal variation. The peak flow (80%) in monsoon and lean flow (20%) in winter/dry season are responsible for salinity. Decreasing in ice melting reduces river water discharge and consequently enhances the salinity in the coastal zone of the country.

Abedin *et al*. (2012) reported that southwest coastal region is part of an inactive delta of large Himalayan river and is protected from tidal surge by the Sundarban mangrove forest. This area is the hub of all types of disasters such as cyclones, tidal surges, floods, drought, salinity intrusions, repeated waterlogging, and land subsidence. Cyclonic tidal surges and floods are the more common disasters, and their effects are frequently experienced at the local level. But silent and invisible disasters such as increased salinity, arsenic contamination, and drought affect local livelihoods, people, and environments in this region. The vulnerability of southwest region to increased salinity, arsenic contamination, and drought are the result of a complex interrelationship among biophysical, social, economical, and technological characteristics of the country. Moreover, in the current and foreseeable future, the country is likely to be affected by the biggest, most long-lasting, and global scale but silent disaster: increased salinity, natural arsenic contamination, and drought. Therefore, this region is thought to be the most disaster-prone region in Bangladesh because of natural disasters and highly vulnerable to the effects of climate change.

Islam (2011) investigate the water salinity approximation in the Sundarban rivers, which will be considered as a tool for decision making. It will make a contribution to develop an interdisciplinary management plan and to ensure that fresh water is supplied to the Sundarban by the Ganges for the protection of mangrove ecosystems The Sundarban is situated in the Ganges catchment area, which is known as the single largest mangrove forest and unique ecosystem in the world. It has an area 6017 km2 and a natural shield that protects the coastal area from storm surges and cyclones. It also plays a potential role in the regional economy and ecosystems. Since the diversion of Ganges water at Farakka Barrage in India from early 1975, as a result the water and soil salinity has penetrated. Consequently, both siltation and increased salinity have degraded water quality in the Sundarban rivers, and threats for mangrove ecosystems. At present, ground water use in the study area is less because of high salinity intrusion. For salinity investigation, time series data for four years (13 rivers) were used for water salinity modelling. The objectives of this paper are to investigate the water salinity approximation in the Sundarban rivers, which will be considered as a tool for decision making. It will make a contribution to develop an interdisciplinary management plan and to ensure that fresh water is supplied to the Sundarban by the Ganges for the protection of mangrove ecosystems.

SRDI (2010) reported that the cultivable areas in coastal districts are affected by varying degrees of soil salinity. It has been recognized that in the coastal zone 8,142 km2 (5.5% of the country) land is salt affected and it is increasing at the rate of 146 km2 per year. The salinity intrusion in coastal areas of Bangladesh has increased over the last decades. A comparative study of the salt affected area from 1973 to 2009 showed that about 0.223 million ha (26.7%) new land was affected by various degrees of salinity during about the last four decades. It was also found that from 2000 to 2009 about 35,440 hectares (3.5%) of new land is affected by various degrees of salinity intrusion last 9 decades. Along with other factors shrimp cultivation plays a major role to increase soil salinity particularly in southwestern coastal areas. Salinity adversely influences several aspects of reproductive growth, including flowering, pollination, fruit development, yield and quantity of food, and seed production. Symptoms of salt injury in plants resemble drought. Both conditions are characterized by water stress (wilting) and reduced growth. Severe injury caused by prolonged exposure or high salinity results in stunted plants and tissue death. Reduced growth caused by salinity is a progressive condition that increases as salinity increases above a plant's tolerance threshold tree species survival in the homestead forests salt affected areas and they have found that in reduction of tree growth (2% per year) and vegetation coverage (1.87% per year). Soil salinity is greatly responsible for affecting cultivable land in coastal districts. It has been recognized that 8,142 km2 (5.5% of the country) land is salt affected and it is increasing at the rate of 146 km2 per year.

2.2. Salinity effect on Soil pH

Mariangela and Francesco (2015) reported that generally, the degree and nature of soil pH is influenced by different anthropogenic and natural activities including leaching of exchangeable bases, decomposition of organic materials, application of commercial fertilizers and other farming practices.

Mahmood *et al*. (2013) reported that the pH of soil solutions has a profound effect on element solubility and availability of a given nutrient in soils. The processes of mineral dissolution and also adsorption at alkaline functional groups are dependent on pH, in addition to the fact that action exchange capacity depends on pH. Alkaline soils are often associated with nutrient excess of the base cations Ca, Mg, K and Na and base anion Cl- and SO_4-2 and also at pH > 8.2 excess carbonate and bicarbonate.

Akram *et al*. (2011) reported that salt-affected soil, pH inhibits water and nutrient uptake although there is sufficient quantity of them in soil.

Naher *et al*. (2011) reported that the pH value of the topsoil at Asasuni upazila in satkhira district of Bangladesh ranged from 5.39 to 6.02 i.e. the soils were slightly acidic to acidic in reaction. In 50-100 cm depth in this area the pH ranged from 6.7 – 6.85 which is nearly neutral. At Kalapara upazila in patuakhali district of Bangladesh the pH values in 50 – 100 cm deep is 5.9 to 6.20 which is slightly acidic. The pH ranged of the soils from 50 - 100 cm deep was 6.49 and 7.2, and from 100 – 150 cm deep was 7.2 – 8.1 which is strongly alkaline.

Rengasamy (2006) report shows the pH of soil–water suspension is greater than the filtered extracts for high land soil. In alkaline sodic soils the pH of a 1:5 suspension is usually from one-half to one pH unit higher than that of a saturated soil paste or a soil suspension prepared by using $CaCl_2$.

SRDI (2001) reported that the pH value varied from 5.7 to 7.7 in salt affected Sathkhira Soil while values varied from.6.66 to7.47 in Bangladesh and that Ghosgaon Series.

2.3. Electrical conductivity (EC) of soil and salinity

Haque (2018) studied about the spatial variability of salt accumulation through the soil profile was studied at Latachapali union of Kalapara upazila, Patuakhali district of Bangladesh. The soil samples were collected from 30 locations covering six villages of the union: Kuakata, Malapara, Fashipara, Khajura, Mothaopara and Tajepara. Five locations were randomly selected from each village. From each location soil samples were collected from three soil depths at 0-2 cm, 2.1-4 cm and 4.1-6 cm. Electrical conductivity of top 0-2 cm soil depth was 20.49 dS/m, in 2.1-4 cm soil depth was 7.14 dS/m and in 4.1-6 cm soil depth 4.15 dS/m. The study soils were strongly acidic having pH value 4.73, 4.99 and 5.20 in 0-2, 2.1-4 and 4.1-6 cm soil depth, respectively. The highest of 8.8 Na:K ratio was found in 0-2 cm soil depth.

Alam *et al.* (2017) investigated on the vulnerabilities of soil and water salinities on crop, fish, and livestock production across the Kalapara coastal belt of Bangladesh. Several parameters were measured as indicators of salinity. The electrical conductivity of soil and water was found to be significant with SO_4^{2-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, NO_2, and PO_4. About 200 ha fodder crops areas are affected each year due to salinity. Ninety-two percent of the areas were found to be salinity affected in the 36 current cropping patterns. Twelve percent of marine fish and 25 percent of shrimp species have disappeared as a result of salinity. The negative impact of soil and water salinity on crops, fish, and livestock has been increasing in this coastal belt.

Machado and Serralheiro. (2017) reported that salinity is a major problem affecting crop production all over the world: 20% of cultivated land in the world, and 33% of irrigated land, are salt-affected and degraded. This process can be accentuated by climate change, excessive use of groundwater (mainly if close to the sea), increasing use of low-quality water in irrigation, and massive introduction of irrigation associated with intensive farming. Excessive soil salinity reduces the productivity of many agricultural crops, including most vegetables, which are particularly sensitive throughout the ontogeny of the plant. The electrical conductivity (EC) of the majority of vegetable crops is low (ranging from 1 to 2.5 $dSm^{-}1$ in saturated soil extracts) and vegetable salt tolerance decreases when saline water is used for irrigation. The objective of this review is to discuss the effects of salinity on vegetable growth and how management practices (irrigation, drainage, and fertilization) can prevent soil and water salinization and mitigate the adverse effects of salinity.

Nahar *et al*. (2016) conducted a study which mainly aims at examining the impact of soil salinization on paddy production. In this direction, two upazillas namely Paikgachha (having salinity level in the range 2-5 dS m^{-1} EC value) and Morrelganj (having salinity level in the range 10-22 dS m^{-1} EC value) has been selected purposively from Khulna and Bagerhat districts respectively. Here from a total of 120 paddy producing farms have been chosen to collect data on farm specific socioeconomic variables and soil samples to test for salinity. Study period covers September to January of 2014 and the paddy type under consideration is transplanted aman. Collected data were then subjected to descriptive and profitability analyses, hypothesis testing, and, production function estimation; where salinity has been considered as one of the explanatory variables. According to study findings, Paikgachha is found to be low saline area having average salinity level of 3.44 dS m^{-1}; whereas average salinity level is 14.38 dS m^{-1} in Morrelganj. Average production volume per acre are respectively 1639.32 and 1531.45 kilogram in low and high-saline regions Hence, on the basis of the analyses carried out, the study concludes that salinity has an adverse impact on paddy production that reduces paddy yield as well as profit margin of the paddy farmers. The study, therefore, suggests controlling salinity through government initiatives and use of salt-tolerant seed varieties by the farmers. Moreover,implementation and coordination of the concerned policies attracts special attention for making the agricultural production system in the coastal regions.

Haque *et al.* (2014) conducted a study to examine the changes in water and soil salinity over the period from February to April, 2014 at Kalapara upazila of Patuakhali district. Water samples were periodically collected from lake, pond, earthen well, deep tube-wells

(5, 15 and 30 km away from the sea) and rivers (Tulatoli, Khaprabhanga, Sonatala and Andharmanik). Soil sampling was done from different crop fields (mustard, sweet gourd, potato, chilli, Khira-cucumber) and water melon and also from Sonatala and Andharmanik River flooded soils inside and outside polders. The electrical conductivity (EC) value of lake and pond waters was below 4 dS/m showing quite safe for irrigation while the EC value of earthen well exceeded 4 dS/m which are suitable in April. Water salinity of deep tube-wells (DTWs) increased as the DTW was closer to the sea, however all EC values were below 4 dS/m that suitable for irrigation, but not suitable for drinking purpose. Salinity level of all rivers tended to rise with the advancement of drying period, and for all dates of sampling, the EC value showed more than 4 dS/m. Soil salinity varied between inside and outside polder, and between mustard and sweet gourd fields, the higher EC values were observed outside polder and in the sweet gourd field. Soil EC levels were all above 4 dS/m particularly in April, crops showed varying degrees of leaf injury depending on the types of crops and extent of soil salinity. The EC values were positively correlated with Na and K contents of soil.

2.4. Soil Organic Matter

Naher *et al*. (2011) reported that topsoil organic status in all the horizons ranges from medium to high at Asasuni upazila in satkhira district of Bangladesh range is 0.85 to 2.8% and 0.55 to 1.89% at Kalapara upazila in Patuakhali district of Bangladesh. Top soil organic matter content in almost all the soils collected from Kalapara upazila are found very low mainly due to the lower topographic position of the soils. Organic matter content gradually decreases with depth followed by increasing trend due to the presence of buried mineral and organic horizons.

Arunakumara and Walpola (2010); (2011) stated that the importance of improving soil OM or soil organic carbon is its effect on improving soil physical status,conserving water, and increasing available nutrients. However, this critically important soil component is strongly influenced by natural and anthropogenic factors. These practices adversely affected the soil organic carbon pool and strongly impacting global warming and climate change (Kumar, 2013). Salinity and sodicity decrease the plant productive and consequently reduce the organic matter input, also affect the active of microorganisms and therefore these can change organic matter decomposition rate.

Loveland and Webb (2003) reported that generally, there is considerable concern that if soil OM concentrations in soils are allowed to decrease too much, the productive capacity of agriculture will be then compromised by deterioration in soil physical properties and by impairment of soil nutrient cycling mechanisms. Soil OM contributes positively to soil fertility, soil tilth, crop production, and overall soil sustainability.

2.5. Soil Organic Carbon

Ipsita *et al*. (2018) conducted a study in cultivated and uncultivated saline soil, in order to assay soil organic carbon (SOC), its particle-size fractions and their influence on cultivation and soil fertility at Sundarban costal area in Bangladesh. Soil samples were taken from the 0 - 15 and 15-30 cm depths from four cultivated fields and from four nearby sites in a native mangrove forest as references. Soil samples were physically fractionated into sand (2000-50 μm), silt (50-2 μm) and clay (<2 μm). Total SOC was analyzed in bulk samples and each size fraction, and the Carbon Management Index (CMI), a widely used indicator of soil quality, was calculated for each field. The CMI in cultivated soils was far below the 100% in reference soils. SOC concentrations decreased in particle size separates in the order clay > silt > sand.

Kizildag *et al.* (2013) stated that the organic carbon and total nitrogen values were found to be low compared with non-saline soils and it is possible to conclude that nitrogen mineralization of saline soils can be affected by the composition of different plants.

SRDI (2003) reported that the organic carbon values varied from 0.40 to 2.54% in the salt affected Rupsa Thana Soil of Khulna District.

Sahoo *et al.* (1995) investigated that in sundarban mangrove Soil and found that the organic carbon value decreased with depth in all the profile with its content ranging from 0.29 to 1.89%.

A research work conducted by Leeper and Uren (1993), they stated that high salinity levels may cause soil inorganic fractions to coagulate but the concentration of salt may cause the organic colloids to disperse and drain from the soil profile. Saline seeps are often colored with dispersed organic colloids

Anwar (1993) found that the organic carbon percentage ranged between 0.51 to 0.64 in two salt affected areas of Patuakhali and Barguna districts of Bangladesh and the high value was obtained at surface soil.

2.6. Soil Nitrogen

Kizildag *et al.* (2013) stated that the total nitrogen values were found to be low compared with non-saline soils and it is possible to conclude that nitrogen mineralization of saline soils can be affected by the composition of different plants.

Awdenegest *et al.* (2013) showed that N of soils indicate the degree of leaching and evaporation of exchangeable bases from surface and sub-surface and in arid area higher percentage base saturation because of higher evaporation than leaching. Therefore, this characteristic is extensively used in soil classification, soil fertility appraisal, and mineral nutrition studies.

Girma *et al.* (2012) reported that the depletion of N is a serious threat to agricultural production and food security; it leads to soil degradation and nutrient depletion, a decline in agricultural and biomass productivity and poor environmental quality.

Nahar (2011) reported that the total nitrogen content of the topsoil is generally low to occasionally high ranging from 0.01 to 0.3%. The total nitrogen of the soils in Asasuni varied from 0.1 to 0.3% while that of Kalapara was 0.05 to 0.09%. Total nitrogen content of the soil from Kalapara was evaluated to be low to very low level than that of the soils from Asasuni. Nitrogen content of the surface horizon is higher than that of subsoil. The poor nitrogen status of salt affecting soil is due to high cropping intensity, high rates of decomposition of organic matter and inadequate application of organic matter in terms of manure, compost, and high volatilization of ammonium nitrogen.

Islam (2011) also found that 100% of the soils studied in saline areas were deficient in Available nitrogen.

Haque (2006) reported that the total N contents of the soils in coastal area in Bangladesh are generally low, mostly around 0.1%. The low N content may be attributed to low organic matter contents of most of the soils.

2.7. Soil Phosphorus

Nahar (2011) reported that the P content of the soils ranged from 1.25 to 9.50 mg/kg and 0.70 to 1.75 mg/kg at Asasuni and Kalapara, respectively, so most of the soils are found deficient in phosphorous. In some areas, phosphorous is found well below the critical level for most of the agricultural crops. Acute deficiency of phosphorous was observed at Kalapara.

Haque (2006) reported that the major part (80%) of the country consists of alluvial sediments deposited by the rivers Ganges, Brahmaputra, Tista, Jamuna, Meghna and their tributaries. Terraces with an altitude of 20-30 m cover about 8% of the country, while hilly areas with an altitude of 10-1000 m occur in the southeastern and northeastern part. The coastal region covers almost 29,000 km2 or about 20% of the country. Again, the coastal areas of Bangladesh cover more than 30% of the cultivable lands of the country. About 53% of the coastal areas are affected by salinity. Agricultural land use in these areas is very poor, which is much lower than country's average cropping intensity. Salinity causes unfavorable environment and hydrological situation that restrict the normal crop production throughout the year. He found that available P status of the soils ranges from 15-25 ppm. Some deficient P soils are also found in Chittagong, Barguna, Satkhira and Patuakhali districts

Portch and Islam (2004) reported that the highest phosphorus (P) availability occurs at the pH 6-7 while at higher or lower pH availability of P availability decreases.

Abu Zofar et al. (2003) reported that in Bangladesh total P concentration ranged from 23 to 37 ppm in the top soil and from 46 to 68 ppm in the subsoil and varied with the physiography. In most soil,the available P concentration was much higher for the topsoil than for the subsoil.

2.8. Soil Potassium

Alam *et al.* (2017) found that the potassium content of the soils of Kalapara ranged from 0.789 -0.12 mol $kg^{-1.}$

Gabrijel *et al.* (2011) reported K is exchangeable base. This basic cation is loosely (depending on the nature and conditions of the soil) attached to the edge of the clay particles or to the soil OM (exchange sites) and are in equilibrium with the concentration of cations in the soil solution.

Robert and Patterson (2006) reported that when potassium salts reach at high levels the soils may disperse and the soil pores become blocked with the subsequent capture of the colloid.

SRDI (2003) reported that the potassium level of south of Khulna and Bagerhat towns ranged between 0.8 to 0.15 mol kg^{-1} during the low flow season. It is also reported that several sub-districts (such as Kachua, Mollahat, and Rultali) south of the Sundarban known to be non-saline in the pre-Farakka period have begun to develop soil salinity during the low flow seasons of 1980s.

2.9. Soil Sulfur

Ahmed *et al*. (2018) investigated the patterns of soil salinity and total sulfur concentration between agricultural and fallow land along a 90 km distance from the coastline in Noakhali. Bangladesh. Soil samples were collected from three depths (0.10 and 30 cm) in four different locations from coastline towards inland following a systematic random sampling. Soil salinity and total nitrogen, phosphorus, potassium, sulfur were analyzed by fitting fixed effect linear models for a full factorial design and then weighted interpolation technique was applied to map spatial patterns of selected soil parameters. Highest soil salinity and sulfur were recorded in surface soils at coastline. (0 km) whereas least in 90 km far from coastline. Soil depth resulted significant differences in phosphorus, potassium and showed significant interactions among the distant points. He found that the sulfur content of the soils of Kalapara 40.0- 57.34 ppm.

Naher (2011) reported that topsoil sulphur status of all the soils were found medium to high and the content was higher at Kalapara than the other site. Regular inundation with tidal water may be the cause of higher sulphur content which ranged from 15.0 to 20 mg/100 kg at Asasuni and 38.0 to 67.0 mg/kg at Kalapara.

Ranjan *et al.* (2007) stated that climate variables, such as precipitation, surface runoff, and temperature can play a big role in affecting sulfur concentration. With lower precipitation amount and warmer temperature, the sulfur concentration will be much less due to lack of groundwater present and increase evaporation.

Rengasamy (2006) found that the sulfur concentration of the soil solution has a positive effect on soil aggregation and stabilization and it can damage soil structure with increasing sulfur concentration in the soil solution.

Salinity problem received very little attention in the past. Nevertheless, symptoms of such land degradation with salinization are becoming too pronounced in recent years to be ignored. Increased pressure of growing population demand more food. It has become imperative to explore the possibilities of increasing potential of these (saline) lands for increased production of food crops. Thus management practices should be taken for minimizing land salinization problem.

CHAPTER 3

MATERIALS AND METHODS

3.1. General information of the study area

Dacope is located at 22.5722°N 89.5111°E. It has 25,377 households and a total area of 991.58 km^2. With an area of 99158 km^2, it is bounded by Batiaghata Upazilla on the north, Pashur River on the south, Rampal and Mongla Upazilas on the east and Paikgachha and Koyra Upazillas on the west. The main rivers are Pasur, Sibsa, Manki, Bhadra. The southern part of this upazilla is surrounded by Sundarban (11790.13 hectares).

Dacope has 10 Unions and one Paurashava, 172 Mauzas/Mahallas, and 212 villages. The names of the union parisods in Dacope are Kamarkhola, krishtanpara, Garuikhali. Here, most of the lands are agro-aquaculture and shrimp (Bagda with white fish) zone based. Only Garuikhali Union is agricultural zone. The soil pH value of high and medium highland areas of the upazilla ranges from 7.90-8.13.

Operationally important NGOs are Bangladesh Association for Sustainable Development (BASD), Asa, BRAC, Caritas, Proshika, World Vision, Gonoshahajjo Sangstha, HEED Bangladesh, Step, World Fish, Nabolok, Rupantar and Prodipon, SPED, Paschim Bajua students welfare Association, Bajua, Dacope, Khulna and Bangladesh Environment and Development Society.

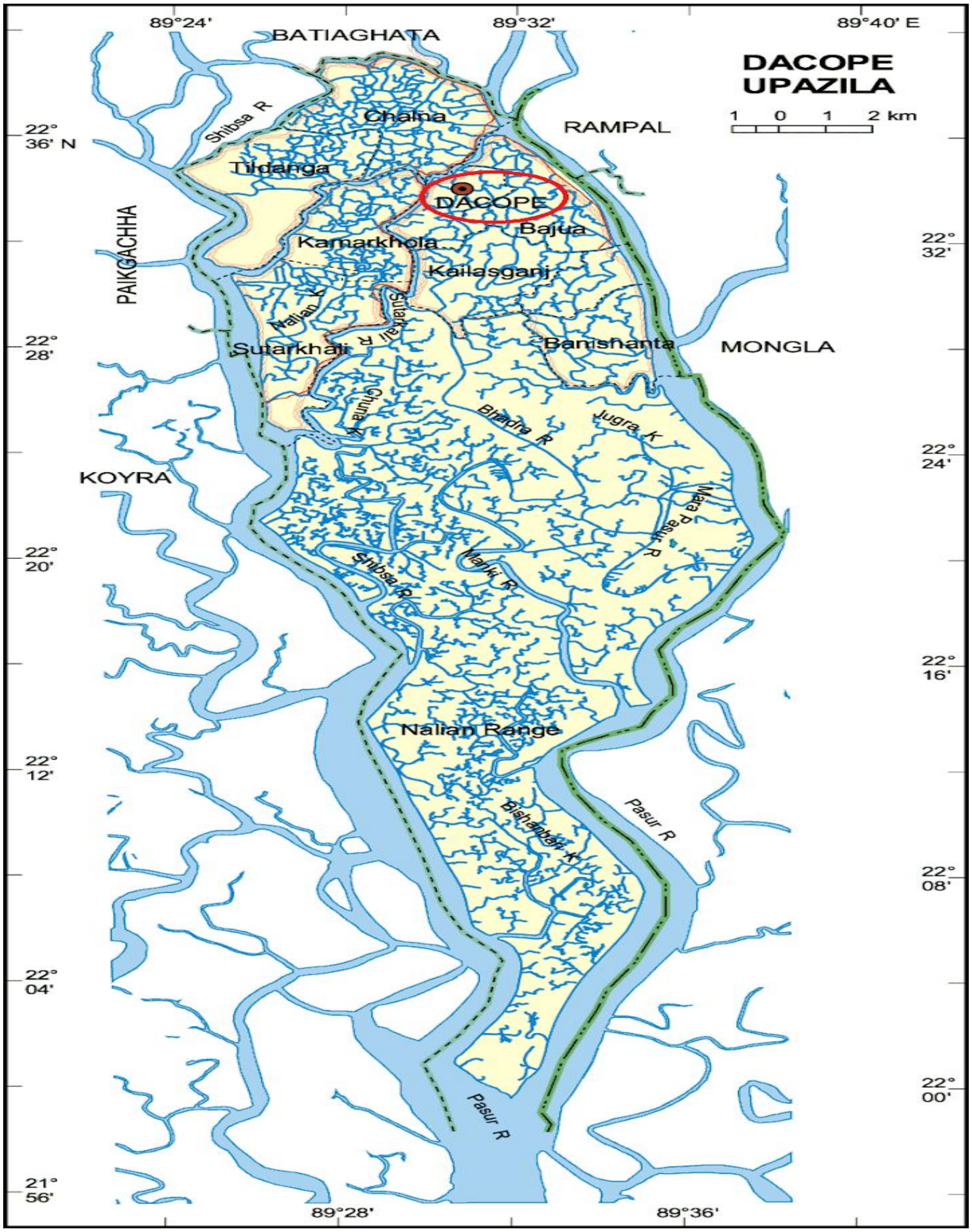

Figure 1. Showing the locale of the study area

3.2 Climatic Condition

The Dacope upazilla lies between 22° 28 /and 22° 43' North latitude and 89° 09' and 89° 23' East longitude in Khulna district of Bangladesh. The climate of this area is classified as tropical. This region is humid during summer and pleasant in winter. Summer begins from mid-April and continues till mid-June. It is extremely hot, stay and comparatively dry. The annual average temperature of this area is 26.3 °C (79.3 °F) and monthly means varying between 12.4°C (54.3 °F) in January and 34.3°C (93.7 °F) in May. The summers here have a good deal of rainfall, while the winters have very little. Annual average rainfall of this area is 1,809.4 millimetres.

3.3 Collection of Data

The whole study in Dacope upazilla is based on the field study which is collected from different locations and also supported by secondary data of the study area.

3.3.1 Primary Data

The primary data has been collected directly from soil sample of Dacope upazilla. The 16 soil samples were collected from Kamarpara at Dacope upazilla which are situated near the Dhaki and Vodra river. The 4 soil samples were collected from Krishtanara at Dacope which is situated near Chunkuri river. Four locations were selected beside these three rivers. These locations were agricultural land, riverbed side, and two side of embankment. From each location soil samples were collected from three soil depths at 0-15 cm,15-30 cm and 30-45 cm. Thus total 20 soil samples were collected for the study. Geographic positioning system (GPS) reading of the sampling location has given in Table 1. Soil samples were collected from each location by means of an auger.

Plate 1.Collection of embankment riverside soil

Plate 2.Collection of embankment countryside soil

Plate 3.Collection of riverbed soil

Plate 4.Collection of agricultural soil

The collected soil samples were carried to the laboratory, air dried, broken down large macro aggregates, ground and passed through a 2-mm sieve to remove weeds and stubbles from the soil. Chemical analysis of the soil sample was done in the laboratory of the Department of Soil Science, Sher-e-Bangla Agricultural University. Chemical analysis was done for electrical conductivity, pH, nitrogen, phosphorus, potassium and sulphur contents following standard methods.

3.3.2 Secondary Data

The secondary data was mainly collected from forest, agriculture, soil and water related sector of Dacope upazilla and Khulna district and all other literatures were collected from published sources available in the books, national and international journals, publications newspapers, web sites and others published and unpublished documents of Government and non-Government.

Table 1: Geographic positioning system (GPS) reading of the sampling location

Sl. No.	Sample ID	Location	Latitude and Longitude	Types of Soil	Compass	Sample Depth	Sample Amount	Physical type	Soil Colour	pH	EC (µs/cm)
1	D1-AS	Kamarkhola	22.592, 89.529	Agril. Soil	47º NE	13 cm	400 gm	Moist	Grey	8.13	550
2	D2-RS	Kamarkhola	22.592, 89.530	River Bed Soil	47º NE	12 cm	350 gm	Wet	Blackish Ash	8.01	536
3	D3-EBS	Kamarkhola	22.592, 89.531	Emb. Country Side	47º NE	14 cm	450 gm	Dry	Ash	7.98	524
4	D4-EBS	Kamarkhola	22.592, 89.532	Emb. River Side	47º NE	15 cm	450 gm	Dry	Ash	7.89	512
5	D5-AS	Kamarkhola	22.592, 89.533	Agril. Soil	83º NE	12 cm	380 gm	Moist	Grey	8.06	605

6	D6-RS	Kamarkhola	22.592, 89.534	River Bed Soil	83º NE	11 cm	350 gm	Wet	Blackish Ash	7.99	697
7	D7-EBS	Kamarkhola	22.592, 89.535	Emb. Country Side	83º NE	15 cm	420 gm	Dry	Ash	8.02	612
8	D8-EBS	Kamarkhola	22.592, 89.536	Emb. River Side	83º NE	15 cm	420 gm	Dry	Ash	8.02	554
9	V1-AS	Kamarkhola	22.592, 89.537	Agril. Soil	113º SE	13 cm	400 gm	Moist	Grey	8.03	567
10	V2-RS	Kamarkhola	22.592, 89.538	River Bed Soil	113º SE	12 cm	350 gm	Wet	Blackish Ash	8	609
11	V3-EBS	Kamarkhola	22.592, 89.539	Emb. Country Side	113º SE	14 cm	450 gm	Dry	Ash	8.06	559
12	V4-EBS	Kamarkhola	22.592, 89.540	Emb. River Side	113º SE	15 cm	460 gm	Dry	Ash	8.02	660
13	V5-AS	Kamarkhola	22.592, 89.541	Agril. Soil	131º SE	12 cm	380 gm	Moist	Grey	8.03	576
14	V6-R_S	Kamarkhola	22.592, 89.542	River Bed Soil	131º SE	11 cm	350 gm	Wet	Blackish Ash	8.1	643
15	V7-EBS	Kamarkhola	22.592, 89.543	Emb. Country Side	131º SE	15 cm	430 gm	Dry	Ash	7.99	712
16	V8-EBS	Kamarkhola	22.592, 89.544	Emb. River Side	131º SE	14 cm	450 gm	Dry	Ash	7.97	843
17	C1-AS	Krishtanpara	22.570, 89.502	Agril. Soil	325º NW	13 cm	300 gm	Moist	Grey	8	556
18	C2-RS	Krishtanpara	22.570, 89.503	River Bed Soil	325º NW	12 cm	280 gm	Wet	Blackish Ash	7.98	507
19	C3-EBS	Krishtanpara	22.570, 89.504	Emb. Country Side	325º NW	14 cm	350 gm	Dry	Ash	7.9	543
20	C4-EBS	Krishtanpara	22.570, 89.505	Emb. River Side	325º NW	15 cm	350 gm	Dry	Ash	8.05	617

(Here D=dhaki,V= vodra, C=chunkuri. AS= agricultural soil, RS= riverbed soil, EBS= embankment soil)

3.4 Data Collection

Pre-testing of the sample collection technique was done in Paikgacha upazilla and final field study was done in 25 November, 2018.

3.5 Data Compilation and Analysis

The collected information was compiled to make a meaningful paper. In course of compilation, sincere advice from my supervisor was taken time to time. After sorting information, data are then analyzed and compiled sequentially and systematically. SPSS version 10.0 have been used for analyzed the collected data.

CHAPTER 4

RESULTS AND DISCUSSION

The research work was accomplish to determine soil salinity of coastal area in Khulna district. Some of the data have been presented and expressed in table(s) and others in figures for case of discussion, comparison and understanding. The analysis of variance of data respect of all the parameters has been shown in Appendix. The results of each parameter have been discussed and possible.

4.1 Soil pH

Soil pH is the negative logarithm of hydrogen ion absorption in soil solution. To measure the degree of soil acidity and alkalinity, soil pH is a very imperative parameter and it helps to know soil properties chemical, biological and indirectly physical environment comprising both nutrients and toxins (Table 2). The pH value of the agricultural soil at Dhaki ranged from 88.05 these pH ranged are strongly alkaline according to USDA**.** At Vodra, the pH values were 8.02 which are strongly alkaline according to USDA. At Chunkuri, the pH values were 8.2. According to USDA pH ranged from 8.2- 8.8 is strongly alkaline. (Table 3) The pH value of the riverbed soil at Dhaki ranged from 7.98-8. pH ranged are moderately alkaline according to USDA . At Vodra, the pH values were 8.01-8.07 which are strongly alkaline according to USDA .At Chunkuri, the pH value was 7.99 which are moderately alkaline. (Table 4) The pH value of the embankment countryside soil at Dhaki ranged from 7.97-8.01. pH ranged are moderately alkaline according to USDA. At Vodra, the pH values were 7.91-8.05 which are moderately alkaline according to USDA. At Chunkuri, the pH value was 7.86 which are moderately alkaline.

Table 02. Analysis of agricultural soil collected from Dhaki, Vodra & Chunkuri river

Location	pH	SD	EC	SD	OM (%)	SD	OC (%)	SD	N (%)	SD	P (ppm)	SD	S (ppm)	SD	K (mol kg^{-1})	SD
D1 -AS	8.12a	0.183	549.08c	12.400	2.54b	0.057	1.42b	0.032	0.190a	0.004	29.95b	0.676	15.68d	0.354	0.200e	0.005
D5 -AS	8.05b	0.182	603.99a	13.640	2.61b	0.059	1.30c	0.029	0.159d	0.004	15.67e	0.354	15.18d	0.343	0.399c	0.009
V1 -AS	8.02c	0.181	566.06bc	12.784	2.78a	0.063	1.03d	0.023	0.149e	0.003	36.74a	0.830	22.56b	0.510	0.419b	0.009
V5 -AS	8.02c	0.181	575.04b	12.987	2.40c	0.054	1.96a	0.044	0.180b	0.004	28.75c	0.649	21.61c	0.488	0.349d	0.008
C1 -AS	8.02c	0.131	558.41bc	17.634	2.31c	0.031	1.01d	0.015	0.166c	0.003	25.12d	0.334	44.64a	0.514	0.892a	0.015

Table 03. Analysis of river bed soil collected from Dhaki Vodra & Chunkuri river

Location	pH	SD	EC (µs cm^{-1})	SD	OM (%)	SD	OC (%)	SD	N (%)	SD	P (ppm)	SD	S (ppm)	SD	K (mol kg^{-1})	SD
D2 -RS	7.98d	0.113	536.36d	10.724	1.03c	0.001	1.69b	0.034	0.030d	0.001	15.01d	0.300	15.86c	0.317	0.677b	0.009
D6 -RS	8.00c	0.060	697.46a	3.960	1.05c	0.021	1.34c	0.027	0.080c	0.002	34.27b	0.685	17.66b	0.353	0.600c	0.012
V2 -RS	8.01b	0.060	609.41c	12.185	1.25b	0.025	0.85d	0.003	0.120a	0.002	23.42c	0.468	10.76d	0.215	0.390d	0.008
V6 -RS	8.07a	0.115	643.43b	12.865	0.61d	0.008	1.95a	0.002	0.020e	0.000	15.38d	0.336	37.92a	0.376	0.0503	0.001
C2 -RS	7.99d	0.160	504.00e	5.757	1.73a	0.019	1.32c	0.014	0.100b	0.001	40.86a	0.440	11.07d	0.273	0.952a	0.003
CV (%)	1.35		1.63		1.46		1.66		2.18		1.80		1.67		1.42	

Table 04. Analysis of embankment country side soil collected from Dhaki Vodra & Chunkuri river

Location	pH	SD	EC (µs cm-1)	SD	OM (%)	SD	OC (%)	SD	N (%)	SD	P (ppm)	SD	S (ppm)	SD	K (mol kg^{-1})	SD
D3 -EBS	7.97ab	0.084	521.63d	9.769	0.90d	0.021	0.95b	0.022	0.180a	0.004	11.98d	0.077	35.45a	0.818	0.799a	0.018
D7 - EBS	8.01ab	0.085	609.85b	6.355	0.40e	0.007	0.44d	0.006	0.060d	0.001	17.98b	0.415	12.85c	0.151	0.799a	0.018
V3 - EBS	8.05a	0.086	558.25c	12.873	1.03c	0.024	1.22a	0.028	0.150b	0.003	14.48c	0.334	4.52d	0.024	0.198c	0.003
V7 - EBS	7.91ab	0.107	711.05a	16.397	1.83a	0.042	0.45d	0.006	0.070c	0.002	12.58d	0.290	16.52b	0.381	0.379b	0.009
C3 - EBS	7.86b	0.137	542.28cd	12.505	1.22b	0.028	0.85c	0.020	0.030e	0.000	34.42a	1.044	12.61c	0.156	0.100d	0.001
CV (%)	1.30		2.05		2.63		1.04		2.59		2.96		2.49		2.72	

Table 05. Analysis of embankment river bed soil collected from Dhaki Vodra & Chunkuri river

Location	pH	SD	EC (µs cm^{-1})	SD	OM (%)	SD	OC (%)	SD	N (%)	SD	P (ppm)	SD	S (ppm)	SD	K (mol kg^{-1})	SD
D4 – EBS	7.89c	0.237	510.67e	10.424	1.73a	0.031	0.43c	0.031	0.109b	0.002	20.17d	0.311	25.34b	0.760	0.907a	0.018
D8 – EBS	8.02a	0.241	554.00d	16.620	0.05d	0.001	1.69a	0.001	0.027d	0.000	25.00b	0.750	15.50d	0.465	0.707b	0.012
V4 – EBS	8.02a	0.241	660.00b	19.800	1.71a	0.051	0.90b	0.051	0.050c	0.001	40.20a	1.206	8.24e	0.132	0.111e	0.002
V8 – EBS	7.97b	0.239	843.00a	25.290	0.60c	0.018	0.23d	0.018	0.050c	0.001	19.50e	0.585	19.03c	0.571	0.420d	0.013
C4 – EBS	8.08a	0.194	613.67c	13.815	1.51b	0.046	1.73a	0.046	0.200a	0.006	24.10c	0.582	55.09a	1.198	0.500c	0.015
CV (%)	1.08		0.92		3.05		2.99		3.16		1.41		2.90		1.29	

Haque (2006) reported that the soil reaction values (pH) range from 6.0-8.4 in coastal area of Bangladesh with the exception of Chittagong and Patuakhali where the pH values range from 5.0-7.8. He also found that most of the soils are moderate to strongly alkaline. Baten *et al* (2015) investigated the impacts of salinity on crop agriculture in south-central coastal zone of Bangladesh and found pH level 7.99. Khan *et al* (2018) reported that the severity of salinity problem in Jabakhali mauza under Shyamnagar Upazila in Satkhira district is increased with the desiccation of the soil**.** The ideal range of pH in soil is 6.0 to 6.5 because most of the plant nutrients are available in this stage. In most cases, a pH range of 6.0-7.5 is optimum for the passable obtainability of nutrients in the soils of Bangladesh. The highest pH value was 8.0 and the lowest pH value was 5.85. The average value is 7.06. In the current study area, most of the soil was alkaline (pH > 7.5**)**

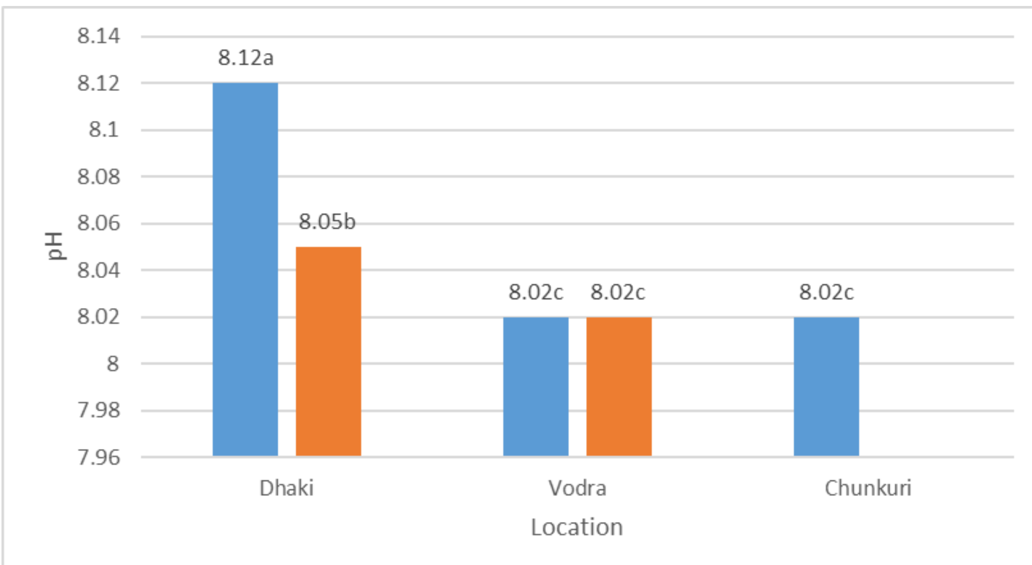

Figure 1. pH of agricultural soil of different locations

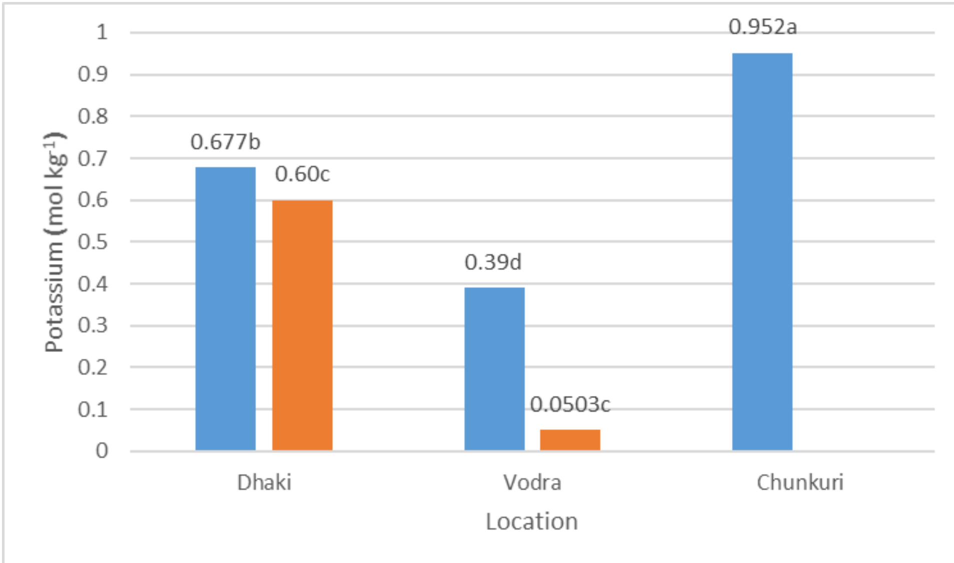

Figure 2. pH of the riverbed soil of different locations

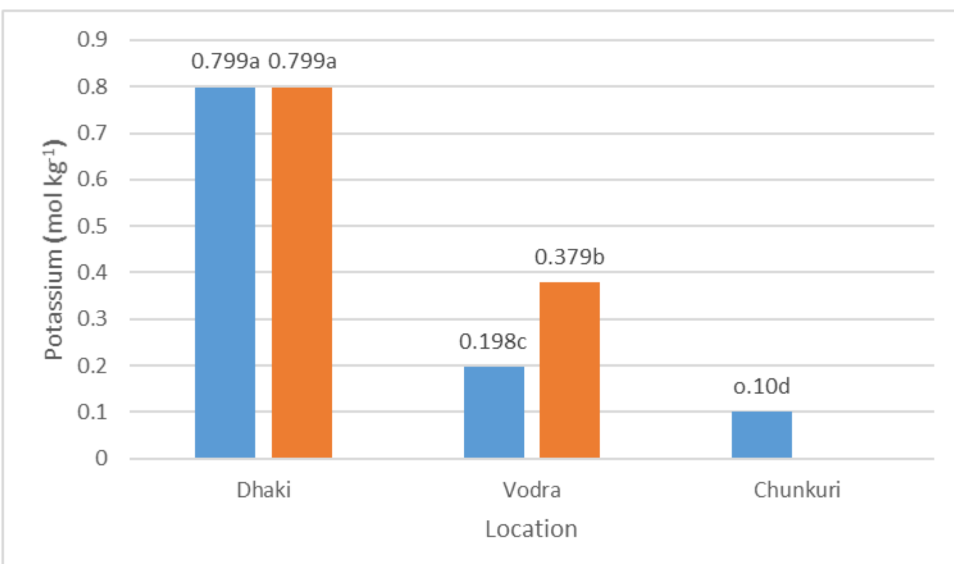

Figure 3. pH of the embankment country side soil of different location

4.2 EC (Electrical Conductivity) of the study areas

Soil salinity usually referred to in terms of EC and this value can be used to predict soil structure stability in relation to irrigation water quality and the sodium adsorption ratio. (Table 2) EC of agricultural soils at Dhaki varies from 549.08-603.99$^{.}$ µs cm$^{-1.}$ In Vodra EC varies from 566.06-575.04 µs cm^{-1} and in Chunkuri EC of soil were 558.41 µs cm^{-1}. EC of all these agricultural soils varies from 549.08-603.99 µs cm^{-1} which expressing medium status of salinity according to the Bookess Tropical Soil Mannal, 1991. (Table 4) EC of embankment countryside soils at Dhaki varies from 521.63-609.85 µs cm^{-1}. In Vodra EC varies from 558.25-711.05 µs cm^{-1} and in Chunkuri EC of soil were 542.28 µs cm^{-1}. EC of all these embankment countryside soils varies from 542.28-609.85 µs cm^{-1} which expressing medium status of salinity according to the Bookess Tropical Soil Mannal,1991. (Table 5) EC of embankment river side soils at Dhaki varies from 510.67-554 µs cm^{-1}. In Vodra EC varies from 660-843 µs cm^{-1} and in Chunkuri EC of soil were 613.67 µs cm^{-1}. EC of all these embankment river side soils varies from 510.67-843 µs cm^{-1} which expressing medium to high status of salinity according to the Bookess Tropical Soil Mannal, 1991. Zaman and Bakri (2003) reported that Bangladesh has 3 million hectares of land affected by salinity, mainly in the coastal and south-east districts, with EC values ranging between 750-2250 µS/cm. High salinity levels may cause soil inorganic fractions to coagulate but the concentration of salt may cause the organic colloids to disperse and drain from the soil profile. Siddique (2018) reported that the EC values of the soil sample at Shymnagar and Tala in Satkhira district ranged from 965 to 4570 µS/cm with an average value of 2527 µS/cm. The highest and lowest EC values of soil samples were recorded at Shymnagar and Tala, respectively. The EC value of the collected soil samples ranged from 150 to 3590 µS/cm with an average value of 1870 µS/cm. The highest EC value was found at Shymnagar (EC = 3590 µS/cm) and the lowest value was recorded at Tala Upzila (EC = 150 µS/cm). The highest EC value of the region indicated that the area is salinity affected. So there can be harmful effect by salt concentration or salinity hazard in respect to EC.

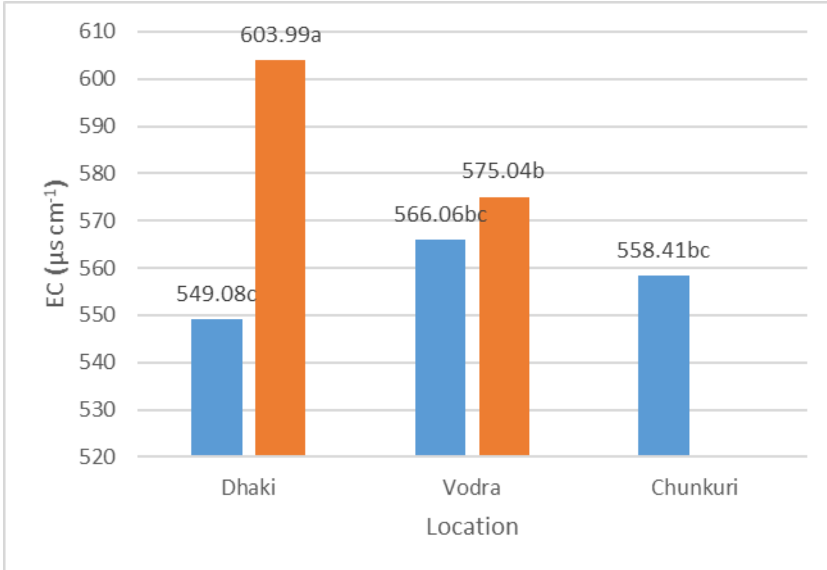

Figure 4. EC of the agricultural soil of different locations

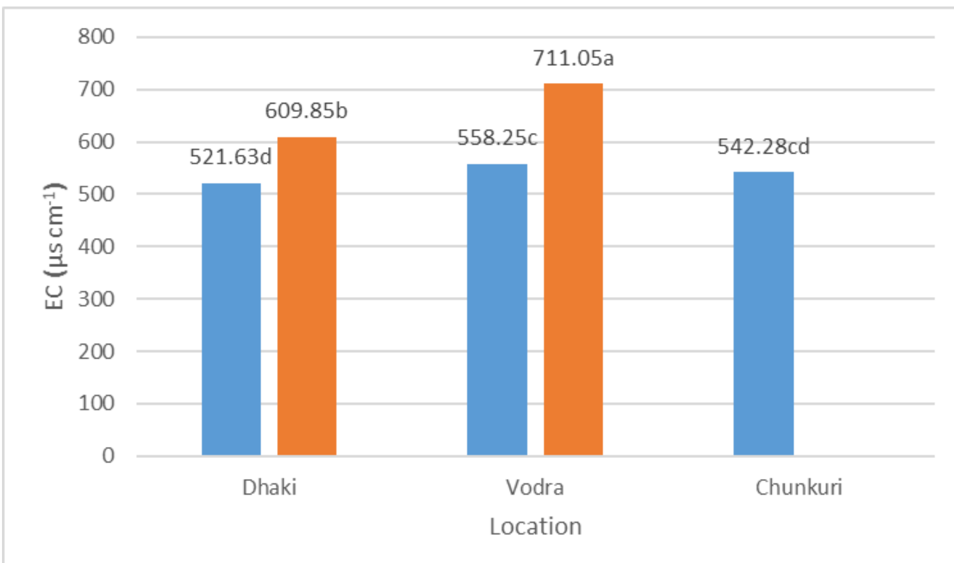

Figure 5. EC of the embankment country side soil of different locations

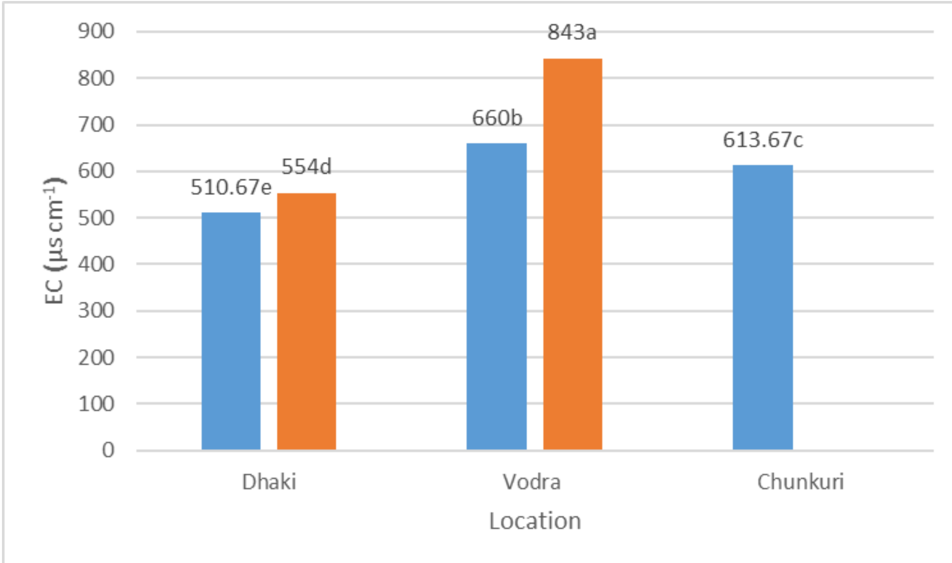

Figure 6. EC of the embankment river side soil of different locations

4.3 OM (Organic Matter) of the study areas

Organic matter contributes to nutrient retention and turnover, soil structure, moisture retention and availability, degradation of pollutants, carbon sequestration and soil resilience**.** (Table 3) OM of riverbed soil in Dhaki varies from 1.03-1.05%. In Vodra OM varies from 0.61-1.25 % and in Chunkuri OM were 1.73%. OM of all these riverbed soils varies from 0.61-1.73%. (Table 5) OM of embankment riverside soil in Dhaki varies from 0.05-1.73%. In Vodra OM varies from 0.60-1.51% and in Chunkuri OM were 1.51%. OM of all these embankment riverside soils varies from 0.05-1.51%. Organic matter content were found medium which were collected from agricultural land in Dhaki. Vodra and Chunkuri. OM content of riverbed and embankment countryside soil were found low and in embankment riverbed soil OM content was very low .Karim *et al.* (1990) found that the organic matter content ranged between 0.10 to 1.00 and 1.15 to 2.27% in two salt affected soils of Bangladesh. SRDI (2003) reported that the organic matter values varied from 0.40 to 2.54% in the salt affected Rupsa Thana Soil of Khulna

District. Naher *et al.* (2011) and Anwar (1993) found that the organic matter percentage ranged between 0.51 to 0.64 in two salt affected areas of Patuakhali and Barguna Districts of Bangladesh. Haque (2006) reported that the soils are in general poor in organic matter content with the exception of Paikgachha upazila of Khulna district, where the topsoils contain high organic matter (7%). The organic matter content of the top soils ranges from less than 1% to 1.5%. The low organic content in soils indicates poor physical condition of the coastal area.

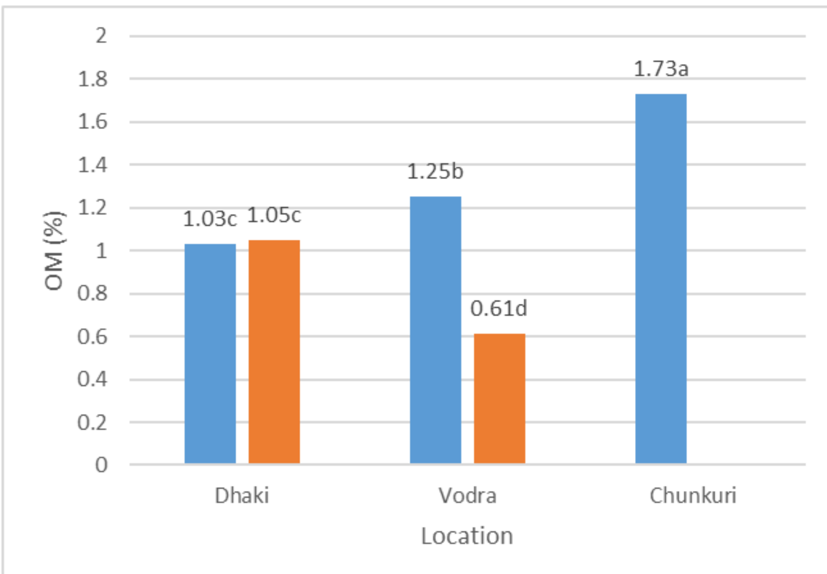

Figure 7. OM of river side soil of different locations

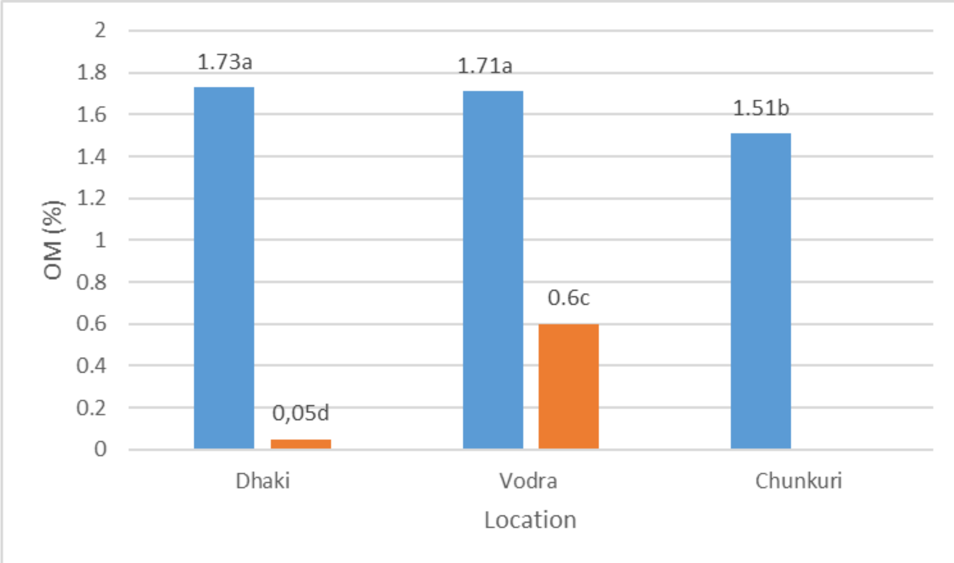

Figure 8. OM of the embankment river side soil of different locations

4.4 Organic Carbon of the study area

Soil organic carbon is a measureable component of soil organic matter. Soil organic carbon (SOC) is believed to play a crucial role for soil functions and ecosystem services. (Table 2) OC of agricultural soil in Dhaki varies from 1.30-1.42%. In Vodra OC varies from 1.03-1.96% and in Chunkuri OC were 1.01%. OC of all these agricultural soils varies from 1.01-1.96%. (Table 3) OC of riverbed soil in Dhaki varies from 1.34-1.69%..In Vodra OC varies from 0.85-1.95 % and in Chunkuri OC were 1.32%. OC of all these riverbed soils varies from 0.85-1.95%. (Table 4) OC of embankment countryside soil in Dhaki varies from 0.44-0.95%. In Vodra OC varies from 0.45-1.22% and in Chunkuri OC were 0.85%. OM of all these embankment countryside soils varies from 0.44-1.22%. Organic carbon content were found low to very low in all type of soil which were collected from Dhaki,Vodra and Chunkuri according to the grading of (BARC, 2012). Iqbal *et al.* (2001) reported that the organic carbon level in most of the arable mineral soils of Bangladesh is generally low and its quantity is believed to be gradually decreasing. They reported that the SOM contents ranged from 0.3 to 1.5% in the upland areas, 1.5 to 2.0% in the medium lowland area and 2.0 to 3.5% in the low land areas. Sahoo *et al.* (1995) conducted an experiment in the sundarban mangrove Soil and found that the organic carbon value decreased with depth in all the profile with its content ranging from 0.29 to 1.89%.

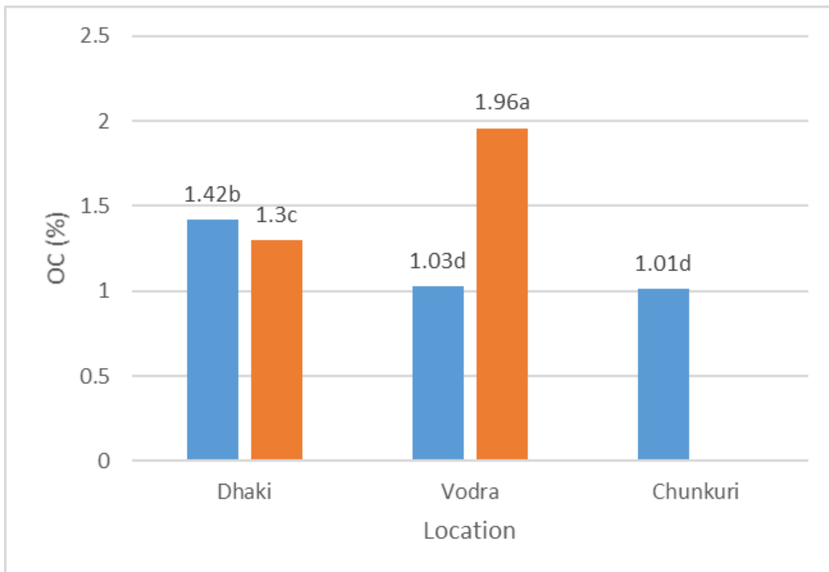

Figure 9: OC of the agricultural soil of different locations

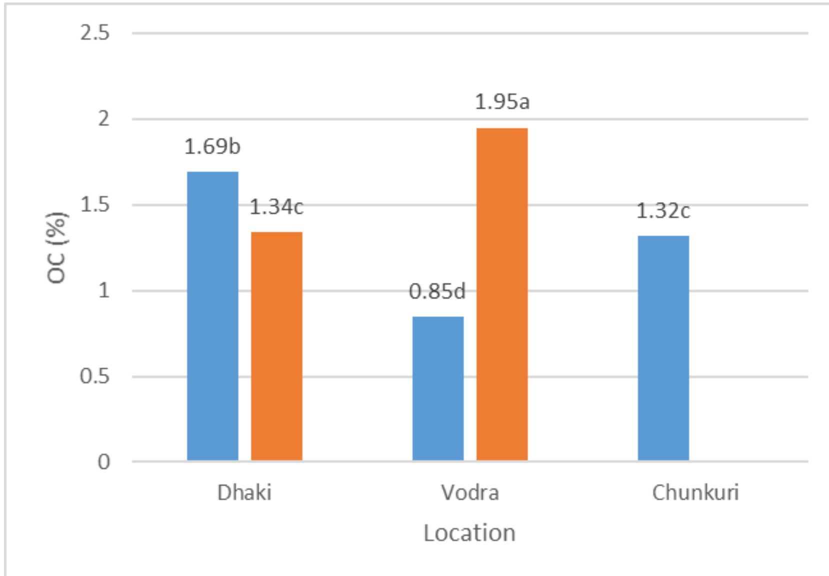

Figure 10. OC of the river bed soil of different locations

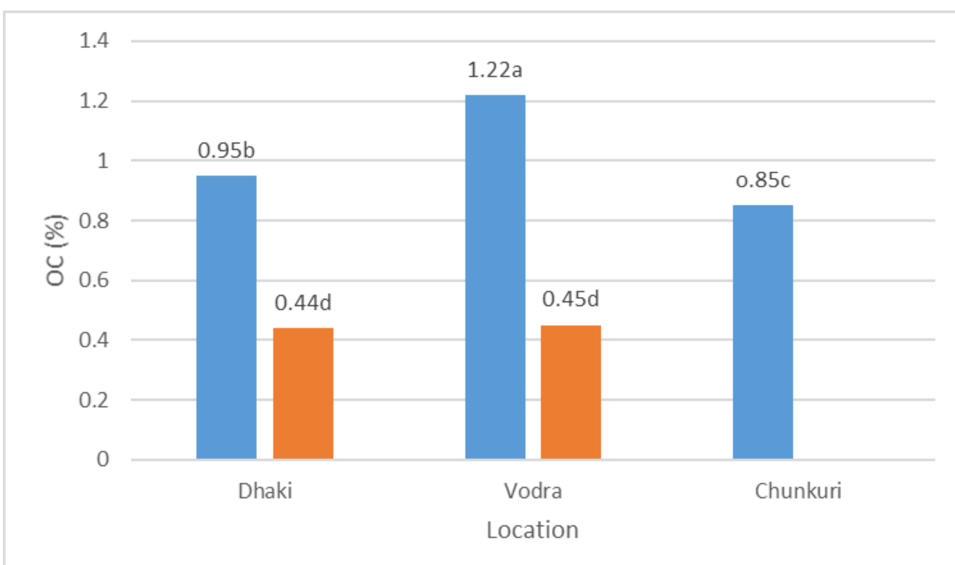

Figure 11. OC of the embankment country side soil of different locations

4.5 N (Nitrogen) of the study areas

Total N Content of agricultural soil in Dhaki varies from 0.159-0.190% (Table 2). In Vodra total N content varies from 0.149-0.180% and in Chunkuri were 0.166%. Total N content of all these agricultural soils varies from 0.149-0.190%. (Table 4) Total N content of embankment countryside soil in Dhaki varies from 0.060-0.180%. In Vodra Total N content varies from 0.07-0.150% and in Chunkuri Total N content were 0.03%. Total N content of all these embankment countryside soils varies from 0.03-0.180%. (Table 5) The total nitrogen content in all type of soil collected from Dhaki,Vodra and Chunkuri were low to very low level according to the grading of (BARC, 2012).Naher *et al.* (2011); Portch and Islam, (1984) found that 100% of the soils were deficient in available nitrogen, which was similar to the present findings. Kizildag *et al.* (2013) reported that the total nitrogen values were found to be low compared with non-saline soils and it is possible to conclude that nitrogen mineralization of saline soils can be affected by the composition of different plants. Haque (2006) reported that the total N contents of the soils in coastal area in Bangladesh are generally low, mostly around 0.1%. The low N content may be attributed to low organic matter contents of most of the soils.

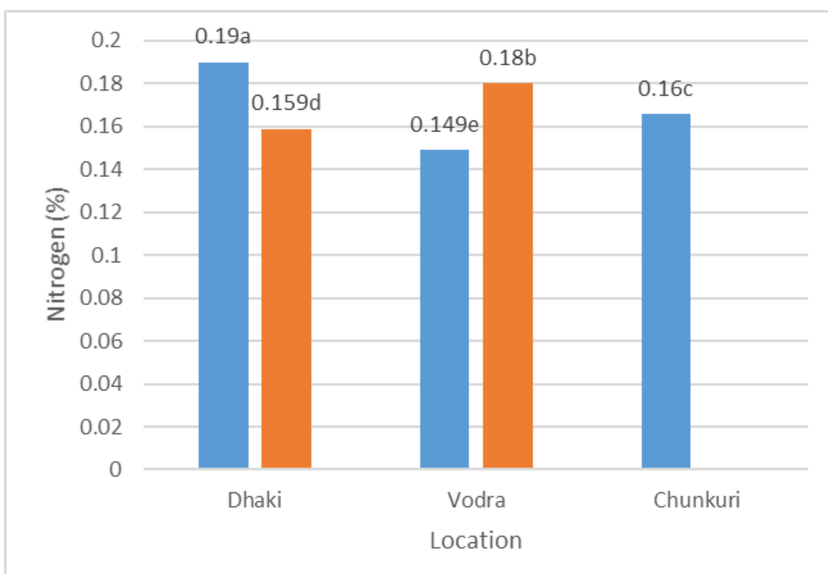

Figure 12. N of the agricultural soil of different locations

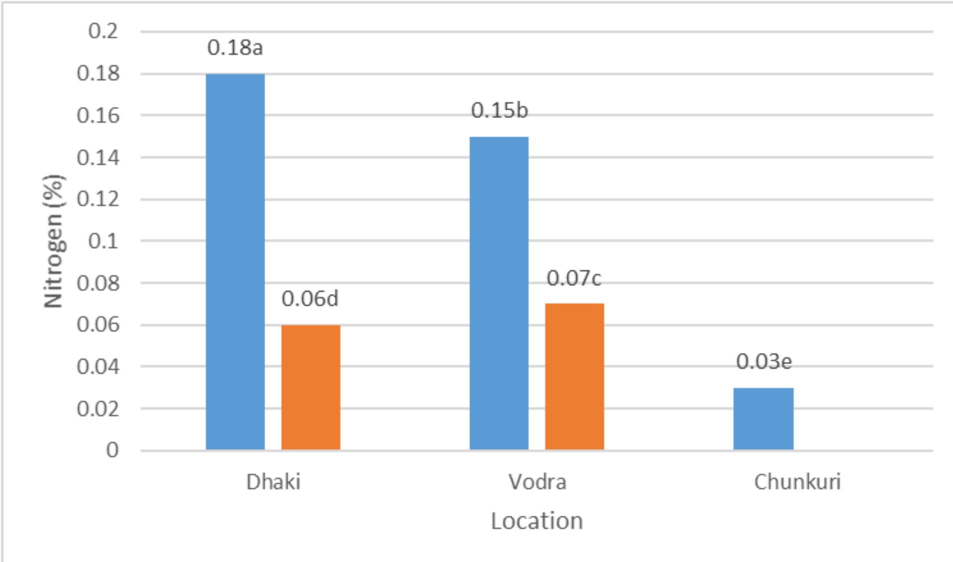

Figure 13: N of the embankment country side soil of different locations

4.6 P (Phosphorus) of the study areas

Total P Content of agricultural soil in Dhaki varies from 15.67-29.95 ppm (Table 2). In Vodra total P content varies from 28.75-36.74 ppm and in Chunkuri total P content were 25.12 ppm. Total P content of all these agricultural soils varies from 15.67-36.74 ppm.(Table 3). Total P content of riverbed soil in Dhaki varies from 15.01-34.27 ppm . In Vodra Total P content varies from 15.38-23.42 ppm and in Chunkuri total P content were 40.86 ppm. Total P content of all these riverbed soils varies from 15.01-40.86 ppm.(Table 4). Total P content of embankment riverside soil in Dhaki varies from 20.17-25 ppm. In Vodra total P content varies from 19.50-40.20 ppm and in Chunkuri were 24.01 ppm. Total P content of all these embankment riverside soils varies from 19.50-40.20 ppm. All of these ranges were medium level according to the grading of (BARC, 2012). Prafitt

(1978) reported that the highest phosphorus (P) availability occurs at the pH 6-7 while at higher or lower pH availability of P decreases. Abu Zofar *et al.* (2003) reported that in Bangladesh total P concentration ranged from 23 to 37 ppm in the top soil and from 46 to 68 ppm in the subsoil and varied with the physiography. In most soil, the available P concentration was much higher for the topsoil than for the subsoil. Haque (2006) reported that available P status of the soils ranges from 15-25 ppm. Some deficient P soils are also found in Chittagong, Barguna, Satkhira and Patuakhali districts.

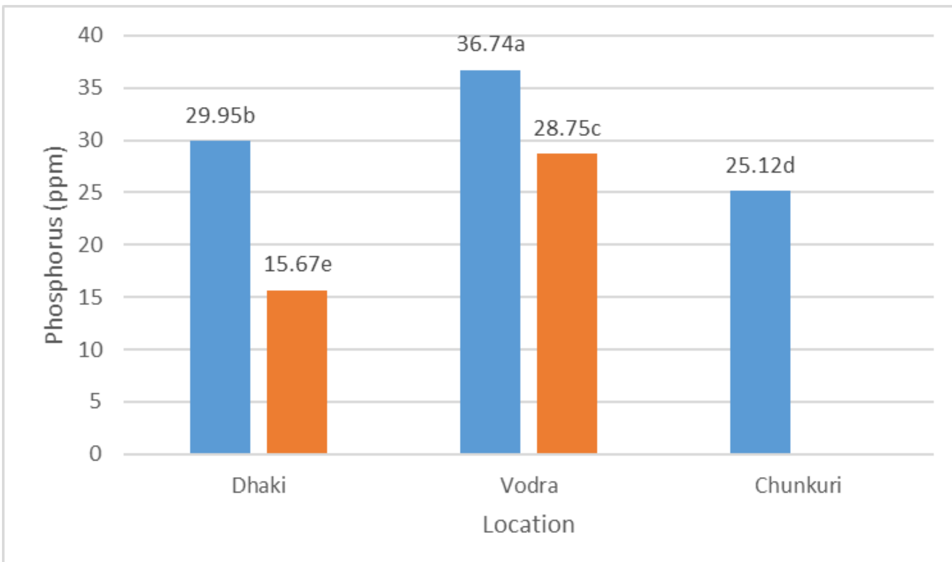

Figure 14. P of the agricultural soil of different locations

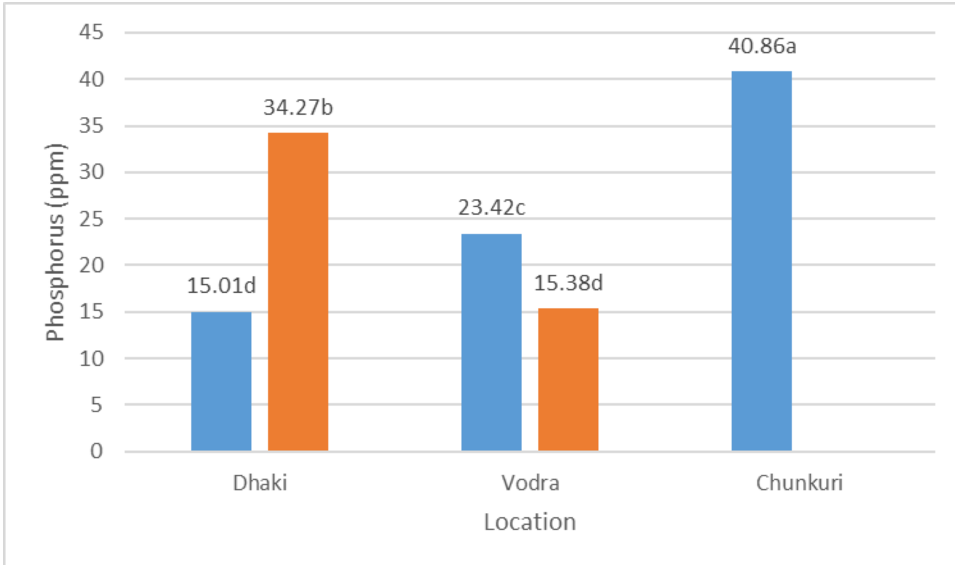

Figure 15. P of the river bed soil of different locations

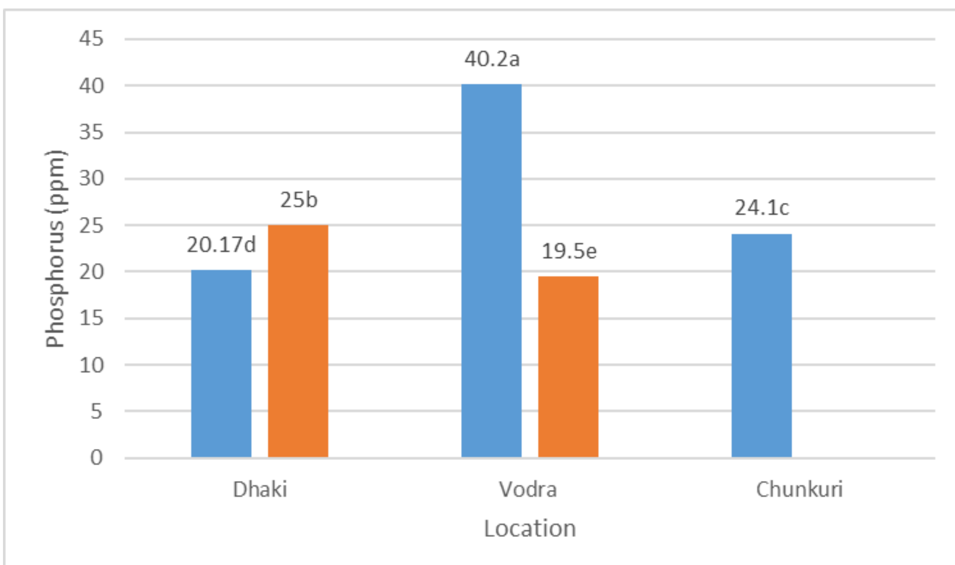

Figure 16. P of the embankment river side soil of different locations

4.7 S (Sulphur) of the study areas

Total S Content of agricultural soil in Dhaki varies from 15.18-15.15.68 ppm (Table 2). In Vodra total S content varies from 21.61-22.56 ppm and in Chunkuri total S content were 44.64 ppm. Total S content of all these agricultural soils varies from 15.18-44.64 ppm.(Table 3). Total S content of riverbed soil in Dhaki varies from 15.86-17.66 ppm. In Vodra Total S content varies from 10.76-37.92 ppm and in Chunkuri total S content were 11.07 ppm. Total S content of all these riverbed soils varies from 10.76-37.92 ppm. (Table 4) Total S content of embankment countryside soil in Dhaki varies from 12.85-35.45 ppm. In Vodra Total S content varies from 4.52-16.52 ppm and in Chunkuri total S content were 12.61 ppm. Total S content of all these embankment countryside soils varies from 4.52-35.45 ppm. (Table 5) Total S content of embankment riverside soil in Dhaki varies from 15.50-25.34 ppm. In Vodra total S content varies from 8.24-19.03 ppm and in Chunkuri were 55.09 ppm. Total S content of all these embankment riverside soils varies from 8.24-55.09 ppm. All of these ranges were medium level according to the grading of (BARC, 2012). Ahmed *et al*. (2019) investigated the patterns of soil salinity and total concentration of sulfur in agricultural and fallow land along a 90 km distance from the coastline in Noakhali. Highest soil salinity and sulfur were recorded in surface soils at coastline. (0 km) whereas least in 90 km far from coastline. Alam *et al.* (2017) found that the sulfur content of the soils of Kalapara 40.0- 57.34 ppm. . .

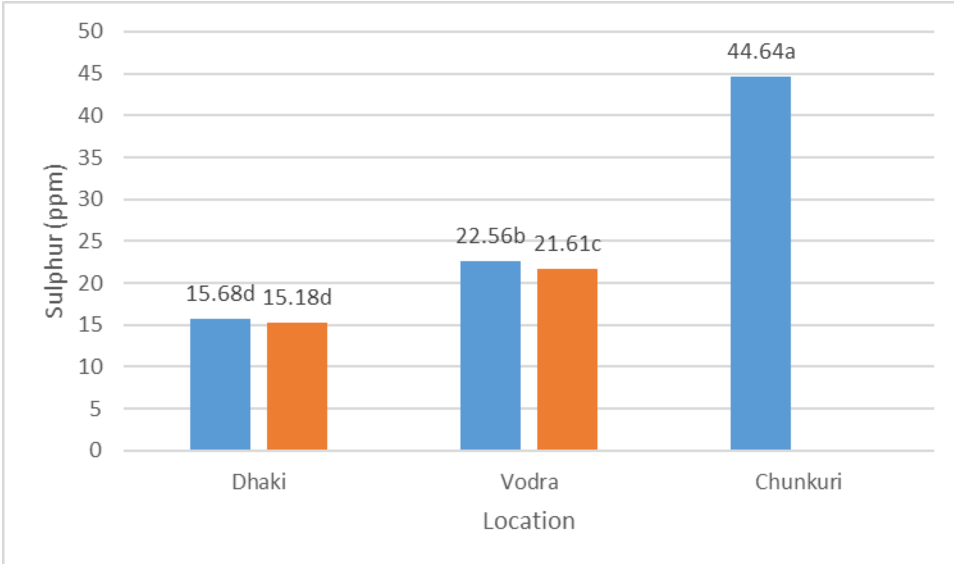

Figure 17. S of the agricultural soil of different locations

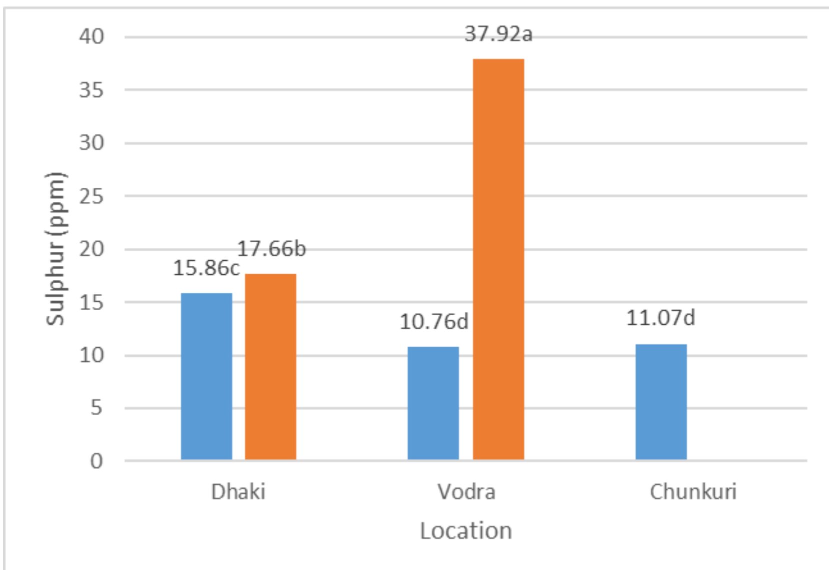

Figure 18. S of the river bed soil of different locations

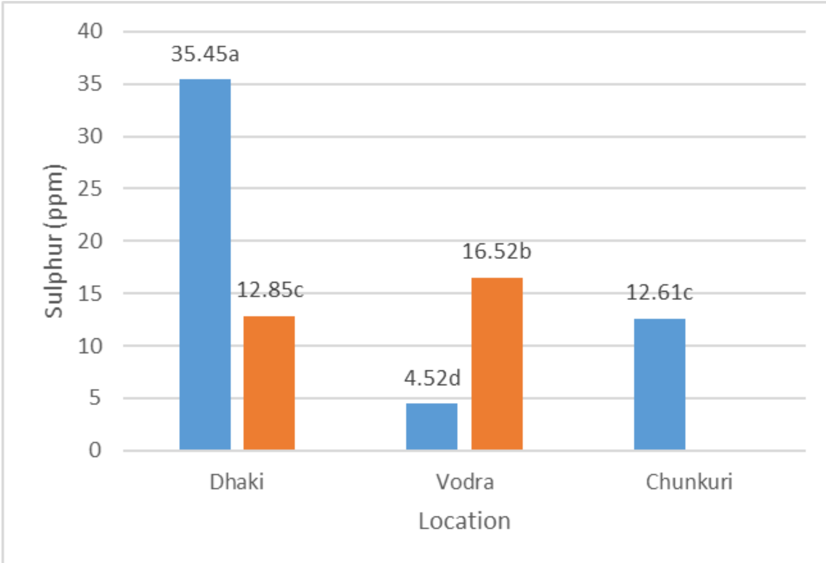

Figure 19. S of the embankment country side soil of different locations

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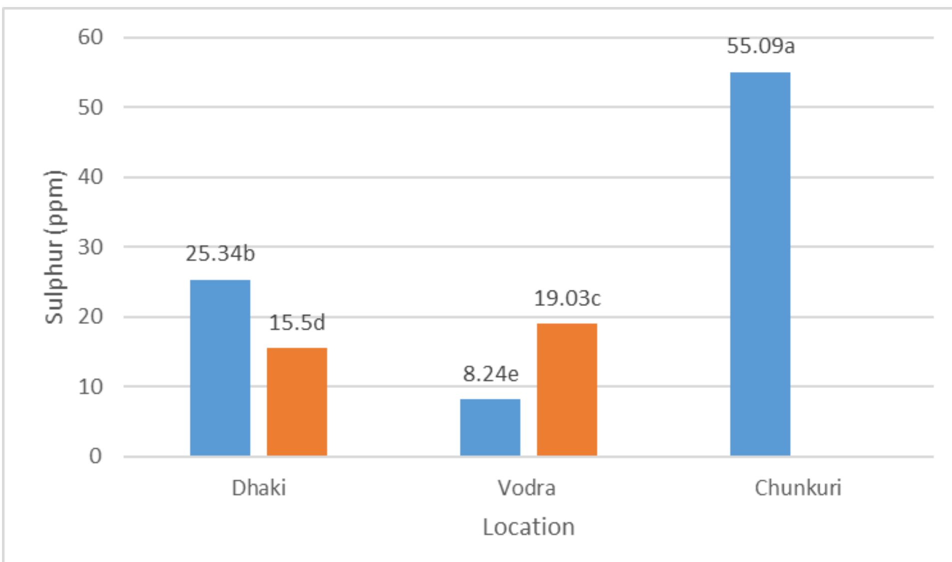

Figure 20. S of the embankment river side soil of different locations

4.8 K (Potassium) of the study areas

Total K content of riverbed soil in Dhaki varies from 0.600-0.677 mol kg^{-1}.In Vodra Total K content varies from 0.390-0.050 mol kg^{-1} and in Chunkuri total K content were 0.952 mol kg^{-1}. Total K content of all these riverbed soils varies from 0.050-0.952 mol kg^{1}(Table 4) Total K content of embankment countryside soil in Dhaki varies from 0.799 mol kg^{-1}. In Vodra Total K content varies from 0.198-0.397 mol kg^{-1} and in Chunkuri total K content were 0.100 mol kg^{-1}. Total K content of all these embankment countryside soils varies from 0.100-0.799 mol kg^{-1} (Table 5) Total K content of embankment riverside soil in Dhaki varies from 0.707-0.907 All of these ranges were medium level according to the grading of (BARC, 2012).In Vodra total K content varies from 0.11-0.42 mol kg^{-1} and in Chunkuri were 0.500 mol kg^{-1}. Total K content of all these embankment riverside soils varies from 0.11-0.907. All of these ranges were low to very low level according to the grading of (BARC, 2012

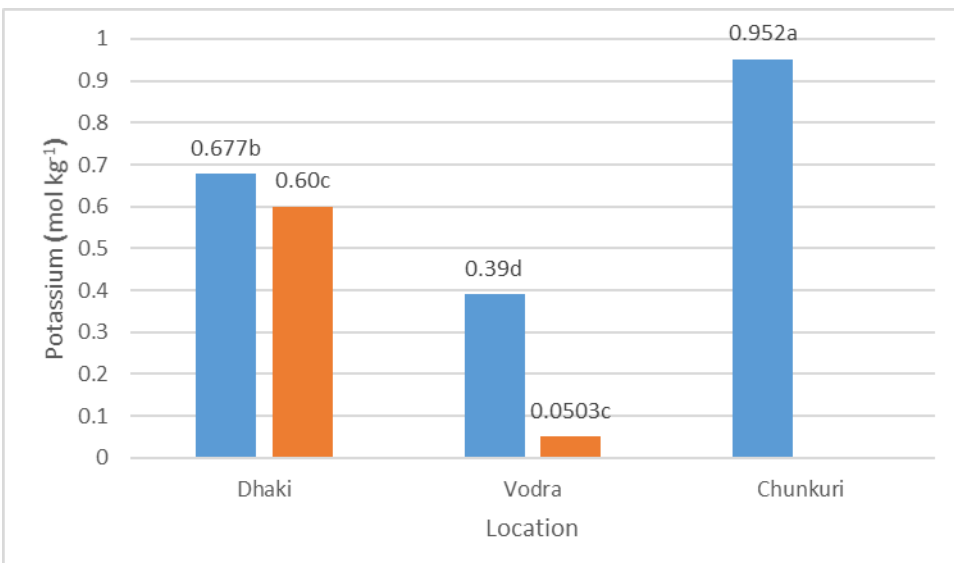

Figure 21. K of the river bed soil of different locations

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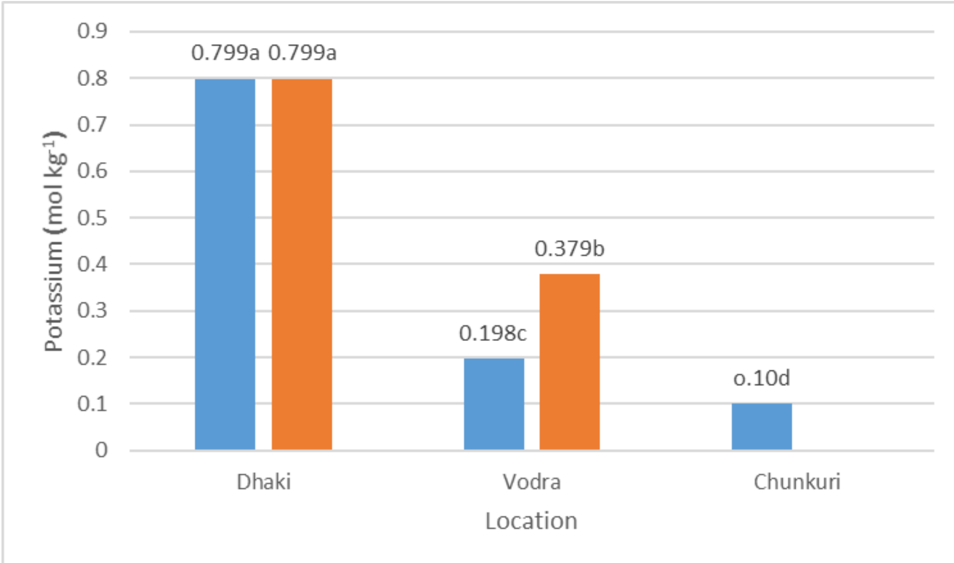

Figure 22 .K of the embankment country side soil of different locations

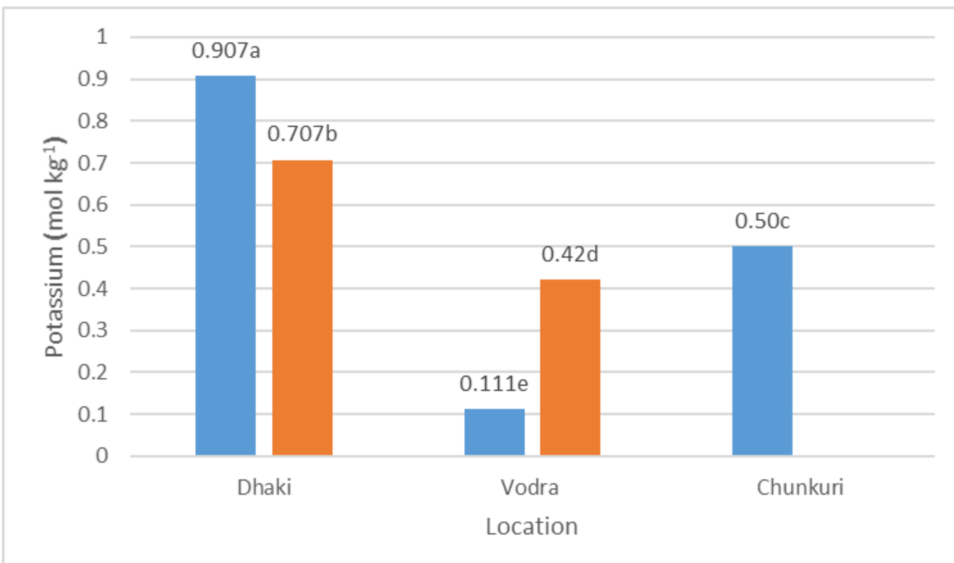

Figure 23. K of the embankment river side soil of different locations

4.9 Correlation matrix between the characteristics

4.9.1 Correlation matrix between the characteristics of the agricultural soil

The correlation matrix between the characteristics of the agricultural soil are determined in the present study which are collected from Dhaki.Vodra and Chunkuri in Dacope upazilla of Khulna district and these correlation are given in the Table 6. It was found that the pH was the most fundamental property in agricultural soil of Dhaki,Vodra and Chunkuri and has positive relation with EC, OM, OC, N, and P. EC showed significant negative relationship with P. OC showed significant negetive relationship with S. OC content showed significant positive relationship with total N and significant negative relationship with K. Total S showed significant positive relationship with K. Naher *et al.* (2011) studied the correlation matrix for physical and chemical properties of soil at Asasuni and Kalapara upazilla and understood that the clay content is the most fundamental property to control chemical properties of soils at Asasuni and Kalapara upazilla.

Table 6. Correlation matrix between the characteristics of the agricultural soil

	Ph	EC	OM	OC	N	P	S	K
pH	1							
EC	.413	1						
OM	.265	.303	1					
OC	.087	.170	-.279	1				
N	.320	-.306	-.466	.632*	1			
P	.044	-.569*	.315	-.051	.023	1		
S	-.102	-.300	-.581*	-.438	-.160	.051	1	
K	-.119	-.061	-.490	-.537*	-.358	-.181	.950**	1

Remarks = ** and * mean correlation significant at the 0.01 and 0.05 levels, N: total N content, OM: organic matter content, Ec: electrical conductivity, P; total P content, K: total K content, S;total S content

4.9.2 Correlation matrix between the characteristics of the river bed soil

The correlation matrix between the characteristics of the riverbed soil are determined in the present study which are collected from Dhaki.Vodra and Chunkuri and these correlation are given in the Table 7. It was found that the pH was the most fundamental property in riverbed soil of Dhaki,Vodra and Chunkuri. EC showed significant negative relationship with OM and K. OM showed significant positive relationship with N and P but significant negative relationship with OC, S and K. OC content showed significant negative relationship with total N and significant positive relationship with S. Total N showed significant positive relationship with P and significant negative relationship with S. Total P showed significant positive relationship with S and significant negative relationship with K. Total S showed significant negative relationship with K.

Table 7. Correlation matrix between the characteristics of the riverbed soil

	pH	EC	OM	OC	N	P	S	K
pH	1							
EC	.248	1						
OM	-.243	-.621*	1					
OC	.194	.011	-.620*	1				
N	-.169	-.077	.752**	-.956**	1			
P	-.152	-.110	.778**	-.475	.683**	1		
S	.342	.446	-.835**	.784**	-.761**	-.532*	1	
K	-.302	-.610*	.849**	-.311	.417	.691**	-.783**	1

Remarks = ** and * mean correlation significant at the 0.01 and 0.05 levels, N: total N content, OM:organic matter content, Ec: electrical conductivity, P; total P content, K: total K content, S;total S content

4.9.3 Correlation matrix between the characteristics of the embankment country side soil

The correlation matrix between the characteristics of the embankment countryside soil are determined in the present study which are collected from Dhaki.Vodra and Chunkuri and these are given in the Table 8. It was found that the pH was the most fundamental property in embankment countryside soil of Dhaki,Vodra and Chunkuri. pH showed negative relationship with OM, P, S and K but positive relationship with EC and N. EC showed significant positive relationship with OM and negative relationship with N, P, S and K. OM content showed significant positive relationship with K and OC showed significant positive relationship with N. Total P showed significant negative relationship with N. Total K showed significant negative relationship with P and significant positive relationship with S.

Table 8. Correlation matrix between the characteristics of the embankment country side soil

	pH	EC	OM	OC	N	P	S	K
pH	1							
EC	.013	1						
OM	-.324	.535*	1					
N	.405	-.413	-.166	.631*	1			
P	-.368	-.314	-.021	.030	-.688**	1		
S	-.104	-.224	-.033	-.068	.455	-.315	1	
K	.253	-.004	-.567*	-.389	.336	-.535*	.640*	1

Remarks = ** and * mean correlation significant at the 0.01 and 0.05 levels, N: total N content, OM: organic matter content, Ec: electrical conductivity, P; total P content, K: total K content, S;total S content

4.9.4 Correlation matrix between the characteristics of the embankment riverside soil

The correlation matrix between the characteristics of the embankment riverside soil are determined in the present study which are collected from Dhaki.Vodra and Chunkuri and these are given in the Table 9. It was found that the pH was the most fundamental property in embankment riverside soil of Dhaki,Vodra and Chunkuri. OM showed negative relationship with EC, pH, OC and K. OM showed significant positive relationship with N and non-significant relation with P, S and K. Total S showed significant positive relationship with total N and Total P showed significant positive relationship with total K.

Table 9. Correlation matrix between the characteristics of the embankment river side soil

	pH	EC	OM	OC	N	P	S	K
pH	1							
EC	.153	1						
OM	-.012	-.228	1					
OC	.280	-.448	-.219	1				
N	.117	-.241	.561*	.309	1			
P	.191	-.025	.336	.208	-.242	1		
S	.159	-.164	.280	.425	.951**	-.406	1	
K	-.137	-.596*	-.174	.015	.167	-.743**	.241	1

Remarks = ** and * mean correlation significant at the 0.01 and 0.05 levels, N: total N content, OM: organic matter content, Ec: electrical conductivity, P; total P content, K: total K content, S;total S content

CHAPTER 5

SUMMARY AND CONCLUSION

Summary

The research work was accomplished for determination of soil salinity in Dacope upazilla of Khulna district. Soil sample were collected from Dhaki,Vodra and Chunkuri river in Dacope upazilla. The primary data has been collected directly from soil sample of dacope upazila. The 16 soil samples were collected from kamarkhola which are situated near the Dhaki and Vodra river. The 4 soil samples were collected from krishtanpara which are situated near Chunkuri river. Four locations were selected beside these three rivers.

The secondary data was mainly collected from forest, agriculture, soil and water related sector of Dacope upazila and Khulna district and all other literatures were collected from published sources available in the books, national and international journals, publications, newspapers, web sites and others published and unpublished documents of government and non-government. Pre-testing of the sample collection was done through a reconnaissance survey in Paikgacha upazila. The final survey was done in 25th November, 2019. The highest pH of the agricultural soil, river bed soil, embankment country side soil and embankment river side soil was 8.12, 8.07, 8.05 and 8.08, respectively and the value are not significant.

Significant variation was observed in EC of different location and the highest EC ($\mu s\ cm^{-1}$) of the agricultural soil, river bed soil, embankment country side soil and embankment river side soil was 603.99, 697.46, 711.05 and 843.00, respectively.

The highest OM (%) of the agricultural soil, river bed soil, embankment country side soil and embankment river side soil are 2.78, 1.73, 1.83 and 1.71, respectively and the variation was significant.

The highest OC (%) of the agricultural soil, river bed soil, embankment country side soil and embankment river side soil are 1.96, 1.95, 1.22 and 1.73, respectively and the value was significant.

The highest N (%) of the agricultural soil, river bed soil, embankment country side soil and embankment river side soil are 0.19, 0.12, 0.18 and 0.2, respectively and all are significant at 1% level of significance.

Significant variation was observed in the value Pin different location and the highest P (ppm) of the agricultural soil, river bed soil, embankment country side soil and embankment river side soil were 36.74, 40.86, 34.42 and 40.20, respectively.

The highest S (ppm) of the agricultural soil, river bed soil, embankment country side soil and embankment river side soil are 44.64, 37.92, 35.45 and 55.09, respectively and the value was significant.

The highest K (mol kg^{-1}) of the agricultural soil, river bed soil, embankment country side soil and embankment river side soil are 0.892, 0.952, 0.799 and 0.907 respectively and the variation was significant.

The area of coastal region of Bangladesh is about 47,201 km^2 which extending along the Bay of Bengal,central coastal zone of Bangladesh, more particularly interior coast. The coastal areas of Bangladesh, with near flat topography and location at the tip of "funnel shaped" Bay of Bengal, are susceptible to a number of natural hazards such as cyclones, tidal surges, salinity intrusion, riverbank erosion, and shoreline recession. The coastal zone of Bangladesh, especially exposed coast has come into focus in a number of policy and academic studies for salinity intrusion, but with the accelerated impacts of climate change salinity extends from the exposed to the interior coast hampering crop production. Estimated salinity concentration has already put a threat to the crop production and a significant yield loss has already been noticed in dry season. In the changing scenario of sea level rise, it has been predicted that the increasing concentration of salinity would create more pressure to the farmer by reducing yield on one hand and threatening livelihood, income generation and food security on the other hand. Therefore, to reduce the future loss and prevent the present loss, the study recommends leaching and selecting salinity tolerant crop varieties as adaptation technique.

CONCLUSION

Soil salinity is a worldwide problem. Bangladesh is no exception to it. In Bangladesh, salinization is one of the major natural hazards hampering crop production. Coastal area in Bangladesh constitutes 20% of the country of which about 53% are affected by different degrees of salinity. Agricultural land use in these areas is very poor. Declining land productivity which shift towards negative nutrient balance is among the main concerns with food security problem in the country. Dacope upazilla in Khulna district is a saline prone area. In this area Electrical conductivity (EC) varies from 510.67·µs $cm^{-1.}$ 843 µs $cm^{-1.}$ Expressing slightly saline to moderately saline. The organic matter content varies from 0.05%—2.78% which is pretty low to medium. The organic carbon content varies from 0.23%-1.96% which is pretty low to medium to high. The pH values varies from 7.4-8.8 which expresses slightly to moderately alkaline soil. Fertility status of most saline soils of Dacope upazilla ranges from low to very low in respect to organic matter content, nitrogen, phosphorus and sulfur. Soil fertility should be improved based on the results obtained in the present study. Thus combating land salinization problem is vital for food security in the country through adoption of long term land management strategy.

RECOMMENDATIONS

1. More implementations and coordination of the concerned policies should be needed for special attention in decision making at the present salinity condition of our country.

2. Monitoring program should be set up to track changes in salinity satus and to monitor the progress of remedial measures.

3. The health of the ecosystems are essential for the well being of the surrounding area of coastal region. So this study recommended the further development of the environmental pollution control and a routine monitoring by responsive authority.

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APPENDICES

Appendix- I. Collected data of saline soil

Sample ID	pH	EC (µs/cm)	OM (%)	OC (%)	N (%)	P (ppm)	S (ppm)	K (mol/kg)
D1-AS	8.13	550	2.54	1.424	0.19	30	15.71	0.20
D2-RS	8.01	536	1.03	1.69	0.03	15	15.85	0.68
D3-EBS	7.98	524	0.90	0.95	0.18	12	35.5	0.80
D4-EBS	7.89	512	1.75	0.43	0.11	20.5	25.34	0.90
D5-AS	8.06	605	2.61	1.307	0.159	15.7	15.21	0.40
D6-RS	7.99	697	1.05	1.34	0.08	34.25	17.65	0.60
D7-EBS	8.02	612	0.40	0.44	0.06	18	12.83	0.80
D8-EBS	8.02	554	0.05	1.69	0.027	25	15.5	0.70
V1-AS	8.03	567	2.78	1.034	0.149	36.80	22.60	0.42
V2-RS	8.00	609	1.25	0.85	0.12	23.4	10.75	0.39
V3-EBS	8.06	559	1.03	1.22	0.15	14.5	4.54	0.20
V4-EBS	8.02	660	1.71	0.90	0.05	40.2	8.34	0.11
V5-AS	8.03	576	2.40	1.96	0.18	28.8	21.65	0.35
V6-RS	8.10	643	0.61	1.95	0.02	15.7	38.23	0.05
V7-EBS	7.99	712	1.83	0.45	0.07	12.6	16.54	0.38

V8-EBS	7.97	843	0.60	0.23	0.05	19.5	19.03	0.42
C1-AS	8.00	556	2.33	1.02	0.17	25.5	44.05	0.89
C2-RS	7.98	507	1.75	1.34	0.10	40.5	11.03	0.95
C3-EBS	7.90	543	1.22	0.85	0.03	34.3	12.53	0.10
C4-EBS	8.05	617	1.50	1.76	0.20	24.2	55.42	0.50

Appendix-II . Soil salinity classes on the basis of Electrical Conductivity

Soil salinity class	EC (µS/cm)	Effects on crop plants
Non-saline	0 – 250	Salinity effects negligible
Slightly saline	250 – 750	Yields of sensitive crops may be restricted
Moderately saline	750 – 2250	Yields of many crops are restricted
Strongly saline	2250-4000	Only tolerant crops yield satisfactorily
Very strongly saline	> 4000	Only very tolerant crops yield satisfactorily

Source: Bookess Tropical Soil Mannal, 199

Appendix III. Classification of soil on the basis of Organic Matter (OM)

Class	**Range (%)**
Very low	< 1
Low	1.0-1.7
Medium	1.8-3.4
High	3.5-5.5
Very high	> 5.5

Source: BARC, 2012

Appendix IV. Classification of soil on the basis of pH

Denomination	**pH range**
Ultra acidic	< 3.5
Extremely acidic	3.5–4.4
Very strongly acidic	4.5–5.0
Strongly acidic	5.1–5.5
Moderately acidic	5.6–6.0
Slightly acidic	6.1–6.5
Neutral	6.6–7.3
Slightly alkaline	7.4–7.8
Moderately alkaline	7.9–8.4
Strongly alkaline	8.5–9.0
Very strongly alkaline	> 9.0

Source: BARC, 2012

Appendix V. Classification of soil on the basis of Organic Carbon

Class	**Range (%)**
Very low	< 1
low	1.0-1.7
Medium	1.8-3.4
High	3.5-5.5
Very high	> 5.5

Source: BARC, 2012

Plate 5. Analyzing soil sample in SAU Soil science laboratory