STATUS OF SEDIMNETATION AND THEIR PROPERTIES ON THE AGRICULTURAL LAND

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CERTIFICATE

This is to certify that the thesis entitled ***'STATUS OF SEDIMENTATION AND THEIR PROPERTIES ON THE AGRICULTURAL LAND'*** *submitted to the faculty of Agriculture, Sher-e-Bangla Agricultural University (SAU), Dhaka, in partial fulfillment of the requirements for the degree of* ***Master of Science (MS)*** *in* ***Agroforestry and Environmental Science****, embodies the result of a piece of bonafide research work carried out by* ***UTPAL KUMAR SHEEL****, Registration No.* ***18-09123,*** *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 duly been acknowledged.

Dated: December, 2020
Place: Dhaka, Bangladesh

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

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THE STATUS OF SEDIMNETATION AND THEIR PROPERTIES ON THE AGRICULTURAL LAND

ABSTRACT

The sediments has a positive impact on soil physical and chemical qualities. The decreasing of sedimentation is causing decline in soil productivity and crop yield which results in severe degradation of environment. Any sediment management strategy performed in this system becomes an intrinsic part of this complex system, according to the goal of our research. This study was conducted at Dacope upazilla under Khulna district. This location was chosen since it is one of the most sediment-prone places. Primary and secondary data were gathered for the investigation. Soil samples were taken from three locations in Dacope upazilla: Dhaki, Vodra, and Chunkuri, using a random sampling approach at 2-3 cm depth. The sediment pH of Dacope upazilla is higher which expresses moderately alkaline (8.12, 8.13 and 8.09). Electrical Conductivity of all these sediments varies from 548.00 to 678.00 µs cm^{-1} expressing moderate to high salinity. The organic matter content is pretty low to medium (1.10 to 2.64 %) in Dhaki, Vodra and Chunkuri river. The highest OM (%) were found in the flow time of Vodra, khalside of Dhaki and ebb time of Chunkuri are 1.87, 2.64, 1.65, respectively and the variation was significant. The Organic carbon were (1.95, 1.69 and 1.97 %) in medium to low level. Nutrient deficiencies for total nitrogen were quite dominant in the study area (0.25, 0.34 and 0.20 %). Total Phosporus were (38.00, 36.80 and 34.30 ppm) and Sulfur contents were (36.54, 32.50 and 32.53 ppm) in medium level. The study's findings suggest that the severity of the sedimentation problem in the studied locations is worsening by the day. Depending on the pH, OM, OC, and other factors, it has an impact on crops and vegetation. The study offers implying essential management plan to implement correct policy based on the detection of sedimentation status in the studied region and a long-term decision-making approach in the Dacope upazilla of Khulna district.

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LIST OF ABBREVIATIONS

FULL WORD	ABBREVIATION
Adenosine triphosphate	ATP
Bangladesh Agricultural Research Institute	BARI
Bangladesh Bureau of Statistics	BBS
Percentage of Coefficient of Variance	CV%
Electrical conductivity	EC
Ebb time	ES
and others	*et al.*
Etcetera	etc.
Flow time	FS
Food And Agriculture Organization	FAO
Kilogram	kg
Least Significant Difference	LSD
Milligram	mg
Mol per kg	mol kg^{-1}
Nitrogen	N
Non Significant	NS
Organic Carbon	OC
Organic Matter	OM
Phosphorus	P
Negative logarithm of hydrogen ion concentration	pH
Parts per million	ppm
Sulfur	S
Sher-e- Bangla Agricultural University	SAU
Standard deviation	SD
Soil Resources Development Institute	SRDI
Tidal River Management	TRM
United Nations Department of Agriculture	USDA
Microsimen per centimeter	µs cm^{-1}
Percentage	%

CHAPTER I

INTRODUCTION

Sediment is a solid material that has been transferred and deposited in a new location. The sediment may consist of stones and minerals, as well as plant and animal remains. It can be as small as a sand grain or as big as a boulder. Sediment transfers from one location to another as a result of erosion. Erosion is the process of removing and transporting rocks or dirt. Sediment may move through water, erosion, ice, or wind. As it often enriches the soil with nutrients, sediment is important. Sediment-rich areas are often rich in biodiversity too. For farming, sedimentary soil is generally better. The most fertile agricultural areas in a region are often the deltas and river banks, where much sediment is deposited.

In river systems, sediment transport plays an important role by serving as an indicator of the erosion and depositional processes that form the morphology of the basin (Dade & Friend, 1998; Church, 2006). In addition, sediment brings vital nutrients to river habitats within the stream flow (MEA, 2005; Julien, 2010; Apitz, 2012).Climate influences are closely related to the hydrological cycle, mainly temperature and precipitation, which in turn drives the transport of sediments (Zhu, *et al*., 2008). That natural state of sediment transport can therefore be influenced by ongoing climate change and increased anthropogenic activities (Walling & Fang, 2003; Walling, 2006). As a result, investigating the sensitivity of sediment transport to changes in hydro-climatic and physical river features is critical for gaining a better knowledge of potential future dynamics.

Khulna is situated south of Jessore and Narail, west of Bagerhat, east of Satkhira, and north of the Bay of Bengal. It is a member of the world's largest delta. The Sundarbans, the largest mangrove forest in the world, lies in the southern part of the delta.

In the south-west of Bangladesh and downstream of the Dhaki, Vodra and Cunkuri rivers are situated. For Khulna town, which belongs to this vast region, the Dhaki, Vodra and Cunkuri River, which is now often referred to as the Dead River is very significant. From various points of view, Dhaki, Vodra and Cunkuri rivers are significant, such as irrigation purposes, the dispatch of municipal sewer media and its dumping ground as well, but the natural flow of the river completely retarded due to human interference and the river is fully converted into a feeder channel. On the city safety dam, the 10 valve sluice gates regulate the current and flow of the Dhaki, Vodra and Cunkuri rivers and from the water courses. The invasion of the river in the 1990s was initiated by some illegal fishermen and land traders. The sluice gates are not well controlled now. The coastal river's geochemical composition, such as the Dhaki, Vodra and Cunkuri rivers in the southwest has not yet received prior publicity. Therefore, it is important to research the hydropedospheric geochemical existence of the Dhaki, Vodra and Cunkuri rivers as the assessment of water, sediment and soil quality is crucial for long term effects on sustainable soil environments.

Bangladesh lies in a vibrant delta. It is a part of the structure of the Ganges-Brahmaputra-Meghna basin. The rivers carry upstream sediment that shows a decreasing trend (Rahman *et al.*, 2018). One third of the river sediment is accumulated on the flood plain and tidal plain, according to the estimated long-term delta sediment budget (Goodbred and Kuehl, 2000) and one third is trapped in the sub-aqueous delta to accrete vertically and advance laterally. The destination of the remaining sediment could not be assessed (Goodbred and Kuehl, 2000) and they concluded that it was probably transported to the deep ocean floor. A large portion of the incoming sediment is transported to the Bay of Bengal, while a portion remains in the coastal floodplain (WARPO and BUET, 2018). However, due to the influence of both climate and anthropogenic interventions that are being examined by many large scale research projects, these sediment budgets shift over time (WARPO and BUET, 209), DECCMA (www.deccma.com) and ESPA Deltas (www.espadelta.net). Therefore, more extensive research on sediment management in Bangladesh, particularly in the south-western region is required.

In the south-west zone, tidal rivers and estuaries are marked by erosion and sedimentation that is eventually discharged into the Bay of Bengal. Most of the rivers in this area are silted up due to natural and anthropogenic interventions (such as climate impacts, polderization). As a result, for quite a long time, the region have been suffering from drainage congestion and water-logging issues. Proper sediment control in the current physical environment is one of the potential solutions to this problem, which would solve the water-logging problem and accelerate land reclamation at the same time.

The problem of sedimentation in this area is exacerbated by the development of coastal polders separating the floodplain from the peripheral rivers. During the 1990s coastal polders were planned. If polders were not present, sedimentation would take place within the protected polder region and the sedimentation area of the floodplain would have increased (WARPO and BUET, 2018). Polders limit the entry into the protected region of sediments and increase sedimentation in vulnerable areas and possibly in rivers. This 'un-managed' sediments are thought to cause water-logging inside polders, although there are other causes, such as poor drainage routes inside polders (Tahsin *et al.*, 2019). There was extreme drainage congestion in this area since the early eighties and water-logging. The Khulna Jessore drainage rehabilitation project referred to as KJDRP was implemented during 1994-2002 to deal with these long-standing issues. Later, a common theory, formally centered on centuries of indigenous water management practices, it was recognized as a Tidal River Management (TRM).TRM will enable the natural flow of tidal water sediment into a beel, which is called the tidal basin, and allow sediment to be deposited in the beel. The outgoing water will erode the river-bed during low tide and increase the conveyance potential.

The major sediment sources in the south-western area of Bangladesh (which is one of the parts of the coastal zone) are primarily from the Lower Meghna estuary. Most of these sediments join the south-western zone through the mouths of large numbers of estuaries due to clockwise oceanic circulation (Haque *et al*., 2016). As mentioned before, (Goodbred and Kuehl, 2000) from a gross estimate presumed that on the floodplain, one third of the in-coming sediments may are deposited. It had been found during a later study that about 23% to 47% of in-coming sediments are deposited on the floodplain (WARPO and BUET, 2019). An equivalent research shows the very fact that sedimentation is spatially variable within the coastal floodplain. In addition, anthropogenic and climatic interventions are primarily influenced by sedimentation in this area (WARPO and BUET, 2019). Sediment management in the area is especially difficult due to spatial variability of sedimentation and impacts due to intrusion. In the western portion, most of the estuaries and rivers lost their conveyance due to sedimentation that caused large-scale water-logging (WARPO and BUET, 2019). On the other side, for ground, sediment is a primary ingredient in the off-shore area reclaim. There are regions that can be considered sediment-excess (mainly rivers and estuaries) and there are areas that can be called sediment-starve area (mainly off-shore region). Tidal River Management (TRM) is one of the region's commonly accepted sediment management activities. TRM is a sediment management practice focused on procedures, but its effect is primarily local. In addition, TRM's implementation mechanism causes social tension. Dredging is another established sediment management method in the area. With the exception of being unusually costly, when long-term morphological time scales are taken into account, dredging sustainability is doubtful. Another well-known sediment control method used for land reclamation in the off-shore area is Cross-dam. However, research on the device effect of cross-dam is still lacking. A process-based sediment control approach to the scheme is a safer option. A thorough study on this particular issue, however, is a research gap in this area. The current research is being performed to fill this void.

Research Objectives:

The ultimate objective of the study is to establish a sustainable plan for sediment management that will redirect sediments from the area of sediment abundance to the region of sediment hunger. This will decrease Water-logging problem compensating effect of sea level rise and accelerating land reclamation. The specific goals of this study are described as:

- To show the upstream sediment loads and their dispersion process in the south-west zone.
- To create a manual for sediment management that focuses on sustainable sediment management activities in the region.
- To analyze the sediment properties in respect of agricultural aspects in the coastal Dacope upazila of Khulna district.

CHAPTER II

REVIEW OF LITERATURE

The goal of this chapter is to discuss past research work relevant to the current study the issue of sediment problem is a global problem. Bangladesh is no exception to this theory. One of the major natural hazards hampering the development of crops due to loss of sediments in Bangladesh. Soil and sediments is a common threat in many parts of the coastal region, according to the SRDI. Any water soluble salts are found in sediments. In the form of soluble salts, plants absorb important plant nutrients, but an excessive accumulation of soluble salts, called sediment salinity, suppresses plant growth. Several studies on sediment have been carried out, but no research has yet been carried out to determine the sediment status of Dacope upazilla's embankment environment, flow and ebb period in Khulna district. However, the analysis of some associated sediment studies is given below in the following sections:

Sediment

Wolman and Miller (1960) claimed that a river channel's stability is essentially dependent on its ability to convey sediments supplied to the river without net erosion or river bed and bank aggradation. The effective discharge, defined as the discharge at which maximum geomorphic work is performed in a river channel, measures the capacity of the river channel.

Wolman and Miller (1960) showed that for long-term channel stability, the flow rate that is most productive in the long-term transport of sediments should be considered as the effective discharge of the river. The principle of geomorphic work was introduced the successful discharge is carried out as the result of the sediment load.

Coleman (1969) determined that the sediment load was transferred to the ocean by summing up the sediment loads of the Ganges and Brahmaputra rivers at Hardinge Bridge and Bahadurabad Ghat, respectively, which are further inland than Mawa. Sediment deposition within the downstream reach was thus overlooked. It should even be noted that an outsized portion of the suspended load of the Ganges is transported to the coastal sea via the Hoogly distributary, additionally to the Ganges-Brahmaputra River in Bangladesh.

Walling and Webb (1981) indicated that the real load would be underestimated by loads measured using sediment rating curves. But the degree of underestimation was reduced by the use of flood event data.

Ashmore and Day (1988) indicated that it is not possible to consider flow events with a single recurrence interval to be indicative of productive or bankfull of discharge for all streams because discharge of basin morphology, drainage area, hydrological regime and mode of transport of sediments are influenced by values (bedload and suspended load).

Ellison (1993) found that the old mangroves could not keep up with sea-level rise rates while the sedimentation rates under mangroves did not drowned, higher elevations were colonized by new mangrove forests.

Leopold (1994) proposed that small flows have abundant frequency, but do not have the ability to hold large amounts of sediments. On the other hand, smaller flows are necessary to have sufficient capacity to move sediments but low probability of occurrence.

Hudson and Mossa (1997) suggested that flow magnitude and frequency provide a useful framework for understanding the timing and flow of sediments from rivers draining a spread of geological and climatic changes and for analyzing the transfer of pollutants related to fluvial sediments to the near shore environments.

Furukawa *et al*. (1997) calculated that, the sedimentation rate in the mangroves by trap method from the edge of the creek, whereas this analysis shows the calculation of the reduction of wave energy in the reduction of wave energy of the forest.

Pitlick and Van Steeter (1998) said that any change in the ratio of water to sediment through the channel dramatically changes the morphology of the channel, and the channel gradually transitions to a new set of discharge values. The deposition of sediment in the riverbed influences the ecological habitat and the preservation of the channel during low flow conditions. For instance, due to low flow, the fish habitat in the Upper Colorado River has been reported to be endangered.

Islam *et al*. (1999) said that in South Asia, the highly dynamic Brahmaputra River carries one of the highest sediment yields in the world.

Islam *et al*. (1999) concluded that the main rivers annually hold over a billion tons of sediment, which is spread through fluvial and tidal processes in the delta.

Goodbred and Kuehl (2000) presumed that one third of in-coming sediments may have been deposited on the floodplain from a gross calculation. In a subsequent analysis, about 23 percent to 47 percent of in-coming sediments were found to be deposited on the floodplain.

Goodbred and Kuehl (2000) found that the applied to the accumulation on the floodplain and coastal plain of one third of the sediment borne by the rivers. The estuaries in the south-west area are silted up by high sediment loads and many natural and anthropogenic interventions (such as climate impacts, Farakka barrage and polderization).

CEGIS (2002) found that, without compensation, people allow their land to be used for the operation of the tidal basin, hoping that the land will increase after three or four years. Monitoring results and community consultation reveal, however, that sedimentation inside the basin doesn't occur needless to say in most cases.

Tutu (2005) found that it is important to understand the sustainability of sediment management activities, like TRM and can be extended to decision-making on long-term sediment management with the goal of sustainably improving local livelihoods. The results of this study are applicable to Bangladesh, but may be evaluated in other deltas for application.

The Institute of Water Modeling (2005) reported that the problem of sedimentation in this area has been worsened by the construction of Coastal polders that de-link the river floodplains upstream flow during the dry season has decreased and decreased.

Cowell *et al*. (2006) indicated that sediment budget methods are most helpful in assessing the beach response to climate change.

Ericson *et al*. (2006) found that a sustainable supply of fluvial sediment is crucial in producing the deposition required to avoid 'drowning' as the only factor that could theoretically offset losses in delta surface elevation.

Woodroffe *et al*. (2006) calculated that, in relation to either the Ganges or Brahmaputra, the combined sediment loads (more than 1 giga tonne per year) from the Ganges and Brahmaputra rivers (note that the Meghna is excluded from consideration as its sediment flow of about 13 million tons (Mt) per year is negligible) have created one of the world's largest and most populous structures for the river delta.

Lenzi *et al*. (2006) reported that the effective discharge was a flow between small and large flows with an intermediate discharge and was originally defined as a discharge or a set of discharges capable of transporting the largest fraction of the long-term sediment load.

EDP (2007) claimed that in the off-shore area, Cross-dam is another well-known sediment management method used for land reclamation. The Bangladesh Water Development Board

(BWDB) suggested 18 possible coastal cross-dam sites. The effect of these cross-dams has not yet been studied on local or complete sedimentation in the area.

Gomez *et al*. (2007) suggested that the alluvial rivers typically have unconfined (not well channelized) water and sediment flow from the drainage basin that can cause various effects, including changes in flow magnitude (volume) and frequency, especially in the long term.

Kettner and Syvitski (2008) argued that a climate-driven hydrological water balance and sediment transport model was used as part of the larger analysis to predict possible climate-driven discharges of water and sediment loads flowing upstream from the catchments into the GBM delta.

Doyle and Shields (2008) identified that an ecologically effective discharge because the discharge that drives the transport of organic matter from sediments, algal growth, retention of nutrients, disruption of macro-invertebrates, and availability of habitat.

Ma *et al*. (2010) proposed that the geomorphic process frequency matters as much as process magnitude, contributing to the belief that most fluvial landforms are formed by moderate floods that occur periodically, rather than by occasional cataclysmic floods. Depending on their length, two floods that peak at the same level will carry drastically different amounts of sediment. Increasing the supply of sediments, particularly fine sediments, is likely to lead to a decrease in the effective discharge as it disrupts the balance between water and sediments; thus, the discharge of the channel becomes less capable of transporting excess sediments.

Paola *et al*. (2011) found that the fine (silts and clays) and the coarse (sand) sediment load both contribute to the construction of the delta, it is widely accepted that it is the most significant fraction of the sand.

Kibria (2011) noted that the increasing soil fertility, fresh sediments supplied by TRM will improve agricultural productivity. However, it is unclear if tidal sediments actually improve soil fertility and to what extent. Soil fertility forms the foundation of agricultural productivity and is essential for the maintenance of livelihoods. The effects of tidal sediment deposition on soil fertility at different geographical locations will therefore be investigated in this study, considering spatial variation of soil properties, nutrient availability, and salinity.

Kibria, (2011) found that, by temporarily removing an embankment segment adjacent to a low-lying beel, TRM requires restoring tidal in-and outflow. The water and sediments from the nearby tidal river drain into the beel with the double-daily high tide. The water flows out of the polder or beel with the twice-daily low tide, leaving part of the sediments within. Over time, fresh sediment deposition is capable of growing low-lying land that can be reclaimed for agricultural use.

Apitz (2012) assessed that from environmental, economic and social perspectives, sediments borne by river systems are important, not least because sediments provide critical nutrients and material for river systems, ecosystems and farmland.

Rogers *et al*. (2013) said that the key sediment carriers are monsoon river discharges from upstream, and tidal flows that divert part of the fluvial sediments that end up in the Bay of Bengal.

Rogers *et al*. (2013) measured that in the Sundarbans area, this sedimentation from March 2008 to October 2008. These 8 months of data were later translated to sedimentation/year. There is minimal secondary data concerning sedimentation in the coastal floodplain.

Amir *et al*. (2013) proposed that a 'embankment option' coupled with TRM would allow embankment construction along both banks of the main channel and then sequentially cut the embankment from upstream to downstream to ensure gradual sedimentation of beels.

Paul *et al*. (2013) showed that the distribution of sediments throughout the tidal basin to avoid lands that are permanently waterlogged.

The Board of Water Production of Bangladesh (2013) stated that the possibility of rearranging the drainage network within a polder. The drainage network rearrangement would allow sediments to be flushed from the sedimentary area of smaller canals to larger peripheral river systems. But the analysis did not demonstrate any clear effect of their theory. They just stated that to test the efficacy of this definition, further study is needed.

Rasul (2014) stated that although integrated resource management across the basin is essential for sustainable development in this regard, so far sediment and erosion management in the region has mainly been a national concern.

Brammer (2014) found that the strategies for sediment management, including tidal flooding and sedimentation are considered essential. To lift the level of land and offset the rates of increase in sea level and land subsidence.

Darby *et al*. (2015) found that with a sea level rise of 1 m, an end-century flood situation is defined for the year 2088. Incoming model simulation values reflect the sediment load in the system. The end-century flood scenario looks almost similar to an extreme flood scenario, except in the end-century scenario sedimentation (confined within the unprotected land) is surprisingly high relative to the extreme flood scenario.

Jin *et al*. (2015) found that not only as a natural agent of flood control, river sediments therefore have substantial economic value, but also deposited river sediments often bear nutrients (carbon, nitrogen, phosphorus) that help sustain agricultural productivity.

Wilson and Goodbred (2015) clarified that the large sediment loads can under natural conditions, drive sediment deposition on the delta surface at sufficiently high rates (~3.5 mm per year) to compensate for slow sea-level rise and natural subsidence driven by compaction.

Whitehead *et al*. (2015) clarified that, in terms of potential sediment availability, the consequences of the latest projections are illustrated. Sediment management to optimize its ability to mitigate relative sea-level rise and to ensure that agriculture can maximize the benefit of natural fertilization given by nutrients that are bound to the finer fraction of the sediment load.

Ray *et al*. (2015) found that in the Brahmaputra river basin, current changes in land use and expansion of river infrastructure are both the sediment and hydrological conditions in the basin are already affected.

Liu (2015) found that taking into account larger spatial perspectives and the growth of cross-border collaboration. Therefore, the region is facing key challenges, especially with ongoing climatic changes, causing altered precipitation and temperature patterns that could leave an imprint on the transport of riverine sediments.

Auerbach *et al*. (2015) estimated that after Cyclone Aila, re-introducing tidal inundation elevated the lands with a sediment rate of ~18 centimeters per year, showing the significant effect of deposition of tidal sediment on recovery of elevation.

Haque *et al*. (2016) found that the major sediment sources are predominantly from the Lower Meghna estuary in the south-western area of Bangladesh (which is also part of the coastal zone). Most of these sediments join the south-western zone through the mouths of large numbers of estuaries due to clockwise oceanic circulation.

Haque *et al*. (2016) suggested that the degrees of uncertainty still prevailing on the calculation of the actual value of incoming sediments in the area are all seen in all these findings. These sediments are gradually transported mainly via the Lower Meghna estuary to the ocean. The oceanic circulation of these sediments from the Lower Meghna estuary in the clockwise direction causes sediment to re-enter through the mouths of large numbers of western estuaries in the south-west zone.

Uddin *et al*. (2016) noted that sedimentation on the river bed and river banks relies primarily on the dynamics of river flow, Load morphology and sediment. On the CC blocks laid on the river side, it has less impact. There are Groynes at Rajshahi just above the study area (upstream). These groynes block the sediment-laid water flows sedimentation is going on the bank side as a consequence.

Gain *et al*. (2017) concluded that a new dynamic polder management strategies are required to enhance the livelihoods of polder management sustainably. The people of southwestern Bangladesh live in a highly sensitive and fragile environment. The reintroduction of TRM sedimentation is seen as an effective method for mitigating the effects of climate change, solving waterlogging problems, and promoting sustainable agriculture.

Rahman *et al*. (2018) performed that a systematic analysis to classify the total amount of sediment load entering the area. The research compiled an estimate of sediment load from secondary literature and the Bangladesh Water Development Board (BWDB) estimated the same data for 48 years (1960-2008) of measured sediment concentration.

A systematic analysis to classify the total amount of sediment load entering the area. The study shows that there are around 500 million tons/year of total incoming sediments through the Ganges-Brahmaputra-Upper Meghna systems. This value is less than half of the incoming sediment values specified in all sediments other reports from earlier (Rahman *et al*. 2018).

WARPO and BUET (2018) observed that Because of spatial heterogeneity sediment management in the area is particularly complicated because of sedimentation and impacts due to intrusion. Owing to sedimentation causing large-scale water-logging, most of the estuaries and rivers in the western part have lost their conveyance.

Al Masud *et al*. (2018) noted that in August 2011, compared to 2006 in the Hari-Teka and Bhadra basins, the Tidal River Management (TRM) definition reduced water-logging to 4243 ha of land. Therefore, in 2011 (during the TRM operation), the total agricultural land was increased by 3005 ha compared to 2006. In the floodplain, the vegetation was also enhanced by 2851 ha of land.

Tahsin *et al*. (2019) indicated that this 'un-managed' sediments are assumed to cause water-logging within polders, although there are other causes, such as insufficient drainage routes within polders.

WARPO and BUET (2019) found that all measurement locations are part of the western scheme within the Sundarban area. The thickness of sedimentation in the area ranges from 0.92 cm to 1.12 cm. There are no polders in the region of Sundarban, but flow resistance is comparatively high. In another study, it was shown that sedimentation outside the poldered area affects water-logging within polders 24 and 25.

WARPO and BUET (2019) found that the floodplain may have deposited one third of the in-coming sediments. In a later analysis, about 23 percent to 47 percent of in-coming sediments were found to be deposited on the floodplain.

WARPO and BUET (2019) showed that water-logging is actually increased by sedimentation in the main river. In the main river, dredging in the area within the drainage zone of the river, it improves the water-logging situation. The dredging impact is not visible outside the drainage zone. With the exception of being unusually expensive, when long-term morphological time scales are taken into account, dredging sustainability is questionable.

WARPO and BUET (2019) showed that sedimentation would occur within the protected area of polders if polders were not present and would have increased the sedimentation area of the floodplain. During the 1960s, the construction of coastal polders that de-linked the floodplains from the peripheral rivers exacerbated the sedimentation problem in this area.

WARPO and BUET (2019) revealed that the spatial variable is sedimentation in the coastal floodplain. Furthermore, sedimentation is largely influenced by anthropogenic and climatic interventions in this area.

Seijger *et al*. (2019) said that it is surprising with regard to agricultural productivity that TRM uses brackish and saline water and sediments to inundate the fields instead of inundating the fields with fresh water and sediments. This can have negative effects on soil fertility following surgery.

pH of Sediment

Forstner and Muller (1973) reported that adsorption, complexation, flocculation, and sedimentation would gradually enrich heavy metals discharged into the water bodies via various sources in the sediments.

Tessier *et al*. (1979) reported that the entire pH 0-14 was chosen in view of various acidification or alkalinization conditions of the river due to the discharge of domestic/industrial wastewater with some degree of treatment and unintentional chemical spills. On the other hand, to predict and clarify the pH leaching activity of pollutants, Visual MINTEQ software was used. Influence of pH on heavy metal speciation in sediments after leaching experiments at various pH values.

Appel and Ma (2002) found that pH is the primary factor regulating the adsorption properties of heavy metals, which controls the solubility of heavy metal hydroxides, carbonates and phosphates and also affects heavy metal hydrolysis in sediments and organic matter, changes in dissolved clay surface charge, and ion pair formation.

Yang *et al*. (2005) analyzed the effect of the transition on heavy metal Cd speciation, and the result showed that the different Cd speciation varies with the change in carbonate fraction pH and Cd content, and the fraction of Fe-Mn oxides increases with pH rising in the pH 4.5-9.5 range.

According to Ramachandra *et al*. (2012), pH has a significant impact on the chemical and biological properties of liquids, hence determining it is critical. It is one of the most essential parameters in water chemistry, and it is measured as intensity of acidity or alkalinity on a logarithmic scale ranging from 0 to 14. It is defined as -log [H+] and is measured as intensity of acidity or alkalinity on a logarithmic scale ranging from 0 to 14. If there are more free H+ ions than OH- ions, the pH is acidic (i.e. pH 7) and if there are more OH- ions, the pH is alkaline (i.e. pH > 7). Acid-base neutralization, water softening, precipitation, coagulation, disinfection, and corrosion control all require a pH of 7. A pH of less than 7 (acidic) is harmful to human health, since it causes corrosion and interferes with the water softening process. Carbonates and bicarbonates contribute to a pH greater than 7 (alkaline), which causes scale formation, hardness, and other issues. The equilibrium between carbon dioxide, bicarbonate, and carbonate ions governs pH in natural water, which ranges from 4.5 to 8.5 but is generally basic.

Depending on the type of the pollutant, the pH of wastewater and polluted natural waterways is lower or higher than 7.

Wang *et al*. (2017) observed that heavy metals such as Cu, Cd, Pb, Zn, Ni, Hg, and Cr, deposited to some degree in sediment, can be harmful to plants, animals, humans, and marine life due to the characteristics of bioaccumulation, persistence, and environmental toxicity.

Electrical conductivity (EC) of Sediment

Ramachandra *et al*. (2012) found that conduction (specific conductance) refers to water's ability to conduct an electrical current it's expressed in desi-Siemens per meter and is full of the concentration, mobility, valency of ions, and resolution temperature. Conduction is imparted once electrolytes during a resolution dissociate into positive (cations) and negative (anions) ions. In water, the bulk of dissolved inorganic compounds ar ionized and contribute to electrical phenomenon. The conduction of the samples permits for a fast and correct analysis of the water supply's dissolved mineral content fluctuation.

Nahar *et al*. (2016) conducted a study aimed primarily at exploring the effect of salinization of sediments on the development of paddy. Two upazillas, namely Paikgachha (with a salinity level in the range of 2-5 dS m^{-1} EC value) and Morrelganj (with a salinity level in the range of 10-22 dS m^{-1} EC value), were intentionally selected from the districts of Khulna and Bagerhat in this direction. Here, data on farm-specific socioeconomic variables and sediment samples for salinity testing were selected from a total of 120 paddy-producing farms. The study period covers September to January of 2014, and aman is transplanted into the paddy form under consideration. Descriptive and profitability studies, hypothesis testing, and production feature estimation were then subjected to the collected data, where salinity was considered one of the explanatory variables. Paikgachha has been found to be a low saline region with an average salinity level of 3.44 dS m^{-1} according to study results, while the average salinity level in Morrelganj is 14.38 dS m^{-1}. In low and high saline areas, the average production volume per acre is 1639.32 and 1531.45 kilograms respectively. Therefore, on the basis of the studies carried out, the study concludes that salinity has an adverse effect on the production of paddy, decreasing both the paddy yield and the paddy farmers' profit margin. Therefore, the study suggests regulating salinity through government interventions and farmers' use of salt-tolerant seed varieties. In addition, specific attention is drawn to the implementation and coordination of the policies concerned in order to develop the agricultural production system in the coastal regions.

Alam *et al*. (2017) examined the soil and water salinity weaknesses in the development of crops, fish and livestock throughout Bangladesh's Kalapara coastal belt. As measures of salinity, several parameters were calculated. With SO_4^{2-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, NO_2, and PO_4, the electrical conductivity of soil and water was found to be important. Approximately 200 ha of fodder crop areas are impacted by salinity per year. Ninety-two percent of the areas in the 36 existing cropping trends have been found to be impaired by salinity. As a result of salinity, twelve per cent of marine fish and 25 per cent of shrimp species have vanished. In this coastal belt, the adverse effect of soil and water salinity on crops, fish, and livestock has been growing.

Machado *et al*. (2017) recorded that salinity is a major problem affecting crop production around the world: 20% of the world's cultivated land is damaged and polluted by salt and 33% of irrigated land. This process would all be accentuated by climate change, the inefficient usage of groundwater (mainly close to the sea), the increased use of low-quality irrigation water and the massive introduction of irrigation associated with intensive farming. Excessive salinity of the sediment decreases the productivity of many crops, including most vegetables, which are especially vulnerable to the antigenicity of the plant. Most vegetable crops have low electrical conductivity (EC) (ranging from 1 to 2.5 dSm^{-1} in saturated soil extracts) and the resistance of vegetable salt decreases when saline water is used for irrigation. The goal of this review is to address the effects of salinity on vegetable growth and how management practices (irrigation, drainage and fertilization) can prevent and reduce the adverse effects of salinity by preventing salinization of sediments and water.

Organic matter of Sediment

Hedges and Keil (1995) noted that one of the most complex and contentious problems in contemporary biogeochemistry is the preservation of organic matter in marine sediments. Primary production rate, organic matter sources, sediment transport processes, sediment deposition rate, bottom water oxygen concentration and O_2 availability are suggested main factors.

Hunt (1996) claimed that, as a progenitor of fossil fuels, a recorder of Earth history, and the ultimate source of essentially all atmospheric O_2, the organic matter retained in sedimentary deposits is significant.

Loveland and Webb (2003) reported that generally, there is considerable concern that if sediment OM concentrations in soils are allowed to decrease too much, the degradation in the physical properties of the soil and the impairment of soil nutrient cycling processes would then undermine the productive potential of agriculture. Sediment OM contributes positively to soil fertility, soil tilth, crop production, and overall soil sustainability of the soil in a positive way.

Organic carbon (OC) of Sediment

Premuzic *et al*. (1982) acknowledged that open ocean sediments deposited under deep water columns are deficient in organic matter, with average organic carbon mass-normalized percentages (percent OC) ranging from 0.1 to 0.3. These organic concentrations are approximately 10 percent of those found in sediments deposited along continental margins of comparable grain size, a trend that also holds when, as opposed to mass, OC sediment contents are normalized to real surface area.

Thomson *et al*. (1993) explained that surface-oxidized marine turbidities indicate that long-term molecular oxygen exposure alone is sufficient to cause such depletions, due to the low OC content of offshore sediments. There are now numerous deep-sea turbidities mentioned.

SRDI (2003) recorded that the organic carbon values ranged from 0.40 to 2.54 percent in the salt affected Rupsa Thana Soil of Khulna District.

Kizildag *et al*. (2013) reported that, relative to non-saline soils, the organic carbon and total nitrogen values were found to be low and it can be inferred that the composition of different plants can affect nitrogen mineralization of saline soils.

Nitrogen of Sediment

Wankel *et al*. (2011) said that the first phase of the nitrification process, Ammonia monooxygenase is catalyzed by ammonia (amoA). To measure the abundance and diversity of ammonia-oxidizing archaeal (AOA) and bacteria (AOB) in soils and sediments, archaeal and bacterial amoA genes have been commonly used as molecular markers.

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.

Yao *et al*. (2016) reported that the sediment N cycling processes in lakes are greatly influenced by water quality and sediment properties. N and carbon (C) concentrations are commonly known as the primary determinants of the process of de-nitrification, as $NO3^{=}$ acts as the acceptor of terminal electrons and organic C acts as the acceptor of terminal electrons a donor of electrons for denitrifying bacteria.

Phosphorus of Sediment

Golterman (2001) pointed out that the release of internal P from lake sediments into the overlying water has become a major source of P. This can cause continuous eutrophication in lakes, even after external inputs have been regulated. Therefore, the numerous chemical phosphorus interconversions, biological efficacy, the exchange of sediments and overlying water have been commonly used.

Abu Zofar *et al*. (2003) stated that the total P concentration in Bangladesh ranged from 23 to 37 ppm in the upper soil and 46 to 68 ppm in the subsoil, and varied with physiography. The usable P concentration was much higher for the topsoil than for the subsoil in most of the soil.

Mulkerrins *et al*. (2004) said that P can be used by microorganisms as an essential nutrient factor. The release of P from sewer sediment risks to the water quality due to eutrophication of water bodies.

Portch (2004) stated that the maximum availability of phosphorus (P) occurs at pH 6-7, whereas the availability of P decreases at greater or lower pH.

Jin *et al*. (2006) stated that at the sediment-water interface, pH, dissolved oxygen (DO) and temperature have a major effect on the release of sediment P, i.e. anoxic levels and higher pH contributed to further release of P into the water.

Solim and Wanganeo (2009) found that a number of studies focused on the latter topic, paying attention to the release of P from the sediment to different types of receiving natural water bodies, such as coastal zones, lakes and rivers.

Dong *et al*. (2011) noted that P release from sediments is a complex system. Factors influencing the release of P from the sediments have been researched and examined extensively.

Kjaergaard *et al*. (2012) found that in sediments, the soluble P content in pore water is around 103 times that of the overlying water. Under the interruption, the P flowed rapidly to the overlying water. Therefore, at the sediments and water interface in storm sewer, the flow rate is a factor that needs to be examined on the P release.

Ramachandra *et al*. (2012) elaborated that when excessive amounts of phosphorus are thrown into aquatic habitats, it becomes a harmful contaminant due to its role in encouraging plant growth. Plants are having so much trouble that the chemical has become a limiting nutrient. The amount of useable phosphate in the soil or water limits the rate at which plants can grow and reproduce (for aquatic plants). Eutrophication is a situation that occurs when excess phosphorus is added to water as a result of anthropogenic activity, and it has the potential to wipe out aquatic ecosystems. The rapid growth of the plant population is a sign of eutrophication (an algal bloom). Phosphate contamination is caused by the inclusion of phosphates in practically every detergent, including household cleaners and laundry soap, fertilizer run-off from agriculture and landscaping, and the decomposition of organic materials. Animal feces can also contribute a lot of phosphate to the water.

Potassium of Sediment

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

Gabrijel *et al*. (2011) found that K has been identified as an interchangeable base. This simple cation is loosely attached to the edge of the clay particles or to the soil OM (exchange sites) (depending on the nature and conditions of the soil) and is in equilibrium with the concentration of cations in the soil solution.

Ramachandra *et al*. (2012) reported that Potassium is found in natural waterways in low amounts (less than 10 mg/L) because potassium-containing rocks are relatively resistant to weathering. It is frequently found in ionic form, with highly soluble salts. Despite its modest size, it plays an important part in the freshwater environment's metabolism.

Alam *et al*. (2017) found that Kalapara's of Patuakhali district sediment potassium content varied from 0.789-0.12 mol kg^{-1}.

Sulfur of Sediment

Rengasamy (2006) found that the sediment solution's sulfur concentration has a negative impact on soil aggregation and stabilization and, with increasing sulfur concentration in the soil solution, can harm the soil structure.

Ranjan *et al*. (2007) suggested that climate variables could play a major role in affecting the concentration of sulfur, such as precipitation, surface runoff, and temperature. With lower precipitation amount and warmer temperature, due to lack of groundwater present and rising evaporation, the sulfur content would be much lower.

Naher *et al.* (2011) reported that topsoil sulphur status of all the sediment 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.

Ramachandra *et al*. (2012) said that Sulfates can be present in all natural waterways, especially those with a lot of salt. Biological oxidation of reduced sulfur adds to the sulfate concentration, in addition to industrial pollution and residential sewage. It is water soluble and hardens when combined with other cations. Due to its conversion to H_2S, sulfate causes scaling in industrial water supplies and odor and corrosion in wastewater treatment systems. Its main sources are sulfate salts from industrial effluent and residential trash (heavy use of detergents).

CHAPTER III

MATERIALS AND METHODS

3.1. General information of the study area

At 22°49′0″N 89°33′0″E on the bank of the Bhairab River, Khulna is situated in south-western Bangladesh. It occupies a total area of 59.57 km^2, while about 4394.46 km^2 is the district itself. It is situated south of Jessore and Narail, west of Bagerhat, east of Satkhira, and north of the Bay of Bengal.

The location of Dacope is 22.5722°N 89.5111°E. It has 25,377 households and an area of 991.58 km^2 in total. It is bordered 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, with an area of 99158 km^2. Pasur, Sibsa, Manki, and Bhadra are the major rivers. Sundarban surrounds the southern portion of this upazilla (11790.13 hectares). There are ten Unions and one Paurashava, 172 Mauzas/Mahallas, and 212 villages in Dacope. Kamarkhola, krishtanpara, Garuikhali are the names of the Union parisodes of Dacope. Most of the land here is based on agro-aquaculture and shrimp (bagda with white fish). The only agricultural zone is the Garuikhali Union. The soil pH value of upazilla in high and medium highland areas varies from 7.90 to 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.

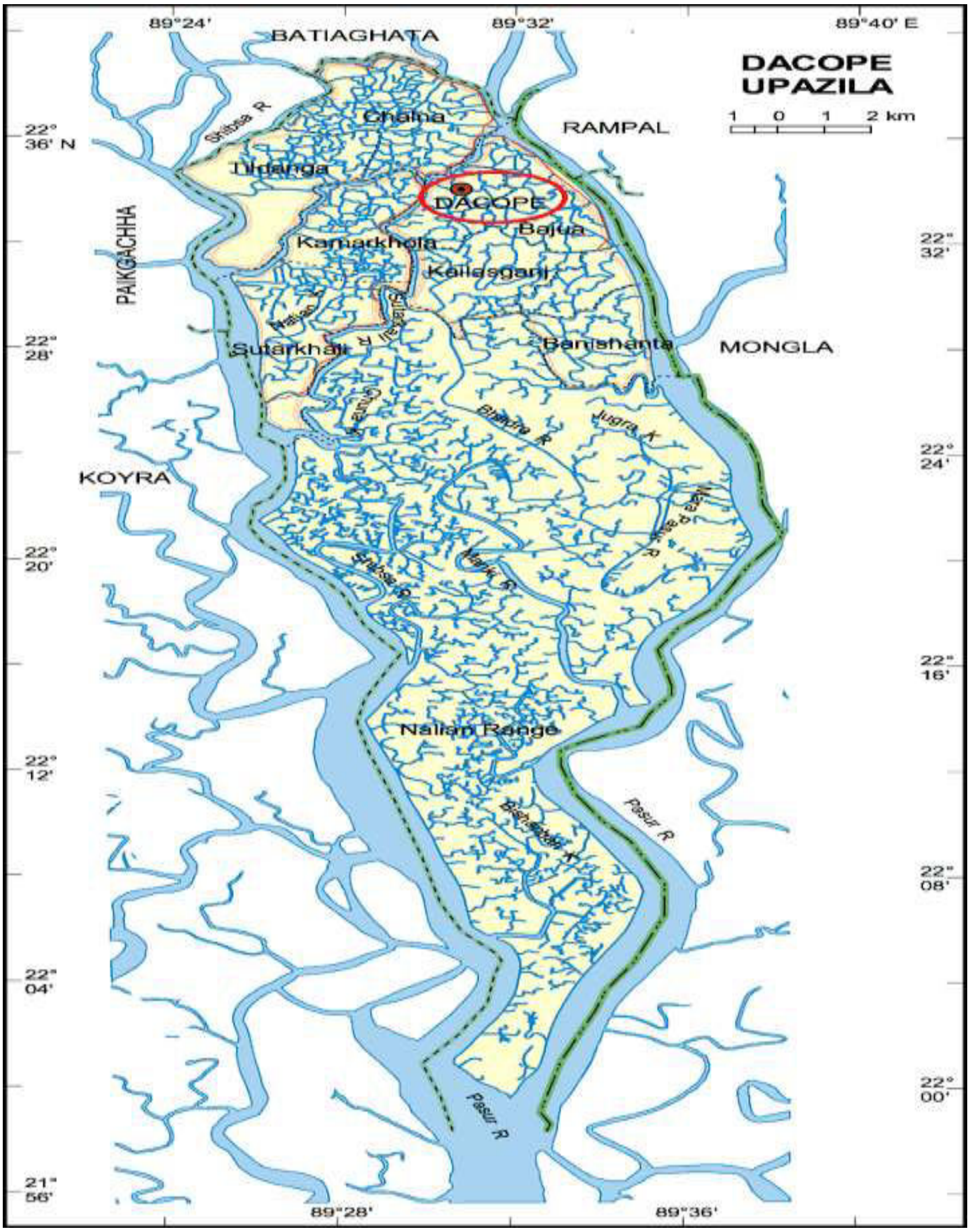

Figure 1. Showing the locale of the study area

3.2 Climatic Condition of the area

The climate of Dacope is mostly tropical. During summer, this area is humid and in winter it is pleasant. From mid-April, summer begins and lasts until mid-June. It's really hot, it stays and it's reasonably dry. The average annual temperature of this region is 26.3°C (79.3°F) and monthly mean temperatures range from 12.4°C (54.3°F) in January to 34.3° C (93.7°F) in May. There is a lot of rainfall in the summers here, although there is very little in the winters. The area's annual average rainfall is 1,809.4 millimetres.

3.3 Source of information

The whole study in Dacope upazilla is based on the information which is collected from the respondents of the study area and this is supported by some secondary data.

3.3.1 Primary Data

The primary data was obtained directly from sediment of the Dacope upazilla. From Kamarkhola at Dacope upazilla, which is located close to the Dhaki and Vodra rivers, here 14 samples were collected. The 4 soil samples collected from Krishtanara at Dacope, which is located near the Chunkuri River. Four sites alongside these three rivers were chosen. There were river side, flow time, ebb time and where always water contain (Khal) side. The depths of 1-3 cm, sediment were collected from each site. Therefore, for the analysis, 18 soil sediment samples were collected in total. In Table 1, the Geographic Positioning System (GPS) gives a reading of the sampling spot. The sediment samples were obtained by means of an auger from each site.

Plate 1. Collection of riverside sediment

Plate 2. Collection of Khal sediment

Plate 3. Collection of flow time sediment

Plate 4. Collection of ebb time sediment

The collected of 18 sediment samples were taken to the laboratory, air dried, large macro aggregates broken down, grounded and passed through a 2 mm sieve to extract weeds and stubbles from the soil. The chemical analysis of the soil sample was performed in the laboratory of Krishi Khamar Sarak of the Soil Resource Development Institute (SRDI), Farmgate, Dhaka, 1215. The Chemical analysis was conducted according to standard methods for pH, electrical conductivity, organic matter (OM), organic carbon (OC), nitrogen, phosphorus, and sulphur content.

3.3.2 Secondary Data

Secondary data were mainly collected from the Dacope upazilla and Khulna district forest, agriculture, soil and water-related sectors, and all other literature was collected from written sources available in books, national and foreign journals, newspaper articles, websites and other government and non-government published and unpublished papers.

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

Sl. No	Sample ID	Location	Latitude and Longitude	Types of Sediment	Compass	Sample Amount	Physical type	Sediment Colour	pH	EC (µs/cm)
1	D1-RS	Kamarkhola	22.592, 89.529	River Sediment	47° NE	480 gm	Moist	Grey	8.10	548
2	D2-KS	Kamarkhola	22.571, 89.491	Khal Sediment	62° NE	370 gm	Moist	Blackish Ash	8.13	612
3	D3-FS	Kamarkhola	22.592, 89.531	Flow tide Sediment	47° NE	500 gm	Wet	Ash	7.98	560
4	D4-ES	Kamarkhola	22.592, 89.532	Ebb tide Sediment	47° NE	360 gm	Wet	Ash	7.87	564
5	D5-RS	Kamarkhola	22.574, 89.576	River Sediment	83° NE	530 gm	Moist	Grey	8.09	618
6	D6-FS	Kamarkhola	22.574, 89.576	Flow tide Sediment	83° NE	320 gm	Wet	Ash	8.02	625
7	D7-ES	Kamarkhola	22.574, 89.576	Ebb tide Sediment	83° NE	350 gm	Wet	Ash	7.92	612

8	V1-RS	Kamarkh ola	22.562, 89.496	River Sedim ent	113º SE	520 gm	Moist	Blacki sh Ash	8.0 4	617
9	V2-KS	Kamarkh ola	22.550, 89.489	Khal Sedim ent	131º SE	390 gm	Moist	Blacki sh Ash	8.1 1	580
10	V3-FS	Kamarkh ola	22.562, 89.496	Flow tide Sedim ent	113º SE	400 gm	Wet	Grey	8.0 0	678
11	V4-ES	Kamarkh ola	22.552, 89.496	Ebb tide Sedim ent	113º SE	460 gm	Wet	Ash	7.9 3	612
12	V5-RS	Kamarkh ola	22.550, 89.489	River Sedim ent	124º SE	430 gm	Moist	Grey	8.1 2	653
13	V6-FS	Kamarkh ola	22.550, 89.489	Flow tide Sedim ent	124º SE	400 gm	Wet	Ash	7.9 9	632
14	V7-ES	Kamarkh ola	22.550, 89.489	Ebb tide Sedim ent	124º SE	560 gm	Wet	Grey	7.9 7	628
15	C1-RS	Krishtan para	22.590, 89.525	River Sedim ent	305º NW	340 gm	Moist	Blacki sh Ash	8.0 8	586
16	C2-KS	Krishtan para	22.591, 89.529	Khal Sedim ent	336º NW	490 gm	Moist	Blacki sh Ash	8.0 9	558
17	C3-FS	Krishtan para	22.590, 89.525	Flow tide Sedim ent	305º NW	410 gm	Wet	Ash	7.9 6	565
18	C4-ES	Krishtan para	22.590, 89.525	Ebb tide Sedim ent	305º NW	510 gm	Wet	Grey	8.0 1	644

(Here, D= Dhaki, V= Vodra, C= Chunkuri, RS= Riverside Sediment, KS= Khalside Sediment, FS= Flow tide Sediment, ES= Ebb tide Sediment

3.4 Data Collection

Pre-testing of the sample collection was performed in Dacope upazilla through a reconnaissance survey. The final survey was carried out on November 25, 2018.

3.5 Data Compilation and Analysis

To make a meaningful paper, the information gathered was compiled. I took sincere advice from my supervisor from time to time during the compilation process. Data is then analyzed and compiled sequentially and systematically after information is sorted. For the analysis of the gathered data, SPSS and 10.0 were used.

CHAPTER IV

RESULTS AND DISCUSSION

Research work was carried out to assess the sediment salinity of the coastal region in the district of Khulna. Some of the data for debate, comparison and interpretation were presented and expressed in table(s) and others in figures. The variance analysis of data conformity with all criteria has been shown in the Appendix. The outcomes of each parameter were explored and made possible.

Agricultural practices have changed stream ecosystems around the world by raising sediment and nutrient loads, increasing stream temperature, changing channel morphology, hydrological regime, and riparian vegetation composition and abundance (Schleiger, 2000). Shelley *et al.* (2016) said that Bangladesh has an agricultural economy, with 76 percent of the population living in rural areas and agriculture accounting for 19.3 percent of GDP. Lazar *et al.* (2015) found that Around 85 percent of people in Bangladesh's coastal region rely on agriculture to make a living. Crops grow well in sediment-amended soils so application to fields where topsoil has been eroded is one potential use.

4.1 Sediment pH

The negative logarithm of hydrogen ion absorption in sediment solution is called sediment pH. Sediment pH is a very imperative variable to calculate the degree of sediment acidity and alkalinity and helps to know the chemical, biological and indirectly physical state of sediment properties containing both nutrients and toxins. Mariangela and Francesco (2015) found that several human and natural processes, such as leaching of exchangeable bases, decomposition of organic materials, application of commercial fertilizers, and other farming methods, all influence the degree and character of sediment pH. According to Mahmood *et al.* (2013), the pH of sediment solutions has a significant impact on element solubility and availability in soils. In addition to the fact that action exchange capacity is pH dependent, mineral dissolution and adsorption at alkaline functional groups are both affected by pH. Alkaline sediments are frequently associated with nutritional excesses of the base cations Ca, Mg, K, and Na, as well as the base anion Cl^- and SO_4^{2-}, as well as carbonate and bicarbonate excesses with pH > 8.2. The pH value of Vodra, Dhaki and Chunkuri rivers sediment ranged from 7.93 to 8.12 (Table 02), 7.87 to 8.13 (Table 03) and 7.96-8.09 (Table 04). According to USDA, the ranged of pH value of Vodra, Dhaki and Chunkuri rivers are moderately alkaline (7.9-8.4). At Vodra river, the pH value of riverside sediment ranged from 8.04 to 8.12, khal side 8.11, flow time ranged from 7.99 to 8.00 and ebb time ranged from 7.93 to 7.97 (Table 02), these ranged are moderately alkaline according to USDA. At Dhaki river, the pH value of riverside sediment ranged from 8.09 to 8.10, khal side 8.13, flow time ranged from 7.98 to 8.02 and ebb time ranged from 7.87 to 7.92 (Table 03), these ranged are also moderately alkaline according to USDA. In Vodra river sediment, pH showed non-significant (Table 02). The highest value of pH 8.13 (Table 03) was found at khal side of Dhaki river and the lowest value of pH 7.87 (Table 03) was found at ebb time of Dhaki river. Haque (2006) stated that in the coastal region of Bangladesh, sediment reaction values (pH) range from 6.0-8.4, with the exception of Chittagong and Patuakhali, where pH values range from 5.0-7.8. He also discovered that most sediment are mild to heavily alkaline. Baten *et al*. (2015) investigated in the south-central coastal zone of Bangladesh, the effects of salinity on crop agriculture and found a pH level of 7.99.

Table 02: Analysis of Sediment collected from Vodra River

Location	pH	EC (µs cm^{-1})	OM (%)	OC (%)	N (%)	P (ppm)	S (ppm)
V1-RS	8.04	617.00	1.10	1.25	0.14	23.40	16.75
V1-KS	8.11	580.00	1.68	1.20	0.25	32.80	24.00
V1-FS	8.00	678.00	1.83	1.70	0.18	38.00	28.34
V1-ES	7.93	612.00	1.48	1.76	0.18	28.24	21.65
V2-RS	8.12	653.00	1.25	1.95	0.05	28.70	28.23
V2-FS	7.99	632.00	1.87	0.45	0.12	22.20	36.54
V2-ES	7.97	628.00	1.52	1.23	0.08	24.50	19.03
Range	7.93-8.12	580.00-678.00	1.10-1.87	0.45-1.95	0.05-0.18	22.20-38.00	16.75-36.54
Mean ± SE	8.02-0.14	628.57-31.36	1.53-0.27	1.36-0.47	0.14-0.06	28.26-5.37	24.93-6.35
LS	0.7315	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LSD $_{(0.05)}$	NS	**	**	**	**	**	**
CV (%)	1.99	2.00	2.05	2.14	1.61	2.59	2.06

Here, V1= Vodra river, RS= Riverside, KS= Khalside, FS= Flow time side, ES= Ebb time side, NS= Non-significant,

**= Significant at 1% level of probability

Table 03: Analysis of Sediment collected from Dhaki River

Location	pH	EC (µs cm^{-1})	OM (%)	OC (%)	N (%)	P (ppm)	S (ppm)
D1-RS	8.10	548.00	1.13	1.42	0.07	18.00	15.85
D1-KS	8.13	612.00	2.64	1.68	0.34	32.34	22.71
D1-FS	7.98	560.00	1.28	0.95	0.19	18.00	32.50
D1-ES	7.87	564.00	1.24	0.43	0.14	20.50	25.34
D2-RS	8.09	618.00	1.25	1.34	0.18	28.00	12.83
D2-FS	8.02	625.00	1.65	1.69	0.15	25.00	25.50
D2-ES	7.92	612.00	1.42	1.03	0.16	36.80	22.60
Range	7.87-8.13	548.00-625.00	1.13-2.64	0.43-1.69	0.07-0.34	18.00-36.80	12.83-32.50
Mean ± SE	8.01-0.23	591.28-34.83	1.51-0.49	1.22-0.42	0.17-0.07	25.52-6.95	22.47-6.21
LS	NS	**	**	**	**	**	**
LSD $_{(0.05)}$	0.8433	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000
CV (%)	3.20	3.31	3.17	3.68	4.30	3.60	3.11

Here, D1= Dhaki river, RS= Riverside, KS= Khalside, FS= Flow time side, ES= Ebb time side, NS= Non-significant,

**= Significant at 1% level of probability

Table 04: Analysis of Sediment collected from Chunkuri River

Location	PH	EC (µs cm^{-1})	OM (%)	OC (%)	N (%)	P (ppm)	S (ppm)
C1-RS	8.08	586.00	1.20	1.02	0.17	25.12	24.05
C1-KS	8.09	551.33	1.26	1.34	0.10	27.60	19.00
C1-FS	7.96	565.00	1.30	0.85	0.08	34.30	32.53
C1-ES	8.01	644.00	1.65	1.97	0.20	34.20	24.42
Range	7.96-8.09	551.33-644.00	1.20-1.65	0.85-1.97	0.08-0.20	25.12-34.30	19.00-32.53
Mean ± SE	8.03±0.17	586.58±39.42	1.35-0.19	1.29-0.44	0.13-0.05	30.30-4.38	25.00-5.14
LS	NS	**	**	**	**	**	**
LSD $_{(0.05)}$	0.8368	0.0005	0.0001	0.0000	0.0000	0.0001	0.0000
CV (%)	2.49	2.75	4.86	4.18	4.17	4.59	4.31

Here, C1= Chunkuri river, RS= Riverside, KS= Khalside, FS= Flow time side, ES= Ebb time side,

NS= Non-significant,

**= Significant at 1% level of probability

Khanom (2016) stated that with the desiccation of the sediment, the severity of the salinity problem in Jabakhali mauza under Shyamnagar Upazila in Satkhira district has increased. Akram *et al*. (2011) reported that salt-affected sediment, pH inhibits water and nutrient uptake although there is sufficient quantity of them in sediment. Since most of the plant nutrients are available at this point, the ideal sediment pH range is 6.0 to 6.5. In most situations, the pH range of 6.0-7.5 in the sediment of Bangladesh is ideal for the passable acquisition of nutrients. The highest pH value was 8.0 and 5.85 was the lowest pH value. The meaning of the average is 7.06. The bulk of the sediment in the current study region was alkaline (pH > 7.5).

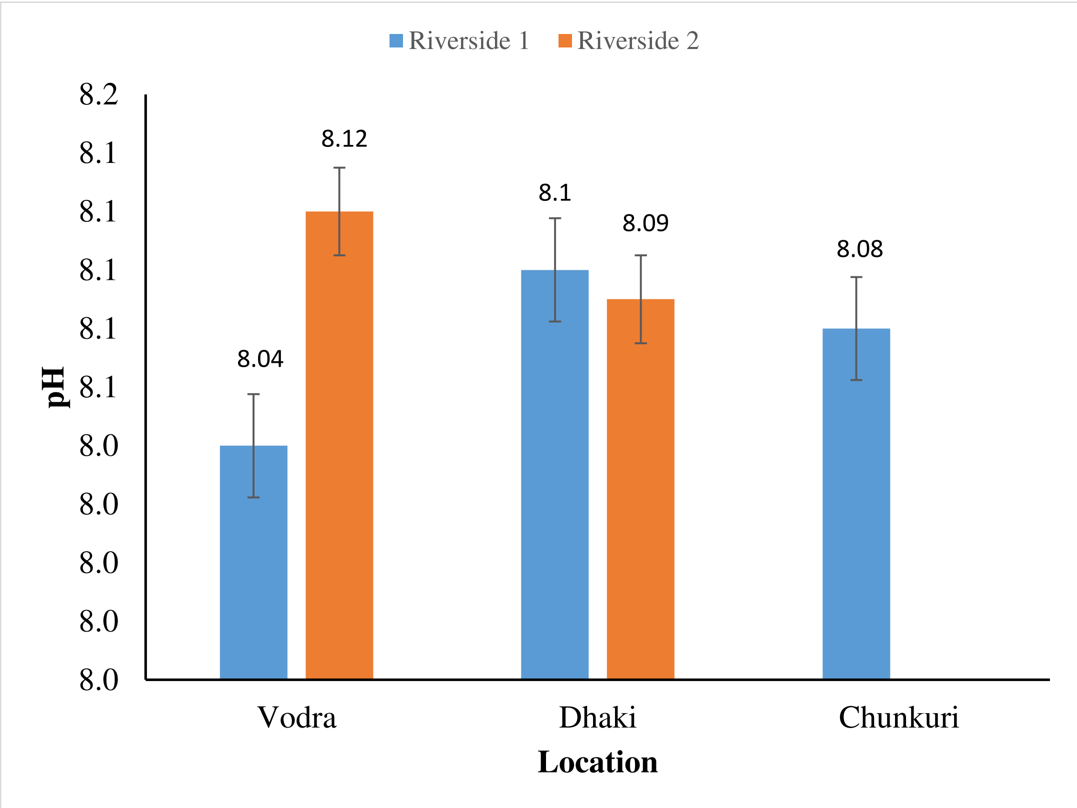

Figure 2. pH of the Riverside sediment of different locations

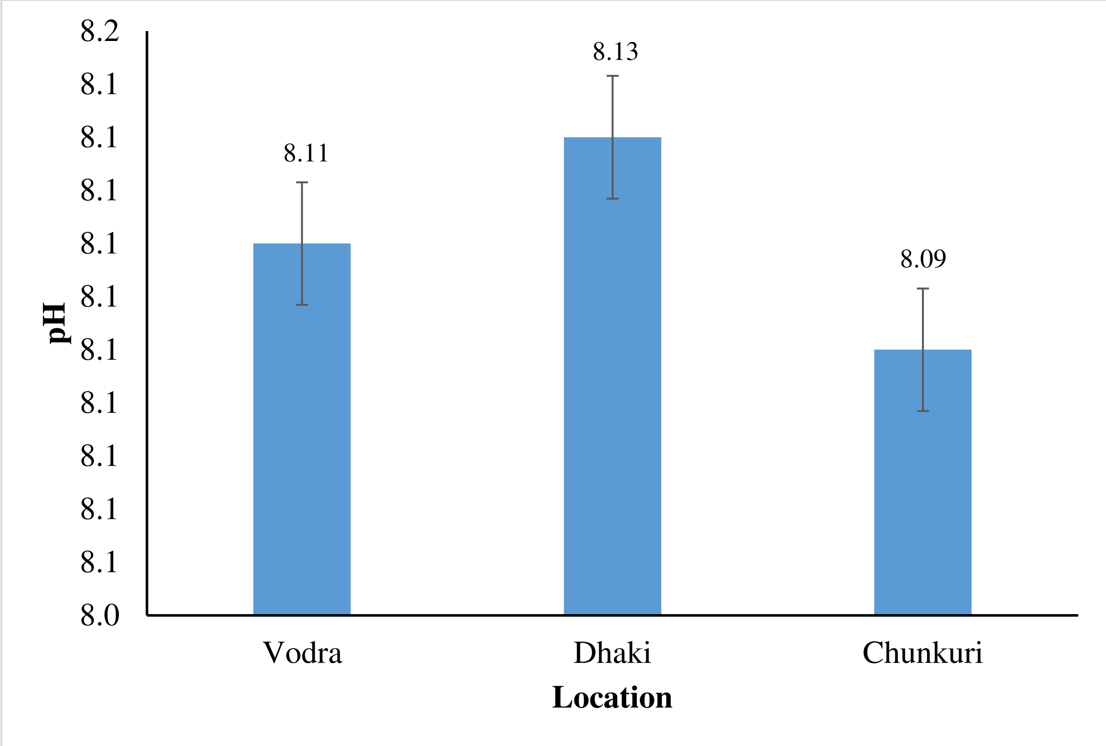

Figure 3. pH of the Khalside sediment of different locations

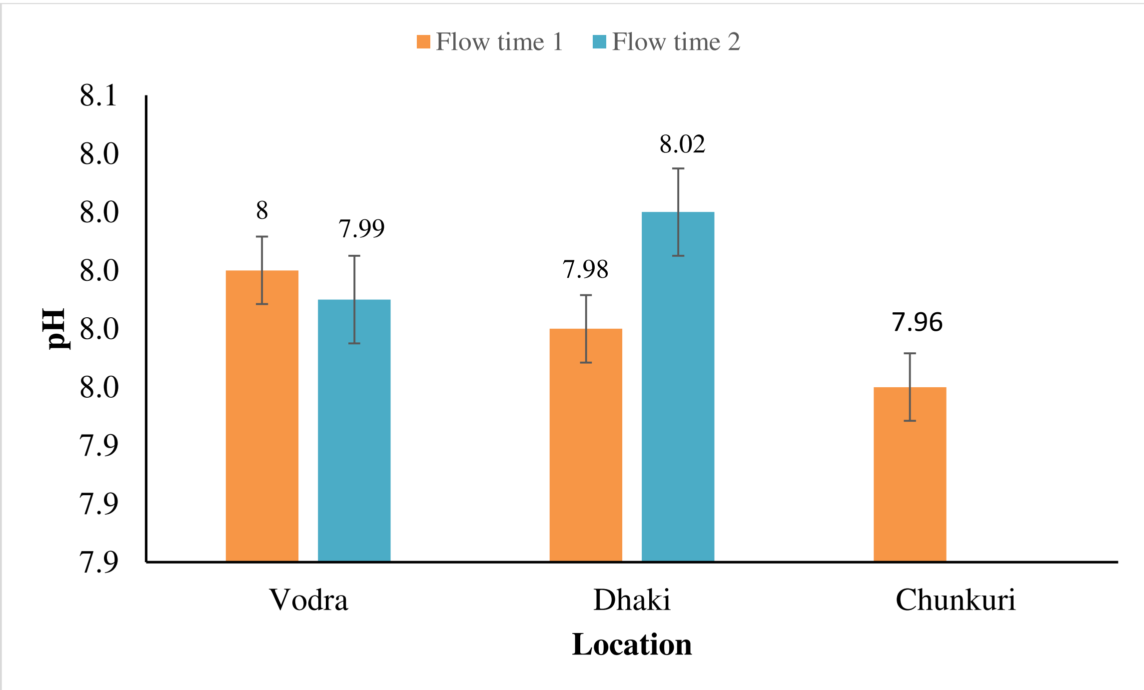

Figure 4. pH of the Flow time sediment of different locations

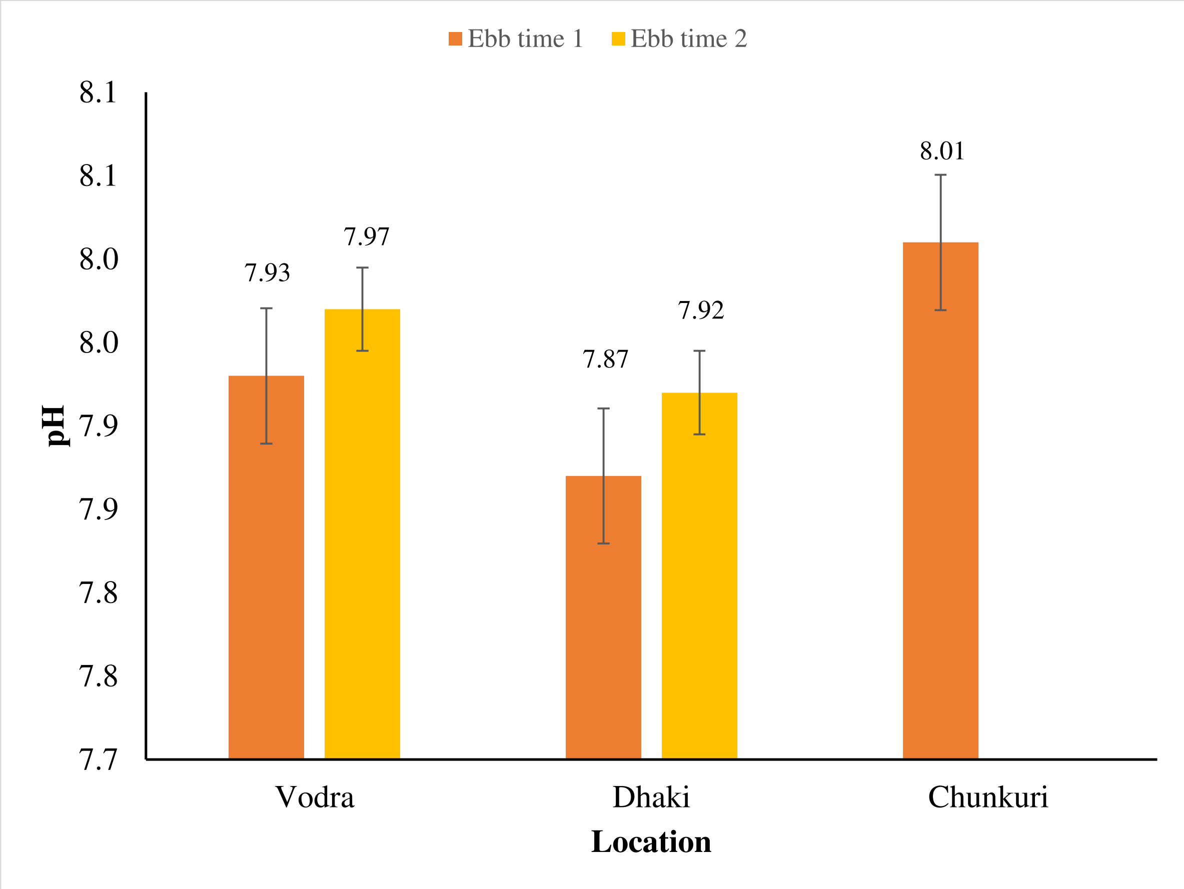

Figure 5. pH of the Ebb time sediment of different locations

4.2 EC (Electrical Conductivity) of the study areas

The calculation of the quantity of electrical current a cloth can bear or the power to hold a current is electrical conductivity. Specific conductance is also called electrical conductivity. An intrinsic property of a material is conductivity. Sediment salinity usually referred to in terms of EC and this value can be used to predict sediment structure stability in relation to irrigation water quality and the sodium adsorption ratio. At Latachapali union of Kalapara upazila, Patuakhali district of Bangladesh, Haque (2018) investigated the spatial variability of salt buildup through the sediment profile. The sediment samples were taken from 30 different areas across the union, including Kuakata, Malapara, Fashipara, Khajura, Mothaopara, and Tajepara. Each town has five spots chosen at random. Sediment samples were taken from three depths in each location: 0-2 cm, 2.1-4 cm, and 4.1-6 cm. Electrical conductivity was 20.49 dS m^{-1} at the top 0-2 cm sediment layer, 7.14 dS m^{-1} in the 2.1-4 cm sediment depth, and 4.15 dS m^{-1} in the 4.1-6 cm sediment depth. In the 0-2, 2.1-4, and 4.1-6 cm sediment depths, the research sediments were strongly acidic, with EC values of 4.73, 4.99, and 5.20, respectively. The greatest Na:K ratio of 8.8 was discovered in the first two centimeters of silt. The EC values of riverside sediment at Vodra, Dhaki and Chunkuri rivers varies from 617.00 to 653.00 (Table 02), 548.00 to 618.00 (Table 03) and 586.00 (Table 04) µs cm^{-1} respectively. The EC values of Khal side sediment at Vodra, Dhaki and Chunkuri rivers ranged from 580.00 (Table 02), 612.00 (Table 03) and 551.33 (Table 04) µs cm^{-1} respectively. All of these EC values expressing medium status of salinity (250 – 750) µs cm^{-1} according to the Bookess Tropical Soil Mannal, 1991. The highest value of EC 678.00 (Table 02) was found at flow time sediment of Vodra river and the lowest value of EC 548.00 (Table 03) was found at riverside sediment of Dhaki river. Zaman and Bakri (2003) stated that Bangladesh, mainly in the coastal and south-eastern districts, has 3 million hectares of salinity-affected land with EC values ranging from 750-2250 µS cm^{-1}. High levels of salinity may cause inorganic soil fractions to coagulate, but salt concentration may cause the organic colloids to disperse and drain from the profile of the soil. Rabbani (2010) recorded that at Shymnagar and Tala in Satkhira district, the EC values of the soil sample ranged from 965 to 4570 µS cm^{-1} with an average value of 2527 µS cm^{-1}. At Shymnagar and Tala, respectively, the highest and lowest EC values of soil samples were reported. The EC value ranged from 150 to 3590 µS cm^{-1} with an average value of 1870 µS cm^{-1} for the soil samples collected. Shymnagar had the highest EC value (EC = 3590 µS cm^{-1}) and Tala Upzila registered the lowest EC value (EC = 150 µS cm^{-1}). The region's highest EC value showed that the area was influenced by salinity. Thus, in relation to EC, there can be harmful effects from salt concentration or salinity risk.

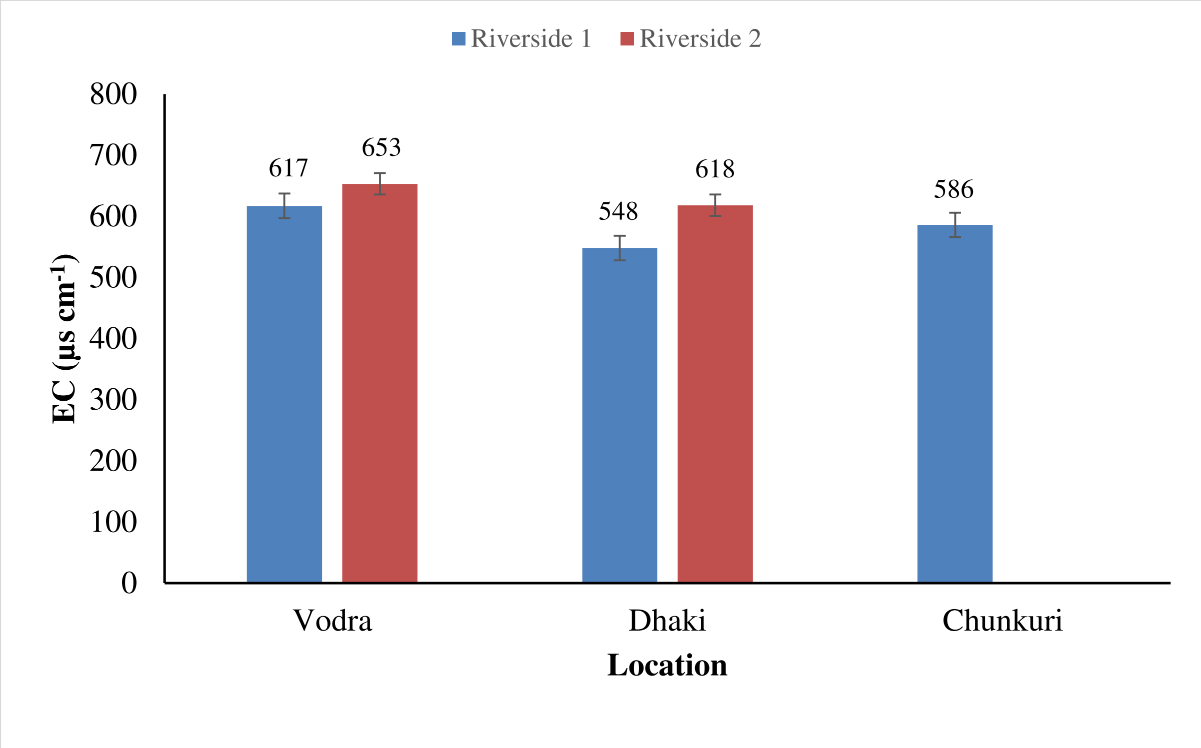

Figure 6. EC of the Riverside sediment of different locations

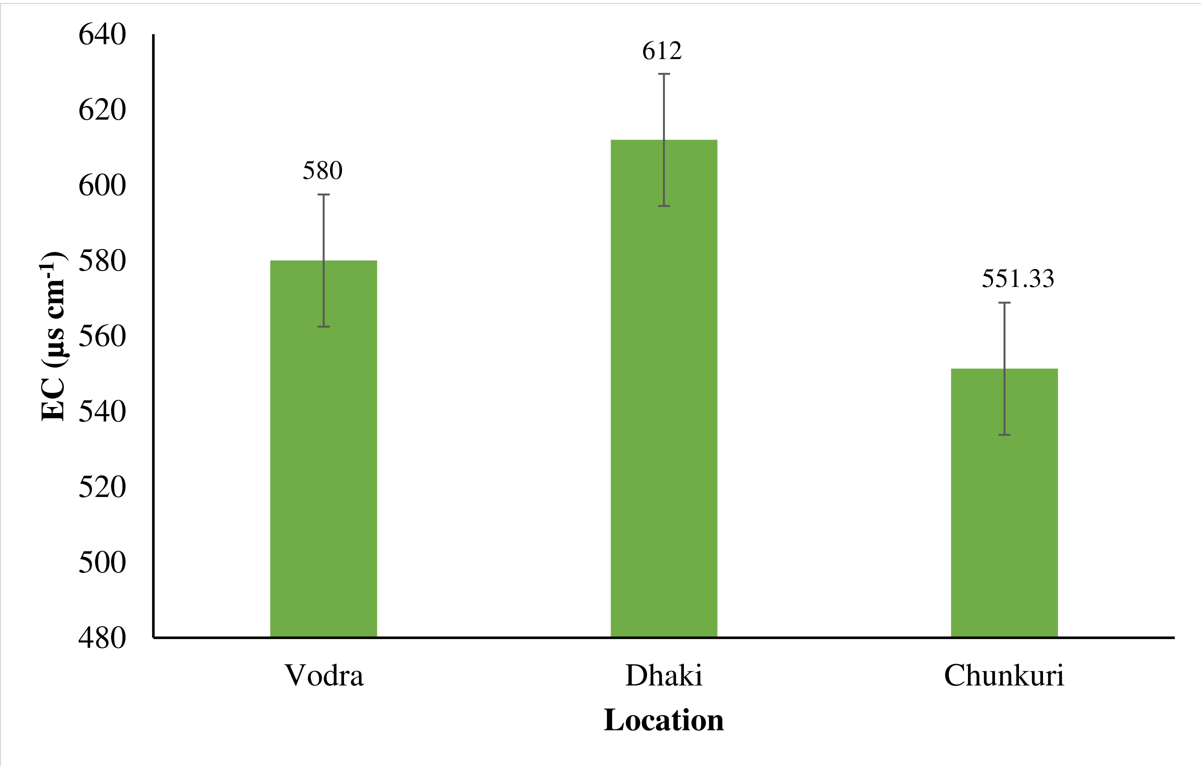

Figure 7. EC of the Khalside sediment of different locations

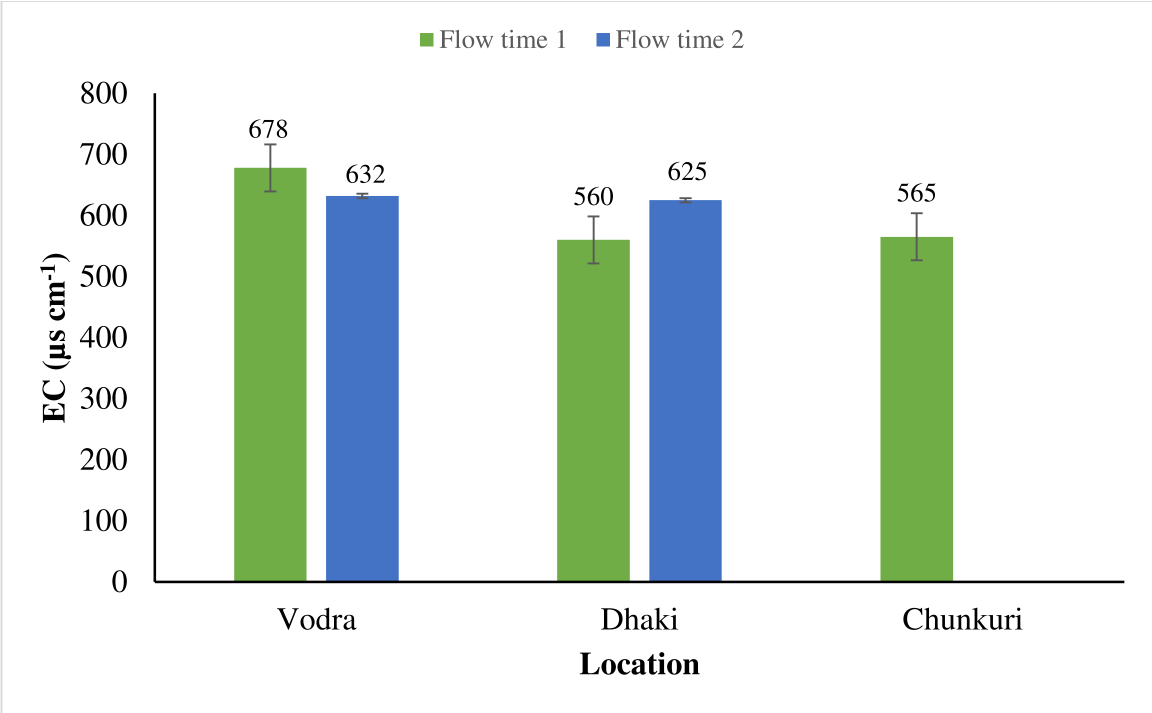

Figure 8. EC of the Flow time sediment of different locations

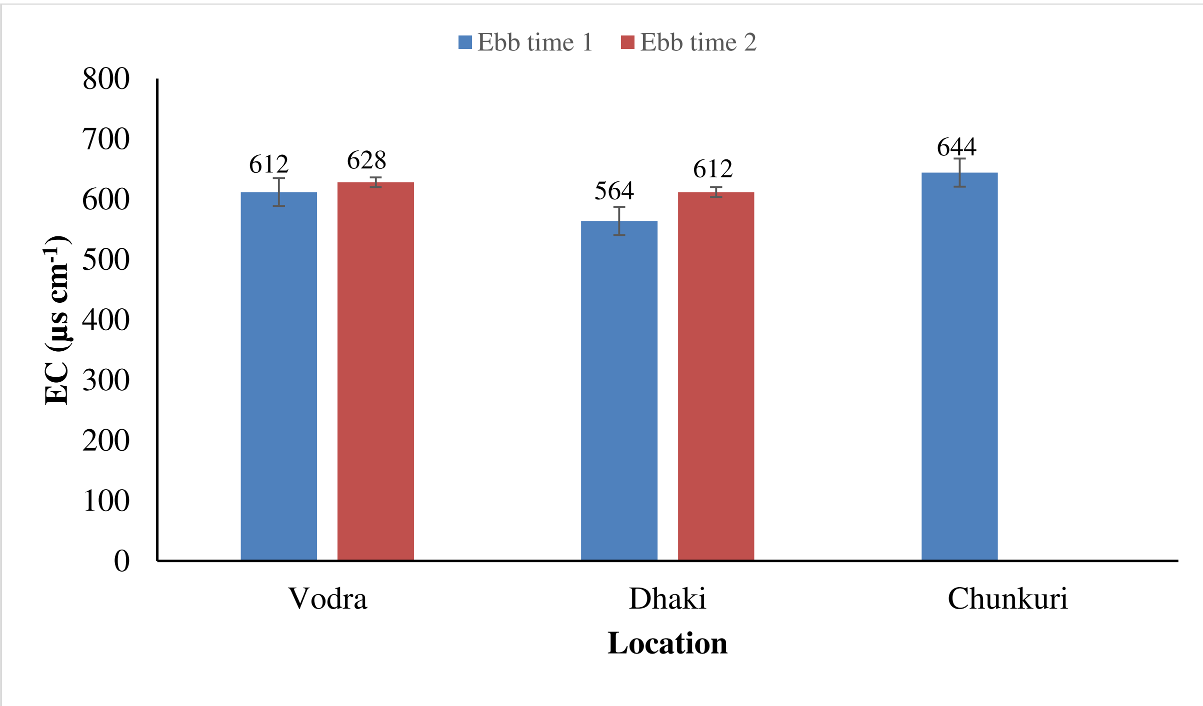

Figure 9. EC of the Ebb time sediment of different locations

4.3 OM (Organic Matter) of the study areas

Organic matter refers to the broad source of compounds found in natural and engineered, terrestrial and aquatic ecosystems that are dependent on carbon. Organic matter (or organic material) is matter that has originated from an organism that has recently been alive. It is capable of decay, or is the result of decay, or is made up of organic substances. There is not just one view of organic matter. It varies according to the context and the topic for which it is used. According to Naher *et al*. (2011), topsoil sediment organic status ranges from medium to high in all horizons at Asasuni upazila in Satkhira district of Bangladesh, and 0.55 to 1.89 percent at Kalapara upazila in Patuakhali district of Bangladesh. The organic matter content of top soil sediments in almost all of the sediments taken from Kalapara upazila is found to be quite low, owing to the sediments' lower topographic position. Due to the presence of buried mineral and organic layers, organic matter content declines with depth before increasing. The OM of riverside sediment in Vodra, Dhaki and Chunkuri rivers varies from 1.10 to 1.25% (Table 02), 1.13 to 1.25% (Table 03) and 1.20% (Table 04) are respectively. According to BARC all of these OM are classified as low category (1.0-1.7%). The OM of Khal side sediment in Vodra, Dhaki and Chunkuri rivers are 1.68% (Table 02), 2.64% (Table 03) and 1.26% (Table 04) are respectively. Among these rivers sediment the OM of the Vodra and Chunkuri rivers are low classes but the Dhaki river are medium (1.8-3.4%) classes according to BARC. The Highest value of OM 2.64% (Table 03) was found at khal side sediment of Dhaki river and the lowest value of OM 1.10% (Table 02) was found at riverside sediment of Vodra river. Karim (2004) found that in two salt influenced sediment of Bangladesh, the organic matter content varied between 0.10 to 1.00 and 1.15 to 2.27 percent. SRDI (2003) recorded that in the salt affected Rupsa Thana Sediment of Khulna District, the organic matter values ranged from 0.40 to 2.54 percent. Naher *et al*. (2011) and Anwar (1993) found that in two salt-affected areas of Bangladesh's Patuakhali and Barguna Districts, the percentage of organic matter ranged from 0.51 to 0.64 percent. Haque (2006) recorded that, with the exception of Paikgachha upazila of Khulna district, where the top soils contain high organic matter, the sediments are generally low in organic matter content (7 percent). The top soils organic matter content varies from less than 1 percent to 1.5 percent. The low organic sediment content means that the coastal region is in poor physical condition.

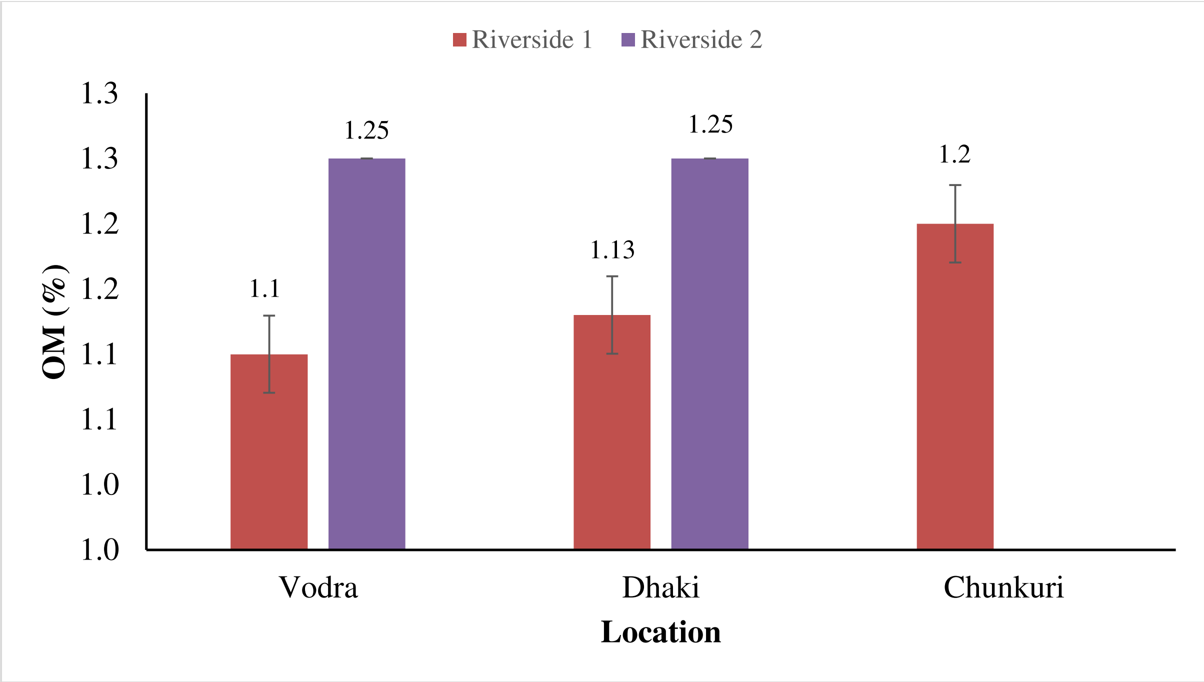

Figure 10. OM of the Riverside sediment of different locations

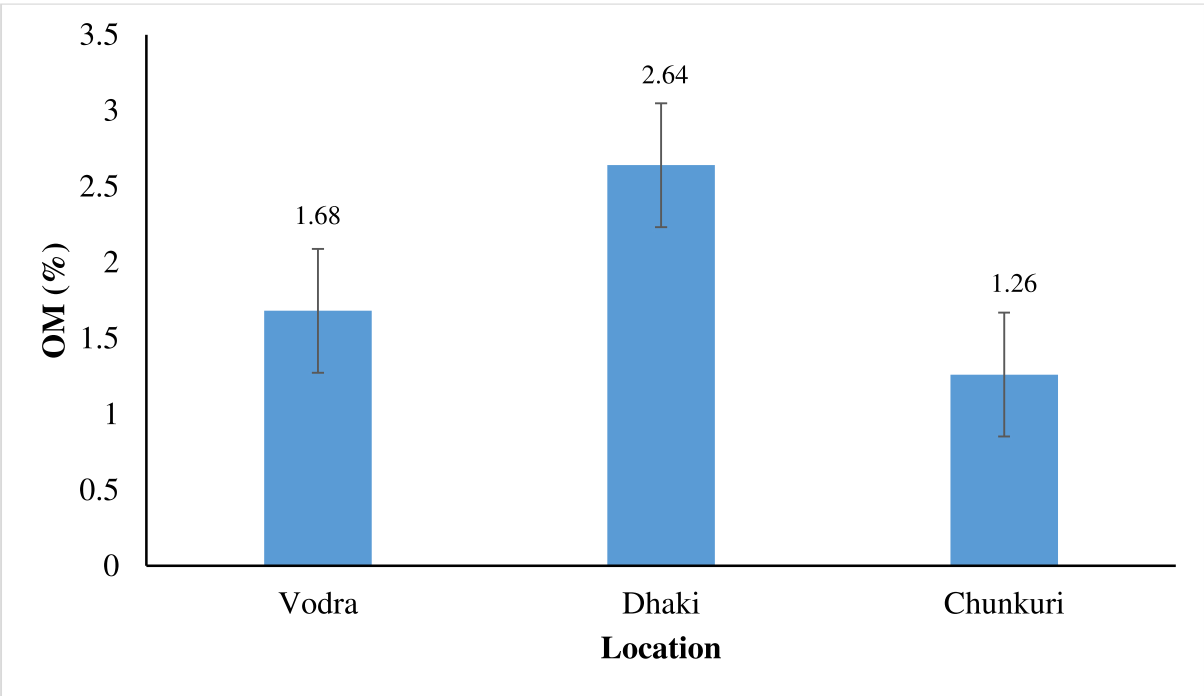

Figure 11. OM of the Khalside sediment of different locations

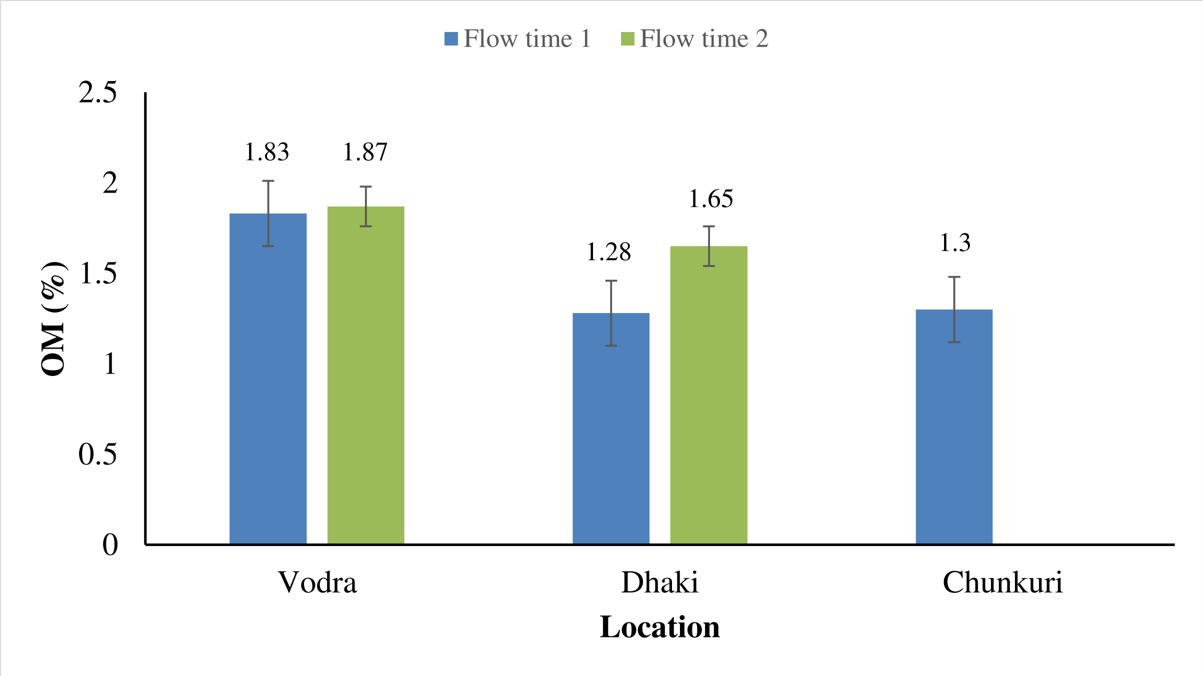

Figure 12. OM of the Flow time sediment of different locations

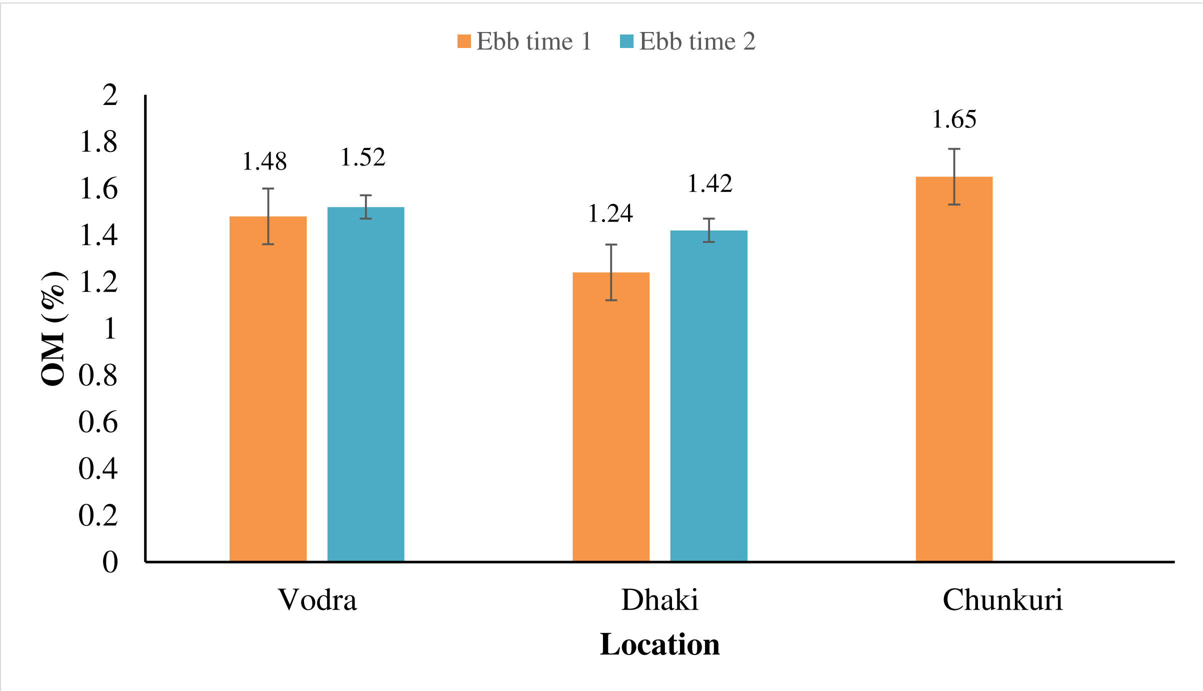

Figure 13. OM of the Ebb time sediment of different locations

4.4 OC (Organic Carbon) of the study areas

At the surface of soils and sediments where detritus is deposited, much of which is derived from aerobic photosynthesis, organic carbon is most abundant. Organic sediment carbon is a measurable portion of organic sediment matter. It is suspected that organic carbon sediment (SOC) plays a crucial role in sediment functions and ecosystem services. At the Sundarban costal area in Bangladesh, Ipsita et al. (2018) conducted a study in cultivated and uncultivated saline soil sediment to assay sediment organic carbon (SOC), its particle-size fractions, and their influence on cultivation and sediment fertility. As a reference, sediment samples were gathered from four farmed fields and four neighboring sites in a native mangrove forest at depths of 0 - 15 and 15-30 cm. Sand (2000-50 m), silt (50-2 m), and clay (2 m) were physically separated from sediment samples. The Carbon Management Index (CMI), a commonly recognized measure of soil quality, was determined for each field, and total SOC was tested in bulk samples and each size fraction. Cultivated soil sediment has a CMI of less than 1%, compared to 100% in reference soil sediment. In the order clay > silt > sand, SOC concentrations declined as particle size separated. The OC of riverside sediment in Vodra, Dhaki and Chunkuri rivers varies from 1.25 to 1.95% (Table 02), 1.34 to 1.42% (Table 03) and 1.02% (Table 04) are respectively. The OC of khal side sediment in Vodra, Dhaki and Chunkri rivers are 1.20% (Table 02), 1.68% (Table 03) and 1.34% (Table 04) are respectively. Organic carbon content were found low (1.0-1.7%) classes in riverside and khal side sediment of Dhaki and Chunkuri rivers, the riverside sediment of Vodra river content medium (1.8-3.4%) classes and the khal side sediment of Vodra river content low classes organic carbon according to the grading of BARC, 2012. The highest value of OC 1.97% (Table 04) was found during ebb time sediment of Chunkuri river. Thse value of OC content medium (1.8-3.4) classes organic carbon according to BRAC. The lowest value of OC 0.43% (Table 03) was found during ebb time sediment of Dhaki river. Thse value of OC content very low (<1) classes organic carbon according to BRAC. Iqbal *et al*. (2009) reported that in most of Bangladesh's arable mineral sediment, the organic carbon level is generally low and its quantity is believed to be decreasing gradually. They reported that in the uplands, 1.5 to 2.0 percent in the medium-low land area and 2.0 to 3.5 percent in the low land areas, the SOC content ranged from 0.3 to 1.5 percent. Sahoo *et al*. (1995) conducted an experiment in the Sundarban mangrove sediment and found that, with its content ranging from 0.29 to 1.89 percent, the organic carbon value decreased with depth in the entire profile.

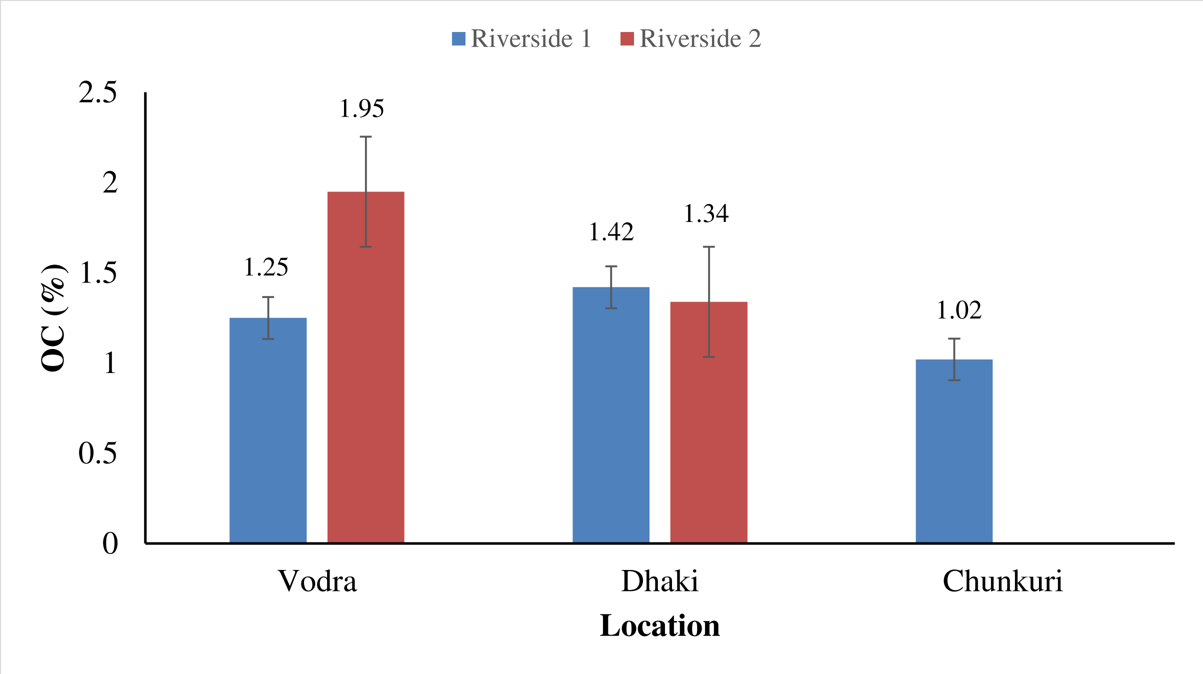

Figure 14. OC of the Riverside sediment of different locations

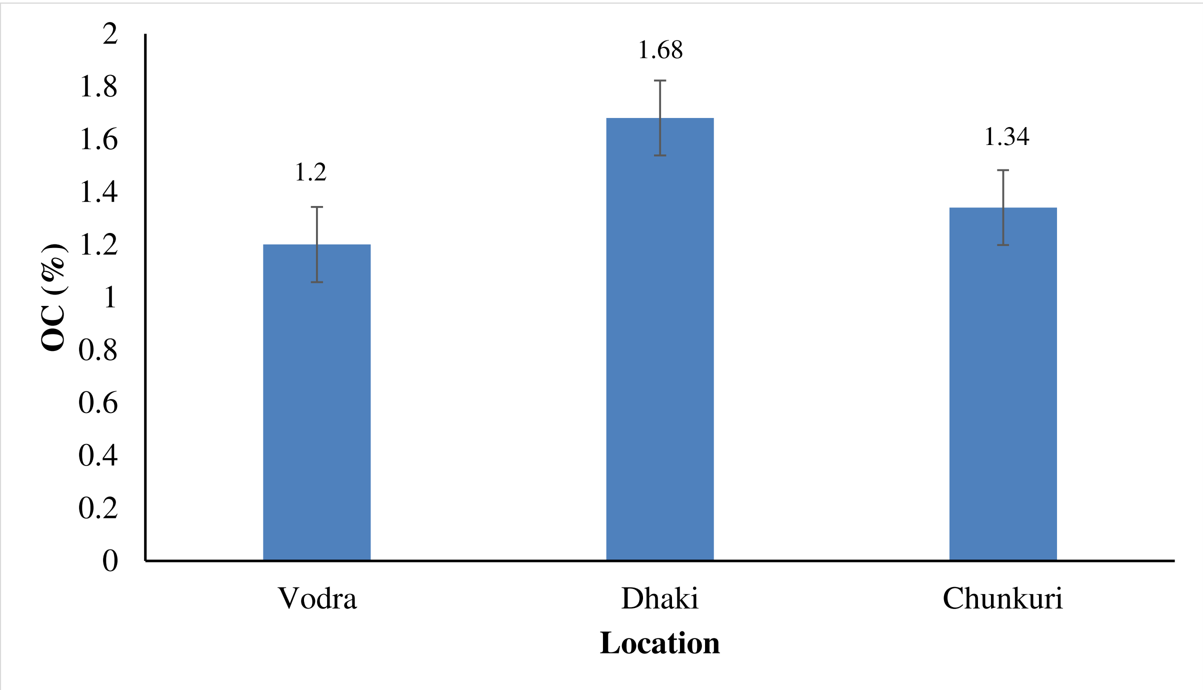

Figure 15. OC of the Khalside sediment of different locations

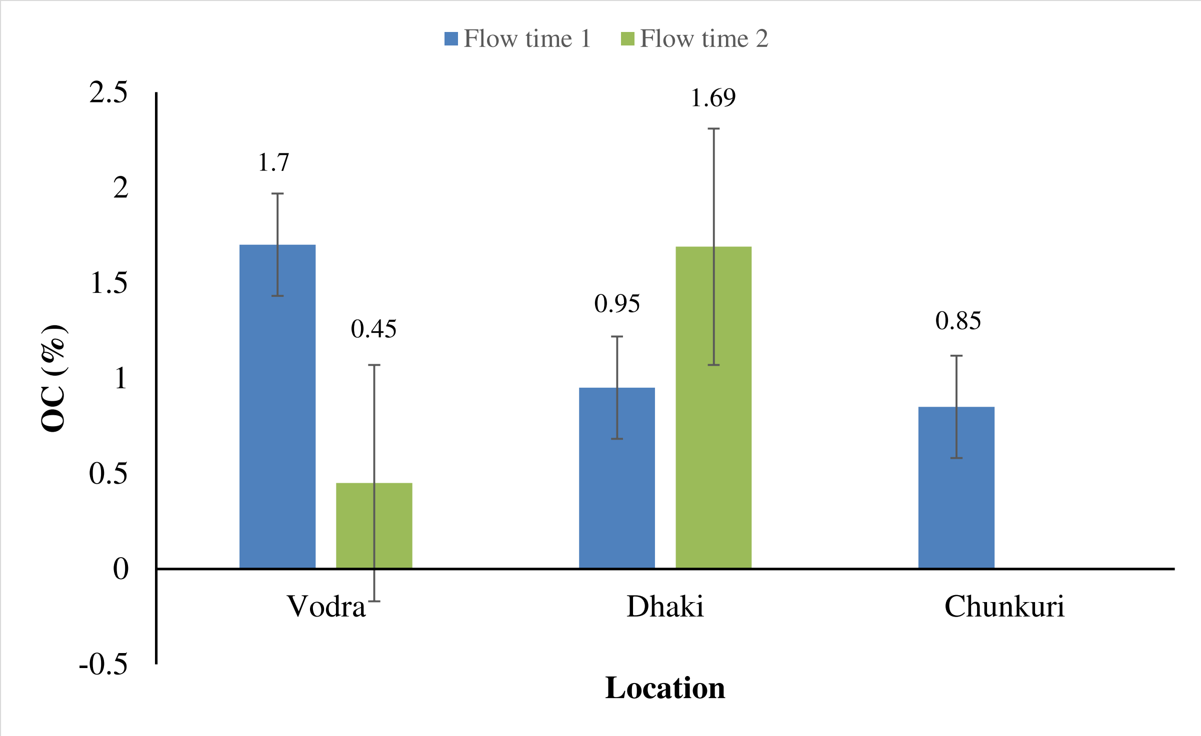

Figure 16. OC of the Flow time sediment of different locations

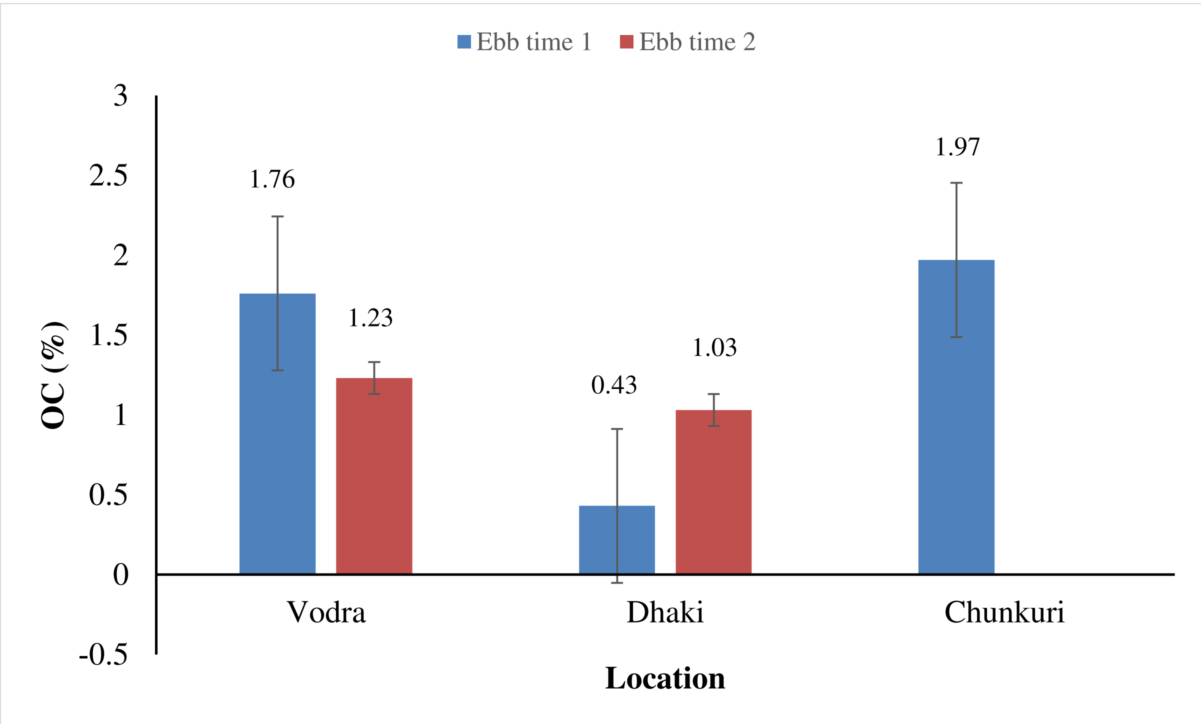

Figure 17. OC of the Ebb time sediment of different locations

4.5 N (Nitrogen) of the study areas

Nitrogen is a non-metallic chemical element that is a colorless, odorless, inert gas that makes up 78 percent of the Earth's atmosphere under normal conditions. In their above-ground tissues, healthy plants often contain 3 to 4 percent nitrogen. In comparison with other nutrients, this is a much greater concentration. The only other nutrients present in higher concentrations are carbon, hydrogen and oxygen, nutrients that don't play a significant role in most soil fertility management programs. Nitrogen is so vital because it is a major component of chlorophyll, the compound used by plants to produce sugars from water and carbon dioxide with sunlight energy (i.e., photosynthesis). According to Girma *et al.* (2012), nitrogen depletion poses a severe danger to agricultural production and food security since it causes soil sediment deterioration and nutrient depletion, as well as a decrease in agricultural and biomass productivity and poor environmental quality. Total N Content of riverside sediment in Vodra, Dhaki and Chunkuri rivers varies from 0.05% to 0.14% (Table 02), 0.07% to 0.18% (Table 03) and 0.17% are respectively. Total N content of khal side sediment in Vodra, Dhaki and Chunkuri rivers varies from 0.25% (Table 02), 0.34% (Table 03) and 0.10% (Table 04) are respectively. In Vodra river during flow time the total Nitrogen content varies from 0.12% to 0.18% (Table 02). Total Nitrogen content of Dhaki river sediment during flow time ranges from 0.15% to 0.19% (Table 03). In Chunkuri river during flow time total Nitrogen content were 0.08% (Table 04). The total nitrogen content in all type of sediment that collected from Dhaki, Vodra and Chunkuri were low to very low level according to the grading of BARC, 2012. The highest Nitrogen content 0.34% (Table 03) was found at khal side sediment of Dhaki river and the lowest Nitrogen content 0.05% (Table 02) was found at riverside sediment of Vodra river. Naher *et al.* (2011); Portch and Islam (1984) found that available nitrogen was deficient in 100 percent of the sediment, which was close to the current findings. Kizildag *et al.* (2013) reported that compared to non-saline sediment, the total nitrogen values were found to be low and it can be concluded that the composition of different plants can affect nitrogen mineralization of saline sediment. Haque (2006) reported that in Bangladesh's coastal region, the total N content of the sediment is generally low, mostly around 0.1%. The low N content can be attributed to most of the sediment's low organic matter content.

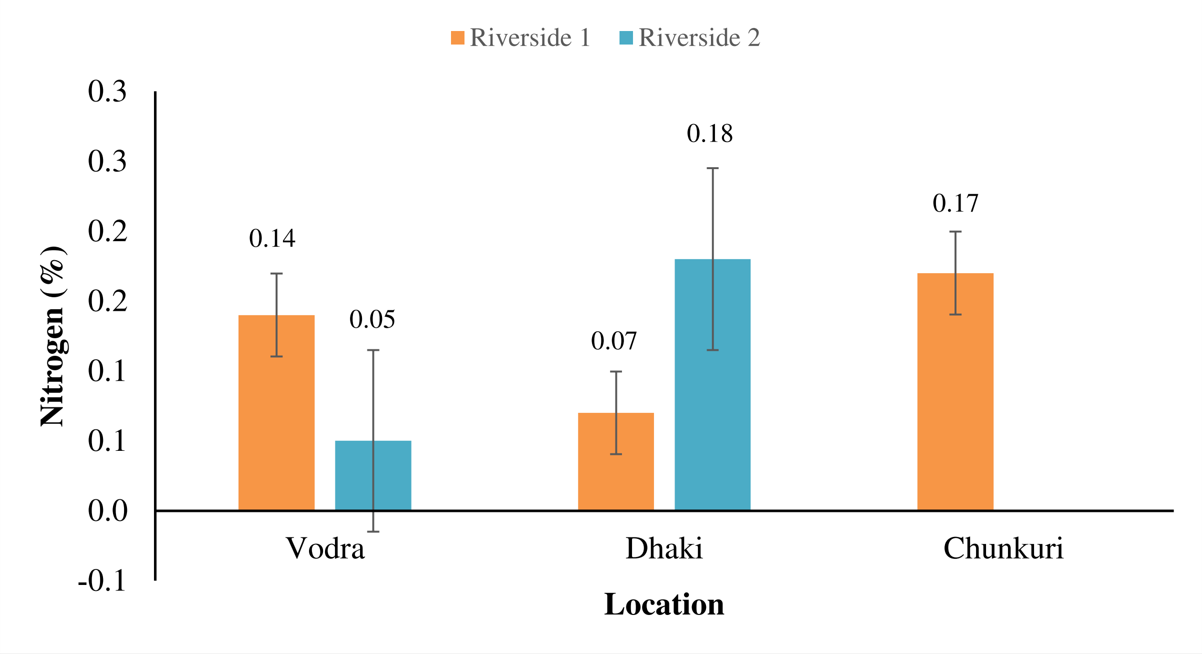

Figure 18. N of the Riverside sediment of different locations

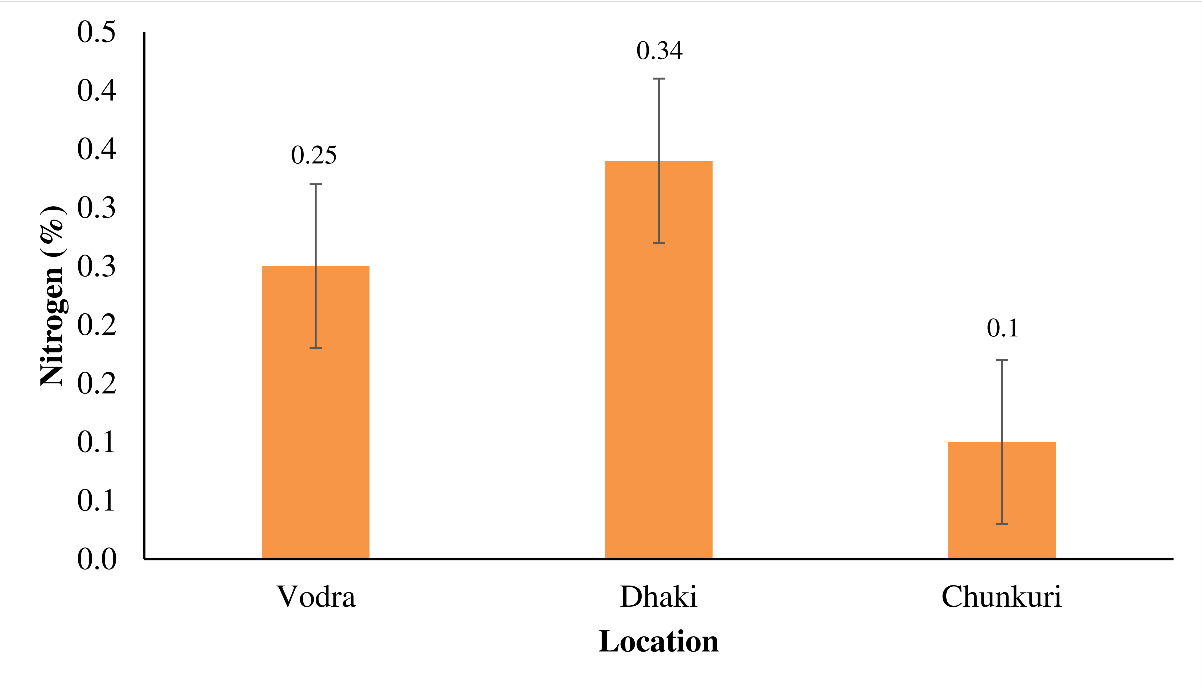

Figure 19. N of the Khalside sediment of different locations

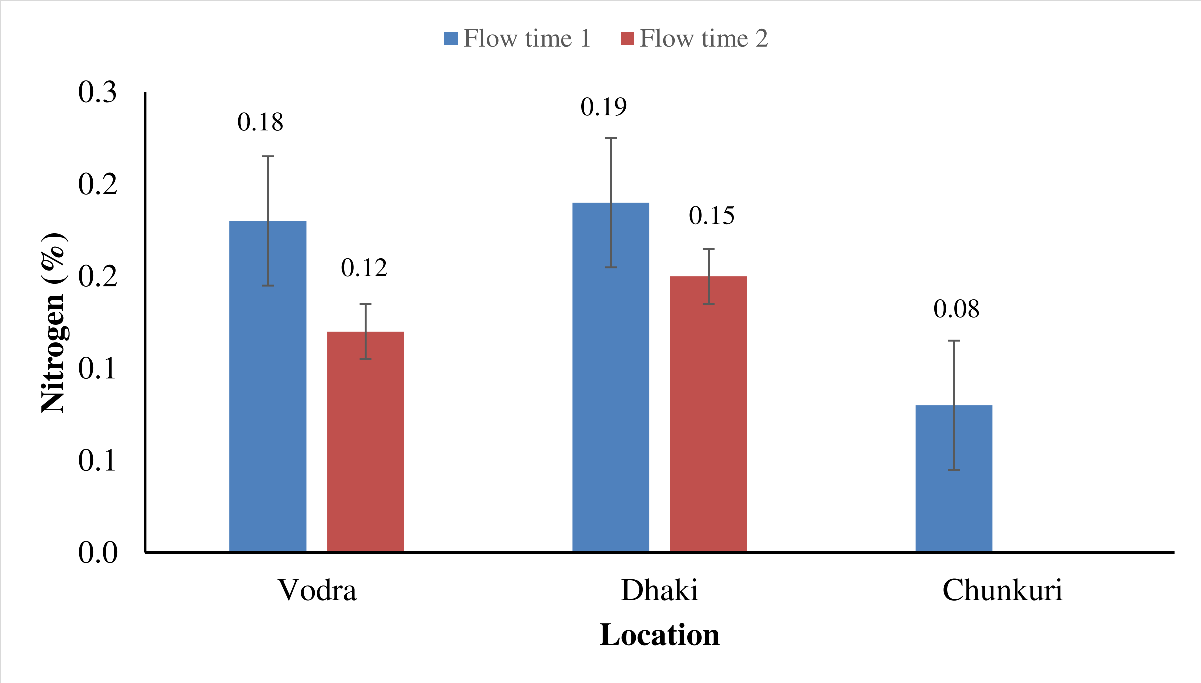

Figure 20. N of the Flow time sediment of different locations

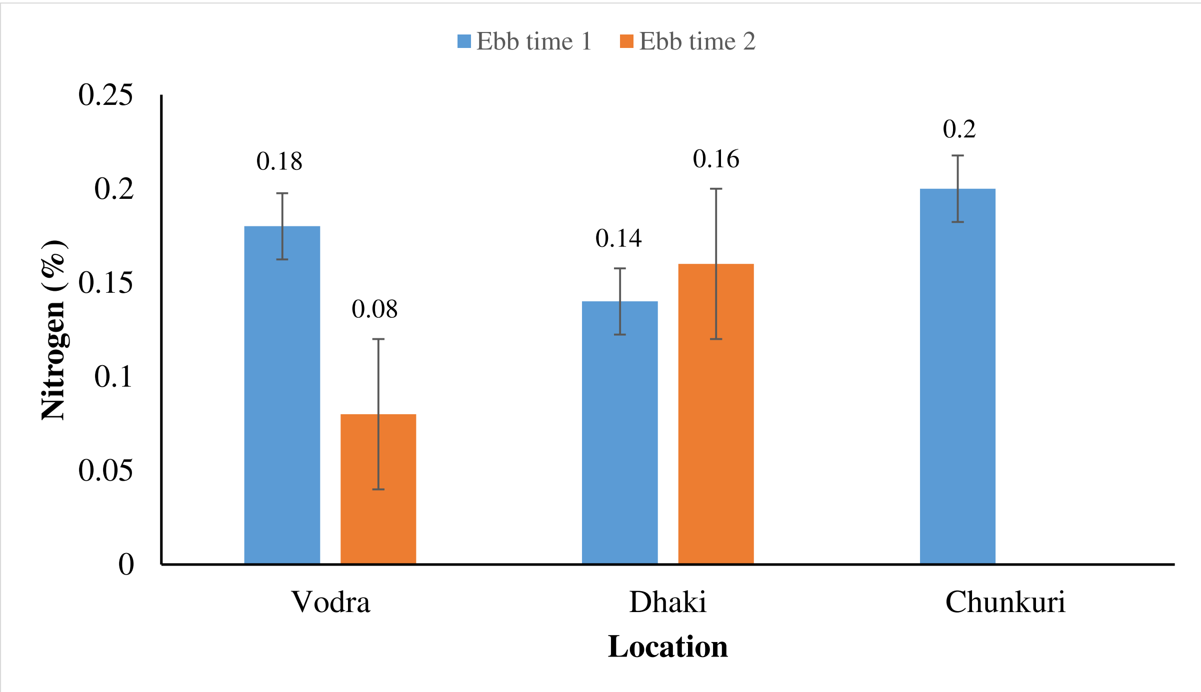

Figure 21. N of the Ebb time sediment of different locations

4.6 P (Phosphorus) of the study areas

Phosphorus is an essential nutrient in the conversion of numerous key biochemical reactions in plants, both as part of several key plant structure compounds and as a catalysis. Phosphorus is particularly noted for its role in the capture and conversion of the energy of the sun into useful plant compounds. A vital component of ATP, the "energy unit" of plants, is phosphorus. During photosynthesis, ATP forms, has phosphorus in its structure, and processes from the start of seedling growth through to grain and maturity formation. Total Phosphorus content of riverside sediment in Vodra, Dhaki and Chunkuri rivers are varies from 23.40 to 28.70 ppm (Table 02), 18.00 to 28.00 ppm (Table 03) and 25.12 ppm respectively. In Vodra river the total Phosphorus content during ebb time sediment 24.50 to 28.24 ppm (Table 02). During ebb time sediment in Dhaki river Phosphorus content varies from 36.80 to 20.50 ppm (Table 03). In Chunkuri river the total Phosphorus content during ebb time sediment were 34.20 ppm (Table 04). Total Phosphorus content of Khal side sediment in Vodra, Dhaki and Chunkuri rivers were 32.80 ppm (Table 02), 32.34 ppm (Table 03) and 27.60 ppm (Table 04) respectively. All of these ranges of Phosphorus content were medium (20-40) level according to the grading of BARC, 2012. The highest value of Phosphorus content 38.00 ppm (Table 02) was found during flow time sediment of Vodra river. These ranges of Phosphorus content were medium (20-40) level according to the grading of BARC, 2012. The lowest value of Phosphorus content 18.00 ppm (Table 03) was found at riverside sediment and during flow time sediment of Dhaki river. These ranges of Phosphorus content were low (<20) level according to the grading of BARC, 2012. Prafitt (1978) stated that the maximum abundance of phosphorus (P) occurs at pH 6-7, while P decreases with higher or lower pH availability. Abu Zofar *et al*. (2003) recorded that the total P concentration in Bangladesh ranged in the top sediment from 23 to 37 ppm and in the sub-sediment from 46 to 68 ppm and varied with physiography. The usable P concentration was much greater for the topsoil in most soil than for the subsoil. Haque (2006) stated that the sediment's accessible P status ranges from 15-25 ppm. There are also some deficient P sediments found in the districts of Chttagong, Barguna, Satkhira and Patuakhali.

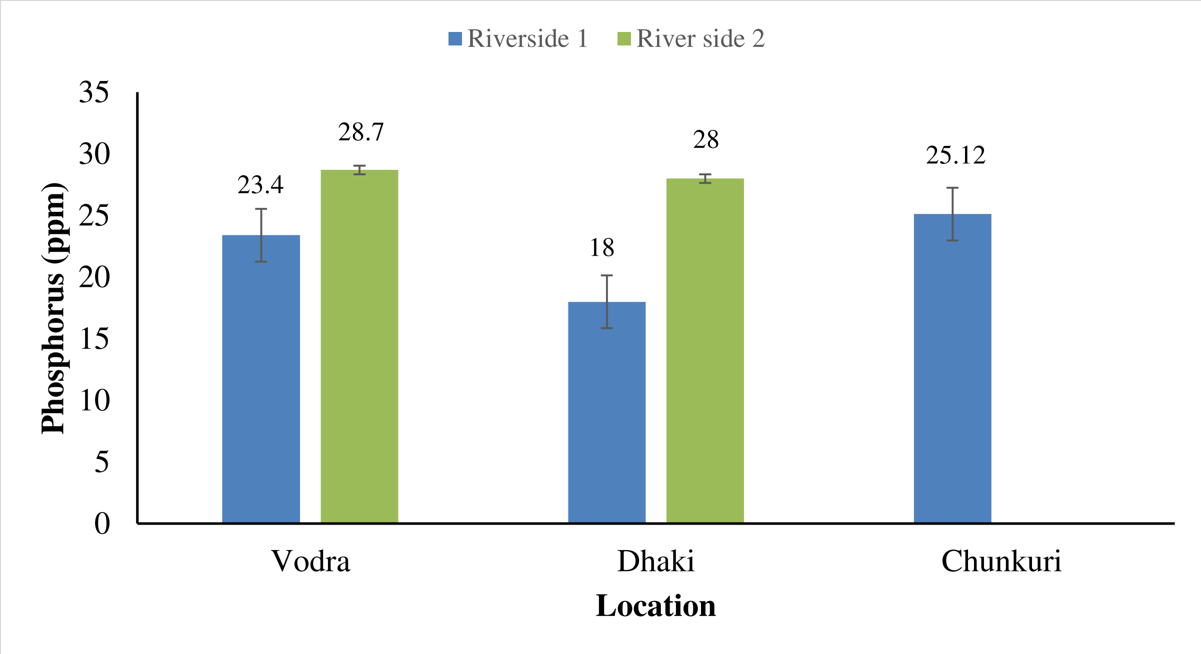

Figure 22. P of the Riverside sediment of different locations

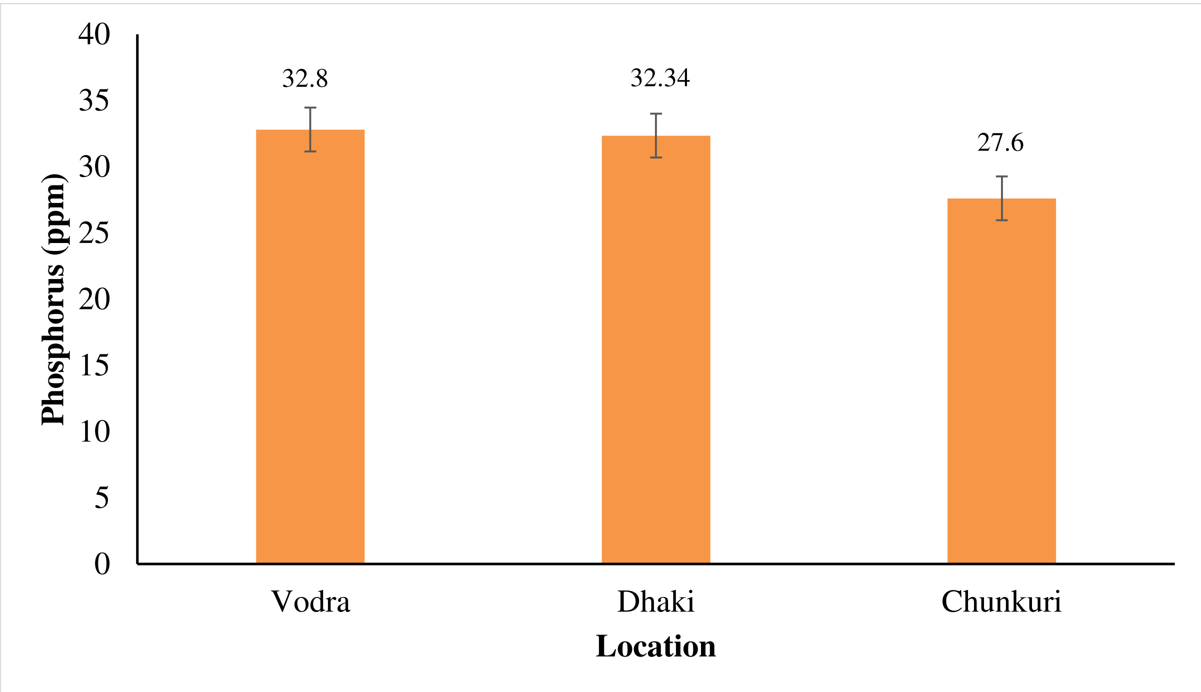

Figure 23. P of the Khalside sediment of different locations

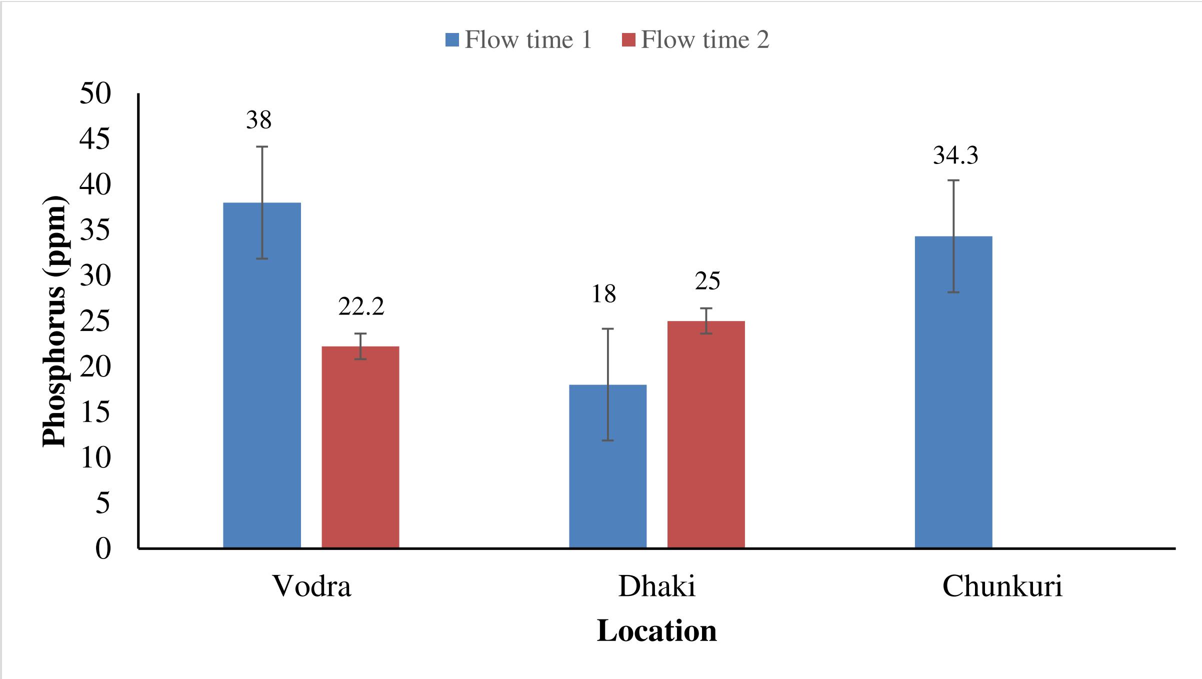

Figure 24. P of the Flow time sediment of different locations

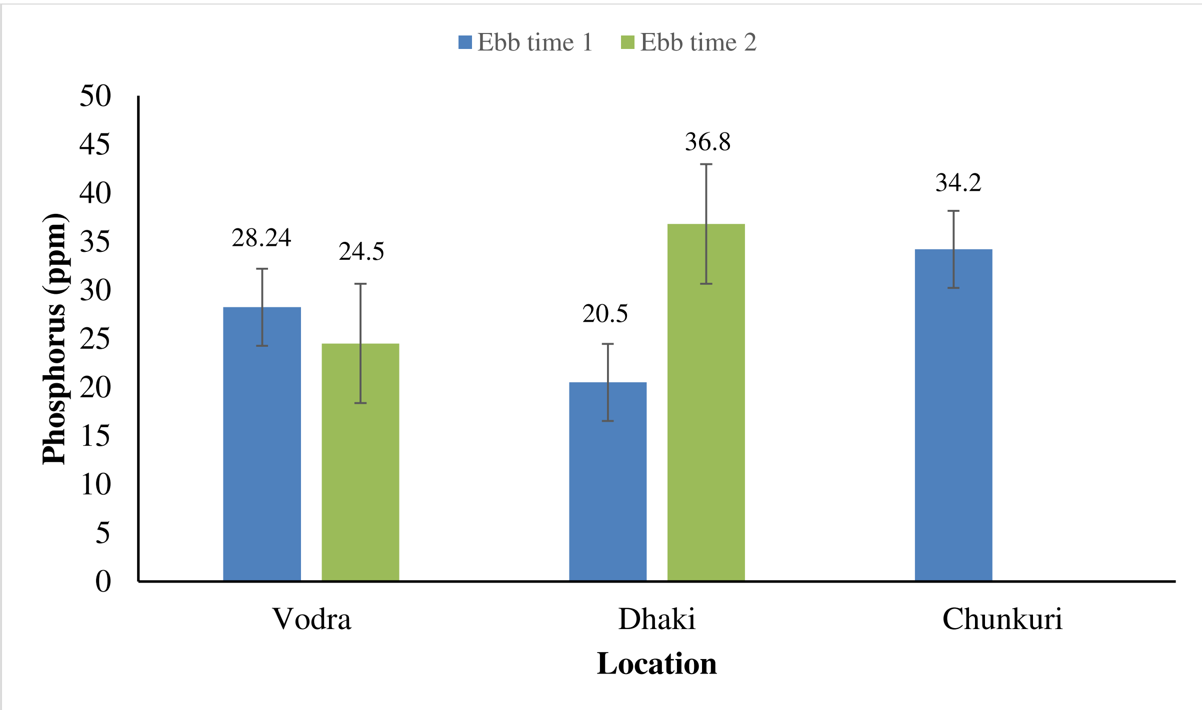

Figure 25. P of the Ebb time sediment of different locations

4.7 S (Sulphur) of the study areas

For microorganisms, plants, animals and human beings, sulphur is an important macronutrient. Sulphur reaches the biological structures in the earth's crust and soil from the S. The soil is the top layer of the earth's crust that has been weathered. It has organic matter in it and is made of living organisms. It is important for the production and growth of all crops. Total Sulphur content of riverside sediment of Vodra, Dhaki and Chunkuri rivers are varies from 16.75 to 28.23 ppm (Table 02), 12.83 to 15.85 ppm (Table 03) and 24.05 ppm (Table 04) respectively. In Vodra river total Sulphur content during flow time sediment ranges from 28.34 to 36.54 ppm (Table 02). Total Sulphur content of Dhaki river during flow time sediment varies from 25.50 to 32.50 ppm (Table 03). In Chunkuri river total Sulphur content during flow time sediment were 32.53 ppm (Table 04). All of these Sulphur content ranges were medium level according to the grading of BARC, 2012. The highest Sulphur content 36.54 ppm (Table 02) was found during flow time sediment of Vodra river and the lowest Sulphur content 12.83 ppm (Table 03) was found at riverside sediment of Dhaki river. Ranjan *et al*. (2007) stated that climate variables such as precipitation, surface runoff and temperature can have a significant impact on sulfur content. Due to a shortage of groundwater and increased evaporation, the sulfur concentration will be substantially lower with fewer precipitation and warmer temperatures. According to Naher (2011), all of the sediments had a medium to high sulphur level, with the content being higher at Kalapara than at the other sites. Higher sulphur concentration, which varied from 15.0 to 20 mg/100 kg at Asasuni and 38.0 to 67.0 mg/kg at Kalapara, could be due to regular flooding with tidal water. Ahmed *et al*. (2018) studied sediment salinity trends and total sulfur concentration in agricultural and fallow land at a distance of 90 km from the coastline in Noakhali. The highest salinity of sediments and sulfur were recorded in coastal surface sediments (0 km), though at least 90 km away from the coastline. The sulfur content of the Kalapara sediment was found to be 40.0-57.34 ppm Alam *et al*. (2017).

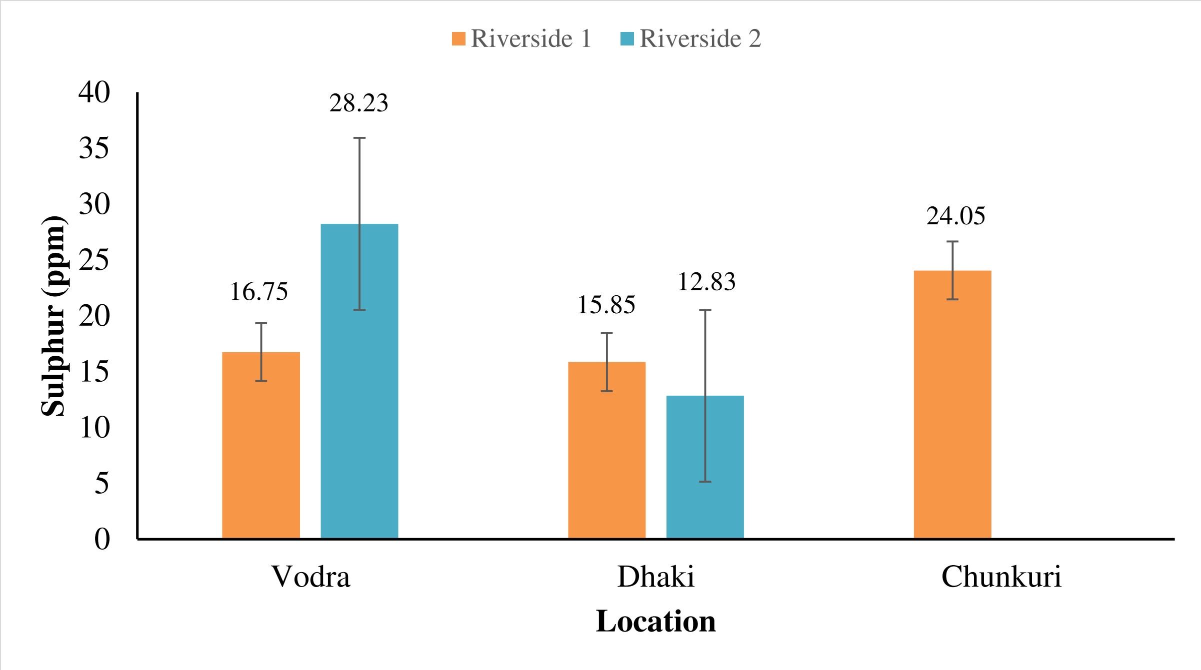

Figure 26. S of the Riverside sediment of different locations

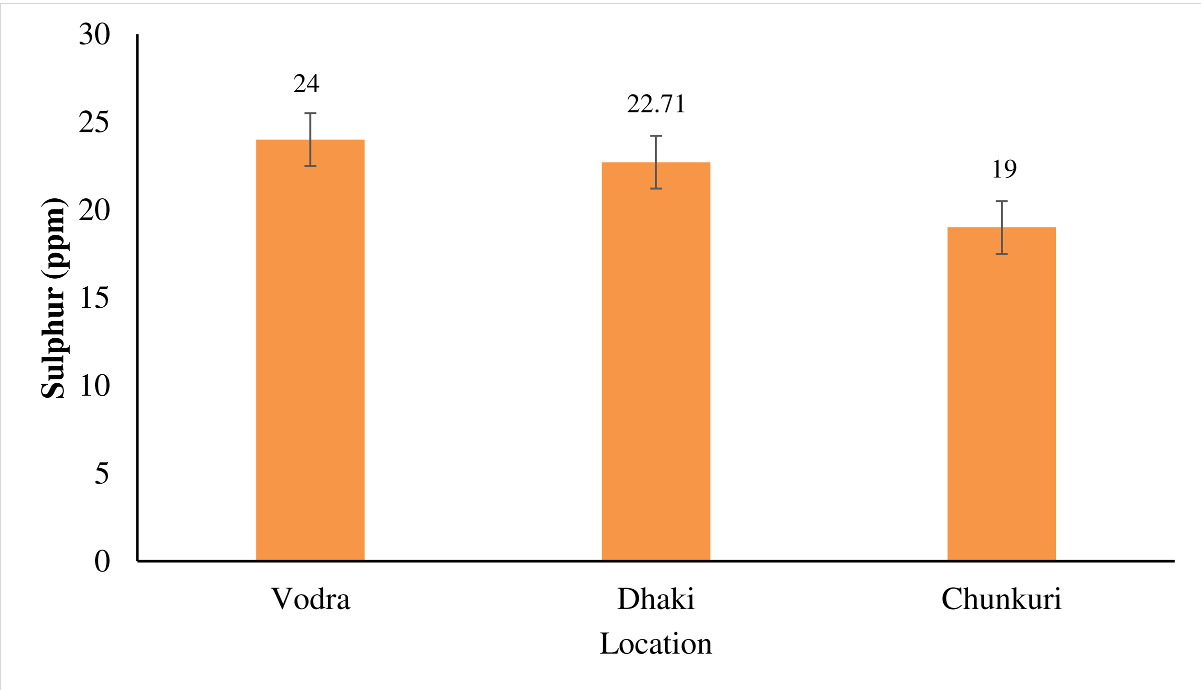

Figure 27. S of the Khalside sediment of different locations

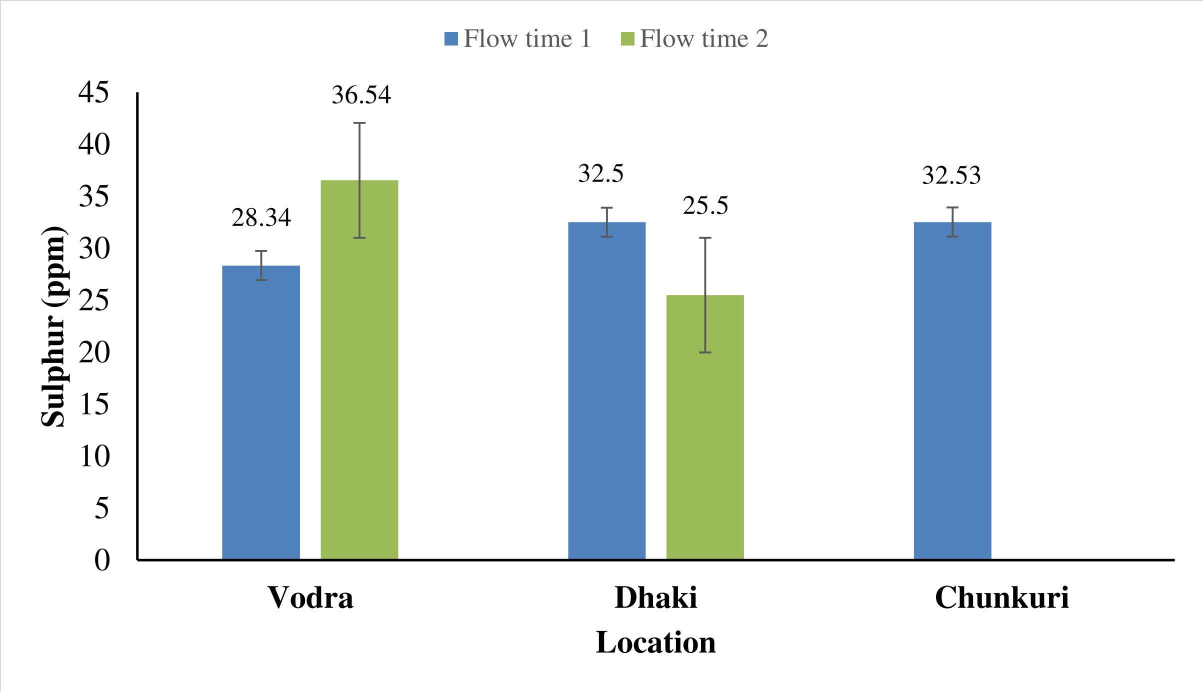

Figure 28. S of the Flow time sediment of different locations

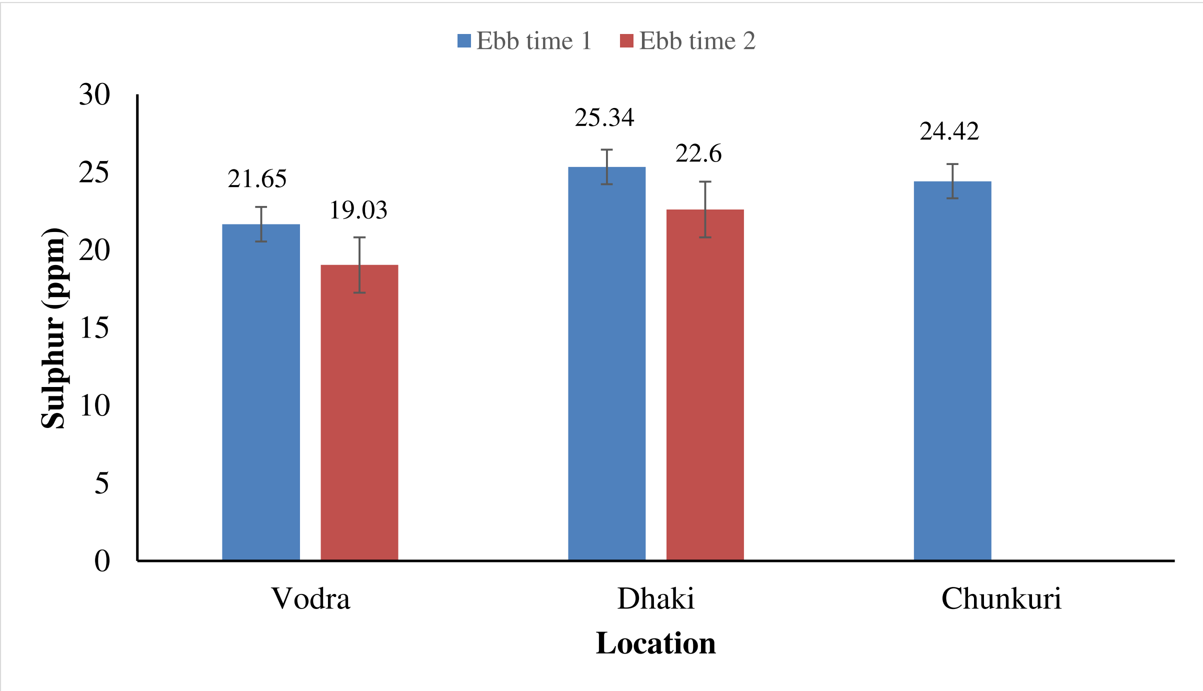

Figure 29. S of the Ebb time sediment of different locations

4.8 Correlation matrix between the characteristics

4.8.1 Correlation matrix between the characteristics of the Vodra River Sediment

The correlation matrix between the characteristics of the Vodra river sediment are obtained in the present study which are collected from Dacope upazila of Khulna district and these correlation are given in the Table 05. The pH was the most fundamental property in Vodra river and has positive non-significant relationship with EC (0.244), OC (0.114), N (0.017), P (0.187) and S (0.098). pH showed negative non-significant relationship with OM (-0.041). EC showed positive non-significant relationship with OM (0.168), OC (0.324), P (0.309) and S (0.386). EC showed negative significant relationship with N (-0.469*). OM showed positive non-significant relationship with N (0.387) and P (0.373). OM showed positive significant relationship with S (0.665**) and negative non-significant relationship with OC (-0.420). OC showed positive significant relationship with P (0.554**) and negative non-significant relationship with N (-0.076) and S (-0.342). N showed positive significant relationship with P (0.522*) and negative non-significant relationship with S (-0.099). P showed positive non-significant relationship with S (0.103).

Table 05. Correlation matrix between the characteristics of the Vodra River Sediment

	pH	EC	OM	OC	N	P	S
pH	1						
EC	0.244	1					
OM	-0.041	0.168	1				
OC	0.114	0.324	-0.420	1			
N	0.017	-0.469*	0.387	-0.076	1		
P	0.187	0.309	0.373	0.554**	0.522*	1	
S	0.098	0.386	0.665**	-0.342	-0.099	0.103	1

** Significant at 0.01 level of probability

* Significant at 0.05 level of probability,

EC: Electrical conductivity, OM: Organic matter content, OC= Organic carbon, N: Total N content, P: Total P content, S: Total S content

4.8.2 Correlation matrix between the characteristics of the Dhaki River Sediment

The correlation matrix between the characteristics of the Dhaki river sediment are obtained in the present study which are collected from Dacope upazila of Khulna district and these correlation are given in the Table 06. The pH was the most fundamental property in Dhaki river and has positive significant relationship with EC (0.503*). The pH showed the positive non-significant relationship with OM (0.243), OC (0.405), N (0.182) and P (0.116). The pH has negative non-significant relationship with S (-0.126). EC showed positive significant relationship with OM (0.471*), 0C (0.498*) and N (0.434*) and P (0.742**). EC showed negative non-significant relationship with S (-0.134). OM showed positive significant relationship with OC (0.547*) and P (0.524*) and N (0.886**). OM showed negative non-significant relationship with S (-0.134). OC showed positive non-significant relationship with N (0.319) and P (0.286). OC showed negative non-significant relationship with S (-0.328). N showed positive significant relationship with P (0.512*) and the negative non-significant relationship with S (-0.208). P showed negative non-significant relationship with S (-0.208). Naher et al. (2011) studied the correlation matrix at Asasuni and Kalapara upazilla for the physical and chemical properties of sediment and understood that the clay content at Asasuni and Kalapara upazilla is the most fundamental property for regulating the chemical properties of sediment.

Table 06. Correlation matrix between the characteristics of the Dhaki River Sediment

	pH	EC	OM	OC	N	P	S
pH	1						
EC	0.503*	1					
OM	0.243	0.471*	1				
OC	0.405	0.498*	0.547*	1			
N	0.182	0.434*	0.886**	0.319	1		
P	0.116	0.742**	0.524*	0.286	0.512*	1	
S	-0.126	-0.134	-0.134	-0.328	0.208	-0.208	1

** Significant at 0.01 level of probability

* Significant at 0.05 level of probability,

EC: Electrical conductivity, OM: Organic matter content, OC= Organic carbon, N: Total N content, P: Total P content, S: Total S content

4.8.3 Correlation matrix between the characteristics of the Chunkuri River Sediment

The correlation matrix between the characteristics of the Chunkuri river sediment are obtained in the present study which are collected from Dacope upazila of Khulna district and these correlation are given in the Table 07. The pH was the most fundamental property in Chunkuri river and has positive non-significant relationship with EC (0.259), OM (0.068), 0C (0.058) and N (0.060). The pH showed the negative non-significant relationship with P (-0.084) and S (-0.214). EC showed positive significant relationship with OM (0.846**), OC (0.732**) and N (0.831**). EC showed positive non-significant relationship with P (0.448) and S (0.035). OM showed positive significant relationship with OC (0.840**) and P (0.681*). OM showed positive non-significant relationship with N (0.571) and S (0.051). OC showed positive significant relationship with N (0.686*), positive non-significant relationship with P (0.289) and negative non-significant relationship with S (-0.425). N showed negative non-significant relationship with P (-0.047) and S (-0.279). P showed positive non-significant relationship with S (0.574).

Table 07. Correlation matrix between the characteristics of the Chunkuri River Sediment

	pH	EC	OM	OC	N	P	S
pH	1						
EC	0.259	1					
OM	0.068	0.846**	1				
OC	0.058	0.732**	0.840**	1			
N	0.060	0.831**	0.571	0.686*	1		
P	-0.084	0.448	0.681*	0.289	-0.047	1	
S	-0.214	0.035	0.051	-0.425	-0.279	0.574	1

** Significant at 0.01 level of probability

* Significant at 0.05 level of probability,

EC: Electrical conductivity, OM: Organic matter content, OC= Organic carbon, N: Total N content, P: Total P content, S: Total S content

CHAPTER V

SUMMARY CONCLUSION AND RECOMMENDATION

The research was carried out in the Dacope upazilla of the Khulna area to determine the sediments. In the Dacope upazilla, sediment samples were taken from the Dhaki, Vodra, and Chunkuri rivers. The primary data was acquired directly from a dacope upazila sediment sample. The 16 sediment samples came from kamarkhola, which is near the Dhaki and Vodra rivers, and the other four soil samples came from krishtanpara, which is near the Chunkuri river. Along the banks of these three rivers, four places were chosen. Secondary data was primarily collected from the Dacope upazila and Khulna district's forest, agriculture, soil, and water-related sectors, while all other literatures were gathered from published sources such as books, national and international journals, publications, newspapers, web sites, and other government and non-government published and unpublished documents. A reconnaissance survey in Paikgacha upazila was used to pre-test the sample collection. On 25 November, 2019, the final survey was completed. The highest pH of the river side, khal side and khal side of three rivers was 8.12, 8.13 and 8.09, respectively and the value are not significant.

Significant variation was observed in EC of different location and the highest EC (µs cm^{-1}) of the flow time, flow time and ebb time of three rivers was 678.00, 625.00 and 644.00, respectively. The highest OM (%) of the flow time, khal side and ebb time of three rivers are 1.87, 2.64 and 1.65, respectively and the variation was significant. The highest OC (%) of the river side, flow time and ebb time of three rivers are 1.95, 1.69 and 1.97, respectively and the value was significant. The highest N (%) of the khal side, khal side and ebb time of three rivers are 0.25, 0.34 and 0.20, respectively and all are significant at 1% level of significance. Significant variation was observed in the value of P in different location and the highest P (ppm) of the flow time, ebb time and flow time of three rivers were 38.00, 36.80 and 34.30, respectively. The highest value of S (ppm) was found in the flow time of three rivers are 36.54, 32.50, 32.53, respectively and the value was significant. The coastal region of Bangladesh covers an area of around 47,201 km^2, spanning along the Bay of Bengal, Bangladesh's central coastal zone, and, more specifically, the inner coast. The coastal areas of Bangladesh are vulnerable to a variety of natural hazards, including cyclones, tidal surges, saline intrusion, sediment intrusion, riverbank erosion, and coastline recession, due to their near flat topography and placement at the tip of the "funnel shaped" Bay of Bengal. The coastal zone of Bangladesh, particularly the exposed coast, has been the subject of a number of policy and academic studies for sediment intrusion, but with the accelerated impacts of climate change, sediment is extending from the exposed to the interior coast, posing a threat to crop production. Estimated decreases in sediment content have already posed a danger to crop productivity, with large output losses observed during the dry season. It has been anticipated that as sea level rises, the diminishing concentration of sedimentation will put additional pressure on farmers, reducing output on the one hand and compromising livelihood, income generation, and food security on the other. As a result, the study advises leaching and the selection of diverse tolerant crop varieties as adaptation techniques to limit future loss and prevent current loss.

CONCLUSION

From the present study, the following conclusion may be drawn –

This study aims to determine appropriate sediment management strategies for Bangladesh's south-west region, which will allow sediment to be diverted from sediment-rich areas to sediment-poor areas. Ranges of incoming sediment load in the region will be assessed to attain this major goal. Sediment has the ability to either improve or deteriorate the soils in which it is deposited. The influence of sediment deposition is determined by the original soil's characteristics, the rate of deposition, the type of material used, and the depth of deposition. Soil quality may improve for a short time, but coarser material tends to impair soil structure and physical properties, as well as reduce fertility. According to secondary statistics, the average range of sedimentation in the Khulna region's coastal floodplain ranges from 0.92cm to 1.12cm. According to the literature, the region's coastal sedimentation is geographically varied. In this study area Electrical conductivity (EC) varies from 548.00 µs cm^{-1} to 678.00 µs cm^{-1} that expressing slightly saline in classes. The organic matter content varies from 1.10% to 2.64% which is pretty low to medium. The organic carbon content varies from 0.43% to 1.97% which is pretty very low to medium in classes. The pH values varies from 7.87 to 8.13 which expresses slightly to moderately alkaline soil. Fertility status of most saline sediments of Dacope upazilla ranges from low to very low in respect to organic matter content, nitrogen, phosphorus and sulfur.

RECOMMENDATIONS

From the above study, the following recommendation is given below -

- ❖ More implementations and coordination of the relevant policies are required for special attention in decision-making in light of our country's current sedimentation situation.
- ❖ To create scenarios for a sediment management approach that will divert sediment from a sediment-excess region to a sediment-starve zone with a uniform distribution of sediment.
- ❖ Understanding the effects of changes in flow and sediment load on sedimentation and morphological processes for various scenarios of upstream water withdrawal and water conservation.

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APPENDICES

Appendix- I. Collected data from Vodra, Dhaki and Chunkuri

Location	pH	EC (μs cm^{-1})	OM (%)	OC (%)	N (%)	P (ppm)	S (ppm)
V1-RS	8.04	617.00	1.10	1.25	0.14	23.40	16.75
V1-KS	8.11	580.00	1.68	1.20	0.25	32.80	24.00
V1-FS	8.00	678.00	1.83	1.70	0.18	38.00	28.34
V1-ES	7.93	612.00	1.48	1.76	0.18	28.34	21.65
V2-RS	8.12	653.00	1.25	1.95	0.05	28.70	28.23
V2-FS	7.99	632.00	1.87	0.45	0.12	22.20	36.54
V2-ES	7.97	628.00	1.52	1.23	0.08	24.50	19.03
D1-RS	8.10	548.00	1.13	1.42	0.07	18.00	15.85
D1-KS	8.13	612.00	2.64	1.68	0.34	32.34	22.71
D1-FS	7.98	560.00	1.28	0.95	0.19	18.00	32.50
D1-ES	7.87	564.00	1.24	0.43	0.14	20.50	25.34
D2-RS	8.09	618.00	1.25	1.34	0.18	28.00	12.83
D2-FS	8.02	625.00	1.65	1.69	0.15	25.00	25.50
D2-ES	7.92	612.00	1.42	1.03	0.16	36.80	22.60
C1-RS	8.08	586.00	1.20	1.02	0.17	25.12	24.05
C1-KS	8.09	551.33	1.26	1.34	0.10	27.60	19.00
C1-FS	7.96	565.00	1.30	0.85	0.08	34.30	32.53
C1-ES	8.01	644.00	1.65	1.97	0.20	34.20	24.42

Appendix-II. Sediment 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, 1991

Appendix III. Classification of sediment 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 sediment 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 sediment 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

Appendix VI. Classification of sediment on the basis of Phosphorus

Class	Range
Low	< 20
Medium	20-40
High	40-100
Excessive	> 100

Source: BARC, 2012