

**SEASONAL AND TIDAL VARIATIONS OF MAJOR
NUTRIENTS IN PASSUR RIVER SYSTEM OF THE
SUNDARBANS, BANGLADESH**



A Thesis

By

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December, 2011

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Style and Content Approved by



A handwritten signature in black ink, appearing to read "Nazmul Ahsan", written over a horizontal line.

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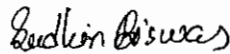
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Declaration

Seasonal and tidal variations of major nutrients in passur river system of the sundarbans, bangladesh

The results presented in this project thesis with the above mentioned title are entirely of the candidate's own investigations and no part of the results has been accepted for any degree nor is it being concurrently submitted for any degree.

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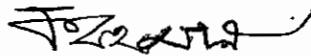
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December, 2012



DEDICATED TO



My Beloved Parents

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Abstract

The Rupsha-Passur River system is one of the biggest and important river System in the Sundarbans region. It is the largest fresh water supplier into the Sundarbans. The unique habitat of the Sundarbans mangrove ecosystem is dependent upon the hydrological and chemical regime. Therefore, a comprehensive study to understand the hydrologic behavior and the changes that have taken place due to anthropogenic activities in and around the area is fundamental to the management of natural resources and environment. This study aimed to evaluate tidal and seasonal variations in concentrations of nitrogen (NH_4^+ , NO_3) and phosphate, sulphate, ammonia in a riverine mangrove forest during the Post-monsoon (October– January 2010), dry (February-May 2011) and Monsoon (June– September 2011) seasons in the Passur River, Sundarban. Spatial and temporal analytical measurement of nutrients was made in the Passur River of sundarban mangrove forest to understand the dissolve nutrient dynamics. Seasonally measurement of physical parameters and dissolved organic nutrients were made at several locations at daytime during high tide and low tide. The 5 selected stations from the upstream to downstream regions exhibited uniformity with respect to water temperature. Significant spatial variations were observed with respect to parameters like water salinity, pH, DO. Along with tidal influences, the anthropogenic factors contributed by the adjacent cities and towns exert a regulatory influence on parameters like NO_3 , PO_4 , SO_4 and Ammonia. Tidal water temperatures during the sampling period were on average $30.6 (\pm 0.4) ^\circ\text{C}$ in monsoon, $30.06 (\pm 4) ^\circ\text{C}$ in Post-monsoon and $20.8 (\pm 0.4) ^\circ\text{C}$ in Dry Winter. Salinity values measured in monsoon 5.42 ppt, whereas salinity in post-monsoon during the sampling period was on average 8.2 ppt and 11 ppt in dry witer. Nitrate, NH_4^+ , Phosphate and sulphate concentrations ranged from 0.08 to 1.23 ppm, from 0.013 to 0.080 ppm, from 0.045 ppm to 1.35 ppm and from 7.30 to 126.92 ppm throughout the study period, respectively. The study results show that the nutrient concentration ranges found higher than the Environmental Quality Standard (EQS) of Bangladesh. The data and information presented in this paper will help as a baseline for future studies about dynamics of water chemistry and its effect on environment.

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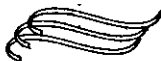
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CHAPTER-ONE

INTRODUCTION

1.0 Introduction



1.0 Background of the study

The Sundarbans forest is the largest continuous productive mangrove wetland ecosystems in the world. It is located at the extreme end of the southern Ganges delta and it is about 10,000 km² in southwest Bangladesh and West Bengal of India. A total area of 62 % lies in the Khulna region of the south western part of Bangladesh, while the remaining 38 % is in India (Siddiqi and Lacerda, 2001). This present Sundarbans area is approximately half the size of the area of mangrove that existed 200 years ago when the area was 17,000 km² the other half being cleared reason of human activities (Hussain and Acharya, 1994). The Bangladesh portion of Sundarbans covers an area of 6017 km² of mangrove forests, wildlife sanctuaries and sand bars, out of this 1874 km² are made up rivers, creeks and canals (Wahid, 1995). The land area of Bangladesh Sundarbans is about 4,017 km² (Katebi, 2001).

The mangrove-dominated Ganges delta – the Sundarbans – is a complex ecosystem comprising one of the three largest single tract mangrove forests of the world (Blasco, 1975). Shared between two neighboring countries, Bangladesh and India, the larger part (62% of the total mangrove ecosystem) is situated in the southwest corner of Bangladesh between latitudes 21°27'30"–22°30'00" North and longitude 89°02'00"–90°00'00" East (Fig.-1). The western boundary of the Bangladeshi Sundarbans follows the Harinbanga–Raimangal–Kalindi river system and abuts with the Indian Sundarbans. To the south the forest meets the Bay of Bengal; to the east it is bordered by the Baleswar River and to the north there is a sharp interface with intensively cultivated land. The natural drainage in the upstream areas, other than the main river channels, is impeded by extensive embankments and polders. The total land area is 4143 km² (including exposed sandbars – 42 km²) and the remaining water area of 1874 km² encompasses rivers, small streams and canals. Rivers in the Sundarbans are meeting places of salt water and freshwater. Thus, it is a region of transition between the freshwater of the rivers originating from the Ganges and the saline water of the Bay of Bengal. The low lying areas are dominated by a network of small creeks, which flow into the main water source during the ebb-flow of the tide. The coast of the Sundarban is criss-crossed by a network of complex estuarine system created by river Rupsa, Passur, Shippa, Arpangasia and others river which open into the Bay of Bengal through the Sundarban Reserved Forest and carry large amounts of

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nutrients that varies with tides and seasons which facilitates the productivity in the area. That's why the coastal environment is very dynamic in nature.

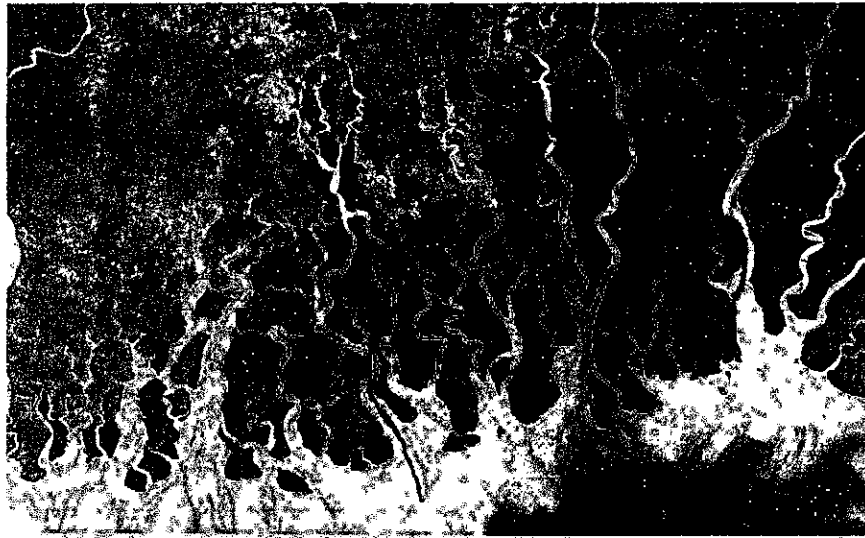


Fig-1: Bangladesh part of sundarbans (covered by red-line).

The mangrove forest of Bangladesh, the largest continuous mangrove forest of the world, is one of the most important coastal features of the country. The existence of the mangrove has increased the values of other coastal and marine resources such as the coastal and marine fisheries by increasing productivity and supporting a wide biological diversity. The artisanal fishery, which is highly influenced by mangroves, has been contributing 85–95% of the total coastal and marine catch of Bangladesh. The mangrove also supports offshore and deep sea fisheries by playing a significant role as nursery ground for many deep sea fishes and shrimps including the giant tiger shrimp (*Penaeus monodon*) which is the major species of the industrial bottom trawl fishery of Bangladesh. The mangrove also contributes significantly in shrimp farming which has been the most significant export-oriented industry since the 1970s.

The Sunderbans has a huge range of fish, crabs, shrimp, lobster, pelecypods, gastropods species. It contributes 2%–5% of the total capture fisheries in Bangladesh. Its water body support 27 families and 53 species of pelagic fish, 49 families and 124 species of demersal fish, 24 species of shrimps, 7 species of crabs, 2 species of gastropods, 6 species of pelecypods, 8 species of lobsters, and 3 species of turtle. So to maintain the water quality is very important in this area.

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Estuaries are important segment of biogeochemical cycle as they regulate the amount of river-borne major and minor elements entering the coastal environment and ultimately the deep ocean. Estuarine ecosystems are complex and dynamic due to strong gradients in chemical composition of water, variable suspended matter concentration and complex hydrodynamic processes. When river water mixes with seawater, different types of physical and chemical processes take place that may affect the partitioning of trace metals between particulate and dissolved phases and hence the composition of the deposited sediments (Forstner, 1983).

The existence of the mangrove has increased the values of other coastal and marine resources such as the coastal and marine fisheries by increasing productivity and supporting a wide biological diversity. The artisanal fishery, which is highly influenced by mangroves, has been contributing 85–95% of the total coastal and marine catch of Bangladesh. The mangrove also supports offshore and deep sea fisheries by playing a significant role as nursery ground for many deep sea and shrimps including the giant tiger shrimp (*Penaeus monodon*) which is the major species of the industrial bottom trawl fishery of Bangladesh. One-third of the country's population is dependent on Sundarbans with over 3.5 million people from the surrounding areas depend directly or indirectly on the Sundarbans for their livelihood, the forest has been reducing alarmingly day by day.

The Sundarbans today is wholly surrounded and pressured to the landward side as an island by human communities and their agricultural and commercial activities. Coastal polders have been commissioned since 1968 in the immediate upstream catchments to enhance agricultural productive potential of land by protecting it from saline intrusion. However, the operation and maintenance cost of the polders are very high and most of them are in very bad condition impeding natural drainage of freshwater into western Sundarbans (PDO-ICZMP, 2005). Commercial shrimp farming inside the polder areas has emerged as a major economic activity of the ever increasing population during the last two decades. It is ranked as the second largest export item of Bangladesh. Major barrages have been built in the upstream to divert freshwater. Industrial activity near the upstream river system as well as nearby second largest seaport has expanded. Islam and Wahab (2005), Agrawala *et al.* (2003) and Amin (2003) notes that the Sundarbans mangrove has been under intensive pressure of exploitation for the last few decades which, in addition to direct clearance and conversion, have placed the mangrove

ecosystem under extreme threat. It is believed that the energy flux of the ecosystem has changed due to changes in the tidal behaviour, the intensity of the annual floods and the sediments they bring with them, differing levels of salinity and industrial and maritime pollution (Syed *et al.* 2001). Recently the importance of estuarine processes in modifying the chemistry of the materials accumulating and passing through this interface has been realized. Several geochemical processes, such as precipitation and flocculation of the dissolved and colloidal substances (Coonley *et al.* 1971; Sholkovitz, 1976 and Gobeil *et al.* 1981) desorption-adsorption phenomenon, chemical diagenesis, and exchange with the bottom sediments (Yeats and Bewers, 1982) have been studied within the mixing zone.

Passur has influence on the Bhairab and is connected with Gorai-Madhumati systems through Atarabanki and Nabaganga Rivers. The Gorai-Madhumati is the major spill river of the Ganges and carries out 12 % of flow of the Ganges (Hussain and Acharya, 1994). The Rupsha-passure river System flow through the middle part of the sundarban mangrove forest and serves as the lifeline for millions of people inhabiting the mangrove dominated Sundarbans. Different types of industries, agricultural land, fish farm, shrimp farm, are situated on the banks of the Rupsha River. A considerable quantity of toxic and hazardous substance is released into this important aquatic system through these industrial effluents along with huge organic load emanating from agricultural and shrimp culture activities and several non-point sources (such as discharges from fishing vessels and trawlers and run-off from adjacent landmasses). Though its huge importance as a forest for its plants, animals and mangrove fishery but there is very limited information regarding its soil and water conditions especially about the nutrient dynamics of this vital water body. So the present study has been undertaken to know some physico-chemical parameters specially the nutrients load of the mangrove water body specially Rupsha-passure river system.

1.2 Objectives of the study

1. To measure NO_3 , PO_4 , NH_4 and SO_4 at different depths and locations of Rupsha-Passur river system.
2. To determine tidal and seasonal fluctuations of nutrient concentration from upstream to downstream.
3. To analysis probable reasons of nutrient variation and its effect to the coastal environment.



CHAPTER-TWO

REVIEW OF LITERATURE

Chapter-2

2.0 Literature Review

The Gorai River is the main tributary of the Ganges which supplies downstream freshwater to the Sundarbans and ensures the ecosystems balance in the coastal region. Since the diversion of the Ganges water at Farakka Barrage in India from early 1975, the salinity level has increased drastically in the south western part of the region. Due to the reduction of the Ganges flows the industries are facing serious problems. Inequality control of the products and fragile affects are demonstrating on agriculture, fisheries, navigation, and hydromorphology, quality of drinking water and mangrove wetlands ecosystems.

Islam (2008), conducted a study on Cultural Landscape Changing due to Anthropogenic Influences on Surface Water and Threats to Mangrove Wetland Ecosystems: A Case Study on the Sundarbans, Bangladesh. He Found that, about 170,000 hectares (20.4%) of new land has been affected by various degrees of salinity during the last three decades. Islam also found that about 38 % of the country's territory and 33 % of its population is already affected by salinity intrusions.

Wahid *et al.* (2006), studied on hydrologic monitoring and analysis in the Sundarbans mangrove ecosystem, Bangladesh. They observed that the concentrations of $\text{NH}_3\text{-N}$, $\text{NH}_4\text{-N}$ and Total Ammonia from March 2001 to January 2003 at 16 monitoring locations in the Sundarbans. They found that $\text{NH}_3\text{-N}$ varies between 0.001 and 0.330 mg/L, with an average concentration of 0.054 mg/L, while concentration of $\text{NH}_4\text{-N}$ varies between 0.040 and 6.74 mg/L, having an average concentration of about 2.218 mg/L. They listed that the average concentration of Total Ammonia ($\text{NH}_3 + \text{NH}_4$) is found to be 2.269 mg/L. Concentrations of Total Ammonia exceeding 3 mg/L are found at some locations from April to June, which indicate sporadic organic pollution at these locations. However, it is seen that almost all of the Total Ammonia remains in its ionic form ($\text{NH}_4\text{-N}$), which indicates (taking temperature into consideration) that the pH of the river system is around 7.5 (and never less than 7), i.e. the river water is alkaline. They observed that the Presence of non-ionized Ammonia ($\text{NH}_3\text{-N}$) in very low proportion is an indication of good quality of river water with respect to Ammoniacal Nitrogen inside the Sundarbans. Although $\text{NH}_3\text{-N}$ does not show any distinct seasonal pattern, concentration of $\text{NH}_4\text{-N}$ and Total Ammonia show a seasonal pattern having the maximum concentration around April- May, and minimum concentration around

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October–November, as observed for BOD and COD. $\text{NO}_3\text{-N}$ concentrations are found to vary between 0.1 and 2.0 mg/L with an average of 0.461 mg/L. These concentrations are indicative of little or no human intervention of the river system. They do not found any distinct seasonal pattern of $\text{NO}_3\text{-N}$. they found Phosphate concentrations as $\text{PO}_4\text{-P}$ are generally low and vary from 0.009 to 0.582 mg/L, average being 0.115 mg/L. As for the $\text{NO}_3\text{-N}$, no distinct seasonal pattern of $\text{PO}_4\text{-P}$ could be observed with the available data. Water quality parameters are compared between coastal and internal river waters based on average of 215 water samples collected over a period of 20 months. They are observed that BOD, COD, Total Ammonia and $\text{NO}_3\text{-N}$ are higher near the coast than in the internal river water while the average concentration of $\text{PO}_4\text{-P}$ in the coastal area is slightly lower than in the internal river water.

Mukhopadhyay *et al.* (2006), studied on Fluxes of nutrients from the tropical River Hooghly at the land–ocean boundary of Sundarbans, NE Coast of Bay of Bengal, India. They said stated that the Ganges drains much of the southern slopes of the Himalayas and yields high-suspended sediment load during the monsoon. They observed that the Hooghly estuary, the first deltaic offshoot of the Ganges and flows through the western part of the Sundarbans mangrove forest is a source for inorganic nutrients due to the high input of litter and sediment associated nutrients that are released during estuarine transport. Dissolved inorganic carbon (DIC), dissolved inorganic nitrogen (DIN), dissolved reactive phosphate (DRP) and silicate budgets and fluxes of the coastal zone of the Hooghly River system have been done by biogeochemical modeling and their annual fluxes were calculated to be $230 \times 10^9 \text{ mol}$ ($2.76 \times 10^6 \text{ t}$), $4705 \times 10^6 \text{ mol}$ ($65.8 \times 10^3 \text{ t}$), $415 \times 10^6 \text{ mol}$ ($12.8 \times 10^3 \text{ t}$), $15.28 \times 10^9 \text{ mol}$ ($42.8 \times 10^3 \text{ t}$), respectively. Out of the total transport, monsoonal runoff could account 64% for DIC, 71% for DIN and 76% for both DRP and silicate. Annual load of sediment out of the estuary to the NE coast of Bay of Bengal was estimated to be $65.19 \times 10^6 \text{ t}$. They stated that, during the estuarine transport 7.5% of DIC and 7.0% of silicate were removed while addition for DIN and DRP were found to be 59% and 44%, respectively. They listed that the Occurrence of light limited conditions and auto-heterotrophic coupling within the estuary results regeneration of nutrients from organic matter originated from external source. They comprised with the estimates of nutrient fluxes through the some mangrove dominated Southeast Asian estuaries.

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PDO-ICZMP (2005), revealed that the Sundarbans today is wholly surrounded and pressured to the landward side as an island by human communities and their agricultural and commercial activities. Coastal polders have been commissioned since 1968 in the immediate upstream catchments to enhance agricultural productive potential of land by protecting it from saline intrusion. However, the operation and maintenance cost of the polders are very high and most of them are in very bad condition impeding natural drainage of freshwater into western Sundarbans.

Mitra *et al.* (2011), conducted a study on spatial and Tidal Variations of Physico Chemical Parameters in the Lower Gangetic Delta Region, West Bengal, India. They stated that the sulphate values in the Lower Gangetic Delta Region, West Bengal, India ranged from 497 to 1200 mg/l during high tide condition and 349 to 1106 mg/l during low tide condition. They observed significant spatial and tidal variations of sulphate in the estuarine stretch of the delta complex. They listed that Sulphate exhibited a higher concentration in the downstream stations under the influence of seawater mixing. The relatively lower concentration of sulphate in the upper estuarine stretch may be due to consumption of the anion by paddy fields along the upstream stations, whereas removal is compensated in the lower part of the estuary by the contribution of seawater and decay of organic matter from mangroves.

Ramanathan *et al.* (1993), studied on environmental geochemistry of the Pichavaram mangrove ecosystem (tropical), southeast coast of India. They stated that the seawater input along with resuspension mixing (turbidity and mixing) of decayed organic matter and oxidation of buried biogenic materials result in enhanced sulphate levels in mangrove waters. They observed that the sulphate value is generally higher during high tide due to the intrusion of seawater from Bay of Bengal which has high concentration of sulphate ions than river water. The nitrate values ranged from 14.67 to 29.89 $\mu\text{g}/\text{l}$ during high tide and 15.88 to 33.99 $\mu\text{g}/\text{l}$ during low tide. Phosphate values ranged from 1.56 to 4.77 $\mu\text{g}/\text{l}$ during high tide and 1.76 to 5.22 $\mu\text{g}/\text{l}$ during low tide.

Datta *et al.* (2008), conducted a study on Chemical flux to the coast of Bangladesh= a review. They listed that the state of chemical flux to the coast of Bangladesh from ex-situ, in-situ point and non point sources of geogenic and anthropogenic origin. Except for ex-

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situ chemical flux, no in-situ chemical flux to the coast of Bangladesh had been studied. The major elemental dissolved flux contributed by the Ganges-Bhramaputra-Meghna(GBM) river system to the coast of Bangladesh for about 5% ($\sim 152 \times 10^6 \text{ t.yr}^{-1}$) of the annual global dissolved chemical flux to the oceans by river. The river system also contributes $\sim 115 \times 10^3 \text{ t.yr}^{-1}$ of dissolved fluoride and $\sim 105 \times 10^3 \text{ t.yr}^{-1}$ of dissolved phosphate to the coast of Bangladesh. The GBM river system is also one of the highest sediment dispersal system of the world and transports about 1060 million tons of sediment to the coast of Bangladesh each year. Studies also showed that DDT in zooplankton, fish and bottom sediments from the Bay of Bengal also occurs in the range of 4.0 to 5.9 ppb 0.3 to 8.6 ppb and 0.032 to 720 ppb respectively. Since the coastal ecosystem is sensitive to chemical changes in the aquatic environment, estimation of chemical flux to the coast of Bangladesh is important.

Wulff and Stigebrandt (1989); Boynton *et al.* (1995); IGBP (1997) and Uncles *et al.* (1998), studied separately that as the chemical fluxes change they may significantly alter the metabolism, biogeochemical cycling of the coastal system. From individual river basin and coastal zone studies e. g. the Baltic region, Mississippi River, Gulf of Mexico, North Sea, Northern Adriatic, the Black sea it was observed that coastal eutrophication was a consequence of elevated levels of waterborne nutrients. However, while it is relatively straightforward to monitor a river's nutrient flux to its receiving estuary, estimation of the subsequent nutrient flux to the coastal zone is much more difficult, owing to the complex dispersive transport resulting from tidal action and biogeochemical processes involved. These processes include inputs of high concentration of nutrients and additions and removals (e.g. particle mediated sorption, particularly in the vicinity of the turbidity maximum)

CHAPTER-THREE

MATERIALS AND METHODS

3.0 Materials and Methods

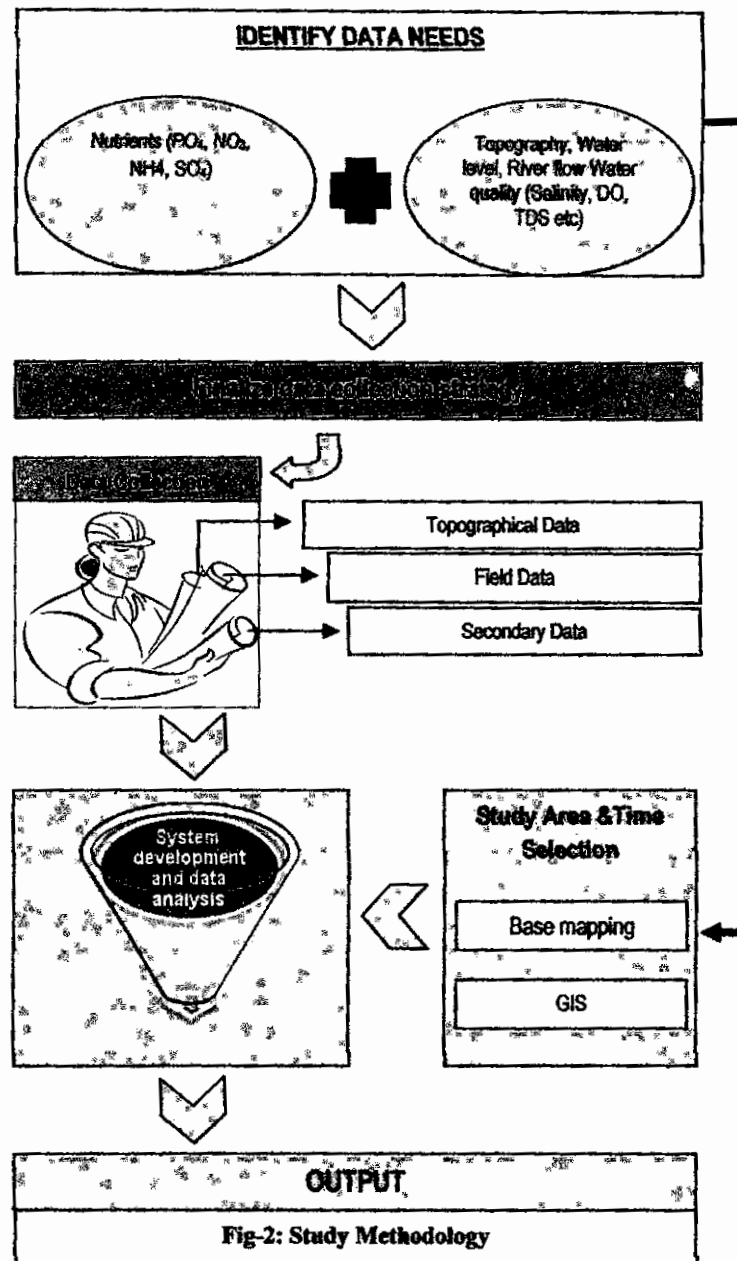


Fig-2: Study Methodology

3.1 Study area

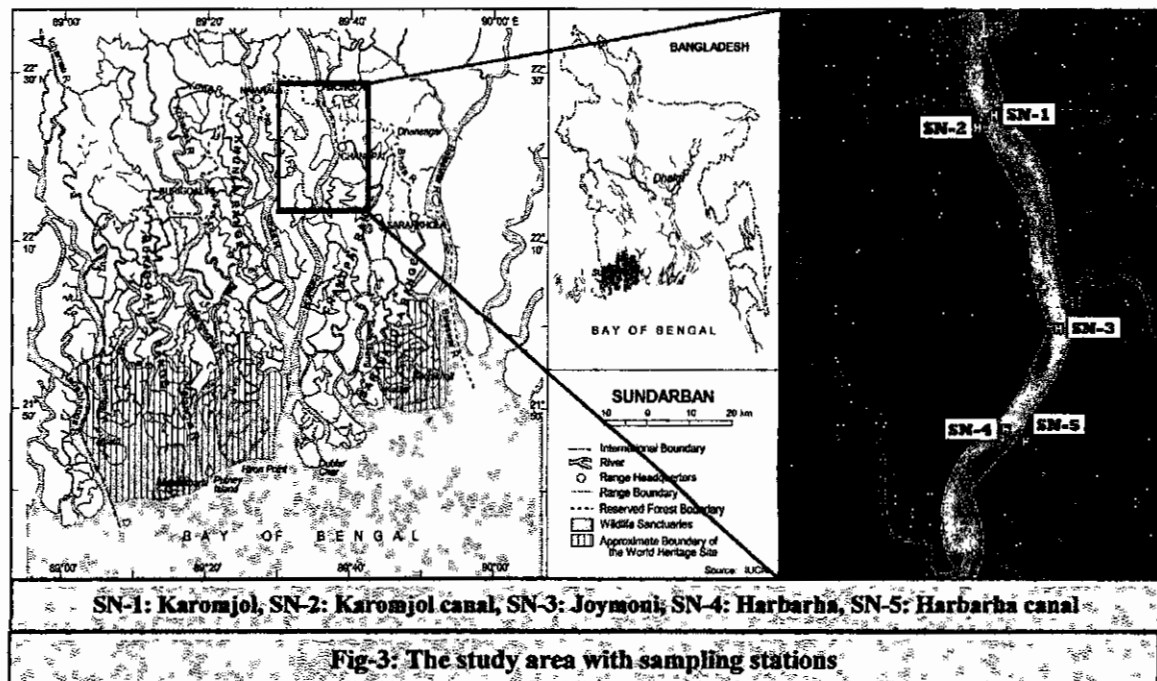
The Passur River is situated in the Central part of Sundarbans. The river originates from the Ganges river system. A large number of channels and creeks flow into larger rivers in the Sundarbans. The largest of these rivers are the remains of the Ganges which has shifted eastward and the Gorai River the main tributary of the Ganges is connected to Passur River and indirectly with Sibsa River which are playing an influential role in the Sundarbans ecosystems.

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Passur has influence on the Bhairab and is connected with Gorai-Madhumati systems through Atarabanki and Nabaganga Rivers. The Gorai-Madhumati is the major spill river of the Ganges and carries out 12 % of flow of the Ganges (Hussain and Acharya, 1994). The total length of the Study area is about 15.71 km. Water samples were collected from Cadpai Range (Rupsha-passure River System), the middle part of Sundarbans (polyhaline zone) of Bangladesh. The depth of the study area varied between 3.96 m and 9.14 m. Five sampling station in Passur River were selected. Details of sampling Station with longitudes, latitudes, average water depth during high and low tide of sampling point are listed below:

Table-1: Name of different sampling station with longitude and latitude.

Sampling station	Longitude	Latitude	Water depth(m)	
			High Tide	Low Tide
Karomjal	89°35'57.86"E	22°25'54.98"N	5.2832	4.1656
Karomjal canal	89°35'24.21"E	22°25'43.22"N	5.2324	3.9624
Joymoni point	89°37'49.65"E	22°20'51.35"N	7.0104	5.8928
Harbaria	89°36'17.67" E	22°17'57.59" N	9.144	7.7216
Harbarha Canal	89°36'55.72" E	22°17'48.28" N	5.6896	4.4704



3.2 Sampling design and data collection

3.2.1 Selection of sampling station

Five stations (Sn.1, Sn.2, Sn.3, Sn.4 and Sn.5) were selected along the 15.71 km length of passur and were located at the middle and river-canal mixing point of the river (Fig.3). Water samples were taken between 2010 and 2011 at five fixed stations at three depths (surface middle and 0.5m above bottom), covering three seasons: monsoon (June-September), post monsoon (October-January), and Dry Winter (February-May).

3.2.2 In-situ data collection

Data collection took a number of different forms. Seasonal sampling of hydrological and water quality parameters at suitable frequency is carried out through the passur river inside the forest during 2010-2011. River water level, flow, salinity, pH and water sample for water quality analysis are included in the sampling program. Depth and tidal fluctuation of rivers were measured by a marked rope which was attached with a heavy weight. Sampling water was collected into the three layer of the water column (surface, mid and bottom). It was collected by a water sampler. Temperature, pH, DO, TDS and conductivity were determined in the field by the multi parameter kits. Salinity was estimated by a refractometer. The flow of the water was measured by a current meter. Transparency of the water was measured by a secchi disk. The samples were collected in three different seasons- monsoon, Post monsoon and dry during the time of high and low tide from October, 2010 to September, 2011.

3.2.3 Collection of water sample for Ex-situ data analysis

Sampling water was collected into the three layer of the water column (surface, mid and bottom). It was collected by a water sampler for nutrients. Then the sample was poured into the 250 ml plastic bottles, immediately preserved in icebox and carried to the laboratory for analysis. The locations of the stations are shown in Fig.-3. Additionally, a large amount of hydrological data from secondary sources, covering the upstream landward catchments, is collected and compiled into the passur water Information Management System – a custom-tailored database developed as part of the study.

3.3 Data analysis

The samples were analyzed in the water chemistry lab of FMRT Discipline, Khulna University. For the main organic nutrient analysis the following methods were used

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- Phosphate was determined by the ascorbic acid method.
- Ammonia was determined by Nesslerization method.
- Nitrate was also determined by Phenol disulphonic acid method.
- sulfate was determined by ascorbic acid method and
- All were estimated spectrophotometrically.



3.4 Analytical Methods Set up

Before starting work important analytical methods regarding the determination of important water nutrients were carried out for standard by following procedure into the Water Chemistry Research Laboratory of Fisheries And Marine Resource Technology Discipline.

3.4.1 Experiment Name: Determination of ammonia by nesslerization method.

Principle

An alkaline solution of potassium iodide and mercuric iodide in the correct proportion contains potassium mercury-iodide (K_2HgI_2) known as nessler reagent. This reacts with small quantities of ammonia to form a reddish brown colloidal compound which is the basis of a sensitive photometric method.

Apparatus

- a. Colometric equipment: It includes the following
 - 1) Spectrophotometer, for use at 400 to 425 nm and providing a light path of 1 cm or long.
 - 2) pH meter equipped with a high pH electrode.

Reagent

Ammonia free water was used for preparing all reagents, rinsing and making all dilution.

- a. Zinc Sulphate Solution
- b. Rochelle Salt Solution
- c. EDTA Reagent
- d. Nessler Reagent
- e. Stock Ammonium solution

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f. Standard Ammonium Solution

Reagent Preparation

Zinc Sulphate Solution

Dissolve 100 gm of $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ and dilute to 1 litre with distill water.

Stabilizer Reagent

EDTA Reagent: Dissolve 50 gm disodium ethelenediamine tetra acetate dehydrate in 60 ml water containing 10 gm NaOH. If necessary apply gentle heat to complete dissolution. Cool to room temperature and dilute to 100 ml.

Rochelle Salt Solution: Dissolve 50 gm of potassium sodium tetrates tetrahydrate $\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$ in 100 ml water. Remove ammonia usually present in the salt by boiling of 30 ml of solution. After cooling dilute to 100 ml.

Note: Use either EDTA or Rochelle Salt to prevent calcium or magnesium precipitation in undistilled sample after addition of alkaline nessler reagent.

Nessler Reagent: Dissolve 100 gm HgI_2 and 70 gm KI in a small quantity of water and add this mixture slowly, with stirring, to a cool solution of 160 gm NaOH dissolved in 500 ml water. Dilute to 1L.

- Store in rubber stoppered borosilicate glassware and out of sunlight to maintain reagent stability for up to a year under normal laboratory condition.

Procedure

Treatment of Undistilled Sample

1 ml ZnSO_4 Solution was added to 100 ml of sample and mixed thoroughly. Then 0.4 to 0.5 ml 6N NaOH solution was added to it and leave it for few minutes until a precipitate form.

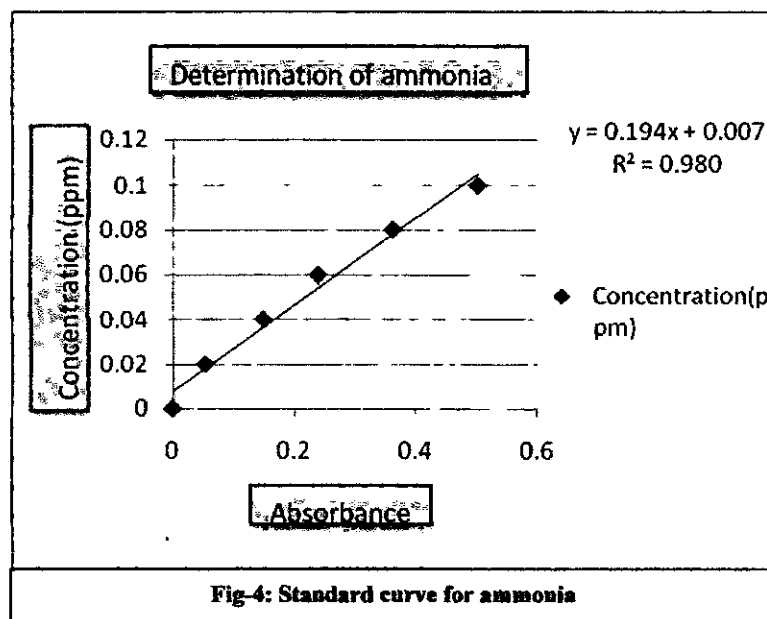
Colour development

50 ml sample or a portion diluted to 50 ml with water was used and 1 drop EDTA reagents or 1-2 drop Rochelle Salt was added and mixed well. Then 2 ml Nessler reagent was added in case of EDTA or 1 ml for Rochelle Salt solution.

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Photometric Measurement

Absorbance or transmittance of the unknown sample was measured with spectrophotometer at 420 nm and was determined from the standard curve.



3.4.2 Experiment Name: Determination of Phosphate by the ascorbic acid method (Blue Method).

Principle

Ammonium molybdate and Potassium antimonyl-tartrate react with orthophosphate in acid medium to form a heteropoly acid phosphomolybdic acid that is reduced to intensely coloured molybdenum blue by Ascorbic acid.

Apparatus

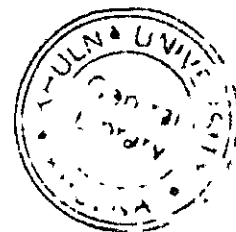
1. Spectrophotometer

Reagents Required:

1. Ammonium paramolybdate $[(\text{NH}_4)_6 \text{Mo}_7\text{O}_{24} \cdot 4 \text{H}_2\text{O}]$
2. Sulfuric acid $[\text{H}_2\text{SO}_4]$

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3. Ascorbic acid [$C_6H_8O_6$]
4. Potassium antimonyl-tartrate [$C_4H_4KO_7Sb.0.5 H_2O$]
5. Anhydrous potassium dihydrogen phosphate [KH_2PO_4]
6. Chloroform [$CHCl_3$]



Reagent Preparation (Strickland and Parsons 1968)

Ammonium molybdate solution: Dissolved 15 grams of ammonium paramolybdate in 500 milliliters of distilled water. Stored in dark plastic bottle. The solution is stable indefinitely.

Sulfuric acid solution: 140 milliliters of concentrated sulfuric acid was Added to 900 milliliters of distilled water. Permitted solution to cool and it was stored in a glass bottle. The solution is stable indefinitely.

Ascorbic acid solution: 27 grams of ascorbic acid dissolved into 500 milliliters of distilled water. It was Stored in freezer in plastic bottle so that solution was frozen. Thaw for use and refreeze at once. The solution is stable for many months. (*Note: should not be kept for more than a week at room temperature*)

Potassium antimonyl-tartrate solution: 0.34 grams of potassium antimonyl-tartrate dissolved in 250 milliliters of distilled water. Stored in glass or plastic bottle. The solution is stable for many months.

Mixed Reagent: 100 milliliters ammonium molybdate, 250 milliliters sulfuric acid, 100 milliliters ascorbic acid, and 50 milliliters potassium antimonyl-tartrate solution was taken together in a dark glass bottle,. This solution will be stable for up to six hours after preparation.

Potassium dihydrogen phosphate (standard): 0.816 grams of anhydrous potassium dihydrogen phosphate dissolved in 1000 milliliters of distilled water. Stored in a dark bottle with 1 ml of chloroform. The solution is stable for many months.

Procedure

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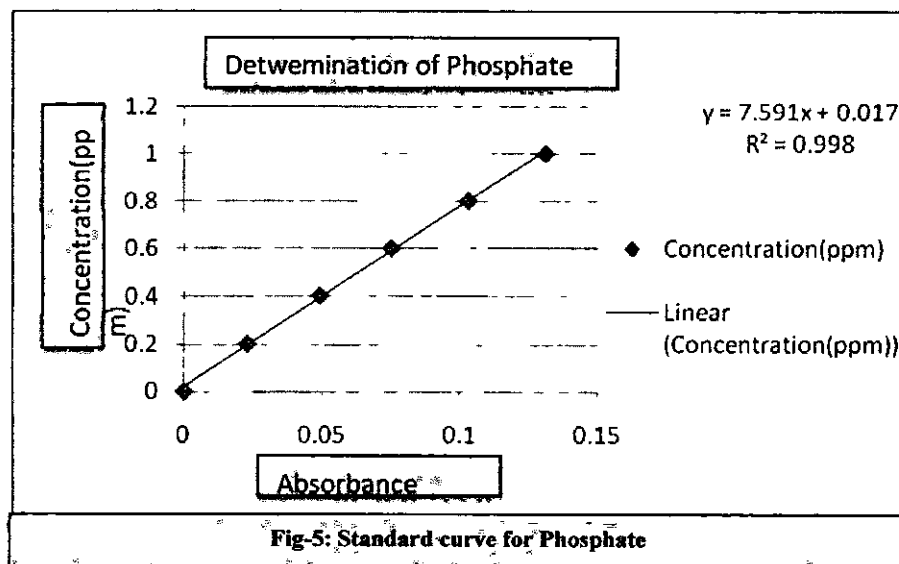
1. 50 mL sample was taken into a conical flask and added .05 mL phenolphthalein indicator.
2. Then 8 mL combined reagent was added and mixed thoroughly.
3. After 10 min. but not more than 30 min. the absorbance of sample was measured at 880 nm using reagent blank as reference.

Preparation of calibration graph

1. Standard phosphate solution was prepared with a concentration ranging from--.
2. Distilled water blank was used with combine reagent to measure absorbance for calibration graph.
3. Plot absorbance vs. phosphate concentration to give a straight line passing through ----

Calculation

$$\text{PO}_4 \text{ mg/L} = \frac{\text{Phosphate in mg} \times 1000}{\text{Volume of sample}}$$



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3.4.3. Experiment Name: Determination of Sulphate by turbidimetry method.

Principle

Sulphate ions are precipitated as barium sulphate in acidic media with barium chloride, absorption of this precipitated suspension then measured by a spectrophotometer.

Apparatus

Colometric equipment: It includes the following

- i) Spectrophotometer, for use at 420 nm and providing a light path of 1 cm or long.
- ii) Stopwatch.
- iii) Nestler's tube (100 ml capacity)

Reagent

- a) Glycerol
- b) Concentrated Hydrochloric Acid (HCl)
- c) Distill Water
- d) Ethyl Alcohol (C_2H_5OH)
- e) Sodium Chloride (NaCl)
- f) Barium Chloride Crystal (BaCl)
- g) Anhydrous Sodium Sulphate (Na_2SO_4)

Reagent Preparation

Conditioning Reagent: Mix 50 ml glycerol with a solution containing 30 ml conc. HCl, 300 ml distill water, 100 ml 95% ethyl alcohol and 75 g NaCl.

Barium Chloride: (Crystal of 20-30 mesh)

Standard sulphate solution (1000 mg/L): Dissolve 1.479 g of anhydrous sodium sulphate (Na_2SO_4) in distill water and dilute to 1000 mg/L.

Procedure

Treatment of Undistilled Sample

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1 ml ZnSO₄ Solution was added to 100 ml of sample and mixed thoroughly. Then 0.4 to 0.5 ml 6N NaOH solution was added to it and leave it for few minutes until a precipitate form.

Colour development

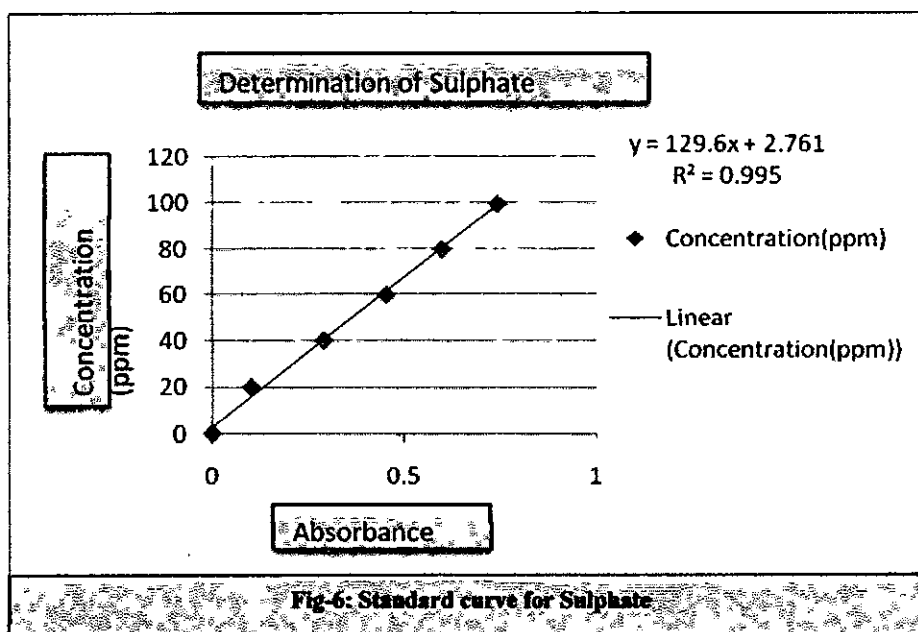
50 ml sample or a portion diluted to 50 ml with water was used and 1 drop EDTA reagents or 1-2 drop Rochelle Salt was added and mixed well. Then 2 ml Nessler reagent was added in case of EDTA or 1 ml for Rochelle Salt solution.

Photometric Measurement

Absorbance or transmittance of the unknown sample was measured with spectrophotometer at 420 nm and was determined from the standard curve.

Calculation

$$\text{SO}_4 \text{ mg/L} = \frac{\text{Sulphate in mg} \times 1000}{\text{Volume of sample}}$$



3.4.4 Experiment Name: Determination of Nitrate by Phenol disulphonic acid method.

Principle

Nitrate in contact with sulphuric acid produces nitric acid which in dry condition (in presence of excess conc. H₂SO₄) brings about nitration of phenol disulphonic acid. This

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nitrophenolic product gives intense yellow colour in alkaline medium which is measured through colorimeter.

Apparatus

Spectrophotometer

Hot water bath

Reagents

phenol disulphonic acid: 25 g of white phenol was dissolved into 150 mL of concentrated sulphuric acid then again added 85 mL of concentrated sulphuric acid. Then it was heated for about 2 hours on a water bath, cooled, and kept the solution in a dark bottle.

Liquor Ammonia: it was diluted with equal volume of water.

Standard nitrate solutions (LR grade): 0.722 g of anhydrous potassium nitrate was dissolved into distilled water to prepare 1 L of stock solution. This stock solution contains 100 mg $\text{NO}_3\text{-N/L}$.

Method

1. 25 mL sample was taken in a porcelain dish and evaporated it to dryness on a hot water bath.
2. 3 mL of phenol disulphonic acid was added to the residue and dissolved the latter by rotating the dish.
3. After 10 minutes, 15 mL of distilled water was added and stirred with a glass rod. On cooling, the contents were washed down into 100 mL volumetric flask.
4. Ammonia (1:1) was added slowly with mixing till the solution was alkaline as indicated by the development of yellow colour due to the presence of nitrate. Then another 2 mL of ammonia was added and the volume made up with distilled water.
5. Intensity of yellow colour was read in the colorimeter at 420 nm (blue filter).
6. 5 mL of distilled water and 1.5 mL of potassium hydroxide solution was taken.

Observations

Preparation of standard curve for nitrate

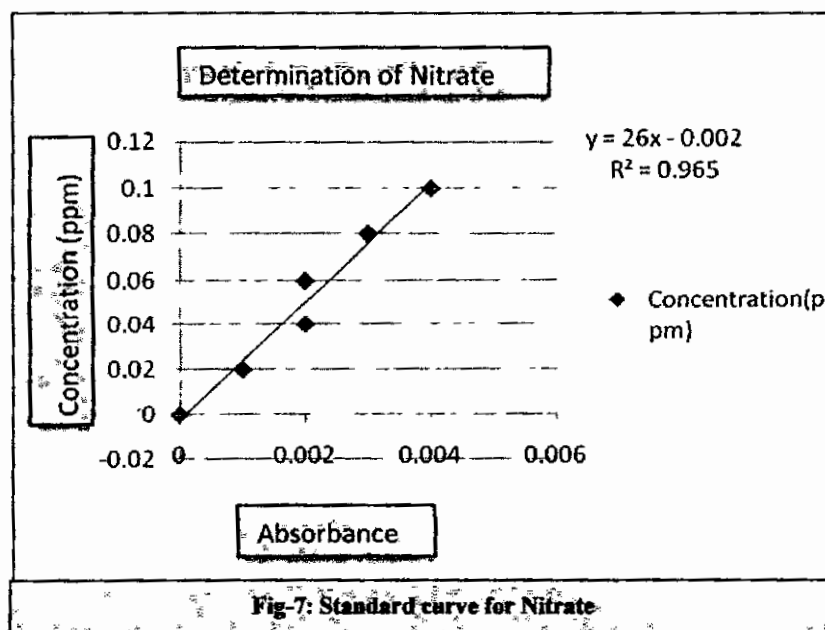
A stock solution containing 100 ppm nitrate-nitrogen (NO_3^-) was prepared by dissolving 0.7215 g of AR grade potassium nitrate (oven-dried and cooled) in distilled water and made the volume to one liter. This was diluted ten times to give a 10 ppm NO_3^- solution. Aliquots were evaporated on boiling water bath to dryness in small porcelain dishes.

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When cooled, 3 mL of phenol disulphonic acid was added and the yellow colour was developed. A blank must be run and correction made by adjusting the colorimeter to zero with blank. A calibration curve was drawn between concentration of NO_3^- and colorimeter reading.

Calculation

$$\text{mg of NO}_3^- / \text{Liter} = \frac{\text{Mg of NO}_3^- \text{ from standard curve}}{\text{mL of sample}}$$





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RESULTS

Chapter-4

4.0 Results

The concentrations of PO_4 , $\text{NO}_3\text{-N}$, $\text{NH}_3\text{-N}$, SO_4 and the overall physical parameters measured in the study period are shown in the table-1 and table-2 respectively.

4.1 Nutrients

4.1.1 Phosphate

The observed concentrations of $\text{PO}_4\text{-P}$ from September 2010 to September 2011 at 5 sampling station in the forest are presented in Table 2. Phosphate concentrations as $\text{PO}_4\text{-P}$ are generally low and vary from 0.107 to 0.254 mg/L during high tide and 0.073 to 0.337 mg/L during low tide in dry winter, 0.057 to 0.435 mg/L during high tide and 0.045 to 0.500 mg/L during low tide in monsoon and 0.374 to 0.764 mg/L during high tide and 0.324 to 1.347 mg/L during low tide in Post monsoon, with an average concentration of 0.323 mg/L. Highest value of $\text{PO}_4\text{-P}$ found in post monsoon and similar value of $\text{po}_4\text{-P}$ found in Dry and monsoon .

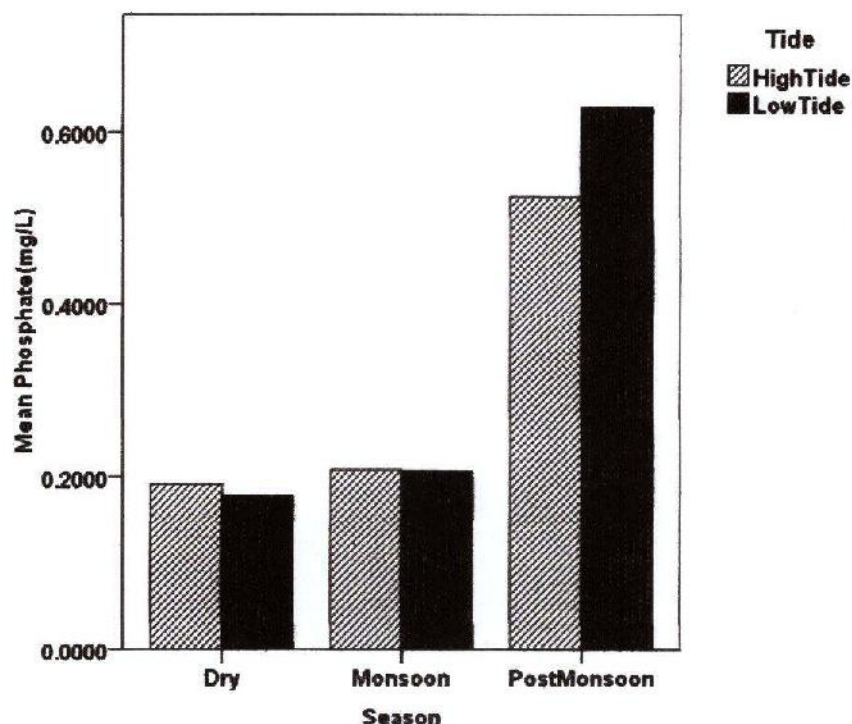


Fig-8: Tidal variation of phosphate in different season.

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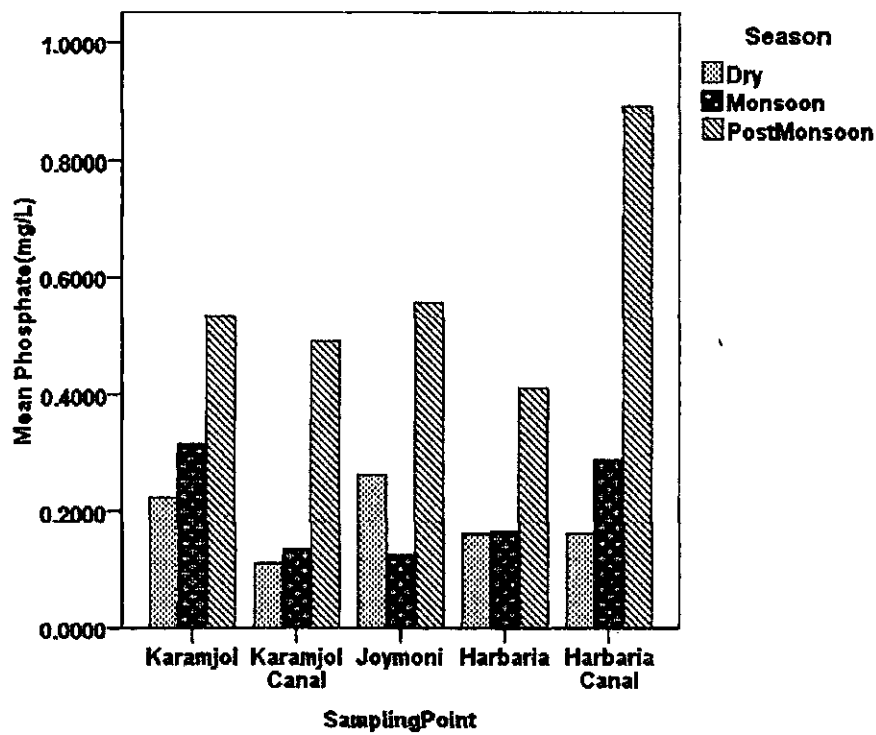


Fig-9: Seasonal variation of phosphate in different sampling station.

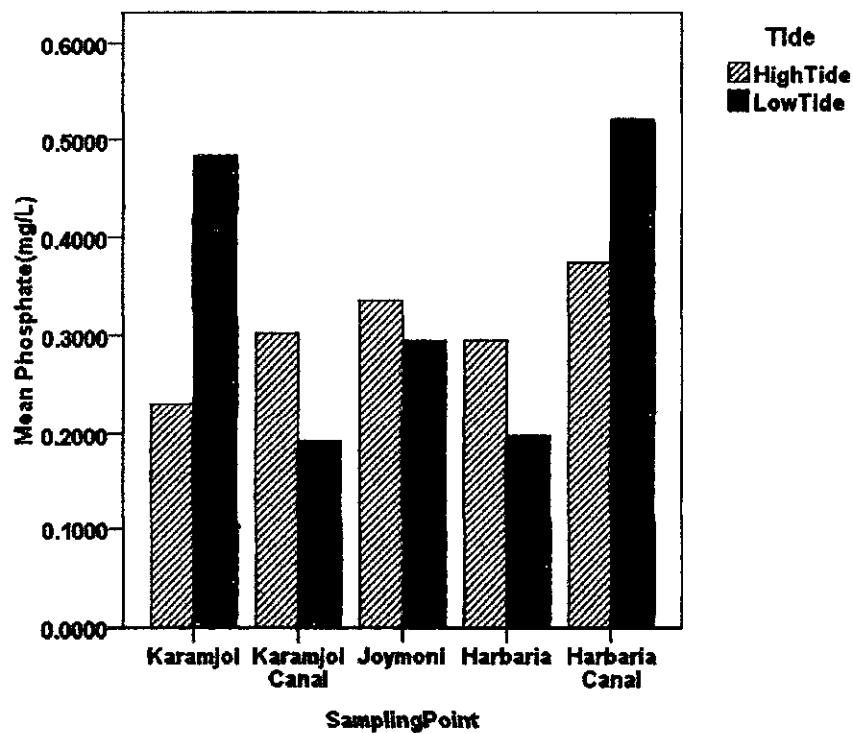


Fig10: Tidal variation of phosphate in different sampling point

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4.1.2 Nitrate

The observed concentrations of nitrate from September 2010 to September 2011 at 5 sampling station in the forest are presented in Table 2. Nitrate concentrations as $\text{NO}_3\text{-N}$ are generally low and vary from 0.033 to 1.233 mg/L during high tide and 0.267 to 0.7 mg/L during low tide in dry winter, 0.024 to 0.037 mg/L during high tide and 0.027 to 0.037 mg/L during low tide in monsoon and 0.497 to 0.968 mg/L during high tide and 0.227 to 0.885 mg/L during low tide in Post monsoon, with an average concentration of

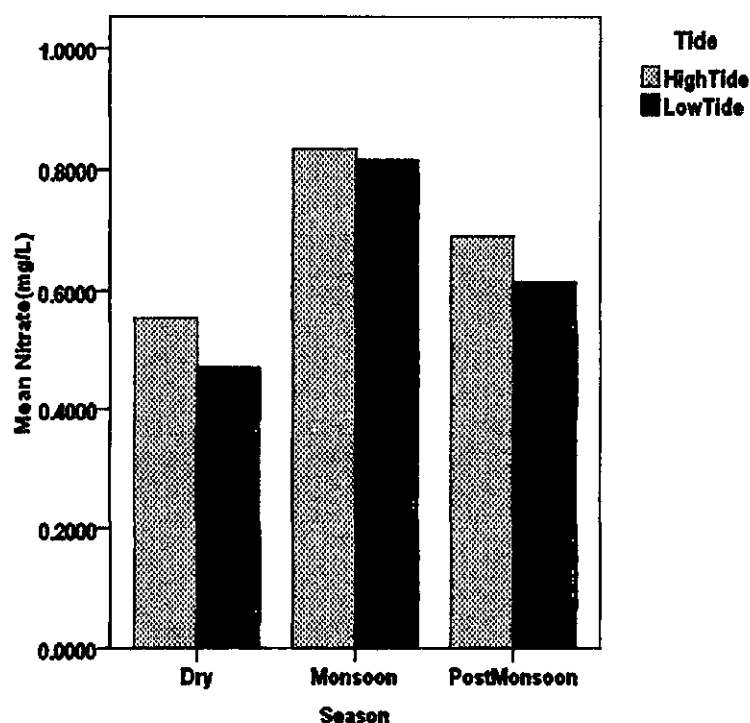


Fig11: Tidal variation of Nitrate in different season.

0.663 mg/L. The highest and lowest value was found in the joymoni and harbaria canal Station of Passur River in the monsoon and Dry season respectively. The tidal variation of $\text{NO}_3\text{-N}$ was also found very irregular pattern. But the highest value was found in the high tide through all seasons.

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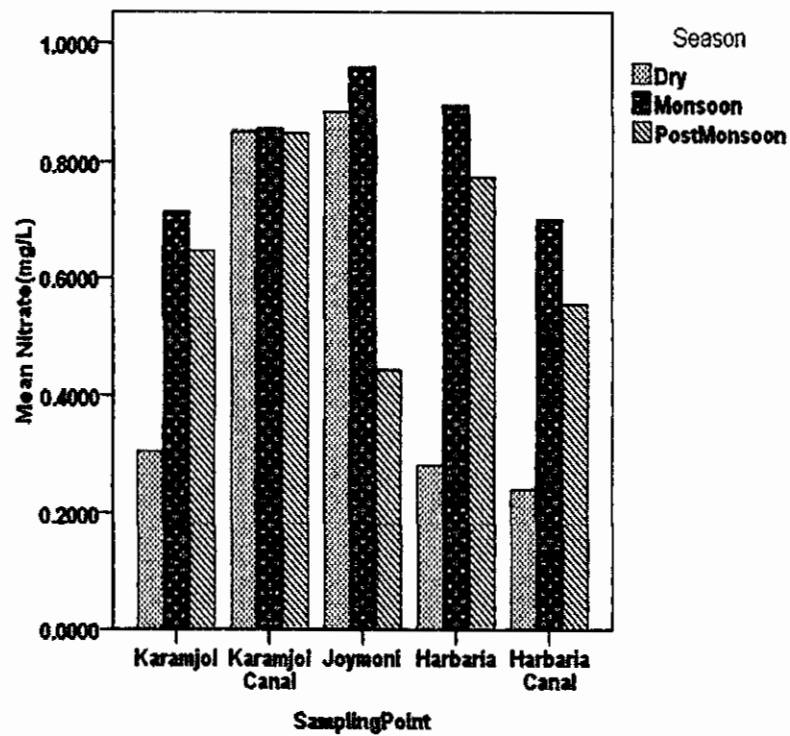


Fig-12: Seasonal variation of Nitrate in different sampling station.

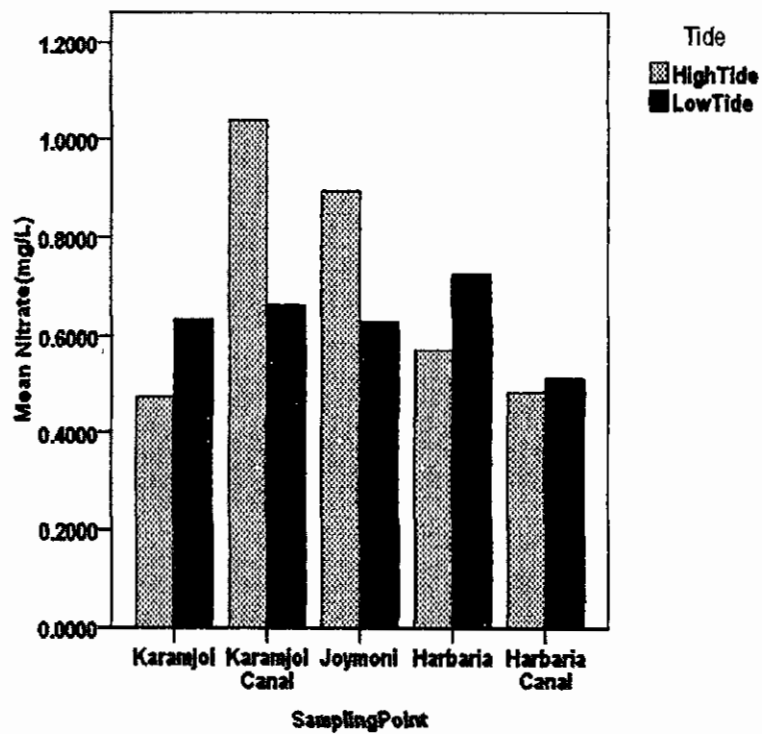


Fig-13: Tidal variation of Nitrate in different sampling point

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4.1.3 Sulphate

Sulphate is a major constituent of seawater and is used as an electron acceptor for the oxidation of organic matter in the absence of oxygen. In the present study the sulphate values ranged from 21.08 to 37.51 mg/L during high tide and 22.55 to 30.47 mg/L during low tide in dry winter, 7.56 to 126.92 mg/L during high tide and 12.488 to 122.26 mg/L during low tide in monsoon and 7.384 to 10.05 mg/L during high tide and 7.301 to 8.421 mg/L during low tide in Post monsoon, with an average concentration of 29.772 mg/L. The sulphate value is generally higher during low tide due to the intrusion of river runoff from upstream which has high concentration of sulphate ions due to anthropogenic input. The maximum concentration of SO_4 was found in herbaria station of Passur River in the monsoon and minimum limit was found in the post-monsoon season and its concentration was found to be raised from upstream to downstream.

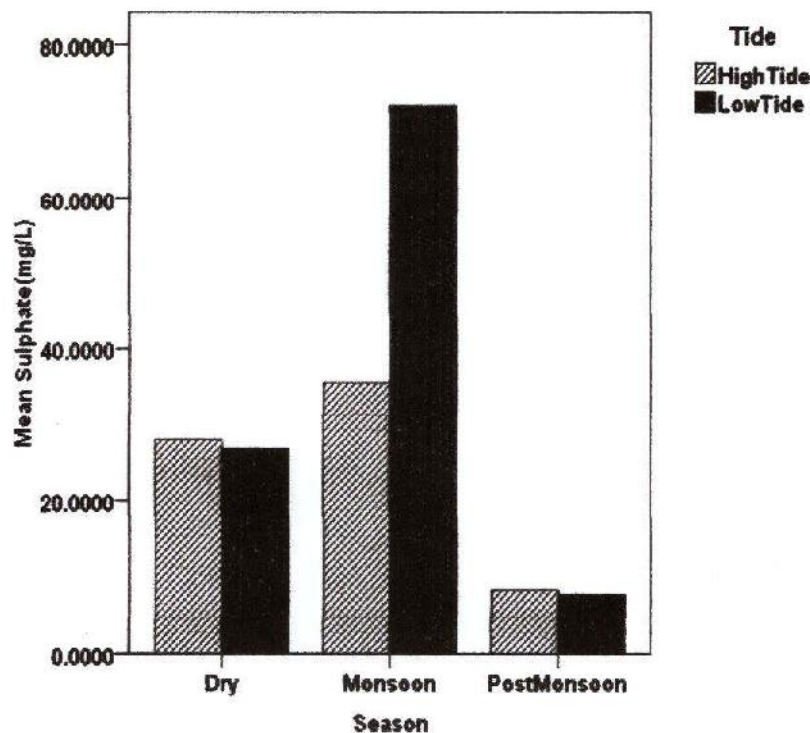


Fig-14: Tidal variation of Sulphate in different season.

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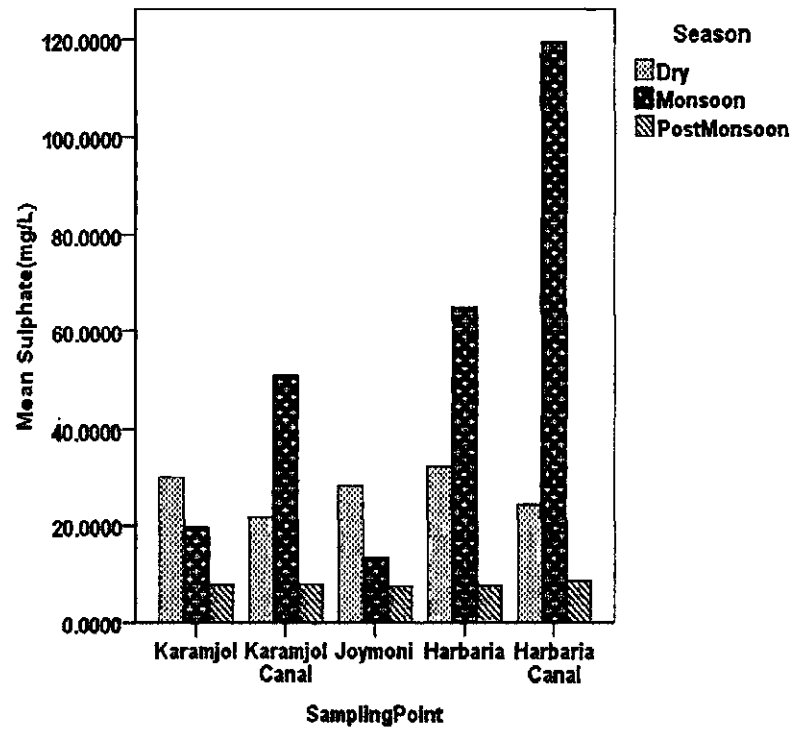


Fig-15: Seasonal variation of Sulphate in different sampling station.

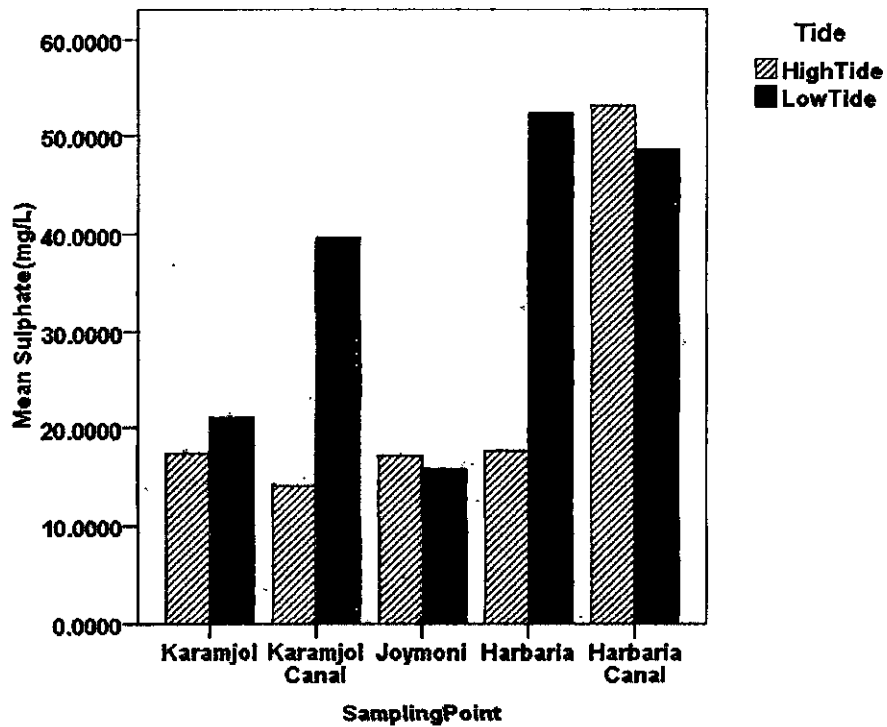


Fig-16: Tidal variation of sulphate in different sampling point

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4.1.4 Ammonia

The observed concentrations of $\text{NH}_3\text{-N}$, $\text{NH}_4\text{-N}$ from March 2001 to January 2003 at 5 sampling station in the forest are presented in Table 2. It is found that $\text{NH}_3\text{-N}$ varies between 0.077 to 0.080 mg/L during high tide and 0.070 to 0.077 mg/L during low tide in Dry winter, 0.013 to 0.018 mg/L during high tide and 0.014 to 0.019 mg/L during low tide in monsoon and 0.034 to 0.054 mg/L during high tide and 0.040 to 0.050 mg/L during low tide in Post monsoon, with an average concentration of 0.016 mg/L. The concentration of $\text{NH}_3\text{-N}$ found higher in the Dry and lowers mostly in monsoon season and in few cases in post monsoon. $\text{NH}_3\text{-N}$ also shows a distinct tidal variation with maximum limit in high tide and minimum limit in low tide.

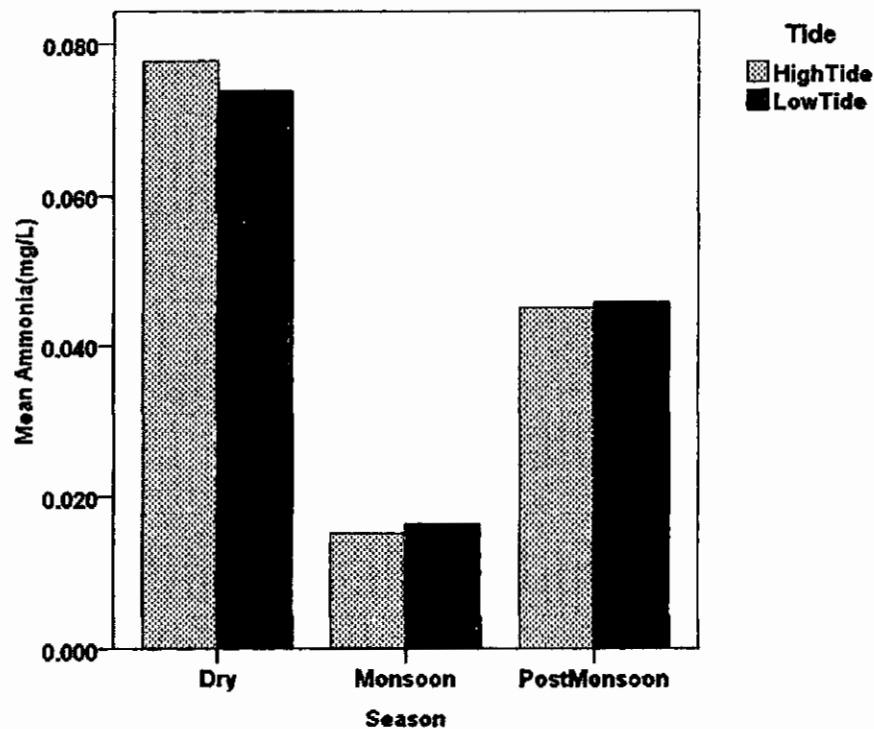


Fig-17: Tidal variation of Ammonia in different season.

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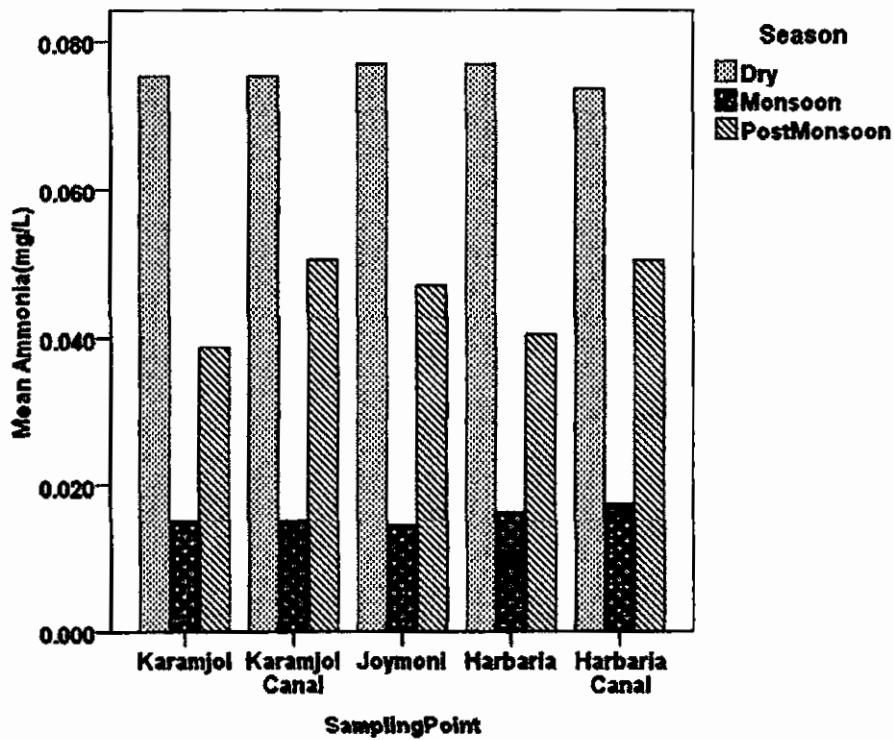


Fig-18: Seasonal variation of Ammonia in different sampling station.

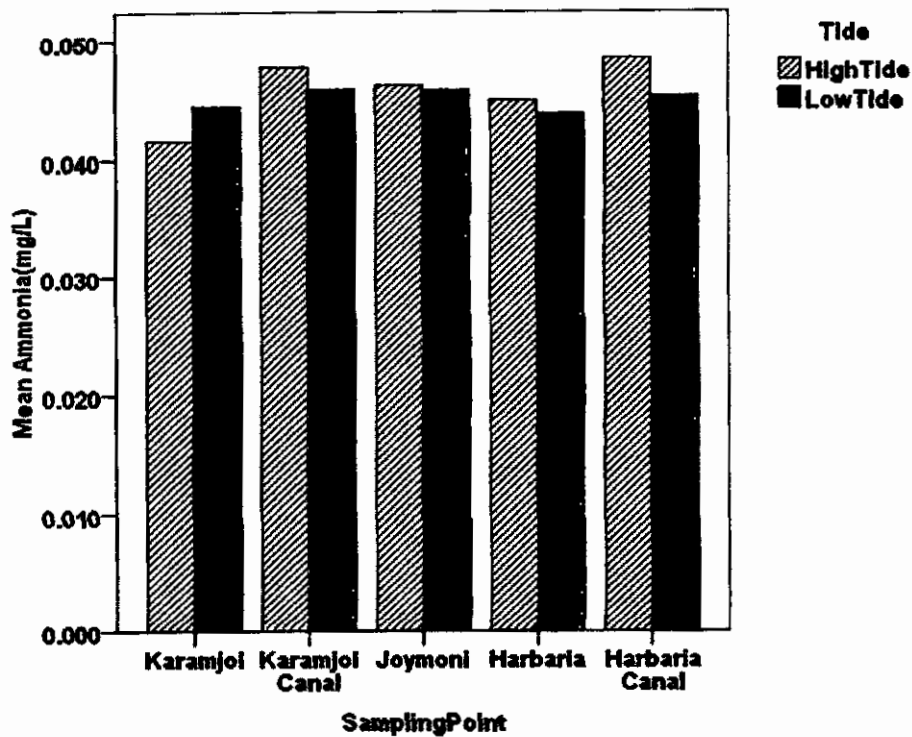


Fig-19: Tidal variation of Ammonia in different sampling point

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4.2 Water Temperature

The water temperature in the study area of Passur River ranged from 19.23°C to 31.57°C with a mean value of 27.15°C. The water temperature found average 29.93°C during high tide and 30.19°C during low tide in post monsoon, 30.05°C during high tide and 31.17 °C during low tide in monsoon and found average temperature 20.97 °C during high tide and 20.57 °C during low tide in dry winter.

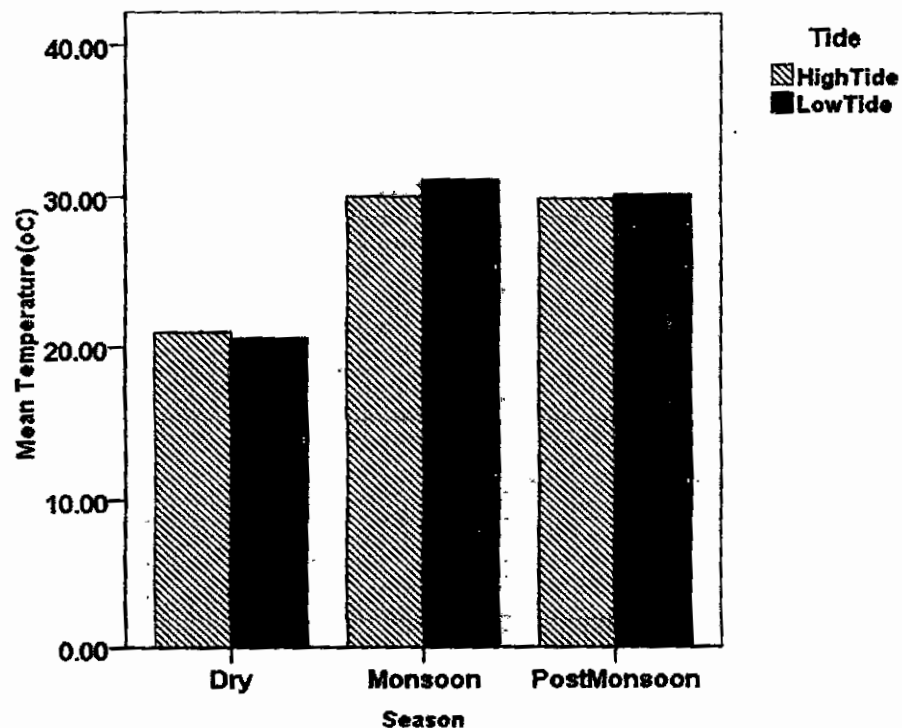


Fig-20: Tidal variation of water Temperature in different season.

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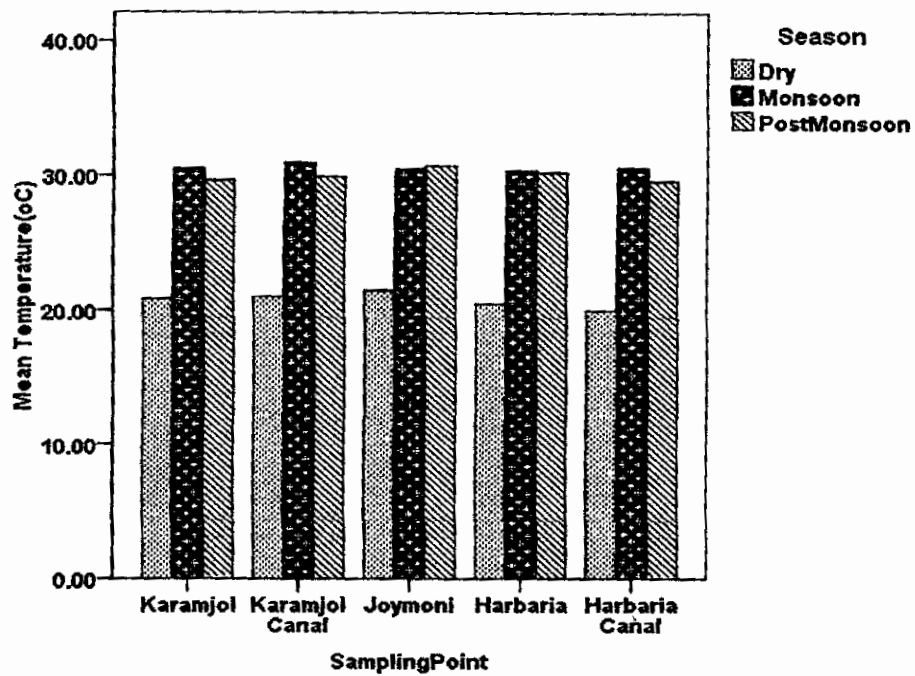


Fig21: Seasonal variation of Temperature in different sampling station.

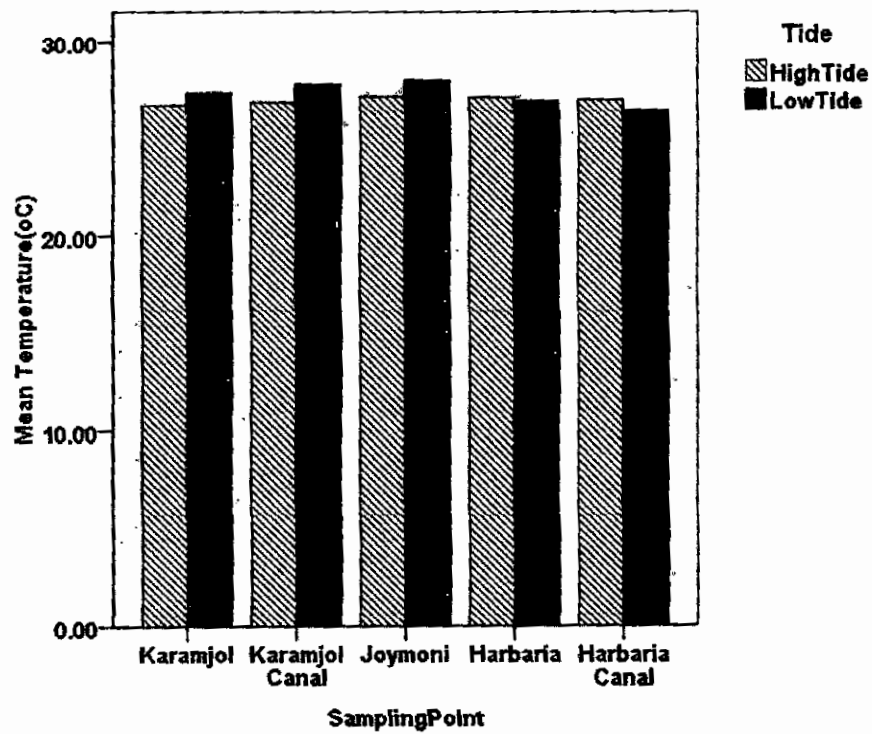


Fig-22: Tidal variation of water Temperature in different sampling point

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The tidal variation of temperature is almost negligible but show significant seasonal variation. Higher temperature found both monsoon and post monsoon season during low tide lower temperature value were observed during dry winter. Temperature level decrease from upstream to down downstream. Lowest value of temperature found in harbarhia canal during low tide (Fig-10).

4.3 Water Salinity

The water salinity values ranged from 13ppt to 10ppt during high tide and 11ppt to 10ppt during low tide in dry winter, 7ppt to 4ppt during high tide and 6ppt to 4ppt during low tide in monsoon and 10ppt to 6ppt during high tide and 10ppt to 7ppt during low tide in post monsoon.

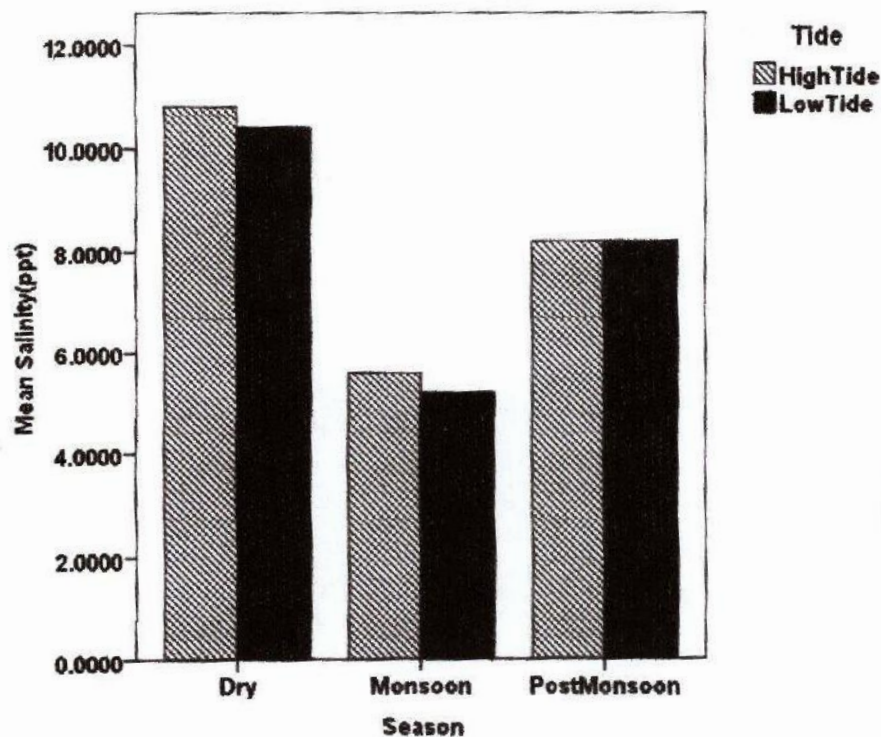


Fig-23: Tidal variation of water salinity in different season.

Significant tidal variation of water salinity (Fig 11) in all the seasons during high and low tide along the river is being regulated by the discharge of freshwater from the upstream. Higher level of salinity found during high tide in dry season.

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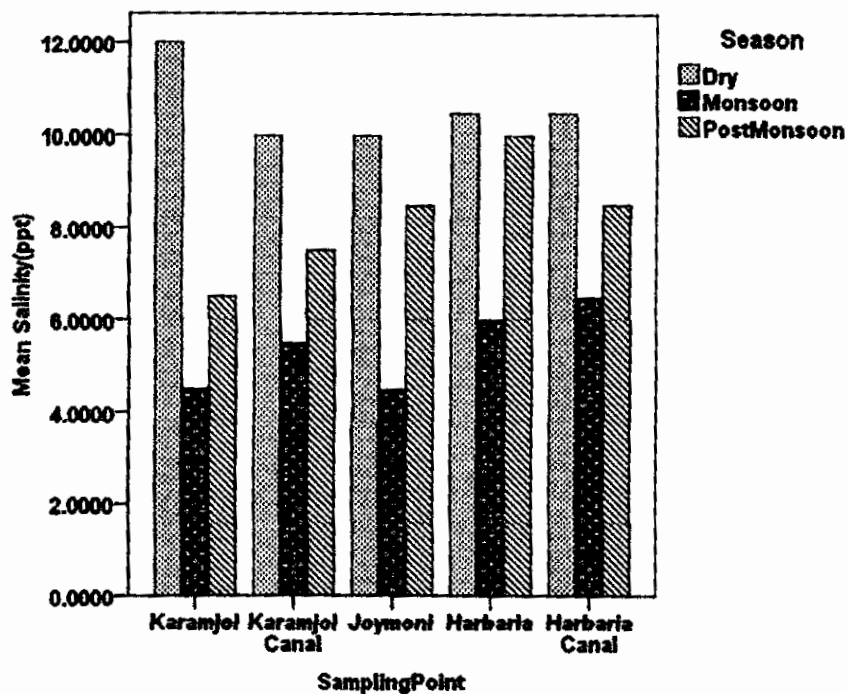


Fig-24: Seasonal variation of salinity in different sampling station.

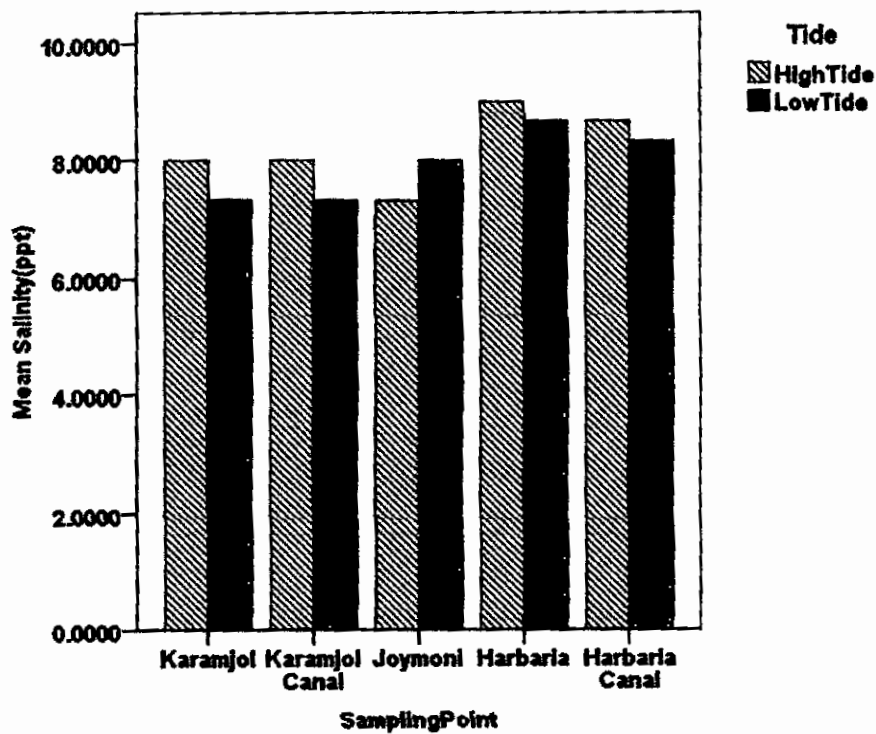


Fig-25: Tidal variation of water salinity in different sampling point

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The salinity values (mean of high tide and low tide) decreased from the downstream to the upstream zone (Figure 13), and the significant spatial variation was found. The discharge of fresh water by the upstream river is responsible for low salinity from upstream to downstream.

4.4 Water pH

The pH of the River Water showed variation within a small range. The values ranged from 7.22 to 7.74 during high tide condition and 7.34 to 7.89 during low tide condition in dry winter, 7.19 to 7.54 during high tide condition and 7.23 to 7.59 during low tide condition in monsoon and 7.73 to 7.83 during high tide condition and 7.77 to 7.97 during low tide condition in post monsoon.

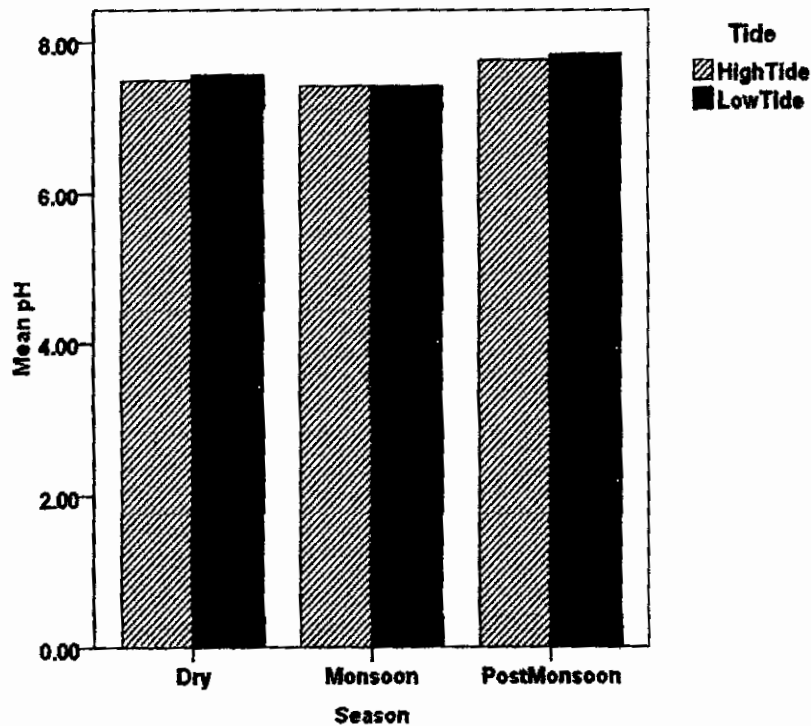


Fig-26: Tidal variation of pH in different season.

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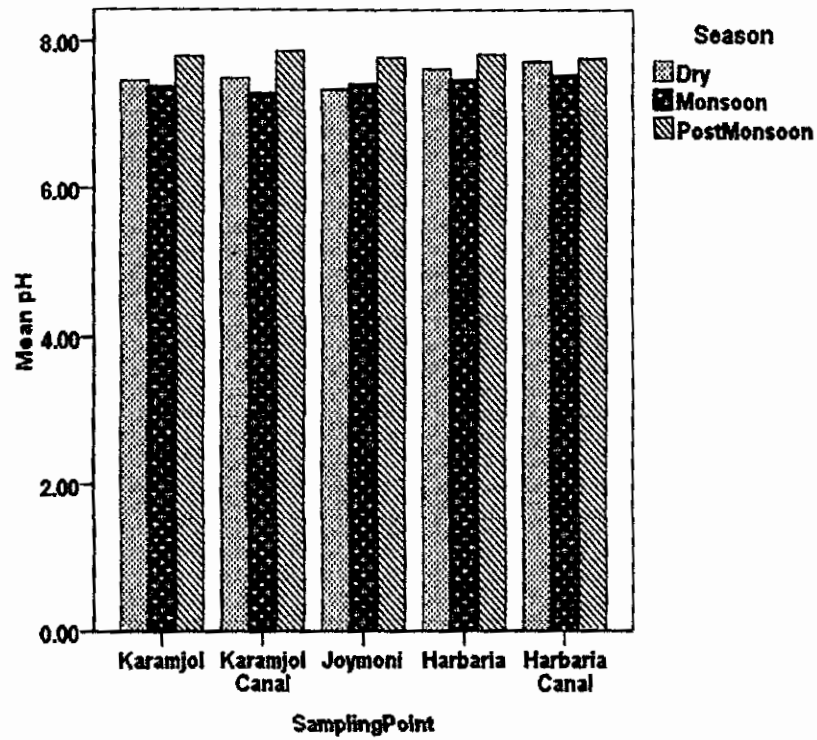


Fig-27: Seasonal variation of pH in different sampling station.

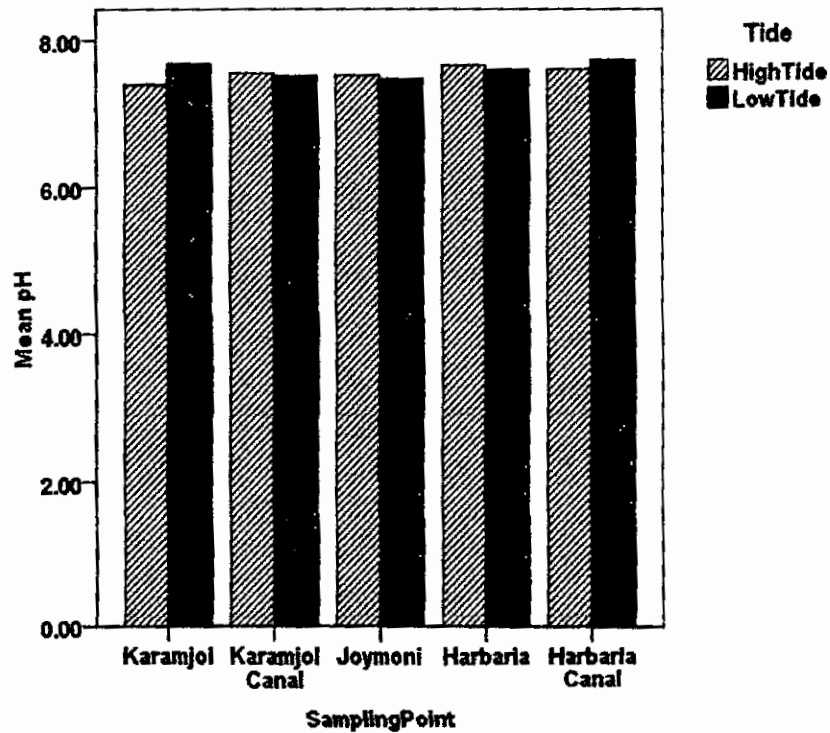


Fig-28: Tidal variation of pH in different sampling point

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4.5 Dissolved Oxygen

Dissolved oxygen values ranged from 5.47 mg/L to 6.43 mg/L during high tide and 5.3 to 7.07 mg/L during low tide in dry winter season, 4.53 mg/L to 5.33 mg/L during high tide and 4.2mg/L to 5.77 to mg/L during low tide in monsoon and 6.97 mg/L to 7.77 mg/L during high tide and 6.27 to 7.13 mg/L during low tide in post monsoon. Its concentration found maximum limit in post monsoon and minimum limit in monsoon.

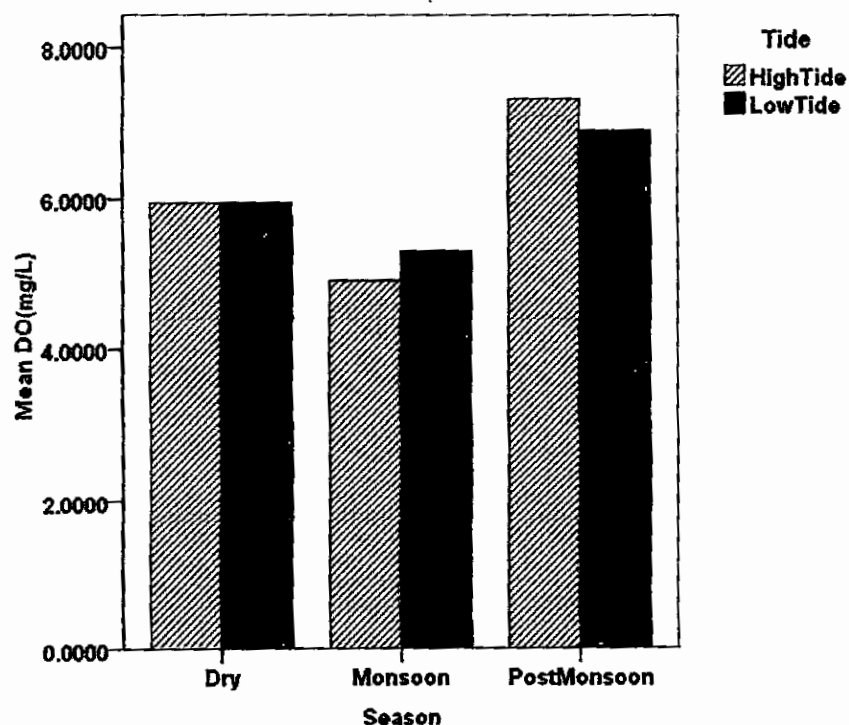


Fig-29: Tidal variation of Dissolve Oxygen in different season.

Its concentration found maximum limit in post monsoon and minimum limit in monsoon (fig 17). The higher values of DO in the upstream stations may be apparently due to DO rich freshwater conveyed through rivers.

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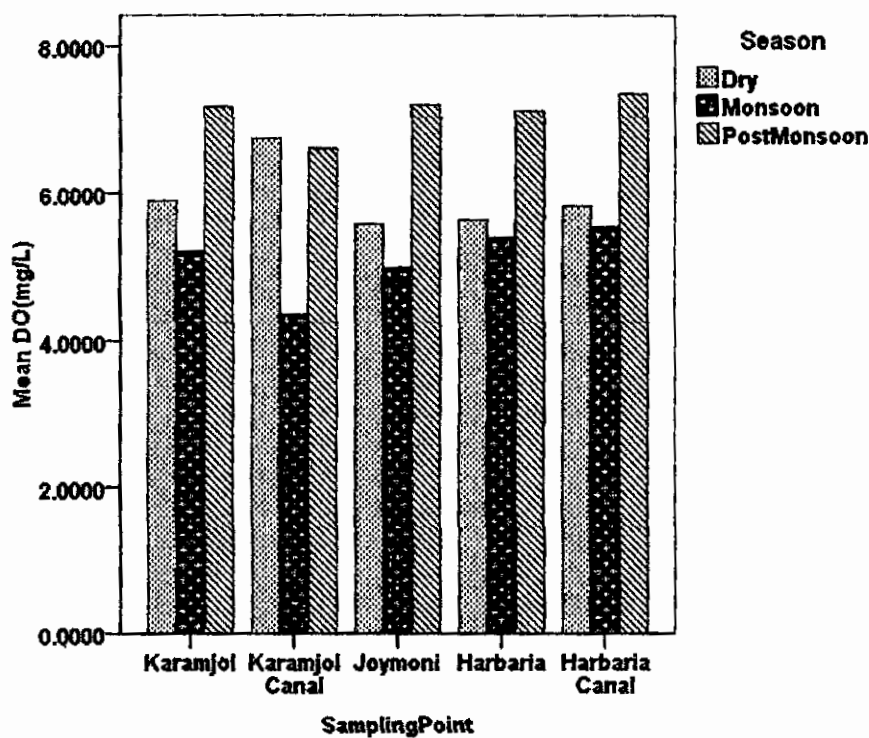


Fig-30: Seasonal variation of Dissolve Oxygen in different sampling station.

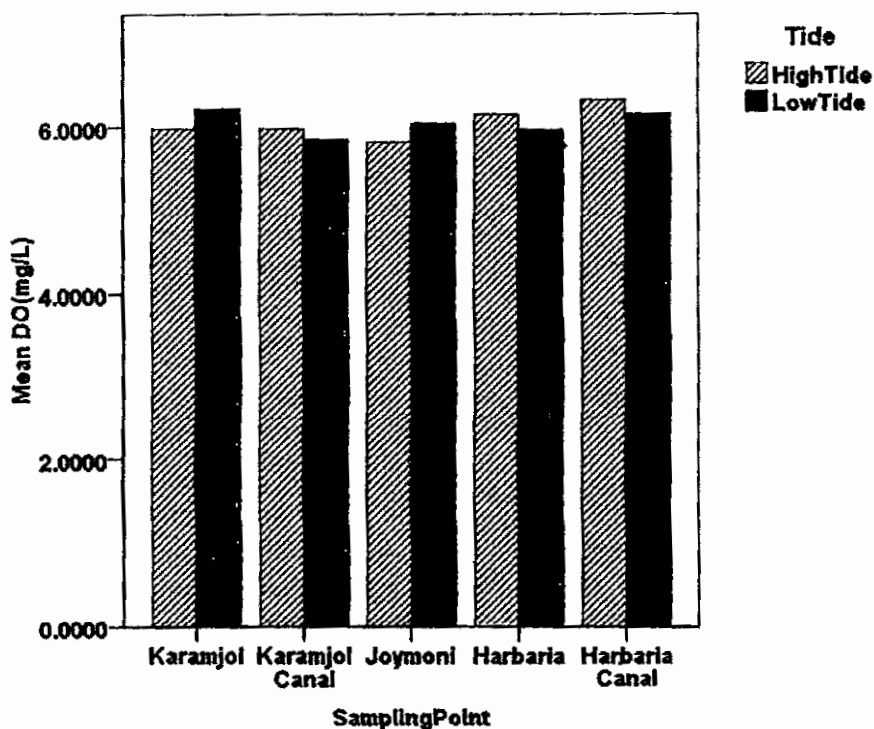


Fig-31: Tidal variation of Dissolve Oxygen in different sampling point

Table-2: Water quality parameter at different depth under different tidal and seasonal condition.

River	Place	Tide	Layer	Temp(°C)			pH			Salinity (ppt)			CO ₂ (mg/l)			DO (ppm)			Depth (ft)	
				Sur	Mid	Bot	Sur	Mid	Bot	Sur	Mid	Bot	Sur	Mid	Bot					
S-1: Post monsoon, S-2: Winter, S-3: monsoon, Sn-1: Karomjal, Sn-2: Karomjal Canal, Sn-3: Joymoni, Sn-4: Harbartha, Sn-5: Harbartha canal	Sn-5	Bot	Mid	28.8	19.1	31.3	7.8	7.8	7.50	8	11	6	8.49	9.85	25.5	6.1	5.7	5.9		
				Sur	30.7	20.8	28.5	7.5	7.7	7.49	9	10	7	4.56	11.1	27.1	8.2	5.3	5.6	21
				Mid	30.1	20.8	29.8	7.9	7.67	7.80	9	10	7	4.67	11.1	27	7.5	5.7	5.2	
	Sn-4	Bot	Mid	30.8	20.8	30.1	7.8	7.33	7.54	9	10	7	4.67	11.1	25.4	7.6	6.7	5.2		
				Sur	29	19.3	32.0	7.8	7.85	7.49	8	11	6	9.4	9.7	24.5	7.5	6.1	5.8	17
				Mid	28.6	19.3	31.1	7.8	7.91	7.60	8	11	6	9.03	9.73	25.1	7.3	5.5	5.8	
	Sn-3	Bot	Mid	31.1	21.8	31.7	7.8	7.15	7.40	9	10	5	3.78	11.6	26	7.3	5.9	5.9		
				Sur	30.3	20.8	30.0	7.9	7.78	7.52	10	11	8	4.37	11.7	27.3	7.3	5.5	5.5	32
				Mid	30.5	20.8	30.0	7.8	7.75	7.52	10	11	6	4.69	11.8	27.4	7.2	5.5	5.1	
	Sn-2	Bot	Mid	30	21.9	28.9	7.6	7.19	7.50	8	10	4	5.12	10.9	27.4	7.1	5.7	4.4		
				Sur	32.1	21.1	30.7	7.73	7.58	7.30	9	10	5	4.3	11.2	27.9	7.1	5.9	5.3	8.5
				Mid	31.5	21.1	30.8	7.82	7.29	7.32	9	10	5	3.52	11.4	27.4	6.9	5.3	4.8	27.5
Sn-1	Bot	Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	26.3	4.9	8	4			
			Sur	30	21.6	31.7	7.9	7.2	7.20	7	10	5	2.85	11	26.2	7	7.5	4		
			Mid	29.9	22.1	28.9	7.8	7.57	7.42	8	10	4	4.24	11.4	27.1	7.3	5.2	4.9	15	
Sn-1	Bot	Mid	29.4	20.5	30.5	7.91	7.6	7.34	8	10	6	4.01	10.8	27.7	7.1	5.8	4.2			
			Sur	29.5	20.5	30.6	7.8	7.74	7.30	8	10	6	3.93	10.9	27.2	7.1	5.5	4.8	21	
			Mid	29.2	20.8	30.7	7.6	7.44	7.40	8	10	6	4.15	11	27.5	6.7	8	4.6		
Sn-1	Bot	Mid	32	21.2	31.2	8	7.62	7.20	7	10	5	2.94	10.9	28	6.9	5.7	4.6	15		
			Sur	32	21.2	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
			Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
Sn-1	Bot	Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12		
			Sur	30	21.6	31.7	7.9	7.2	7.20	7	10	5	2.85	11	26.2	7	7.5	4		
			Mid	29.9	22.1	28.9	7.8	7.57	7.42	8	10	4	4.24	11.4	27.1	7.3	5.2	4.9	15	
Sn-1	Bot	Mid	29.4	20.5	30.5	7.91	7.6	7.34	8	10	6	4.01	10.8	27.7	7.1	5.8	4.2			
			Sur	29.5	20.5	30.6	7.8	7.74	7.30	8	10	6	3.93	10.9	27.2	7.1	5.5	4.8	21	
			Mid	29.2	20.8	30.7	7.6	7.44	7.40	8	10	6	4.15	11	27.5	6.7	8	4.6		
Sn-1	Bot	Mid	32	21.2	31.2	8	7.62	7.20	7	10	5	2.94	10.9	28	6.9	5.7	4.6	15		
			Sur	32	21.2	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
			Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
Sn-1	Bot	Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12		
			Sur	30	21.6	31.7	7.9	7.2	7.20	7	10	5	2.85	11	26.2	7	7.5	4		
			Mid	29.9	22.1	28.9	7.8	7.57	7.42	8	10	4	4.24	11.4	27.1	7.3	5.2	4.9	15	
Sn-1	Bot	Mid	29.4	20.5	30.5	7.91	7.6	7.34	8	10	6	4.01	10.8	27.7	7.1	5.8	4.2			
			Sur	29.5	20.5	30.6	7.8	7.74	7.30	8	10	6	3.93	10.9	27.2	7.1	5.5	4.8	21	
			Mid	29.2	20.8	30.7	7.6	7.44	7.40	8	10	6	4.15	11	27.5	6.7	8	4.6		
Sn-1	Bot	Mid	32	21.2	31.2	8	7.62	7.20	7	10	5	2.94	10.9	28	6.9	5.7	4.6	15		
			Sur	32	21.2	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
			Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
Sn-1	Bot	Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12		
			Sur	30	21.6	31.7	7.9	7.2	7.20	7	10	5	2.85	11	26.2	7	7.5	4		
			Mid	29.9	22.1	28.9	7.8	7.57	7.42	8	10	4	4.24	11.4	27.1	7.3	5.2	4.9	15	
Sn-1	Bot	Mid	29.4	20.5	30.5	7.91	7.6	7.34	8	10	6	4.01	10.8	27.7	7.1	5.8	4.2			
			Sur	29.5	20.5	30.6	7.8	7.74	7.30	8	10	6	3.93	10.9	27.2	7.1	5.5	4.8	21	
			Mid	29.2	20.8	30.7	7.6	7.44	7.40	8	10	6	4.15	11	27.5	6.7	8	4.6		
Sn-1	Bot	Mid	32	21.2	31.2	8	7.62	7.20	7	10	5	2.94	10.9	28	6.9	5.7	4.6	15		
			Sur	32	21.2	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
			Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
Sn-1	Bot	Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12		
			Sur	30	21.6	31.7	7.9	7.2	7.20	7	10	5	2.85	11	26.2	7	7.5	4		
			Mid	29.9	22.1	28.9	7.8	7.57	7.42	8	10	4	4.24	11.4	27.1	7.3	5.2	4.9	15	
Sn-1	Bot	Mid	29.4	20.5	30.5	7.91	7.6	7.34	8	10	6	4.01	10.8	27.7	7.1	5.8	4.2			
			Sur	29.5	20.5	30.6	7.8	7.74	7.30	8	10	6	3.93	10.9	27.2	7.1	5.5	4.8	21	
			Mid	29.2	20.8	30.7	7.6	7.44	7.40	8	10	6	4.15	11	27.5	6.7	8	4.6		
Sn-1	Bot	Mid	32	21.2	31.2	8	7.62	7.20	7	10	5	2.94	10.9	28	6.9	5.7	4.6	15		
			Sur	32	21.2	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
			Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
Sn-1	Bot	Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12		
			Sur	30	21.6	31.7	7.9	7.2	7.20	7	10	5	2.85	11	26.2	7	7.5	4		
			Mid	29.9	22.1	28.9	7.8	7.57	7.42	8	10	4	4.24	11.4	27.1	7.3	5.2	4.9	15	
Sn-1	Bot	Mid	29.4	20.5	30.5	7.91	7.6	7.34	8	10	6	4.01	10.8	27.7	7.1	5.8	4.2			
			Sur	29.5	20.5	30.6	7.8	7.74	7.30	8	10	6	3.93	10.9	27.2	7.1	5.5	4.8	21	
			Mid	29.2	20.8	30.7	7.6	7.44	7.40	8	10	6	4.15	11	27.5	6.7	8	4.6		
Sn-1	Bot	Mid	32	21.2	31.2	8	7.62	7.20	7	10	5	2.94	10.9	28	6.9	5.7	4.6	15		
			Sur	32	21.2	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
			Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
Sn-1	Bot	Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12		
			Sur	30	21.6	31.7	7.9	7.2	7.20	7	10	5	2.85	11	26.2	7	7.5	4		
			Mid	29.9	22.1	28.9	7.8	7.57	7.42	8	10	4	4.24	11.4	27.1	7.3	5.2	4.9	15	
Sn-1	Bot	Mid	29.4	20.5	30.5	7.91	7.6	7.34	8	10	6	4.01	10.8	27.7	7.1	5.8	4.2			
			Sur	29.5	20.5	30.6	7.8	7.74	7.30	8	10	6	3.93	10.9	27.2	7.1	5.5	4.8	21	
			Mid	29.2	20.8	30.7	7.6	7.44	7.40	8	10	6	4.15	11	27.5	6.7	8	4.6		
Sn-1	Bot	Mid	32	21.2	31.2	8	7.62	7.20	7	10	5	2.94	10.9	28	6.9	5.7	4.6	15		
			Sur	32	21.2	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
			Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
Sn-1	Bot	Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12		
			Sur	30	21.6	31.7	7.9	7.2	7.20	7	10	5	2.85	11	26.2	7	7.5	4		
			Mid	29.9	22.1	28.9	7.8	7.57	7.42	8	10	4	4.24	11.4	27.1	7.3	5.2	4.9	15	
Sn-1	Bot	Mid	29.4	20.5	30.5	7.91	7.6	7.34	8	10	6	4.01	10.8	27.7	7.1	5.8	4.2			
			Sur	29.5	20.5	30.6	7.8	7.74	7.30	8	10	6	3.93	10.9	27.2	7.1	5.5	4.8	21	
			Mid	29.2	20.8	30.7	7.6	7.44	7.40	8	10	6	4.15	11	27.5	6.7	8	4.6		
Sn-1	Bot	Mid	32	21.2	31.2	8	7.62	7.20	7	10	5	2.94	10.9	28	6.9	5.7	4.6	15		
			Sur	32	21.2	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
			Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.9	28.3	4.9	8	4	12	
Sn-1	Bot	Mid	29.6	21.4	31.2	8	7.4	7.28	7	10	5	3.01	10.							

S-1: Post monsoon, S-2: Winter, S-3: monsoon, Sn-1: Karomjal, Sn-2: Karomjal Canal, Sn-3: Joymoni, Sn-4:

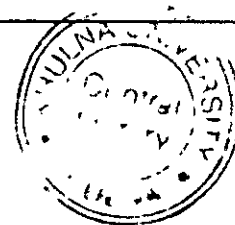
Harbartha, Sn-5: Harbartha canal

Table-3: Concentration of different nutrients at discrete layers under different tidal and seasonal condition.

River	Station	Tide	Layer	NH ₃			NO ₃			PO ₄			SO ₄		
				S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃
Pressure	SN-1	High	Surface	0.02	0.07	0.02	0.04	0.6	0.02	0.36	0.17	0.10	4.78	25.8	18.45
			Middle	0.02	0.07	0.01	0.03	0.2	0.02	0.29	0.08	0.12	4.54	28	16.89
			Bottom	0.04	0.07	0.01	0.04	0	0.03	0.42	0.27	0.16	4.55	27.36	10.16
		Low	Surface	0.04	0.07	0.01	0.04	0	0.02	1.15	0.08	0.77	6.22	27.36	20.91
			Middle	0.04	0.07	0.02	0.04	0.8	0.03	0.5	0.17	0.39	5.57	26.87	27.00
			Bottom	0.03	0.06	0.02	0.03	0	0.04	0.38	0.47	0.34	5.19	28.91	24.93
	SN-2	High	Surface	0.04	0.08	0.01	0.03	1.2	0.03	0.45	0.07	0.09	5.06	18.93	14.69
			Middle	0.04	0.07	0.02	0.04	1.9	0.04	0.42	0.13	0.19	5.57	22.56	15.08
			Bottom	0.05	0.07	0.01	0.15	0.6	0.04	1.09	0.07	0.10	5.57	13.48	10.28
		Low	Surface	0.05	0.07	0.02	0.3	0.8	0.04	0.42	0.16	0.03	4.67	15.3	129.65
			Middle	0.04	0.06	0.01	0.32	0.1	0.03	0.26	0.07	0.07	4.8	21.13	4.45
			Bottom	0.04	0.06	0.02	0.47	0.5	0.03	0.21	0.07	0.34	5.7	22.95	132.24
	SN-3	High	Surface	0.05	0.07	0.02	0.32	0.7	0.04	0.38	0.3	0.06	4.67	32.28	13.78
			Middle	0.04	0.07	0.01	0.55	1.2	0.03	1.47	0.14	0.02	4.28	27.23	17.93
			Bottom	0.03	0.07	0.01	0.4	1.3	0.04	0.39	0.07	0.09	6.09	19.84	13.01
		Low	Surface	0.05	0.07	0.02	0.48	0.6	0.02	0.42	0.39	0.12	4.97	24.63	20.78
			Middle	0.03	0.07	0.02	0.41	0.9	0.05	0.43	0.27	0.16	5.58	23.6	9.12
			Bottom	0.04	0.07	0.01	0.37	0.6	0.05	0.15	0.3	0.31	3.89	26.58	7.56
	SN-4	High	Surface	0.04	0.07	0.02	0.03	0	0.04	0.3	0.17	0.06	5.19	25.93	5.23
			Middle	0.01	0.07	0.02	0.04	0.1	0.03	0.32	0.35	0.23	5.84	30.99	7.95
			Bottom	0.05	0.07	0.02	0.04	0.1	0.04	0.47	0.06	0.57	5.7	47.32	9.51
		Low	Surface	0.01	0.07	0.01	0.04	0.4	0.04	0.32	0.07	0.02	3.89	21.26	114.35
			Middle	0.04	0.07	0.02		0.1	0.03	0.55	0.13	0.05	5.06	23.99	120.83
			Bottom	0.05	0.07	0.02		0.9	0.03	0.4	0.07	0.06	4.67	28.65	131.59
	SN-5	High	Surface	0.05	0.07	0.02		0	0.04	0.48	0.18	0.40	4.41	16.21	119.28
			Middle	0.05	0.07	0.01		0	0.03	0.41	0.18	0.37	5.57	20.1	130.29
			Bottom	0.04	0.07	0.02		0.1	0.02	0.37	0.35	0.53	11.9	23.08	131.20
		Low	Surface	0.04	0.07	0.01		0	0.04	0.22	0.05	0.14	4.02	24.24	105.02
			Middle	0.04	0.05	0.02		0.4	0.03	2.86	0.05	0.15	4.67	24.37	117.98
			Bottom	0.04	0.07	0.03		0.7	0.02	0.81	0.07	0.15	5.32	22.04	114.74

S-1: Post monsoon, S-2: Winter, S-3: monsoon, Sn-1: Karomjal, Sn-2: Karomjal Canal, Sn-3: Joymoni,

Sn-4: Harbarha, Sn-5: Harbarha canal



 CHAPTER-FIVE**DISCUSSION**

Chapter-5

5.0 Discussion

We found the water temperature in the study area ranged from 19.23°C to 31.57°C with a mean value of 27.15°C. The water temperature found average 29.93°C during high tide and 30.19 during low tide in post monsoon, 30.05°C during high tide and 31.17 °C during low tide in monsoon and found average temperature 20.97°C during high tide and 20.57°C during low tide in dry winter . The estuarine stretch did not exhibit significant tidal variation of surface water temperature; neither the spatial variation was prominent. The uniformity in water temperature values is due to high specific heat of the aquatic phase, which enables water to resist much fluctuation of temperature than the adjacent landmasses. The water temperature has considerable effect on phytoplankton population density by influencing the process of cyst germination (Ishikawa and Taniguchi, 1994; Blanco, 1995). The present spatial and tidal uniformity in surface water temperature, however, has the least probability to affect the plankton community of the estuary.

The salinity values increased from the upstream to the downstream zone. During high tide water from Bay of Bengal enter the present estuarine zone due to which the salinity rises. However, during low tide the effect of fresh water discharge from the upstream rivers lower the salinity of the study area. Such variation of salinity with tide was also documented by several earlier workers (NEERI, 1976; Mitra, 2000 and Mukhopadhyay *et al.*, 2006).

Table-4: Salinity increase from upstream to Downstream

Seasons	Upstream to Downstream →		
	Karomjol	Joymoni	Harbaria
Dry	12	10	10.5
Monsoon	4.5	4.5	6
Post monsoon	6.5	8.5	10

Salinity condition in the Sundarbans is highly dependent on the volume of freshwater coming from the upstream and the nature of tide. Salinity near the coast and inside the forest varies over a number of different timescales. Daily peak salinity at the coast generally coincides with the arrival of high water, whereas the daily range of salinity level varies with season.

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Salinity at Passur is influenced by freshwater flow in the upstream river which is connected with the Ganges through the Gorai River during post monsoon and the dry season. Salinity remains 5 to 4 ppt during the monsoon due to large amount freshwater flow. It increases steadily from post monsoon period and starts decreasing from the end of May and falls rapidly from the onset of monsoon flow.

The concentration of dissolve oxygen falls in the monsoon. On the other hand most nutrient concentration found raised in the monsoon. Thus DO and nutrient shows almost inverse relationship. For example- Water column phosphorus concentrations have also been shown to increase under conditions. This is because some of the iron oxyhydroxides that bind phosphate are converted to iron sulfides during sulfate reduction (an anaerobic process) and the iron sulfides cannot bind phosphorus. Averages DO of 6.05 mg/L observed in the study area. The higher values of DO in the upstream stations may be apparently due to DO rich freshwater conveyed through river. Significant tidal variation of DO (Table 5) with relatively higher value during low tide period is the result of more freshwater during this phase of the tidal cycle. The contributory role of fresh water to increase dissolved oxygen was confirmed by Nair (1985) while working in the Kalpakkam waters.

Table-5: concentration of DO during high and low tide in different sampling station.

Sampling station	DO (mg/L)	
	High tide	Low tide
Karomjol	5.98	6.22
Karomjol canal	5.98	5.84
Joymoni	5.82	6.04
Harbaria	6.16	5.97
Harbaria canal	6.33	6.17

It is found that $\text{NH}_3\text{-N}$ varies between 0.08 to 0.08 mg/L during high tide and 0.07 to 0.08 mg/L during low tide in Dry winter, 0.013 to 0.018 mg/L during high tide and 0.014 to 0.019 mg/L during low tide in monsoon and 0.034 to 0.054 mg/L during high tide and 0.040 to 0.050 mg/L during low tide in Post monsoon, with an average concentration of 0.016 mg/L. The concentration of $\text{NH}_3\text{-N}$ found higher in the Dry and lowers mostly in monsoon season and in few cases in post monsoon. $\text{NH}_3\text{-N}$ also shows a distinct tidal variation with maximum limit in high tide and minimum limit in low tide. Presence of

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non-ionized Ammonia ($\text{NH}_3\text{-N}$) in very low proportion (an average of .016 mg/L) is an indication of good quality of river water with respect to Ammoniacal Nitrogen inside the Sundarbans. Because higher concentration of it causes toxicity in water body. The reason of maximum concentration in monsoon can be the huge river run off and runoff from agricultural areas (e.g. fertilisers), urban stormwater and wastewater (including sewage), eroded soils and aquaculture. The present findings is slightly lower than the findings of Wahida *et al.* (2007) an average of 0.054 mg/L and IWM (2003) found 0.001 to 0.33 mg/L and the average range was 0.043 mg/L.

Table-6: Average concentration of different nutrients for whole tides in the passur river (mg/L).

	$\text{NH}_3\text{-N}$	$\text{NO}_3\text{-N}$	PO_4	SO_4
Dry	0.075667	0.511333	0.184667	27.46067
Monsoon	0.015711	0.8248	0.206775	53.8304
Post Monsoon	0.045333	0.653267	0.577	8.025667

The average $\text{NO}_3\text{-N}$ concentration of 0.663 mg/L are indicative of little or no human intervention of the river system. The irregular distribution of $\text{NO}_3\text{-N}$ throughout the year and irrespective of tide can be the cause of greater N_2 concentration in the air and continuous mixing of N_2 between air and water takes place. The present value is slightly lower than the findings of Wahida *et al.* (2007) an average of 0.461 mg/L.

The average value of SO_4 29.772 mg/L indicates availability of SO_4 in the water body. In the present study Significant spatial and tidal variations of sulphate were observed in the Rupsha-passur river sustem. Sulphate exhibited a higher concentration in the downstream stations under the influence of seawater mixing. The relatively lower concentration of sulphate in the upper estuarine stretch may be due to consumption of the anion by paddy fields along the upstream stations, whereas removal is compensated in the lower part of the estuary by the contribution of seawater and decay of organic matter from mangroves. Similar observations were reported by several researchers. According to Ramanathan *et al.* (1993) seawater input along with resuspension mixing (turbidity and mixing) of decayed organic matter and oxidation of buried biogenic materials result in enhanced sulphate levels in mangrove waters. The sulphate value is generally higher during high tide in monsoon due to the intrusion of River runoff from upstream land.

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CONCLUSION

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6.0 Conclusion

The study provides comprehensive spatial and temporal characterization of hydrological regime of the Sundarbans mangrove ecosystem of Bangladesh. It also demonstrates the need for regular monitoring considering the rapid industrial and agricultural development around the forests. With the onset of monsoon, the central part experiences the greatest reduction in salinity level. Augmentation of the freshwater inflow from the upstream reduces the salinity in the Rupsha and passur river system. The high nutrient load in the upstream zone is an indication of rising population density and subsequent anthropogenic pressure around the area the major nutrients show significant seasonal and tidal variation. $\text{NO}_3\text{-N}$ concentrations are found to vary between 0.0833 and 1.233 mg/L with an average of 0.633 mg/L with no distinct seasonal variation. Phosphate concentrations as $\text{PO}_4\text{-P}$ are generally low and vary from 0.0448 to 1.347 mg/L, average being 0.323 mg/L. SO_4 concentrations are found to vary between 7.30 and 141.0442 mg/L with an average of 126.92 mg/L with an average concentration of 29.772 mg/L. $\text{NH}_3\text{-N}$ varies between 0.013 and 0.080 mg/L, with an average concentration of 0.016 mg/L. Electric Conductivity (EC) found to vary from 2.93 to 30 mS. Thus the highly productive mangrove water body provides a suitable home ground for thousands of aquatic organisms including fish and contributes to the preservation of biodiversity and plays a great role to the economic development of the country.

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