CHAPTER I

BENTHIC HABITAT
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Benthic habitat comprises hydrography and sediment, which plays an important role in governing the population of the benthic community inhabiting in this realm. Many times, either single or combined parameters influences these benthic population over the space and time. In this chapter, two sections were made e.g., hydrographic and sedimentological conditions of different study stations (stn. 1 to 5) for the purpose of discussion.

A. HYDROGRAPHIC CONDITION

The Karnataka state comprises three maritime districts namely Uttara Kannad, Udupi and Dakshina Kannada, of which the Uttara Kannada district having a total coastal stretch of about 144 km extending from Majali in the north to Bhatkal in south. This maritime coast is blessed with four major riverine systems like, Kali, Gangavali, Aghanashini and Sharavathi. These riverine systems plays an important role in changing the physico-chemical features of the nearby coastal areas as well as changing the topographic contour at the estuarine mouth and its neighbouring water bodies. Kali river is one of
such riverine system, whose impact on the Karwar bay’s (near shore area) hydrographical conditions is severe.

A review over these researches reveals that, the significant role of habitat and it’s physico-chemical parameters in producing, controlling and in cases catalyzing the recolonization of faunal communities is remarkable.

**Hydrographic parameters:**

A good amount of studies on hydrographic conditions of West coast of India has been carried out by several workers but limited studies were done on Karwar coast in recent past years. George (1953), Seshappa and Jayaraman (1956), Subrahmanyan (1959), Ramamirtham and Jayaraman (1960), Qasim et al., (1972), Balakrishnan and Shynamma (1976) have studied the hydrographical conditions of various parts of the west coast of India.

But the present work is the only available description of the hydrography in recent period of the bottom water of Kali river and its adjacent backwater areas. Whereas previous works being mostly confined to the surface water, mid or bottom waters either bay or estuary at particular period of the biological year.

Various hydrographic parameters were estimated to give a clear picture of an environment of study sites to arrive at an exact relationship of hydrography to the macrobenthos at Kali River. The hydrographic results are tabulated under Tables 2 to 30 and the monthly variation in the hydrographic parameters at different study sites are represented in Figures 2 to 10 respectively.

STUDY SITE 1:

Water Temperature: The water temperature did not show any drastic variation either during the study period or among the seasons. A lowest temperature was recorded during September (26.12 °C) and highest (31.35 °C) during May month (Table 2). Maximum water temperature profile was established during pre monsoon season (30.07°C) and minimum (28.27° C) during monsoon period with an intermediate value of 28.37°C in post monsoon (Table 17).
The water temperature did not show any drastic variation among the study sites, of course little escalated values were noticed during the warmer months (April-May) at all study sites (Table 2 and Fig.2). It is surmised from the Table 8 that, the mean lowest (28.54°C) recorded in station 4 while the station 3 showed highest mean temperature value of 29.44°C and this could be probably due to the shallow depth of the study site. Monthly and seasonal variation of water temperature values and mean values of various hydrographic parameters at study site-1 are given in the Table 2, 7, 8 and 22.

**Salinity:** Salinity showed wide range of variation during the study period with minimum 2.81% (July) and maximum 31.15 (April) with moderate values during December-March (25.34-30.11%) respectively (Table 2 and Fig.3). Seasonally it showed a wide range of variation with minimum (4.54%) during southwest monsoon period and maximum (29.52%) during pre monsoon period with an intermediate values being established during post monsoon season (18.65%) [Table 17]. Monthly variation of salinity values and mean values of various hydrographic parameters at study site-2 are given in the Table 2, 7, 9 and 23.
**Dissolved Oxygen:** Dissolved oxygen content fluctuated between 4.26 mg/l (October) and 6.75 mg/l (January). Low values were recorded during September to November (4.26-5.63 mg/l) during the study period (Table 2 and Fig.4). Table 17 explains the seasonal variation of this parameter, with minimum (5.65 mg/l) during post monsoon and maximum (6.07 mg/l) in southwest monsoon with moderate 5.72 mg/l content in pre monsoon period.

Monthly variation of dissolved oxygen values and mean values of various hydrographic parameters at study site-1 are given in the Table 2,7,10 and 24.

**Hydrogen ion concentration:** Hydrogen ion concentration did not vary much between the months and the season. It varied from 7.21-8.12 (Table 2 and Fig.5) and seasonally it varied between 7.39 (post monsoon), 7.50 (pre monsoon) and 7.65 (south west monsoon) respectively (Table 17). Monthly variation of salinity values and mean values of various hydrographic parameters at study site-1 are given in the Table 2,7,11 and 25.

**Suspended matter:** Maximum suspended matter was noticed during June – September (0.12-0.44 gm/l) and minimum during December –March (0.06-0.11 gm/l) [Table 2 and Fig.6]. Among three seasons, it varied 0.14 gm/l (post monsoon), 0.07 gm/l (pre monsoon), and 0.29 gm/l (south west monsoon).
[Table 17]. Monthly variation of suspended matter values and means values of various hydrographic parameters at study site-1 are given in the Table 2,7,12 and 26.

**Phosphate-P:** This nutrient salt showed a bimodal peak, one during October – January (1.53-2.43\(\mu\)g at/l) and second during March-May (1.18-1.63 \(\mu\)g at/l) with a low values (1.73-1.98 \(\mu\)g at/l) during monsoon months (June-September) [Table 2 and Figure 7]. Seasonally it varied between 1.82 \(\mu\)g at/l, 1.40 \(\mu\)g at/l and 1.12 \(\mu\)g at/l in post, pre and southwest monsoon seasons (Table 17) respectively. Monthly variation of phosphate values and mean values of various hydrographic parameters at study site-1 are given in the Table 2, 7, 14 and 28. Seasonally it varied between 2.9\(\mu\)g at/l, 5.14 \(\mu\)g at/l and 7.70 \(\mu\)g at/l (Table 17).

**Nitrate-N:** Primary peak was noticed in December (7.43 \(\mu\)g at/l) and there after it gradually decreased and fall was noticed in February (0.33 \(\mu\)g at/l) and again attaining the secondary peak in August (1.18 \(\mu\)g at/l) month respectively (Table 2 and Figure 8). Monthly variation of nitrate values and mean values of various hydrographic parameters at study site-1 are given in the Table 2, 7, 14 and 28. Seasonally it varied between 2.9\(\mu\)g at/l, 5.14 \(\mu\)g at/l and 7.70 \(\mu\)g at/l (Table 17).
**Nitrite-N:** Primary peak was noticed in December (1.73 μg at/l) and thereafter it gradually decreased and fall was noticed in March (0.21 μg at/l) and again attaining the secondary peak in August (1.18 μg at/l) (Table 2 and Figure 9). Monthly variation of nitrate values and mean values of various hydrographic parameters at study site-1 are given in the Table 2, 7, 15 and 29. Seasonally it varied between 1.48 μg at/l, 0.59 μg at/l and 0.69 μg at/l (Table 17).

**Silicate-Si:** Moderate silicate concentration was noticed during September-November (29.43-32.16 μg at/l) whereas minimum during December-February (19.72-30.73 μg at/l) periods. But, thereafter a gradual increasing trend was noticed from March and attaining peak in July registering highest concentration (44.64 μg at/l) of this nutrient salt (Table 2 and Figure 10). Silicate found in maximum concentration during southwest monsoon season (39.42 μg at/l) and minimum during post monsoon season with a concentration value of 27.64 μg at/l (Table 17). Monthly variation of silicate values and mean values of various hydrographic parameters at study site-1 are given in the Table 2, 7, 16 and 30.
STUDY SITE 2:

**Water Temperature:** The water temperature did not show any drastic variation either during the study period or among the seasons. A lowest temperature was recorded during January (26.21°C) and highest (32.23°C) during May (Table 3) with a yearly mean of 29.01°C. Maximum water temperature profile was established during pre monsoon season (30.64°C) and minimum (27.89°C) during post monsoon period while during southwest monsoon an intermediate value of 28.50°C was noticed (Table 18).

The water temperature did not show any drastic variation among the study sites, of course little escalated values were noticed during the warmer months (April-May) at all study sites (Table 3 & Fig.2). It is surmised from the Table 8 that, the mean lowest (28.54°C) recorded in station 4 while the station 3 showed highest mean temperature value of 29.44°C and this could be probably due to the shallow depth of the study site. Monthly variation of water temperature values and mean values of various hydrographic parameters at study site-2 are given in the Table 3, 7, 8 and 22.
Salinity: Salinity showed wide range of variation during the study period with minimum of 2.48‰ (August) and maximum 29.31‰ (March) with moderate values during December-March (24.53-29.31‰) with a yearly mean of 17.16‰ (Table 3 and Fig.3). Seasonally it showed a wide range of variation with minimum (4.47‰) during southwest monsoon period and maximum (25.74‰) during pre monsoon period with an intermediate values being established during post monsoon season (21.28‰) [Table 18]. Monthly variation of salinity values and mean values of various hydrographic parameters at study site-2 are given in the Table 3, 7, 9 and 23.

Dissolved Oxygen: Dissolved oxygen content fluctuated between 4.63 mg/l (October) and 6.93 mg/l (January). Low values were recorded during August to September (5.12-5.36 mg/l) during the study period (Table 3 and Fig.4) with a yearly mean of 6.02 mg/l. Table 18 explains the seasonal variation of this parameter, with minimum (5.73 mg/l) during southwest monsoon and maximum (6.50 mg/l) in pre monsoon with moderate 5.83 mg/l content in post monsoon period. Monthly variation of dissolved oxygen values and mean values of various hydrographic parameters at study site-2 are given in the Table 3, 7, 10 and 24.
**Hydrogen ion concentration:** Hydrogen ion concentration did not vary much among the months and the season. It varied from 7.10-7.82 (Table 3 and Fig.5) with a yearly mean of 7.43 and seasonally it varied between 7.35 (post monsoon), 7.51 (pre monsoon) and 7.41 (southwest monsoon) (Table 18). Monthly variation of hydrogen ion concentration values and mean values of various hydrographic parameters at study site-2 are given in the Table 3,7,11 and 25.

**Suspended matter:** Maximum suspended matter was noticed during June – August (0.23-0.53gm/l) and minimum during March (0.04 gm/l) [Table 3 and Fig.6] with a yearly mean of 0.18 μg at/l. Among three seasons, it varied 0.13 gm/l (post monsoon), 0.07 gm/l (pre monsoon), and 0.35 gm/l (south west monsoon) [Table 18]. Monthly variations of suspended matter values and mean values of various hydrographic parameters at study site-2 are given in the Table 3,7, 12 and 26.

**Phosphate-P:** This nutrient salt showed a bimodal peak, one during October-December (2.05-2.15μg at/l) and second during February-April (1.73-1.98 μg at/l) with a low values (1.52-1.84 μg at/l) during monsoon months (June-July) with a yearly mean of 1.67 μg at/l. Seasonally it varied between 1.90 μg at/l,
1.62 µg at/l and 1.50 µg at/l in post, pre and southwest monsoon seasons (Table 18) respectively. Monthly variation of phosphate values and mean values of various hydrographic parameters at study site-2 are given in the Table 3, 7, 13 and 27.

**Nitrate-N:** Primary peak was noticed in January (7.51 µg at/l) and there after it gradually increased and peak was noticed in April (12.12 µg at/l) and again attaining the secondary peak in June (18.18 µg at/l) month respectively (Table 3 and Figure 8). Lowest value of this nutrient salt was noticed in November with a value of 0.51 µg at/l with a yearly mean of 7.90 µg at/l. Nitrate found in maximum concentration during monsoon season (11.17 µg at/l) and minimum during post monsoon season with a concentration value of 4.40 µg at/l while a moderate values (8.12 µg at/l) recorded during pre monsoon respectively (Table 18). Monthly variation of nitrate values and mean values of various hydrographic parameters at study site-2 are given in the Table 3, 7, 14 and 28 respectively.

**Nitrite-N:** Primary peak was noticed in January (1.51 µg at/l) and there after it gradually decreased and fall was noticed in May (0.55 µg at/l) and again attaining the secondary peak in October (0.91 µg at/l) month respectively (Table
3 and Figure 9). Lowest value of this nutrient salt was noticed in August with a value of 0.42µg at/l with a yearly mean of 8.22µg at/l. Nitrite found in maximum concentration during post monsoon season (1.05µg at/l) and minimum during southwest monsoon season with a concentration value of 0.59µg at/l) with a moderate values (0.76 µg at/l) recorded during pre monsoon respectively (Table 18). Monthly variation of nitrate values and mean values of various hydrographic parameters at study site-2 are given in the Table 3,7,15 and 29 respectively.

Silicate-Si: Moderately high silicate concentration was noticed during July-September (38.08-42.06 µg at/l) whereas minimum during December-January (18.32-27.82 µg at/l) periods. But, thereafter a gradual increasing trend was noticed from June and attaining peak in July registering highest concentration (42.06 µg at/l) of this nutrient salt (Table 3 and Figure 10) with a yearly mean of 33.15 µg at/l. Silicate found in maximum concentration during southwest monsoon season (38.19µg at/l) and minimum during post monsoon season with a concentration value of 30.38 µg at/l) respectively (Table 18). Monthly variation of silicate values and mean values of various hydrographic parameters at study site-2 are given in the Table 3,7,16 and 30 respectively.
STUDY SITE 3:

Water Temperature: The water temperature did not show any wide variation either during the study's monthly period or among the seasons. A lowest temperature was recorded during January (27.41°C) and highest (32.81°C) during May month (Table 4) with a yearly mean of 29.60°C. Maximum water temperature profile was established during pre monsoon season (31.09°C) and minimum (28.66°C) during post monsoon period while during monsoon an intermediate value of 29.15°C was noticed (Table 19).

The water temperature did not show any drastic variation among the study sites, of course little escalated values were noticed during the warmer months (April-May) at all study sites (Table 8 & Fig.2). Monthly variation of water temperature values and mean values of various hydrographic parameters at study site-3 are given in the Table 3, 7, 9 and 22.

Salinity: Salinity showed wide range of variation during the study period with minimum of 2.72‰ (August) and maximum 30.15‰ (April) with moderate values during December-March (23.62-29.95‰) with a yearly mean of 19.00 ‰ respectively (Table 4 and Fig.3). Seasonally it showed a wide range of
variation with minimum (5.68\%) during monsoon period and maximum (29.17 \%) during pre monsoon period with an intermediate values being established during post monsoon season (22.17\%) [Table 19]. Monthly variation of salinity values and mean values of various hydrographic parameters at study site-3 are given in the Table 3,7, 9 and 23.

**Dissolved Oxygen:** Dissolved oxygen content fluctuated between 4.12 mg/l (September) and 6.51 mg/l (June). High values were recorded during December to April (6.22-6.45 mg/l) during the study period (Table 4 and Fig.4) with a yearly mean of 5.78 mg/l. Table 19 explains the seasonal variation of this parameter, with minimum (5.52 mg/l) during post monsoon and maximum (6.08 mg/l) in pre monsoon with moderate 5.74 mg/l content in southwest monsoon period. Monthly variation of dissolved oxygen values and mean values of various hydrographic parameters at study site-3 are given in the Table 3,7,10 and 24.

**Hydrogen ion concentration:** Hydrogen ion concentration did not vary much among the months and the season. It varied from 7.01-7.93 (Table 4 and Fig.5) with a yearly mean of 7.47 and seasonally it varied between 7.25 (post monsoon), 7.61 (pre monsoon) and 7.58 (southwest monsoon) (Table 19).
Monthly variation of hydrogen ion concentration values and mean values of various hydrographic parameters at study site-3 are given in the Table 3, 7, 11 and 25.

**Suspended matter:** Maximum suspended matter was noticed during June – July (0.58-0.64gm/l) and minimum during October-November (0.17-0.12gm/l) [Table 4 and Fig.6] with a yearly mean of 0.21 gm/l. Among three seasons, it varied 0.12 gm/l (post monsoon), 0.06gm/l (pre monsoon), and 0.46gm/l (southwest monsoon) [Table 19]. Monthly variations of suspended matter values and mean values of various hydrographic parameters at study site-3 are given in the Table 3, 7, 12 and 26.

**Phosphate-P:** This nutrient salt showed a peak during September (1.93µg at/l) second during November (1.81µg at/l) with low values of 0.89 & 0.1 µg at/l during monsoon months (May-June) with a yearly mean of 1.34 µg at/l. Seasonally it varied between 1.69 µg at/l, 1.17 µg at/l and 1.15 µg at/l in post, pre and monsoon seasons (Table 19) respectively. Monthly variation of phosphate values and mean values of various hydrographic parameters at study site-3 are given in the Table 3, 7, 13 and 27.
**Nitrate-N:** This salt showed a bimodal peak during the study period. Primary peak was noticed in December (7.84 µg at/l) and there after it gradually decreased and fall was noticed in February (0.08 µg at/l) and again attaining the secondary peak in March and April (6.94 & 6.43 µg at/l) month, whereas third peak was noticed during June-August (9.21-10.54 µg at/l) (Table 4 and Figure 8). Lowest value of this nutrient salt was noticed in November with a value of 0.06 µg at/l with a yearly mean of 4.74 µg at/l. Nitrate found in maximum concentration during southwest monsoon season (7.37 µg at/l) and minimum during post monsoon season with a concentration value of 2.44 µg at/l (Table 19). Monthly variation of nitrate values and mean values of various hydrographic parameters at study site-3 are given in the Table 3, 7, 14 and 28.

**Nitrite-N:** This salt showed a bimodal peak during the study period. Primary peak was noticed in October (0.69 µg at/l) and there after it decreased and again attaining the secondary peak in January (1.21 µg at/l) month (Table 4 and Figure 9). Lowest value of this nutrient salt was noticed in April with a value of 0.08 µg at/l with a yearly mean of 0.64 µg at/l. Nitrite found in maximum concentration during post monsoon season (0.84 µg at/l) and minimum during southwest monsoon season with a concentration value of 0.41 µg at/l (Table
19). Monthly variation of nitrate values and mean values of various hydrographic parameters at study site-3 are given in the Table 3, 7, 15 and 29.

**Silicate-Si**: Compared to other two nutrients, this salt showed maximum concentration in this study site during June-September study tenure, probably this could be due to influx of riverine water, which consists high content of this salt. Moderate silicate concentration was noticed during September-November (33.41-43.14 µg at/l) whereas minimum during December (16.43 µg at/l) period. But, thereafter a gradual increasing trend was noticed from January and attaining peak in July registering highest concentration (42.58 µg at/l) of this nutrient salt (Table 4 and Figure 10) with a yearly mean of 33.76 µg at/l. Silicate found in maximum concentration during monsoon season (39.21 µg at/l) and minimum during pre monsoon season with a concentration value of 31.02 µg at/l (Table 19). Monthly variation of silicate values and mean values of various hydrographic parameters at study site-3 are given in the Table 3, 7, 16 and 30.
STUDY SITE 4:

**Water Temperature:** The water temperature did not show any drastic variation either during the study period or among the seasons. A lowest temperature was recorded, during July (26.81°C) and highest (30.11 & 30.33°C) during November and May month (Table 5) with a yearly mean of 28.59°C. Maximum water temperature profile was established during pre monsoon season (29.39°C) and minimum (27.86°C) during monsoon period while during post monsoon an intermediate value of 28.52°C was noticed (Table 20).

The water temperature did not show any drastic variation among the study sites, of course little high values were noticed during the warmer months (April-May) at all study sites (Table 8 & Fig.2). Monthly variation of water temperature values and mean values of various hydrographic parameters at study site-4 are given in the Table 5,7,8 and 22.

**Salinity:** Salinity showed wide range of variation during the study period with minimum of 2.14% (August) and maximum 29.23% (November) with moderate values during December-February (24.85-25.23%) with a yearly mean of 20.17 % (Table 5 and Fig.3). Seasonally it showed a wide range of
variation with minimum (9.51%) during southwest monsoon period and maximum (26.52%) during pre monsoon period with an intermediate values being established during post monsoon season (24.51%) [Table 20]. Monthly variation of salinity values and mean values of various hydrographic parameters at study site-4 are given in the Table 5,7,9 and 23.

**Dissolved Oxygen:** Dissolved oxygen content fluctuated between 5.23 mg/l (December) and 6.75 mg/l (February). High values were recorded during July to September (6.31-6.63 mg/l) during the study period (Table 5 and Fig.4) with a yearly mean of 6.17 mg /l. Table 20 explains the seasonal variation of this parameter, with minimum (5.88 mg/l) during post monsoon, maximum (6.47 mg/l) in pre monsoon while in southwest monsoon a moderate of 6.17 mg/l content recorded. Monthly variation of dissolved oxygen values and mean values of various hydrographic parameters at study site-4 are given in the Table 5, 7, 10 and 24.

**Hydrogen ion concentration:** Hydrogen ion concentration did not vary much among the months and the season. It varied from 7.11-7.93 (Table 5 and Fig.5) with a yearly mean of 7.54 and seasonally it varied between 7.44 (post monsoon), 7.41 (pre monsoon) and 7.74 (southwest monsoon) respectively
(Table 20). Monthly variation of hydrogen ion concentration values and mean values of various hydrographic parameters at study site-4 are given in the Table 5, 7, 11 and 25.

**Suspended matter:** Maximum suspended matter was noticed during June-July (0.44-0.57 gm/l) and minimum during April-May (0.05 gm/l) [Table 5 and Fig.6] with a yearly mean of 0.18 mg/l. Among three seasons, it varied 0.12 gm/l (post monsoon), 0.06 gm/l (pre monsoon), and 0.37 gm/l (monsoon) [Table 20]. Monthly variations of suspended matter values and mean values of various hydrographic parameters at study site-4 are given in the Table 5, 7, 12 and 26.

**Phosphate-P:** This nutrient salt showed a bimodal peak, one during October-November (1.72 & 1.61 µg at/l), second during January (1.64 µg at/l) with a low values of 0.02 & 0.74 µg at/l during March & July months with a yearly mean of 1.09 µg at/l (Table 5 and Figure 7). Seasonally, it varied between 1.64 µg at/l, 0.68 µg at/l and 0.96 µg at/l in post, pre and monsoon seasons (Table 20) respectively. Monthly variation of phosphate values and mean values of various hydrographic parameters at study site-4 are given in the Table 5, 7, 13 and 27.
Nitrate-N: This salt showed a trimodal peak during the study period. Primary peak was noticed in December (7.14 μg at/l) and there after it gradually increased and again attaining the secondary peak in April (11.39 μg at/l) and registered third peak in July month (11.02 μg at/l) respectively (Table 5 and Figure 8) with a yearly mean of 5.44 μg at/l. Lowest value of this nutrient salt was noticed in February with a value of 0.07 μg at/l with a yearly mean of 5.44 μg at/l. Nitrate found in maximum concentration during southwest monsoon season (7.80 μg at/l) and minimum during post monsoon season with a concentration value of 2.34 μg at/l) and relatively moderate value (6.19 μg at/l) noticed during pre monsoon season (Table 20). Monthly variation of nitrate values and mean values of various hydrographic parameters at study site-4 are given in the Table 5, 7, 14 and 28.

Nitrite-N: This salt showed a bimodal peak during the study period. Primary peak was noticed in September (0.83 μg at/l) and there after it gradually decreased again attaining the secondary peak in January (0.98 μg at/l) month respectively (Table 5 and Figure 9). Lowest value of this nutrient salt was noticed in April and July with a value of 0.12 & 0.07 μg at/l with a yearly mean of 0.59 μg at/l. Nitrite found in maximum concentration during post monsoon season (0.75 μg at/l) and minimum during southwest monsoon season with a
concentration value of 0.47µg at/l) and relatively moderate value (0.57µg at/l) noticed during pre monsoon season (Table 20). Monthly variation of nitrate values and mean values of various hydrographic parameters at study site-4 are given in the Table 5,7,15 and 29.

**Silicate-Si:** Compared to other two nutrient salts, this salt showed maximum concentration in this study site during the monsoon period probably this could be due to influx of riverine water, which consists high content of this salt. Moderate silicate concentration was noticed during September-November (34.41-48.11µg at/l) whereas minimum during December-January (28.12-24.78 µg at/l) periods. But, thereafter a gradual increasing trend was noticed from February and attaining peak in July, registering highest concentration (47.42 µg at/l) of this nutrient salt (Table 5 and Figure 10) with a yearly mean of 37.18 µg at/l. Silicate found in maximum concentration during southwest monsoon season (39.52 µg at/l) and minimum during post monsoon season with a concentration value of 33.04 µg at/l) (Table 20). Monthly variation of silicate values and mean values of various hydrographic parameters at study site-4 are given in the Table 5,7,16 and 30.
STUDY SITE 5:

**Water Temperature:** The water temperature did not show any drastic variation either during the study period (monthly) or among the seasons. A lowest temperature was recorded during August (27.53°C) and highest (30.23°C) during May month (Table 6) with a yearly mean of 28.75°C. Maximum water temperature profile was established during pre monsoon season (28.99°C) and minimum (28.38°C) during monsoon period while during post monsoon an intermediate regime (28.87°C) was noticed (Table 21).

The water temperature did not show any drastic variation among the study sites, of course little high values were noticed during the warmer months (April-May) at all study sites (Table 8 & Fig.2). Monthly variation of water temperature values and mean values of various hydrographic parameters at study site-4 are given in the Table 6,7,8 and 22.

**Salinity:** Salinity showed wide range of variation during the study period with minimum of 1.28% (August) and maximum 31.15% (October) with moderate values during November-March (21.46-27.89%) with a yearly mean of 21.07
% respectively (Table 6 and Fig.3). Seasonally it showed a wide range of variation with minimum (9.72%) during monsoon period and maximum (28.47 %) during pre monsoon period with an intermediate values being established during post monsoon season (25.04%) [Table 21]. Monthly variation of salinity values and mean values of various hydrographic parameters at study site-5 are given in the Table 6,7,9 and 23.

Dissolved Oxygen: Dissolved oxygen content fluctuated between 4.22 mg/l (December) and 6.53 mg/l (June). High values were recorded during in November (6.32mg/l), January (6.11 mg/l) and March (6.23 mg/l) during the study period (Table 6 and Fig.4) with a yearly mean of 5.58 mg /l. Table 21 explains the seasonal variation of this parameter, with minimum (5.28 mg/l) during post monsoon and maximum (5.85 mg/l) in southwest monsoon with moderate 5.63 mg/l content in pre monsoon period. Monthly variation of dissolved oxygen values and mean values of various hydrographic parameters at study site-5 are given in the Table 6,7,10 and 24.

Hydrogen ion concentration: Hydrogen ion concentration did not vary much among the months and the season. It varied from 7.01-7.95 (Table 6 and Fig.5) with a yearly mean of 7.46 and seasonally it varied between 7.37 (post
monsoon), 7.31 (pre monsoon) and 7.68 (southwest monsoon) respectively (Table 21). Monthly variation of hydrogen ion concentration values and mean values of various hydrographic parameters at study site-5 are given in the Table 6, 7, 11 and 25.

**Suspended matter:** Maximum suspended matter was noticed during July (0.92 gm/l) and minimum during March-May (0.06, 0.04 & 0.05 gm/l) [Table 6 and Fig.6] with a yearly mean of 0.18 gm/l. Among three seasons, it varied 0.11 gm/l (post monsoon), 0.07 gm/l (pre monsoon), and 0.35 gm/l (southwest monsoon) [Table 21]. Monthly variations of suspended matter values and mean values of various hydrographic parameters at study site-5 are given in the Table 6, 7, 12 and 26.

**Phosphate-P:** This nutrient salt showed a bimodal peak, one during October (1.48 μg at/l), second during January (1.39 μg at/l) with a low values of 0.76 μg at/l (June) with a yearly mean of 7.48 μg at/l (Table 6 and Figure 7). Seasonally, it varied between 1.43 μg at/l, 0.91 μg at/l and 0.82 μg at/l in post, pre and southwest monsoon seasons (Table 21) respectively. Monthly variation of phosphate values and mean values of various hydrographic parameters at study site-5 are given in the Table 6, 7, 13 and 27 respectively.
Nitrate-N: This salt did not show any marked variation in its concentration during the present study period. Primary peak was noticed in October (1.48 µg at/l) and there after it gradually decreased except in January (1.39 µg at/l) and fall was noticed in July (0.64 µg at/l) and again attained the peak in August (1.02 µg at/l) month respectively (Table 6 and Figure 8). Lowest value of this nutrient salt was noticed in July with a value of 0.64 µg at/l with a yearly mean of 1.04µg at/l. Nitrate found in maximum concentration during post monsoon season (1.42 µg at/l) and minimum during southwest monsoon season with a concentration value of 0.82-µg at/l and relatively moderate value (0.91 µg at/l) noticed during monsoon season (Table 21). Monthly variation of nitrate values and mean values of various hydrographic parameters at study site-5 are given in the Table 6,7,14 and 28.

Nitrite-N: This salt did not show any marked variation in its concentration during the present study period. Primary peak was noticed in September (0.78 µg at/l) and there after it gradually decreased and secondary peak established in January (0.86 µg at/l) [Table 6 and Figure 8]. Lowest value of this nutrient salt was noticed in April with a value of 0.09µg at/l with a yearly mean of 0.55µg at/l. Nitrite found in maximum concentration during post monsoon season
(0.68 µg at/l) and minimum during southwest monsoon season with a concentration value of 0.44 µg at/l and relatively moderate value (0.54 µg at/l) noticed during pre monsoon season (Table 21). Monthly variation of nitrate values and mean values of various hydrographic parameters at study site-5 are given in the Table 6,7,15 and 29.

Silicate-Si: Compared to other two nutrient salts, this salt showed maximum concentration in this study site during the pre & southwest monsoon seasons during the present study tenure. Moderate silicate concentration was noticed during July-September (36.71-39.76 µg at/l) whereas minimum during December & January (15.61 & 22.32 µg at/l) periods. But, thereafter a gradual increasing trend was noticed from February and attaining peak in May, registering highest concentration (42.19 µg at/l) of this nutrient salt (Table 6 and Figure 10) with a yearly mean of 37.24 µg at/l. Silicate found in maximum concentration during southwest monsoon season (40.84 µg at/l) and minimum during post monsoon season with a concentration value of 30.69 µg at/l (Table 21). Monthly variation of silicate values and mean values of various hydrographic parameters at study site-5 are given in the Table 6,7,16 and 30.
**Water Temperature:** Oscillation in water temperature at the bottom waters was of the order of 3°C, ranging from 26.12 to 29.44°C. It is clear from the Table 8 and Figure 2 that, this parameter did not show any drastic variation among the stations and seasons; more or less uniform pattern (28.54 to 29.44°C) of distribution was noticed in all study sites. Maximum water temperature was noticed during the pre monsoon and minimum during monsoon and this trend noticed in all study sites during the present study period.

**Salinity:** This parameter showed its wide range (16.08-19.60 %o) in all the five study stations (Table 9) with highest peak (25.74-29.52 %o) being in pre monsoon and lowest (4.47-9.70%o) during southwest monsoon period (Table 23).

**Dissolved oxygen:** With less fluctuation, the dissolved oxygen content at all study stations during the year ranged from 5.65 to 6.19mg/l. It is surmised from the Table 10 & 24 and Figure 4 that, the dissolved oxygen increased during the southwest monsoon and later gradually decreased in subsequent seasons. It is also noticed that none of the study stations are oxygen depleted ones during the study tenure.
Hydrogen ion concentration (pH): The pH of the water sample did not vary much at the study stations and had a range between 7.25-7.44; 7.3-7.6 and 7.41-7.74 during post, pre and southwest monsoon seasons (Table 11 & 25 and Fig.5). There is no remarkable fluctuation in this parameter among the stations and it varied between 7.06 and 8.33.

Suspended matter: Table 12 & 26 and Figure 6 explains wide range of fluctuation of this parameter among the station (0.16-0.21 gm/l) and season (0.11-0.14 gm/l; 0.06-0.07 gm/l and 0.29-0.46 gm/l in respective post, pre and southwest monsoon.

Phosphate-P: The mean values of this nutrient salt varied from 1.02 to 1.68 µg at/l at study stations 1 to 5 during the present study tenure. Station 1 & 2 showed higher values at station 2 than the station 1. These values are comparatively higher than the values found at stations 3, 4 & 5, which are located in the upper reaches of the river Kali. This nutrient salt showed wide range of fluctuation during different seasons and values are of 1.40-1.90µg at/l, 0.68-1.62 µg at/l and 0.82-1.50 µg at/l during post, pre and southwest monsoon seasons (Table 13 & 27 and Figure 7).
Nitrate-N: During period of present observation, a wide variation was noticed at each station such as 4.92; 7.77, 5.01, 5.73 and 1.02-μg at/l at station 1 to 5 respectively. As it is evident from Table 14 & 28 and Figure 8 that a gradual increasing trend of the nutrient salt from pre monsoon to southwest monsoon season in river Kali biotope.

Nitrite-N: During period of present study, a slight variation was noticed at each station such as 0.97, 0.77, 0.66, 0.58 and 0.54 μg at/l at station 1 to 5 respectively. As it is evident from Table 15 & 29 and Figure 9 that a gradual increasing trend of the nutrient salt from post monsoon to pre monsoon season in the study sites located in the river Kali biotope.

Silicate-Si: The maximum concentration of this nutrient salt was occurred during the southwest monsoon (June-September) and minimum during pre monsoon season (February-May) with a moderate values observed during the post monsoon season (Table 16 & 30 and Figure 10).

Discussion:

Wide ranges in water temperature values were noticed during three different seasons (Table 22). In the post monsoon, it oscillated between 27.89
& 28.87°C while during pre monsoon, it has fluctuated between 28.99 & 31.09°C whereas comparatively lower values (27.86-29.15°C) were found during southwest monsoon season. During the present study period, it was noticed maximum water temperature was noticed during the pre monsoon season and minimum in monsoon season in all study stations. Similar findings were noticed by earlier workers in this region (Naik, 1986, Naik and Neelakantan and 1990 Naik et al., 2004). Variation in water temperature between the stations could be due to different timings of recording.

A bimodal distribution of water temperature of Karwar bay and river Kali reported by earlier workers (Noble, 1968, Annigeri, (1968,72), Naik (1986), Naik et al., (1992) of surface waters. Noble (1968), Naik (1986), Naik et al., (1992) have reported a secondary mode during October to January (post monsoon) and primary peak during February to May (pre monsoon). The range of temperature in each study station was 27.32 -28.63°C; 27.56-28.82°C; 27.6-31.05°C; 27.01-31.55°C and 27.52-32.08°C respectively. The lower temperature values were encountered during the southwest monsoon and there after gradually increased. Thermal structure of estuarine waters are controlled fundamentally by the temperature of the sea and run off water and this holds good only for the estuaries which are short and have little development of sand
and mud flats. All the minima and maximal values were noticed during August, April & May months. In the present investigation, where the first fall observed during the southwest monsoon while the northeast monsoon fall is not as pronounced as the previous one. A similar trend was observed by Ramamurthy (1965), Naik (1986), Naik et al., (2004) in the surface waters temperature in the seas water off the North Kanara. The differential depth of the water column and position of the study station, which also contribute to the small regional variations of the parameter in the surface water of Kali river (Neelakantan et al., 1986, Naik et al., 2004).

Salinity:

The variation in salinity values at different study sites is given in the Table 9 & 23 and Figure 3. The maximum salinity values noticed during the month of April and May in all study sites (Fig. 3). The maximum salinity content was noticed in station 5 and low at station 2. The lower saline values incurred at station 2 could be probably due to the fresh water influx from upper riverine stretch and land drainage. A similar findings have been recorded by several workers in this area are Noble, 1968; Annigeri, 1968 & 72, Naik, 1986; Naik et al., 1992 & 2004. The extreme discharge to the northern sector of Karwar bay influences the salinity structure spatially and temporally. The mean
salinity ranged between 16.08% (station 2) and 19.60% (station 5). The land runoff and river influx into inshore waters of Karwar drastically declines the salt content of water during the southwest monsoon period. Salinity attained a high value (25.74-29.52%) during the pre monsoon season and low (4.47-9.70%) during monsoon season (Table 23). The lower salt concentration during the southwest monsoon and high during pre monsoon season while during post monsoon season (Table 23) a moderate regime of salinity established. The average value of salt content among the study stations 1-5, are of 4.54, 4.47, 5.68, 9.51 and 9.70%, respectively. The variation of this parameter could be due to the location of the study stations at different biotope of river Kali resulting drastic variation in the salinity values over space and time. In Kali estuary, the distribution of salinity depends upon the variations in the amount of run off from the land and precipitation during monsoon and not to mention the tidal amplitude whose effect is prominent within the seasons. The transition from these low values to the higher ones of the summer takes place gradually during the post monsoon months (Naik and Neelakantan, 1991).

Dissolved Oxygen:

According to Parson's et al., (1977), the water movement through the sediment is of primary importance in determining the oxygen supply to the
benthic systems. The pelagic floral stretch and circulation appears to be the major factor influencing the content of the dissolved oxygen in the stations of Karwar bay and river Kali. The rich oxygenated condition prevailed in all the stations during the present study period (Table 10). The mean high oxygen content of station 3 (4.45 mg/l) suggests the lesser density of aerobic heterotrophics like microorganisms there in (Parsons et al., 1977) and rich growth of faunal community but the poor oxygenation of surface waters at station 1 (3.27 mg/l) denotes reduced sulphide containing zone underlying the oxidised layer of sediment surface (Fenchel, 1969, Fenchel and Riedl, 1970; Sudarshana, 1983). The mean values at station 1, 3 and 5 were of 5.76, 5.65 and 5.57 mg/l respectively. The values of this parameter seems to fluctuate in different seasons. Among the three seasons, the lowest oxygen content was noticed during post monsoon ranging from 5.28-5.88 mg/l (Table 24) and highest oxygen values (5.85-6.17 mg/l) were noticed during southwest monsoon season (Table 24). Intermediate values were noticed during post monsoon season. This could be probably due to the enormous suspension load of microalgae in pre monsoon that has depressed the average to a lower order (Naik, 1986). It was also noticed that, the dissolved oxygen content was gradually increased from station 2 to 5 (5.65-6.19mg/l). During the present study tenure
it was noticed that none of the stations could be designated as oxygen depleted ones.

**Hydrogen ion concentration:**

The hydrogen ion concentration did not vary much among study station during different months (Table 1 and Figure 5). A more or less uniform pattern of distribution of this parameter is noticed in all these study stations, with a low value in pre monsoon (February-May) and an intermediate values (alkaline) noticed during the post monsoon while comparatively higher value recorded during southwest monsoon season. The variation in average hydrogen ion concentration (pH) values among the study stations is negligible. The mean values recorded at station 1-5 are 7.54, 7.43, 7.46, 7.56 and 7.44 respectively (Table 1 and Figure 5). In the present study, the pH values ranged from 7.01 to 8.30. According to Perkins (1976), the range of pH of estuaries and coastal waters under normal and unpolluted conditions is between 6.7 and 9.25 respectively.

**Suspended matter:**

Suspended matter was found highest in station 3 with a mean value of 0.21 g/l and low value (0.16 g/l) at station 1. In all, the suspension matter was
found high in all stations with considerably more suspension matter was noticed at station 3. The high suspension matter in the stations could possibly be composed of fine sediments particles in a consequence of high content of planktonic organisms or detritus at station 4 & 5 whereas in the station 3 it could be due to the composed fine sediment particles as a result of the sand mining and other activities in the near by vicinity (Table 12,26 and Figure 6) gives some information regarding the distribution of suspension matter in different study sites during the study period. The suspension matter values vary temporarily in considerable magnitude. The maximum suspension matter was noticed during southwest monsoon and post monsoon (Table 26) season. The increase in suspension matter in all the study sites during post monsoon season may be due to the high concentration of planktonic organisms. Whereas in south west monsoon this could be probably due to the river run off and land run off which contributes maximum amount of sand particles as well as detritus and plankton. According to Jerlov et al.,(1978), more often the suspended particles are conglomerates containing various components and concentration of suspended matter varies from less than 0.1 mg/l in open ocean to many grams/l in estuaries and near shore waters. The main sources of suspended matter in the bay and near shore waters are river run off, biological activities and Collin dust, intense coastal abrasion and churning up sedimentary materials. The strip of
high suspended matter does not spread wider which may be due to presence of
strong shoreline currents do not permit its dispersal very far off the shore.

Nutrients:

The nutrients (phosphate, nitrate, nitrite and silicate) have exhibited
tempo-ro-spatial seasonal variations during the present study period. The
dissolved nutrients like Phosphate-phosphorus, Nitrate-nitrogen, Nitrite-
nitrogen and Silicate-silicon concentration were also considerably high in
coastal waters as well as in the Kali riverine biotope (Table 13-16 & 27-30 and
Figure 7-10). Noble (1968), recorded high concentration during June to
October, Annigeri (1972) has reported high nutrient level during December
(1965-67) and November (1966-67). In the present study, the maximum
concentration of nutrients (phosphate and nitrate) was observed during the post
monsoon followed by the pre monsoon season. But, the silicate concentration
was found maximum during the monsoon season in all the study sites (Table
13-16 & 27-30 and Figure 7-10).

Phosphate:

The variation in the dissolved inorganic phosphate content among the
study stations is presented in Table 13 & 27 and Figure 7. The range of
phosphate value in the five study stations varied between 0.84-2.43 (Station 1), 0.85-2.12 (Station 2), 0.1-1.93 (station 3), 0.02-1.72 (station 4) and 0.64-1.48 μg at/l (Station 5). The mean values of phosphates vary between 1.02 (Station 5) and 1.68 μg at/l (Station 2). The phosphate content varied considerably in temporally but it did not vary much spatially. A low concentration of this nutrient salt was noticed during southwest monsoon season whereas during post monsoon highest values of phosphate were recorded in all the study sites. Kesavrao (1989) states that during high biological active movement period, the lower values of these nutrient elements were observed and certain physical and chemical process are more important than the biological processes in determining the phosphate distribution in coastal waters during monsoon season. Verlenkar and Qasim (1983) observed the particulate phosphorus ranged between 0.70 and 5.18 μg at/l in coastal waters of Goa and they were more or less similar to that found in the Bay of Bengal (0.93-4.65 μg at/l) observed by Rao and Rao (1975). The lower values of phosphate at station 4 and 5 may be due to influx of land run off, which contains lower phosphate content. Annigeri (1972), Naik (1986), Naik and Neelakantan, 1991 and Naik et al., (2004) observed a similar results in the inshore waters of Karwar bay and in the river Kali. During the post monsoon and pre monsoon, the concentration of the Phosphate-phosphorus was more but the concentration in later was not as
pronounced as in the former season. A similar type of distribution was noticed in the Cochin backwaters by Balakrishnan and Shynamma (1976), Naik and Neelakantan (1991) in the Karwar waters and Naik et al., 2004. The low concentration of this nutrient salt during the south west monsoon season in all the study sites, could be due to the heavy influx of riverine water in to the inshore waters where in former habitat contains low concentration of the salt.

**Nitrate:**

Table 14, 28 and Figure 8 gives information regarding the distributional trend of nitrate-nitrogen values at different study sites during the study tenure. In all the study sites, station 2 showed a maximum concentration of this nutrient salt whereas station 5 was comparatively low in nitrate concentration. A maximum concentration was noticed during January (primary peak) and secondary peak during August in both stations located in the inshore waters (Figure 8). Values were found maximum during October-December (primary peak) and May-July (secondary peak) in the stations located in the Kali river biotope. In post monsoon the values varied between 1.40 (station 5) and 4.40µg at/l (station 2) whereas in the post monsoon the nitrate values showed a lower concentration (1.40-4.40µg at/l) in all the study sites (Table 28). During southwest monsoon season a comparatively higher values than pre monsoon
were noticed in all the study sites. The nitrate content in station 1-5 varied considerably with a mean value of 4.92 (Station 1), 7.77 (station 2), 5.01 (Station 3), 5.73 (Station 4) and 1.02 µg/l (Station 5) [Table 14].

The Nitrate concentration in all the study sites showed more or less similar pattern of distribution as in the case noticed elsewhere (Balakrishnan and Shynamma (1976), Qasim (1983) Naik (1986), Naik and Neelakantan (1991) and Naik et al., 2004). A similar pattern of distribution of this nutrient salt was noticed by earlier workers in the Karwar waters (Ramamurthy, 1965; Noble, 1968; Naik, 1986; Naik et al., 1990 and Naik and Neelakantan, 1991). The lower concentration of this nutrient salt may be due to the intake by phytoplankton and registering their high growth profile during this period. In many cases, this nutrient salt acts as a limiting factor in governing the population of microscopic benthic plant and animal community.

Nitrite:

The variation in the dissolved inorganic nitrite content among the study stations is presented in Table 15 & 29 and Figure 9. The range of nitrite value varied between the five study stations varied between 0.1-1.73 (Station 1), 0.1-1.51 (Station 2), 0.40-1.21 (Station 3), 0.07-0.91 (Station 4) and 0.06-0.86 µg
at/l (Station 5). The mean values of nitrite vary between 0.54 (Station 5) and 0.97 μg at/l (Station 1). The nitrite content varied considerably in temporally but it did not vary much spatially. During southwest monsoon season, this nutrient salt showed minimum values like that of phosphate, whereas during post monsoon a highest value of nitrite recorded in all the study sites. Verlenkar and Qasim (1983) estimated the particulate nitrite in coastal waters of Goa and it was found to be in similar range as noticed Rao and Rao (1975) in the Bay of Bengal. At station 4 and 5 the concentration of this nutrient salt was found to be very meager probably due to the low content of this salt in the land runoff. Similar observations were made by the earlier worker also (Naik (1986), Naik and Neelakantan, 1991 and Naik et al., 2004) in the river Kali. In the preceding and succeeding period of southwest monsoon, the concentration of the nitrite-nitrogen was less whereas in latter case it was found to be comparatively high. Balakrishnan and Shynamma (1976) have noticed such kind of distribution in Cochin backwaters also. The low concentration of This nutrient salt was found to be in low quantity in all the study sites during the south west monsoon season, as river contains this salt in lesser quantity only (Naik et al., 2004).
Silicate:

The silicate concentration showed more or less uniform pattern of distribution during the study period at all study sites (Table 16 & 30 and Figure 10) but wide variation among the seasons. The mean value of silicate at station 1-5 were of 33.06 (Station 1), 33.68 (Station 2), 34.42 (Station 3), 37.74 (Station 4) and 37.20 μg at/l (Station 5) [Table 16]. The minimum silicate concentration was noticed at station 2 (18.32-44.06 μg at/l) and maximum at Station 1 (19.72-44.64 μg at/l). Temporally this nutrient salt varied considerably with a low value during post monsoon (27.64-33.04 μg at/l) while maximum values were noticed in all the study station during the southwest monsoon period 38.19-40.20 μg at/l (Table 30). Increase in silicate level may be attributed to the bacterial decomposition of planktonic detrital component (Naik and Neelakantan, 1991).

The concentration of silicate was much under the influence of southwest monsoon when heavy rainfall, inflow of freshwater and land drainage was more (Naik and Neelakantan, 1991). It is surmised from the data (Table 16, 30 and Figure 10) that a similar trend was also noticed in the present study. Peak of silicate occurred during the southwest and at the onset of the post monsoon season. Rao and George (1959), Ramamurthy (1965), Sudarshana (1981), Naik
Naik and Neelakantan (1991) observed that river water contains high concentration of silica. The influx of river water and land drainage appears to contribute largely to the rise in the silicate in the inshore waters of Karwar during the south-west monsoon season (Noble, 1968). The silicate shows an inverse relation to salinity, a similar relationship between the two parameters was noticed earlier (Ramamurthy, 1965; Noble, 1968; Naik, 1986; Naik and Neelakantan, 1991 and Naik et al., 2004) inshore waters of Karwar and in the Kali river biotope. A similar trend was observed by Jayaraman (1951 & 54) and Ganapathi and Rao (1988) in the Bay of Bengal.

The variation of these nutrient salts at different study sites located in the coastal waters of Karwar as well as in the river Kali are primarily influenced and controlled by the activity of upwelling process and high rate of precipitation in this region.

The correlation coefficients (r) among various hydrographic parameters at study station 1 is given in the Table 31. Out of the total 45 correlations tabulated between two parameters, 10 were found to have significant correlations (r >0.304). From this, 2 correlations were significant at 5% level (r >0.304- <0.392) and 8 correlations at 1% (r >0.393) level. The negative
(inverse) correlations were found in eight cases, water temperature with pH, suspended matter, nitrite & silicate, the salinity with pH, suspended matter, nitrate & silicate. The dissolved oxygen with phosphate and nitrite. The pH with phosphate and nitrite, suspended matter with phosphate & nitrite; the phosphate with nitrate and silicate; nitrate with nitrite and lastly the nitrite with silicate. Some of the highly significant correlations (r>0.393) were discernible between water temperature and salinity, dissolved oxygen between pH & nitrate; whereas pH between nitrate and silicate, Suspended matter and nitrate & silicate; and phosphate with nitrite. Regarding single correlation, water temperature with salinity (r=0.54; p<0.01) and phosphate with nitrite (r=0.52; p<0.01) showed a significant correlation between them.

The correlation coefficients (r) among various hydrographic parameters at study station 2 is given in the Table 32. Out of the total 45 correlations tabulated between two parameters, 6 were found to have significant correlations (r >0.304). From this, 1 correlation was significant at 5% level (r >0.304 <0.392) and 5 correlations at 1% (r>0.393) level. The negative (inverse) correlations were found in seven cases, (i) between water temperature and pH, suspended matter, phosphate & nitrate; (ii) salinity and suspended matter, nitrate & silicate; (iii) dissolved oxygen and nitrate, suspended matter phosphate,
nitrite & silicate; (iv) pH and suspended matter, nitrite & silicate; (v) suspended matter and phosphate & nitrite; (vi) phosphate and nitrate & silicate; (vii) nitrate and nitrite. Some of the highly significant correlations (r>0.393) were discernible between salinity & dissolved oxygen, dissolved oxygen & nitrate, suspended matter & nitrate & silicate, and nitrite & silicate. Regarding single correlation, dissolved oxygen & nitrate and nitrite & silicate significant correlation only (p<0.01).

The correlation coefficients (r) among various hydrographic parameters at study station 3 are given in the Table 33. Out of the total 45 correlations tabulated between two parameters, 10 were found to have significant correlations (r >0.304). From this, 2 correlations were significant at 5% level (r >0.304<0.392) and 8 correlations at 1% (r>0.393) level. The negative (inverse) correlations were found in eight cases, [between water temperature and suspended matter (r=-0.21), phosphate (r=-0.30), nitrate (r=-0.08), nitrite(r=-0.28) and silicate(r=-0.04); between salinity and pH (r=-0.06) suspended matter (r=-0.77), nitrate (r=-0.46) and silicate (r=-0.55). Between dissolved oxygen and phosphate (r=-0.30) and silicate(r=-0.36), between pH and phosphate (r=-0.63) and nitrite (r=-0.57), between suspended matter and phosphate (r=-0.48) and nitrite (r=-0.49) between phosphate and nitrate (r=-
and silicate \( (r=-0.17) \) and between nitrate and nitrite \( (r=-0.58) \) and nitrite and silicate \( (r=-0.37) \) \( (p<0.05) \). Some of the highly significant correlations \( (r>0.393; \ p<0.01) \) were discernible between salinity, dissolved oxygen, pH, suspended matter, nitrate, nitrite and silicate. Phosphate did not show any significant correlations with any other parameters studied.

The correlation coefficients \( (r) \) among various hydrographic parameters at study station 4 are given in the Table 34. Out of the total 45 correlations tabulated between two parameters, 8 were found to have significant correlations \( (r>0.304) \). From this, 4 correlations were significant at 5% level \( (r>0.304 <0.392) \) and 4 correlations at 1% \( (r>0.393) \) level. The negative (inverse) correlations were found in eight cases, [between water temperature and pH \( (r=-0.77) \), suspended matter \( (r=-0.61) \), phosphate \( (r=-0.05) \) & nitrate \( (r=-0.45) \), between salinity and dissolved oxygen \( (r=-0.37) \), pH \( (r=-0.63) \), suspended matter \( (r=-0.55) \), nitrate \( (r=-0.21) \) and silicate \( (r=-0.20) \); between dissolved oxygen and suspended matter \( (r=-0.12) \), phosphate \( (r=-0.30) \), nitrate \( (r=-0.13) \) and nitrite \( (r=-0.20) \); between pH and phosphate \( (r=-0.24) \), nitrite \( (r=-0.27) \) and silicate \( (r=-0.03) \); between suspended matter and phosphate \( (r=-0.07) \) and nitrite \( (r=-0.44) \); between phosphate and nitrate \( (r=-0.23) \) and nitrite \( (r=-0.55) \); between nitrate and silicate \( (r=-0.42) \) and between nitrite and silicate \( (r=-0.33) \)]
Some of the highly significant correlations (r>0.393; p<0.01)) were discernible between water temperature & salinity, between pH & Suspended matter and nitrate, between suspended matter & nitrate. Dissolved oxygen, pH, phosphate did not show any significant correlations with any other parameters studied. Regarding single correlation, salinity with water temperature (r=0.60; p<0.01) and suspended matter with pH (r=0.47; p<0.01) were noticed.

The correlation coefficients (r) among various hydrographic parameters at study station 5 are given in the Table 35. Out of the total 45 correlations tabulated between two parameters, 8 were found to have significant correlations (r >0.304). From this, 1 correlation was significant at 5% level (r >0.304 <0.392) and 7 correlations at 1% (r>0.393) level. The negative (inverse) correlations were found in twenty cases, [between water temperature and dissolved oxygen (r=-0.04), pH(r=-0.15), suspended matter (r=-0.26), phosphate (r=-0.01), between salinity and dissolved oxygen (r=-0.23), pH (r=-0.17), suspended matter (r=-0.55), silicate (r=-.03); nitrate (r=-0.18) & silicate (r= -0.31), between dissolved oxygen and nitrate (r=-0.22) & nitrite (r=-0.05), between pH and phosphate (r=-0.30), nitrate (r=-0.08) and nitrite (r=-0.10) between suspended matter and phosphate (r= -0.19), nitrate (r=-0.40) and nitrite (r=-0.55); between phosphate and nitrate (r= -0.23) & nitrite (r= -0.55); between
nitrate and silicate ($r= -0.42$) and between nitrite & silicate ($r= -0.33$) 
($p<0.05$). Some of the highly significant correlations ($r>0.393; p<0.01$) were
discernible between water temperature, salinity, suspended matter, nitrate, 
nitrite and silicate. Dissolved oxygen, pH and phosphate did not show any 
significant correlations with any other parameters studied. Regarding single 
correlation, salinity with water temperature ($r=0.40; p<0.01$), pH with suspended matter ($r= 0.58; p<0.01$), nitrate with salinity ($r= 0.44; p<0.01$)& nitrite with salinity ($r= 0.50; p<0.01$) were noticed.

**B. SEDIMENTOLOGICAL CONDITION:**

Sedimentology plays an important role in the storage and release of nutrient into the water column, the mineralization of organic carbon deposits by various kinds of microbes. In association with other parameters, the sediment is responsible for the variations in densities of majority of benthic organisms. The substrate features namely sediment temperatures, pH, moisture content, organic carbon and sediment texture are probably responsible in the density variations of benthic organisms.
Study Station 1

Sediment temperature: Temperature did not show much variation during the study period and was oscillated between 27.12 and 28.18°C with yearly mean of 27.75 (±0.34). Higher temperature profile was noticed during the pre monsoon and low during southwest monsoon (Table 36 and Figure 11).

Interstitial water: Maximum interstitial water content of sediment noticed during November and April but more pronounced values were recorded during June and August at station 1. Overall during the study period, the values varied from 25.35 to 29.72% with yearly mean of 28.05 (±1.08) [Table 36 and Figure 12].

Coefficient of Sorting (So): A marked variation noticed in the values of this parameter. Maximum values recorded during March, May and June and minimum during October, November and January (Figure 13). During the study tenure, the values were ranged between 0.2354 (January) and 0.8925 (June) with yearly mean of 0.53 (±0.23) [Table 37].

Median diameter: Higher values of median diameter were recorded during April to June (1.56-1.85) and in September (1.72) whereas lower value noticed
in December (0.12) with a yearly mean of 0.92 (±0.62) (Table 37 and Figure 14).

Skewness: Values did not show any marked variation during the study period but higher values were noticed during March (1.72), May (1.75) and June (1.78) and lower values in September (0.72) and July (0.74) (Table 37 and Figure 15).

Study Station 2

Sediment temperature: Temperature values ranged between 27.41 (July) and 29.33°C (March) with yearly mean of 28.56 (±0.49). Higher temperature profile was noticed during the pre monsoon and low during southwest monsoon period (Table 36 and Figure 11).

Sediment temperature did not vary much among the five study stations and all stations showed more or less similar pattern of distribution during the study period. The yearly mean varied between 27.71 (Stn. 4) and 28.56 (Stn. 2). In all study stations, maximum temperature recorded during pre monsoon and minimum during southwest monsoon season. Variation in values at study sites could be due to recording at different timings.
Interstitial water: High interstitial water content of sediment was noticed during January to February but more pronounced values were recorded during May to July with peak during June (32.45) in this station. Overall, during the study period, the values varied from 28.21 to 32.45% with yearly mean of 30.28 (±1.32) [Table 36 and Figure 11).

Coefficient of Sorting (So): A marked variation noticed in the values of this parameter. Maximum values recorded during December (1.5018) and February (1.4573) and minimum during July (1.0855) and August (1.0554), (Figure 13). During the study tenure, the values ranged between 1.0554 (August) and 1.5018 (December) with yearly mean of 1.18 (±0.14) [Table 37).

Median diameter: Higher values of median diameter were recorded during December (0.1978) whereas lower value noticed in August (0.1386) with a yearly mean of 0.16 (±0.01) (Table 37 and Figure 14).

Skewness: Higher values were noticed during February (1.3143) and lower values in December (0.9156) (Table 37 and Figure 15).
Study Station 3

Sediment temperature: This parameter showed marked variation in time series, with minimum value of 25.11°C during August and maximum registered during April (31.22°C) with yearly mean of 28.08°C (± 1.54). Higher temperature profile was noticed during the pre monsoon and low during southwest monsoon. Period (Table 36 and Figure 11).

Interstitial water: Figure 12 and Table 36 explains the variation of interstitial water content of sediment and it was noticed that during January to March more pronounced values were recorded during August and with peak in September (24.72) in this station. Overall, during the study period, the values varied from 21.32 (May) to 24.72% with yearly mean of 22.92 (±0.98) [Table 36 and Figure 11].

Coefficient of Sorting (So): A marked variation noticed in the values of this parameter. Maximum values recorded during December (1.5018) and February (1.4573) and minimum during July (1.0855) and August (1.0554), (Figure 13). During the study tenure, the values were ranged between 1.0554 (August) and 1.5018 (December) with yearly mean of 1.18 (±0.14) [Table 37].
Median diameter: Higher values of median diameter were recorded during December (0.1978) whereas lower value noticed in August (0.1386) with a yearly mean of 0.16 (±0.01) (Table 37 and Figure 14).

Skewness: Higher values were noticed during February (1.3143) and lower values in December (0.9156) (Table 37 and Figure 15).

Study Station 4

Sediment temperature: More or less uniform pattern of temperature regime established at study station during the present study tenure. As it is surmised from the Table 36 and Figure 11, higher temperature regime established during the pre monsoon season and lower level noticed during the southwest monsoon season. In a year, temperature value ranged between 27.31°C and 28.29°C with yearly mean of 27.71°C (SD ± 0.32).

Interstitial water: Values of interstitial water content in the sediment of this station did not show any drastic variation over the space and time. The values
were oscillated between 26.55 and 29.32% with a yearly mean of 27.48\% (SD ± 0.67) [Table 36 and Figure 12].

**Coefficient sorting:** Table 37 and Figure 13 explains the variation in sorting coefficient values in the study station. The parameter showed values ranging from 0.1193 (November) to 0.9175 (June) with yearly mean of 0.65 (SD ± 0.26). In September and October month’s values were found to be high (0.6623-0.6715) and suddenly declined in November and gradually increased thereafter attaining the peak during March to June (0.9073-0.9175).

**Median diameter:** In this study station, median diameter of sediment varied between 0.21 (October) and 3.23 (April) with yearly mean of 1.74, SD ±1.44 (Table 37 and Figure 14). It showed sudden increase in value in the month of November and declined in following four months and again attained the peak in April and was found stable in next five months i.e., till September.

**Skewness:** Minimum and maximum skewness values were noticed during November (0.24) and June (1.84) with a mean of 1.39 (SD ± 0.43) (Table 37 and Figure 15). It showed increasing trend from December to March and
then more or less stable values were recorded till June later again declined in July and once again showed increase in values.

Study Station 5

**Sediment temperature:** Marked variation in values of this parameter was noticed during the present study tenure. Lower values were noticed during December (25.72°C) and August (25.63°C) whereas high value was noticed in April (31.43°C). As it is surmised from the Table 36 and Figure 11, higher temperature regime established during the pre monsoon season and lower level noticed during the southwest monsoon season. During the present study tenure, the temperature values ranged between 25.63°C and 31.43°C with yearly mean of 27.78°C (SD ± 1.56).

**Interstitial water:** Values of interstitial water content in the sediment of this station did not show much variation over the space and time but it showed comparatively low values on par with other study stations. The interstitial water content of sediment varied with little marginal values ranging from 24.72 to 28.45% with a yearly mean of 27.21% (SD ± 0.93) [Table 36 and Figure 12].
Coefficient sorting: Variation in sorting coefficient values in the study station is given in Table 37 and Figure 13. The parameter showed marked variation over space and time, registering higher values during September (0.6718) and lower values June (0.1101) and August (0.1751). The values were found ranging from 0.1101 (June) to 0.6718 (September) with yearly mean of 0.32 (SD ± 0.17).

Median diameter: In this study station, median diameter of sediment varied between 0.35 (September) and 1.75 (November) with yearly mean of 0.99, SD ±0.79 (Table 37 and Figure 14). Lower values were noticed during September and January while first and second peaks were recorded during November (1.75) and February (3.30). From March to September it showed more or less higher values (0.66-1.01) except in the month of June (0.36).

Skewness: Minimum and maximum skewness values were noticed during November (0.5565) and July (1.8446) with a mean of 1.01 (SD ± 0.36) (Table 37 and Figure 15). Marked variation was noticed in the values of skewness, with low during November (0.5565) increased to 1.3951 in December later gradually declined till June attaining peak in July thereafter again declined.
Sediment temperature did not vary much among the five study stations and yearly mean varied between 27.71 (Stn. 4) and 28.56 (stn.2). In all study stations, maximum temperature recorded during pre monsoon and minimum during southwest monsoon season. Variation in values recorded could be due to the different timings.

Among the five study stations, the lowest values were recorded at station 3 and highest at station 2 (Figure 12). In all these study stations, maximum interstitial water content values were recorded during southwest monsoon and in post monsoon seasons. Yearly mean of station 1 to 5 are of 28.05 (±0.34), 30.28 (±1.32), 22.92 (±0.98), 27.48 (±0.67) and 27.21% (±0.93) respectively (Table 36 and Figure 12).

Among five stations, maximum values were noticed at station 2 throughout the study period whereas minimum values noticed at station 5 with little high values during November to January when compared to station 4 (Figure 13). Yearly mean of all the stations recorded at study stations 1 to 5 are 0.53 (±0.23), 1.18 (±0.14), 0.32 (±0.10), 0.65 (±0.26) and 0.32 (±0.17) respectively (Table 37).
Table 37 and Figure 11 explain the variation trend of the median diameter parameter at all five-study stations during the present study period. Maximum values were recorded at station 4 during April to September whereas other stations showed more or less similar trend but for station 5, the values were remained uniformly stable throughout the study period (0.35-3.30). Yearly mean values with SD in parenthesis, at study station 1-5 are of 0.92 (± 0.62), 0.16 (± 0.01), 0.44 (± 0.15), 1.73 (± 1.44) and 0.99 (± 0.79) respectively (Table 37).

Among five study stations, Station 4 showed comparatively higher values of skewness during March to June (1.41-1.84) and lower during November month (0.24). Station 2 showed stable and uniform pattern of values throughout the study period (0.91-1.31). The yearly mean values of this parameter are of 1.26 (± 0.36), 1.00 (± 0.09), 1.08 (± 0.37), 1.39 (± 0.43) and 1.01 (± 0.36) respectively. Values given in the parenthesis are SD values (Table 37).

Sand, Silt and Clay:

Figure 17 explains monthly variation in sediment texture at station 1 during the present study period. Highest proportion of sand was noticed in all the months ranging from 45.23 (March) to 78.45% (September). This is
followed by the silt component. Clay found to be in low proportions compared to sand and silt throughout the study period (Table 38). Sediment texture in station 1 is portrayed in Fig. 22.

Seasonally, sand dominated in all three seasons, 59.21%, 52.58% & 61.08% during post, pre and southwest monsoon seasons respectively. Silt found in maximum proportion during pre-monsoon (32.47%) whereas clay found in maximum during post monsoon (17.84%) (Table 39). The yearly mean of these components i.e., sand, silt & clay were of 57.62%, 27.43% & 14.94% during respectively.

Monthly variation in sediment texture at station 2 during the present study period is given in the Figure 18. Highest proportion of sand was noticed in all the months ranging from 39.45% (March) to 81.55% (September). This is followed by the silt component and values ranged between 12.23% (September) and 43.56% (March). Except in March, silt remained lower than sand proportion. Clay found to be in low proportions compared to sand and silt throughout the study period (Table 38) and found minimum in November (1.01%) and maximum in December (19.95%). Sediment texture in station 2 is portrayed in Fig. 23.
Seasonally, sand dominated in all three seasons, 59.28%, 49.46% & 58.87% during post, pre and southwest monsoon seasons. Silt found in maximum proportion during pre-monsoon (38.05%) whereas clay also found maximum during pre monsoon (12.48%) (Table 39). The yearly mean of these components i.e., sand, silt and clay were of 55.87%, 33.98 and 10.15% during post, pre and southwest monsoon seasons.

Monthly variation in sediment texture at station 3 during the present study period is given in the Figure 19. Highest proportion of sand was noticed in all the months ranging from 48.96% (March) to 63.45% (February and July). This is followed by the silt component and values ranged between 25.32% (September) and 36.15% (May). Clay found to be in low proportions compared to sand and silt through out the study period (Table 38 and Fig.19) and found minimum in February (3.13%) and maximum in March (16.79%). Sediment texture in station 3 is portrayed in Fig. 24.

Seasonally, sand dominated in all three seasons, 59.02%, 57.46% & 60.14% during post, pre and southwest monsoon seasons respectively. Silt found in maximum proportion during pre-monsoon (34.54%) whereas clay also found maximum during post monsoon (10.22%) (Table 39). The yearly mean of
these components i.e., sand, silt and clay were of 58.87%, 32.08% and 9.04% respectively.

Monthly variation in sediment texture at station 4 during the present study period is given in the Figure 20. Highest proportion of sand was noticed in all the months ranging from 48.45% (May) to 65.26% (October). The silt component ranged between 12.42% (September) and 35.33% (June). Clay found to be remained in low proportions compared to sand and silt through out the study period except during September, December and January (Table 38 and Fig. 20) when it was found maximum than silt proportion (29.04%, 28.05% & 36.93%). Sediment texture in station 4 is portrayed in Fig. 25.

Seasonally, sand dominated in all three seasons, 52.67%, 54.70% & 52.78% during post, pre and southwest monsoon seasons respectively. Silt found in maximum proportion during southwest monsoon (30.78%) whereas clay found maximum during post monsoon (23.77%) (Table 39). The yearly mean of these components i.e., sand, silt and clay were of 53.38%, 27.14% & 19.48% respectively.
Monthly variation in sediment texture at station 5 during the present study period is given in the Figure 21. Sand was noticed in maximum proportion in all the months except in the month of January and February, when it was found lower than silt proportion and annually it ranged from 26.45% (January) to 78.15% (September). This is followed by the silt component and values ranged between 11.33% (September) and 58.32% (February). Clay found to be in low proportions compared to sand and silt throughout the study period (Table 39 and Fig. 21) and found minimum in March (4.92%) and maximum in January (28.29%). Sediment texture in station 5 is portrayed in Fig. 26.

Seasonally, sand dominated in all three seasons, 50.74%, 50.36% & 55.68% during post, pre and southwest monsoon seasons respectively. Silt found in maximum proportion during pre-monsoon (39.85%) whereas clay found maximum during post monsoon (22.44%) (Table 39). The yearly mean of these components i.e., sand, silt and clay were of 52.26%, 31.52% and 16.21% respectively.

The high percentages of organic carbon may be due to relatively denser benthic populations present in the saline waters. During the pre and post
monsoon months while the lower amounts of organic matter present in the sediment may be due to the fresh water influx in the bay during southwest monsoon period. Similar observations were made in other parts of west coast of India by several workers (Fernando, 1981; Kidwai et al., 1972, Murthy et al., 1969; Ramachandran et al., 1985). The sediment texture also plays a very important role in contributing the organic carbon to the benthic realm. The finer grain sizes are believed to hold good amount of these materials within it. In general, according to Sanders (1956), all the clay mineral except Kaolin bind the organic carbon and the area with the high percentage of clay is capable of having high proportion of organic carbon during the different seasons. Similar findings were also noticed in the present investigation especially in the lower reaches of the river Kali.

It is a known factor that a whole set of benthic organisms depend directly or indirectly on the nature and texture of bottom sediment in which they live. The organisms, which live wholly within the sediment, belong to the former category and those organisms, which depend on the sediment only for the purpose of support to the latter. The factors like organic carbon, sediment texture etc are the determinant factors for the survival, growth and propagation of the benthic organisms, especially of in-fauna in an aquatic environment.
Wide variation in the percentage composition of sand, silt and clay was observed over the seasons and stations. Sediment texture being predominantly sandy in nature, the average percentage composition was observed to be about 70% (post monsoon), 60% (pre monsoon) and 69% (southwest monsoon). However, few of stations showed less than 45% in each of the seasons. Silt and clay percentage range from 10-30 percent and 5-40 percent respectively depending on the season and location of the sites.
### Table 2. Monthly variation in different hydrographic parameters at station 1.

<table>
<thead>
<tr>
<th>Months</th>
<th>Temp (°C)</th>
<th>Sal. (o/oo)</th>
<th>Diss. Oxyg. (mg/l)</th>
<th>pH</th>
<th>Susp. matr (g/l)</th>
<th>Phosphate (ug at/l)</th>
<th>Nitrate (ug at/l)</th>
<th>Nitrite (ug at/l)</th>
<th>Silicate (ug at/l)</th>
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Table 3. Monthly variation in different hydrographic parameters at station 2.

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Table 9 Monthly variation in the Salinity (ppt) in Study Stations 1 to 5.

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<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
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<td>3.06</td>
<td>2.86</td>
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<td>1.93</td>
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<tr>
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</tr>
<tr>
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<tr>
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</tr>
<tr>
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<td>29.95</td>
<td>28.84</td>
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</tr>
<tr>
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Table 10 Monthly variation in the Dissolved Oxygen (mg/ltr.) in Study Stations 1 to 5.

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<th>Stn.5</th>
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<td>5.72</td>
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<td>4.43</td>
<td>5.81</td>
<td>4.45</td>
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<td>6.23</td>
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<td>5.12</td>
<td>5.15</td>
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<td>5.53</td>
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<tr>
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<td>6.12</td>
<td>5.43</td>
<td>6.61</td>
<td>5.72</td>
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<tr>
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Table 11 Monthly variation in the Hydrogen ion concentration in Study Stations 1 to 5.

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<th>Stn.4</th>
<th>Stn.5</th>
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<td>7.01</td>
<td>7.69</td>
<td>7.68</td>
</tr>
<tr>
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<td>7.12</td>
<td>7.11</td>
<td>7.93</td>
</tr>
<tr>
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<td>7.43</td>
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<tr>
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</tr>
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<td>7.22</td>
<td>7.76</td>
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<td>7.95</td>
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<td>7.63</td>
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<tr>
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<tr>
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<td>7.47</td>
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<td>7.46</td>
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Table 12 Monthly variation in the Suspended matter (mg/l) in Study Stations 1 to 5.

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<th>Stn.4</th>
<th>Stn.5</th>
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<td>0.18</td>
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<tr>
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<td>0.19</td>
<td>0.17</td>
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<tr>
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<td>0.12</td>
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<td>0.06</td>
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<td>0.06</td>
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<td>0.04</td>
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<td>0.09</td>
<td>0.06</td>
<td>0.05</td>
<td>0.05</td>
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<td>0.64</td>
<td>0.44</td>
<td>0.11</td>
</tr>
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<td>0.29</td>
<td>0.27</td>
<td>0.21</td>
</tr>
<tr>
<td>Sept.</td>
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<td>0.21</td>
<td>0.31</td>
<td>0.19</td>
<td>0.18</td>
</tr>
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<td>0.21</td>
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Table 13 Monthly variation in the Phosphate (ug at/ltr.) in Study Stations 1 to 5.

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<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
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<td>1.02</td>
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<td>1.21</td>
<td>1.14</td>
<td>0.74</td>
<td>0.64</td>
</tr>
<tr>
<td>Aug.</td>
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<td>2.12</td>
<td>1.44</td>
<td>1.21</td>
<td>1.02</td>
</tr>
<tr>
<td>Sept.</td>
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<td>1.81</td>
<td>1.93</td>
<td>0.99</td>
<td>0.86</td>
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<td>1.67</td>
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Table 14 Monthly variation in the Nitrate (ug at/ltr.) in Study Stations 1 to 5.

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<th>Stn.3</th>
<th>Stn.4</th>
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<td>6.14</td>
<td>0.52</td>
<td>0.56</td>
<td>0.86</td>
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<tr>
<td>Oct.</td>
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<td>0.96</td>
<td>0.63</td>
<td>0.24</td>
<td>1.48</td>
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<td>0.06</td>
<td>0.81</td>
<td>1.37</td>
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<td>8.81</td>
<td>7.84</td>
<td>7.14</td>
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</tr>
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<td>1.22</td>
<td>1.16</td>
<td>1.39</td>
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<td>0.07</td>
<td>1.02</td>
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<td>10.01</td>
<td>6.94</td>
<td>9.84</td>
<td>1.05</td>
</tr>
<tr>
<td>Apr.</td>
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<td>12.12</td>
<td>6.43</td>
<td>11.39</td>
<td>0.78</td>
</tr>
<tr>
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<td>4.15</td>
<td>4.2</td>
<td>3.44</td>
<td>0.79</td>
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<tr>
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<td>9.21</td>
<td>10.42</td>
<td>0.76</td>
</tr>
<tr>
<td>Jul.</td>
<td>10.34</td>
<td>12.05</td>
<td>10.54</td>
<td>11.02</td>
<td>0.64</td>
</tr>
<tr>
<td>Aug.</td>
<td>9.94</td>
<td>8.32</td>
<td>9.21</td>
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<td>1.02</td>
</tr>
<tr>
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<td>0.86</td>
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<tr>
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Table 15 Monthly variation in the Nitrite (ug at/ltr.) in Study Stations 1 to 5:

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<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
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<td>0.61</td>
<td>0.83</td>
<td>0.78</td>
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<tr>
<td>Oct.</td>
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<td>0.91</td>
<td>0.69</td>
<td>0.72</td>
<td>0.64</td>
</tr>
<tr>
<td>Nov.</td>
<td>1.25</td>
<td>0.9</td>
<td>0.68</td>
<td>0.54</td>
<td>0.52</td>
</tr>
<tr>
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<td>0.79</td>
<td>0.74</td>
<td>0.68</td>
</tr>
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<td>1.51</td>
<td>1.21</td>
<td>0.98</td>
<td>0.86</td>
</tr>
<tr>
<td>Feb.</td>
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<td>1.28</td>
<td>1.06</td>
<td>0.91</td>
<td>0.73</td>
</tr>
<tr>
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<td>0.21</td>
<td>1.09</td>
<td>0.96</td>
<td>0.62</td>
<td>0.68</td>
</tr>
<tr>
<td>Apr.</td>
<td>0.67</td>
<td>0.10</td>
<td>0.08</td>
<td>0.12</td>
<td>0.09</td>
</tr>
<tr>
<td>May</td>
<td>0.51</td>
<td>0.55</td>
<td>0.56</td>
<td>0.63</td>
<td>0.64</td>
</tr>
<tr>
<td>Jun.</td>
<td>0.10</td>
<td>0.56</td>
<td>0.55</td>
<td>0.54</td>
<td>0.49</td>
</tr>
<tr>
<td>Jul.</td>
<td>0.82</td>
<td>0.55</td>
<td>0.06</td>
<td>0.07</td>
<td>0.06</td>
</tr>
<tr>
<td>Aug.</td>
<td>1.18</td>
<td>0.42</td>
<td>0.40</td>
<td>0.42</td>
<td>0.42</td>
</tr>
<tr>
<td>Sept.</td>
<td>0.86</td>
<td>0.83</td>
<td>0.61</td>
<td>0.83</td>
<td>0.78</td>
</tr>
<tr>
<td>Mean</td>
<td>1.00</td>
<td>0.80</td>
<td>0.49</td>
<td>0.59</td>
<td>0.55</td>
</tr>
<tr>
<td>S.D.+/-</td>
<td>0.36</td>
<td>0.37</td>
<td>0.34</td>
<td>0.28</td>
<td>0.25</td>
</tr>
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</table>
Table 16  Monthly variation in the Silicate (ug at/ltr.) in Study Stations 1 to 5.

<table>
<thead>
<tr>
<th>Months</th>
<th>Stn.1</th>
<th>Stn.2</th>
<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept.2001</td>
<td>32.16</td>
<td>31.11</td>
<td>36.43</td>
<td>34.41</td>
<td>40.23</td>
</tr>
<tr>
<td>Oct.</td>
<td>29.43</td>
<td>31.33</td>
<td>33.41</td>
<td>31.14</td>
<td>44.12</td>
</tr>
<tr>
<td>Nov.</td>
<td>31.13</td>
<td>44.06</td>
<td>43.14</td>
<td>48.11</td>
<td>40.71</td>
</tr>
<tr>
<td>Dec.</td>
<td>19.72</td>
<td>18.32</td>
<td>16.43</td>
<td>28.12</td>
<td>15.61</td>
</tr>
<tr>
<td>Jan.2002</td>
<td>30.26</td>
<td>27.82</td>
<td>31.23</td>
<td>24.78</td>
<td>22.32</td>
</tr>
<tr>
<td>Feb.</td>
<td>30.73</td>
<td>33.78</td>
<td>33.16</td>
<td>36.08</td>
<td>38.26</td>
</tr>
<tr>
<td>Mar.</td>
<td>31.41</td>
<td>30.65</td>
<td>31.62</td>
<td>40.01</td>
<td>42.1</td>
</tr>
<tr>
<td>Apr.</td>
<td>30.08</td>
<td>31.06</td>
<td>31.32</td>
<td>40.09</td>
<td>40.82</td>
</tr>
<tr>
<td>May</td>
<td>27.86</td>
<td>28.04</td>
<td>27.96</td>
<td>39.76</td>
<td>42.19</td>
</tr>
<tr>
<td>Jun.</td>
<td>41.81</td>
<td>41.5</td>
<td>40.17</td>
<td>38.68</td>
<td>42.13</td>
</tr>
<tr>
<td>Jul.</td>
<td>44.64</td>
<td>42.06</td>
<td>42.58</td>
<td>47.42</td>
<td>39.76</td>
</tr>
<tr>
<td>Aug.</td>
<td>39.07</td>
<td>38.08</td>
<td>37.66</td>
<td>37.56</td>
<td>38.67</td>
</tr>
<tr>
<td>Sept.</td>
<td>32.16</td>
<td>31.11</td>
<td>36.43</td>
<td>34.41</td>
<td>40.23</td>
</tr>
<tr>
<td>Mean</td>
<td>33.06</td>
<td>33.68</td>
<td>34.42</td>
<td>37.74</td>
<td>37.2</td>
</tr>
<tr>
<td>S.D. +/-</td>
<td>6.38</td>
<td>7.01</td>
<td>6.72</td>
<td>6.44</td>
<td>8.14</td>
</tr>
<tr>
<td>Hydrographic parameters</td>
<td>Post Monsoon</td>
<td>Pre Monsoon</td>
<td>SW Monsoon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------</td>
<td>-------------</td>
<td>------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Temperature (°C)</td>
<td>28.37</td>
<td>30.07</td>
<td>28.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salinity (%)</td>
<td>18.65</td>
<td>29.52</td>
<td>4.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>5.65</td>
<td>5.72</td>
<td>6.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.39</td>
<td>7.51</td>
<td>7.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended matter (g/l)</td>
<td>0.14</td>
<td>0.07</td>
<td>0.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphate (µg at/l)</td>
<td>1.82</td>
<td>1.4</td>
<td>1.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrate (µg at/l)</td>
<td>2.9</td>
<td>5.14</td>
<td>7.7</td>
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<td></td>
</tr>
<tr>
<td>Nitrite (µg at/l)</td>
<td>1.48</td>
<td>0.59</td>
<td>0.69</td>
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<td></td>
</tr>
<tr>
<td>Silicate (µg at/l)</td>
<td>27.64</td>
<td>30.02</td>
<td>39.42</td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydrographic parameters</th>
<th>Post Monsoon</th>
<th>Pre Monsoon</th>
<th>SW Monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Temperature (°C)</td>
<td>27.89</td>
<td>30.64</td>
<td>28.5</td>
</tr>
<tr>
<td>Salinity (%)</td>
<td>21.28</td>
<td>25.74</td>
<td>4.47</td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>5.83</td>
<td>6.50</td>
<td>5.73</td>
</tr>
<tr>
<td>pH</td>
<td>7.35</td>
<td>7.51</td>
<td>7.41</td>
</tr>
<tr>
<td>Suspended matter (g/l)</td>
<td>0.13</td>
<td>0.07</td>
<td>0.35</td>
</tr>
<tr>
<td>Phosphate (µg at/l)</td>
<td>1.9</td>
<td>1.62</td>
<td>1.5</td>
</tr>
<tr>
<td>Nitrate (µg at/l)</td>
<td>4.4</td>
<td>8.12</td>
<td>11.17</td>
</tr>
<tr>
<td>Nitrite (µg at/l)</td>
<td>1.05</td>
<td>0.76</td>
<td>0.59</td>
</tr>
<tr>
<td>Silicate (µg at/l)</td>
<td>30.38</td>
<td>30.88</td>
<td>38.19</td>
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</table>
Table 19. Seasonal variation in the different hydrographic parameters at study station 3

<table>
<thead>
<tr>
<th>Hydrographic parameters</th>
<th>Post Monsoon</th>
<th>Pre Monsoon</th>
<th>SW Monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Temperature (°C)</td>
<td>28.66</td>
<td>31.09</td>
<td>29.15</td>
</tr>
<tr>
<td>Salinity (%)o</td>
<td>22.17</td>
<td>29.17</td>
<td>5.68</td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>5.52</td>
<td>6.08</td>
<td>5.74</td>
</tr>
<tr>
<td>pH</td>
<td>7.25</td>
<td>7.61</td>
<td>7.58</td>
</tr>
<tr>
<td>Suspended matter (g/l)</td>
<td>0.12</td>
<td>0.06</td>
<td>0.46</td>
</tr>
<tr>
<td>Phosphate (ug at/l)</td>
<td>1.69</td>
<td>1.17</td>
<td>1.15</td>
</tr>
<tr>
<td>Nitrate (ug at/l)</td>
<td>2.44</td>
<td>4.41</td>
<td>7.37</td>
</tr>
<tr>
<td>Nitrite (ug at/l)</td>
<td>0.84</td>
<td>0.67</td>
<td>0.41</td>
</tr>
<tr>
<td>Silicate (ug at/l)</td>
<td>31.05</td>
<td>31.02</td>
<td>39.21</td>
</tr>
</tbody>
</table>

Table 20. Seasonal variation in the different hydrographic parameters at study station 4

<table>
<thead>
<tr>
<th>Hydrographic parameters</th>
<th>Post Monsoon</th>
<th>Pre Monsoon</th>
<th>SW Monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Temperature (°C)</td>
<td>28.52</td>
<td>29.39</td>
<td>27.36</td>
</tr>
<tr>
<td>Salinity (%)o</td>
<td>24.51</td>
<td>26.52</td>
<td>9.51</td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>5.88</td>
<td>6.47</td>
<td>6.17</td>
</tr>
<tr>
<td>pH</td>
<td>7.44</td>
<td>7.41</td>
<td>7.74</td>
</tr>
<tr>
<td>Suspended matter (g/l)</td>
<td>0.12</td>
<td>0.06</td>
<td>0.37</td>
</tr>
<tr>
<td>Phosphate (ug at/l)</td>
<td>1.64</td>
<td>0.68</td>
<td>0.96</td>
</tr>
<tr>
<td>Nitrate (ug at/l)</td>
<td>2.34</td>
<td>6.19</td>
<td>7.8</td>
</tr>
<tr>
<td>Nitrite (ug at/l)</td>
<td>0.75</td>
<td>0.57</td>
<td>0.47</td>
</tr>
<tr>
<td>Silicate (ug at/l)</td>
<td>33.04</td>
<td>38.99</td>
<td>39.52</td>
</tr>
<tr>
<td>Hydrographic parameters</td>
<td>Post Monsoon</td>
<td>Pre Monsoon</td>
<td>SW Monsoon</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------</td>
<td>-------------</td>
<td>------------</td>
</tr>
<tr>
<td>Water Temperature (°C)</td>
<td>28.87</td>
<td>28.99</td>
<td>28.38</td>
</tr>
<tr>
<td>Salinity (%)</td>
<td>25.04</td>
<td>28.47</td>
<td>9.72</td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>5.28</td>
<td>5.63</td>
<td>5.85</td>
</tr>
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<td>pH</td>
<td>7.37</td>
<td>7.31</td>
<td>7.68</td>
</tr>
<tr>
<td>Suspended matter (g/l)</td>
<td>0.11</td>
<td>0.07</td>
<td>0.35</td>
</tr>
<tr>
<td>Phosphate (ug at/l)</td>
<td>1.43</td>
<td>0.91</td>
<td>0.82</td>
</tr>
<tr>
<td>Nitrate (ug at/l)</td>
<td>1.42</td>
<td>0.91</td>
<td>0.82</td>
</tr>
<tr>
<td>Nitrite (ug at/l)</td>
<td>0.86</td>
<td>0.54</td>
<td>0.44</td>
</tr>
<tr>
<td>Silicate (ug at/l)</td>
<td>30.69</td>
<td>40.21</td>
<td>40.84</td>
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</table>
Table 22. Seasonal variation in the Water temperature (°C) at study station 1-5.

<table>
<thead>
<tr>
<th>Season</th>
<th>Stn.1</th>
<th>Stn.2</th>
<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoM</td>
<td>28.37</td>
<td>27.895</td>
<td>28.66</td>
<td>28.525</td>
<td>28.87</td>
</tr>
<tr>
<td>PrM</td>
<td>30.07</td>
<td>30.64</td>
<td>31.09</td>
<td>29.39</td>
<td>28.99</td>
</tr>
<tr>
<td>SWM</td>
<td>27.83</td>
<td>28.38</td>
<td>28.79</td>
<td>27.65</td>
<td>28.36</td>
</tr>
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</table>

Table 23. Seasonal variation in the Salinity (%) at study station 1-5.

<table>
<thead>
<tr>
<th>Season</th>
<th>Stn.1</th>
<th>Stn.2</th>
<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoM</td>
<td>18.65</td>
<td>21.28</td>
<td>22.17</td>
<td>24.50</td>
<td>25.04</td>
</tr>
<tr>
<td>PrM</td>
<td>29.52</td>
<td>25.74</td>
<td>29.17</td>
<td>26.50</td>
<td>28.47</td>
</tr>
<tr>
<td>SWM</td>
<td>4.54</td>
<td>4.47</td>
<td>5.68</td>
<td>9.51</td>
<td>9.703</td>
</tr>
</tbody>
</table>

Table 24. Seasonal variation in the Dissolved oxygen (mg/l) at study station 1-5.

<table>
<thead>
<tr>
<th>Season</th>
<th>Stn.1</th>
<th>Stn.2</th>
<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoM</td>
<td>5.65</td>
<td>5.83</td>
<td>5.52</td>
<td>5.88</td>
<td>5.28</td>
</tr>
<tr>
<td>PrM</td>
<td>5.72</td>
<td>6.50</td>
<td>6.08</td>
<td>6.47</td>
<td>5.63</td>
</tr>
<tr>
<td>SWM</td>
<td>6.07</td>
<td>5.73</td>
<td>5.74</td>
<td>6.17</td>
<td>5.85</td>
</tr>
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</table>

Table 25. Seasonal variation in the pH at study station 1-5.

<table>
<thead>
<tr>
<th>Season</th>
<th>Stn.1</th>
<th>Stn.2</th>
<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoM</td>
<td>7.39</td>
<td>7.35</td>
<td>7.25</td>
<td>7.44</td>
<td>7.37</td>
</tr>
<tr>
<td>PrM</td>
<td>7.5</td>
<td>7.5</td>
<td>7.6</td>
<td>7.4</td>
<td>7.3</td>
</tr>
<tr>
<td>SWM</td>
<td>7.65</td>
<td>7.41</td>
<td>7.58</td>
<td>7.74</td>
<td>7.68</td>
</tr>
</tbody>
</table>

Table 26. Seasonal variation in the Suspended matter (g/l) at study station 1-5.

<table>
<thead>
<tr>
<th>Season</th>
<th>Stn.1</th>
<th>Stn.2</th>
<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoM</td>
<td>0.14</td>
<td>0.13</td>
<td>0.12</td>
<td>0.12</td>
<td>0.11</td>
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<tr>
<td>PrM</td>
<td>0.07</td>
<td>0.07</td>
<td>0.06</td>
<td>0.06</td>
<td>0.07</td>
</tr>
<tr>
<td>SWM</td>
<td>0.29</td>
<td>0.35</td>
<td>0.46</td>
<td>0.37</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Table 27. Seasonal variation in the Phosphatae-P (ug at/I) at study station 1-5.

<table>
<thead>
<tr>
<th>Season</th>
<th>Stn.1</th>
<th>Stn.2</th>
<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoM</td>
<td>1.82</td>
<td>1.90</td>
<td>1.69</td>
<td>1.64</td>
<td>1.40</td>
</tr>
<tr>
<td>PrM</td>
<td>1.4</td>
<td>1.62</td>
<td>1.17</td>
<td>0.68</td>
<td>0.91</td>
</tr>
<tr>
<td>SWM</td>
<td>1.12</td>
<td>1.50</td>
<td>1.15</td>
<td>0.96</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Table 28. Seasonal variation in the Nitrate-N (ug at/I) at study station 1-5.

<table>
<thead>
<tr>
<th>Season</th>
<th>Stn.1</th>
<th>Stn.2</th>
<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoM</td>
<td>2.90</td>
<td>4.40</td>
<td>2.44</td>
<td>2.34</td>
<td>1.40</td>
</tr>
<tr>
<td>PrM</td>
<td>5.14</td>
<td>8.12</td>
<td>4.41</td>
<td>6.19</td>
<td>0.91</td>
</tr>
<tr>
<td>SWM</td>
<td>7.70</td>
<td>11.17</td>
<td>7.37</td>
<td>7.8</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Table 29. Seasonal variation in the Nitrite-N (ug at/I) at study station 1-5.

<table>
<thead>
<tr>
<th>Season</th>
<th>Stn.1</th>
<th>Stn.2</th>
<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoM</td>
<td>1.48</td>
<td>1.05</td>
<td>0.84</td>
<td>0.75</td>
<td>0.68</td>
</tr>
<tr>
<td>PrM</td>
<td>0.59</td>
<td>0.76</td>
<td>0.67</td>
<td>0.57</td>
<td>0.54</td>
</tr>
<tr>
<td>SWM</td>
<td>0.69</td>
<td>0.59</td>
<td>0.41</td>
<td>0.47</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Table 30. Seasonal variation in the Silicate-Si (ug at/I) at study station 1-5.

<table>
<thead>
<tr>
<th>Season</th>
<th>Stn.1</th>
<th>Stn.2</th>
<th>Stn.3</th>
<th>Stn.4</th>
<th>Stn.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoM</td>
<td>27.64</td>
<td>30.38</td>
<td>31.05</td>
<td>33.04</td>
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<td>30.88</td>
<td>31.02</td>
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<td>38.19</td>
<td>39.21</td>
<td>39.52</td>
<td>40.20</td>
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</table>
Table 31. Correlation coefficients (r) among the different hydrographic parameters at study station 1.

<table>
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<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>0.54**</td>
<td>0.11</td>
<td>-0.35</td>
<td>-0.16</td>
<td>0.08</td>
<td>0.18</td>
<td>-0.37</td>
<td>-0.27</td>
</tr>
<tr>
<td>B</td>
<td></td>
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<td>0.12</td>
<td>-0.22</td>
<td>-0.79</td>
<td>0.17</td>
<td>-0.14</td>
<td>0.36*</td>
<td>-0.72</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td>1</td>
<td>0.44**</td>
<td>0.19</td>
<td>-0.56</td>
<td>0.39**</td>
<td>-0.03</td>
<td>0.22</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>0.11</td>
<td>-0.54</td>
<td>0.41**</td>
<td>-0.12</td>
<td>0.60**</td>
</tr>
<tr>
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<td></td>
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<td>-0.26</td>
<td>0.47**</td>
<td>-0.45</td>
<td>0.68**</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td>-0.53</td>
<td>0.52**</td>
<td>-0.58</td>
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<tr>
<td>G</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
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<td>0.31*</td>
</tr>
<tr>
<td>H</td>
<td></td>
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<td></td>
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</tr>
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</table>

*Significant at 5% level r = 0.304
**Significant at 1% level r = 0.393

A = Water Temperature  F = Phosphate
B = Salinity          G = Nitrate
C = Dissolved Oxygen  H = Nitrite
D = pH                I = Silicate
E = Suspended matter
Table 32. Correlation coefficients ($r$) among the different hydrographic parameters at study station 2.

<table>
<thead>
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<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
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<td>0.02</td>
<td>-0.15</td>
<td>-0.14</td>
<td>-0.01</td>
<td>-0.014</td>
<td>0.1</td>
<td>0.12</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>0.64**</td>
<td>0.35*</td>
<td>-0.71</td>
<td>0.07</td>
<td>-0.16</td>
<td>0.27</td>
<td>-0.47</td>
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</tr>
<tr>
<td>C</td>
<td>1</td>
<td>0.23</td>
<td>-0.14</td>
<td>-0.57</td>
<td>0.51**</td>
<td>-0.14</td>
<td>-0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
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<td>-0.44</td>
<td>0.04</td>
<td>0.15</td>
<td>-0.16</td>
<td>-0.24</td>
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<td></td>
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<tr>
<td>E</td>
<td>1</td>
<td>-0.43</td>
<td>0.48**</td>
<td>-0.05</td>
<td>0.58**</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>-0.6</td>
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<tr>
<td>G</td>
<td>1</td>
<td>0.46</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>1</td>
<td>0.42**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at 5% level $r = 0.304$
**Significant at 1% level $r = 0.393$

A = Water Temperature  
B = Salinity  
C = Dissolved Oxygen  
D = pH  
E = Suspended matter  
F = Phosphate  
G = Nitrate  
H = Nitrite  
I = Silicate
Table 33. Correlation coefficients (r) among the different hydrographic parameters at study station 3.

<table>
<thead>
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<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>0.40**</td>
<td>0.07</td>
<td>0.41*</td>
<td>-0.21</td>
<td>-0.3</td>
<td>-0.08</td>
<td>-0.28</td>
<td>-0.04</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>0.48**</td>
<td>-0.06</td>
<td>-0.77</td>
<td>0.2</td>
<td>-0.46</td>
<td>0.50**</td>
<td>-0.55</td>
<td></td>
</tr>
<tr>
<td>C</td>
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<td>0.38*</td>
<td>0.06</td>
<td>-0.3</td>
<td>0.11</td>
<td>0.24</td>
<td>-0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>0.40**</td>
<td>-0.63</td>
<td>0.44**</td>
<td>-0.57</td>
<td>0.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>-0.48</td>
<td>0.51**</td>
<td>-0.49</td>
<td>0.52**</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>F</td>
<td>1</td>
<td>-0.6</td>
<td>0.31*</td>
<td>-0.17</td>
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<td></td>
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<td></td>
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<tr>
<td>G</td>
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<td>-0.58</td>
<td>0.07</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
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<td>-0.37</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>1</td>
<td>1</td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Significant at 5% level $r = 0.304$

**Significant at 1% level $r = 0.393$

A = Water Temperature
B = Salinity
C = Dissolved Oxygen
D = pH
E = Suspended matter
F = Phosphate
G = Nitrate
H = Nitrite
I = Silicate
Table 34. Correlation coefficients (r) among the different hydrographic parameters at study station 4.

<table>
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<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
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<td>-0.77</td>
<td>-0.61</td>
<td>-0.05</td>
<td>-0.45</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>-0.37</td>
<td>-0.63</td>
<td>-0.55</td>
<td>0.05</td>
<td>-0.21</td>
<td>0.32*</td>
<td>-0.2</td>
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</tr>
<tr>
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<td>0.11</td>
<td>-0.12</td>
<td>-0.3</td>
<td>-0.13</td>
<td>-0.2</td>
<td>0.37*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>0.47**</td>
<td>-0.24</td>
<td>0.53**</td>
<td>-0.27</td>
<td>-0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>-0.07</td>
<td>0.41**</td>
<td>-0.44</td>
<td>0.30*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>-0.57</td>
<td>0.37*</td>
<td>-0.47</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>G</td>
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<td>-0.76</td>
<td>-0.7</td>
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</tr>
<tr>
<td>H</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>1</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Significant at 5% level r = 0.304
**Significant at 1% level r = 0.393

A = Water Temperature  F = Phosphate
B = Salinity           G = Nitrate
C = Dissolved Oxygen   H = Nitrite
D = pH                 I = Silicate
E = Suspended matter   

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Table 35. Correlation coefficients (r) among the different hydrographic parameters at study station 5.

<table>
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<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>0.40**</td>
<td>-0.04</td>
<td>-0.15</td>
<td>-0.26</td>
<td>-0.01</td>
<td>0.05</td>
<td>0.09</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>-0.23</td>
<td>-0.17</td>
<td>-0.55</td>
<td>0.25</td>
<td>0.44**</td>
<td>0.50**</td>
<td>-0.03</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>-0.22</td>
<td>-0.05</td>
<td>0.30*</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>0.58**</td>
<td>-0.3</td>
<td>-0.08</td>
<td>-0.1</td>
<td>0.43*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>-0.19</td>
<td>-0.4</td>
<td>-0.55</td>
<td>0.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>-0.23</td>
<td>-0.55</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>1</td>
<td>0.56**</td>
<td>-0.42</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>1</td>
<td>-0.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>1</td>
<td></td>
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</tr>
</tbody>
</table>

*Significant at 5% level $r = 0.304$

**Significant at 1% level $r = 0.393$

A = Water Temperature
B = Salinity
C = Dissolved Oxygen
D = pH
E = Suspended matter
F = Phosphate
G = Nitrate
H = Nitrite
I = Silicate
Table 36 Monthly variation in Temperature (°C) and interstitial water (%) of sediments at study station 1-5.

<table>
<thead>
<tr>
<th></th>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>Station 4</th>
<th>Station 5</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept.2001</td>
<td>27.32</td>
<td>28.11</td>
<td>28.22</td>
<td>29.32</td>
<td>28.12</td>
<td>22.81</td>
</tr>
<tr>
<td>Oct.</td>
<td>27.36</td>
<td>26.44</td>
<td>28.31</td>
<td>28.21</td>
<td>29.14</td>
<td>21.52</td>
</tr>
<tr>
<td>Nov.</td>
<td>28.12</td>
<td>25.35</td>
<td>29.23</td>
<td>28.43</td>
<td>27.23</td>
<td>22.15</td>
</tr>
<tr>
<td>Dec.</td>
<td>27.85</td>
<td>27.82</td>
<td>28.72</td>
<td>30.21</td>
<td>26.72</td>
<td>22.21</td>
</tr>
<tr>
<td>Mar.</td>
<td>28.14</td>
<td>28.01</td>
<td>29.33</td>
<td>29.56</td>
<td>28.42</td>
<td>23.12</td>
</tr>
<tr>
<td>Apr.</td>
<td>28.11</td>
<td>28.82</td>
<td>28.88</td>
<td>30.52</td>
<td>31.22</td>
<td>22.72</td>
</tr>
<tr>
<td>Jun.</td>
<td>28.01</td>
<td>28.63</td>
<td>28.33</td>
<td>32.45</td>
<td>28.22</td>
<td>22.82</td>
</tr>
<tr>
<td>Jul.</td>
<td>27.68</td>
<td>29.14</td>
<td>27.41</td>
<td>32.26</td>
<td>26.12</td>
<td>23.54</td>
</tr>
<tr>
<td>Aug.</td>
<td>27.72</td>
<td>29.72</td>
<td>28.24</td>
<td>29.23</td>
<td>25.11</td>
<td>24.66</td>
</tr>
<tr>
<td>Sept.</td>
<td>27.54</td>
<td>28.32</td>
<td>29.11</td>
<td>30.12</td>
<td>27.82</td>
<td>24.72</td>
</tr>
<tr>
<td>Mean</td>
<td>27.75</td>
<td>28.05</td>
<td>28.56</td>
<td>30.28</td>
<td>28.08</td>
<td>22.92</td>
</tr>
<tr>
<td>S.D. +/-</td>
<td>0.34</td>
<td>1.08</td>
<td>0.49</td>
<td>1.32</td>
<td>1.54</td>
<td>0.98</td>
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</table>
Table 37: Co-efficient of sorting (So), Median diameter (Md) (in mm.) and co-efficient of skewness (Sk) of the sediments.

<table>
<thead>
<tr>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>So</td>
<td>Md</td>
<td>Sk</td>
</tr>
<tr>
<td>Sept. 2001</td>
<td>0.4525</td>
<td>0.36</td>
</tr>
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<td>October</td>
<td>0.3175</td>
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</tr>
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<td>November</td>
<td>0.2711</td>
<td>0.48</td>
</tr>
<tr>
<td>December</td>
<td>0.6951</td>
<td>0.12</td>
</tr>
<tr>
<td>Jan. 2002</td>
<td>0.2354</td>
<td>0.45</td>
</tr>
<tr>
<td>February</td>
<td>0.3126</td>
<td>0.48</td>
</tr>
<tr>
<td>March</td>
<td>0.8614</td>
<td>1.23</td>
</tr>
<tr>
<td>April</td>
<td>0.4615</td>
<td>1.56</td>
</tr>
<tr>
<td>May</td>
<td>0.8863</td>
<td>1.85</td>
</tr>
<tr>
<td>June</td>
<td>0.8925</td>
<td>1.74</td>
</tr>
<tr>
<td>July</td>
<td>0.4683</td>
<td>1.23</td>
</tr>
<tr>
<td>August</td>
<td>0.5627</td>
<td>0.36</td>
</tr>
<tr>
<td>September</td>
<td>0.4582</td>
<td>1.72</td>
</tr>
<tr>
<td>Mean.</td>
<td>0.53</td>
<td>0.92</td>
</tr>
<tr>
<td>SD +/-</td>
<td>0.23</td>
<td>0.62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Station 4</th>
<th>Station 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>So</td>
<td>Md</td>
</tr>
<tr>
<td>Sept. 2001</td>
<td>0.6715</td>
</tr>
<tr>
<td>October</td>
<td>0.6623</td>
</tr>
<tr>
<td>November</td>
<td>0.1193</td>
</tr>
<tr>
<td>December</td>
<td>0.2155</td>
</tr>
<tr>
<td>Jan. 2002</td>
<td>0.4682</td>
</tr>
<tr>
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<td>0.7075</td>
</tr>
<tr>
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<td>0.9081</td>
</tr>
<tr>
<td>April</td>
<td>0.9073</td>
</tr>
<tr>
<td>May</td>
<td>0.9141</td>
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So = Co-efficient of Sorting  
Md = Median diameter  
Sk = Skewness
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Table 39. Seasonal variation in Sand, Silt and Clay proportion at study station

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Table 40. Percentage composition of Organic carbon in the sediment in the study stations 1-5.

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Fig. 2 Monthly variation in water temperature at station 1-5.
Fig. 3 Monthly variation in Salinity at study stations 1-5
Fig. 4 Monthly variation in Dissolved oxygen at study stations 1-5
Fig. 5 Monthly variation in pH (Hydrogen ion concentration) at different study stations 1-5
Fig. 6 Monthly variation in Suspended matter at study stations 1-5.
Fig. 8 Monthly variation in Nitrate-N at study stations 1-5.
Fig. 9 Monthly variation in Nitrite-N at study stations 1-5.
Fig. 10 Monthly variation in Silicate-Si at study stations 1-5.
Fig. 11 Monthly variation in the Sediment temperature at study stations 1-5.
Fig. 12 Interstitial water at study stations 1-5.
Fig. 13 Monthly variation in the Sorting coefficient at study stations 1-5
Fig. 14 Monthly variation in the median diameter at study stations 1-5.
Fig. 15 Monthly variation in the Skewness at study stations 1-5.
Fig. 16 Monthly variation in the Organic carbon at study stations 1-5.
Fig. 17 Monthly variation in sediment texture at study station 1.
Fig. 18 Monthly variation in the sediment texture at Study station 2.
Fig. 19 Monthly variation in the sediment texture at Study station 3.
Fig. 20 Monthly variation in the sediment texture at Study station 4.
Fig. 21 Monthly variation in the sediment texture at Study station 5.
Fig. 22. Sediment texture in Station 1.
Fig. 23. Sediment texture in Station 2.
Fig. 24. Sediment texture in Station 3:
Fig. 25. Sediment texture in Station 4.
Fig. 26. Sediment texture in Station 5.