IV. EXPERIMENTAL RESULTS

4.1. Meteorology

4.1.1. Rainfall

The monthly rainfall distribution in the study area during the present investigation is presented in Table 1. The total rainfall recorded from January 2005 to December 2005 was 3296.10 mm. The maximum precipitation was observed in the month of July (1129.3 mm) and minimum in the month of December (3.0 mm). No rainfall was recorded in January, February and March.

4.1.2. Air temperature

The air temperature was measured at the beginning of each sampling and the monthly variations are presented in Table 2. The air temperature fluctuated between 25.64°C in September and 34.22°C in May. In general the lower values of air temperature were observed in monsoon season in comparison to pre and post-monsoon season.
4.2. Hydrography

4.2.1. Water temperature

The water temperature is presented in Table 3 and depicted graphically in Figure 2. The temperature at station 1 located at the confluence fluctuated from 23.30°C in September to 31.40°C in April. The water temperature at station 2 and 3, ranged from 23.60°C in September to 31.80°C in April and May respectively. While at station 4 and 5, the water temperature varied from 23.50°C in September to 33.20°C in May. At all the stations, surface water temperature was lowest in July, August, September and December and highest in April and May.

4.2.2. Water pH

The water pH at different stations in the Haladi-Chakra estuarine complex is presented in the Table 4 and depicted graphically in Figure 3. At station 1, the minimum pH was 6.91 in July and the maximum pH was 8.12 in May. At station 2 and 3, the minimum pH was 6.81 in July and the maximum was 7.90 in May; whereas at station 4 and 5, the pH varied from 6.61 in July to 7.99 in December.

4.2.3. Water dissolved oxygen

The dissolved oxygen content of the surface water at different stations during the present study is presented in Table 5 and depicted graphically in Figure 4. The dissolved oxygen content at station 1 varied from 0.00 mg/l in September and 7.56 mg/l in June. At station 2 and 3, the dissolved oxygen varied from minimum of 0.41 mg/l during September to a maximum of 7.81 mg/l in June. At station 4 and 5, the minimum of 0.00 mg/l in September and maximum of 7.23 mg/l in June was recorded.

4.2.4. Water salinity

The spatial and temporal variation of water salinity is presented in Table 6 and depicted graphically in Figure 5. At station 1, the salinity was fluctuated from
2.28 ppt in June to 34.49 ppt in May. The surface water salinity at station 2 and 3 varied from 0.21 ppt in August to 34.20 ppt in May. While at station 4 and 5, the salinity varied from 0.31 ppt in August to 33.78 ppt in May.

4.3. Nutrients

4.3.1. Nitrogenous nutrients

4.3.1.1. Ammonia-nitrogen

The distribution of ammonia-nitrogen in Haladi-Chakra estuarine complex at different stations in different months is presented in Table 7 and depicted graphically in Figure 6. The surface water ammonia-nitrogen content at station 1 varied between 0.87 µg-at/l in October and 14.18 µg-at/l in May. Whereas in station 2 and 3, ammonia-nitrogen concentration showed wide variation of 0.10 µg-at/l in October to 17.99 µg-at/l in July. While at station 4 and 5, it varied between 0.27 µg-at/l in October and 13.75 µg-at/l in May. Almost all the stations showed minimum ammonia-nitrogen concentration in October and maximum in May.

4.3.1.2. Nitrite-nitrogen

The seasonal and spatial distribution of nitrite-nitrogen in the Haladi-Chakra estuarine complex is presented in Table 8 and depicted graphically in Figure 7. The surface water nitrite-nitrogen concentration at station 1 ranged between 0.82 µg-at/l in March and 3.34 µg-at/l in January. At station 2 and 3, nitrite varied from 0.20 µg-at/l in March to 2.77 µg-at/l in November; whereas at station 4 and 5, it fluctuated between 0.60 µg-at/l in April to 4.23 µg-at/l in July. The lowest content was recorded in June month except at station 4 in Chakra estuary and the highest was observed in the month of January.

4.3.1.3. Nitrate-nitrogen
The fluctuation in the concentration of nitrate-nitrogen in various stations of Haladi-Chakra estuarine complex are presented in Table 9 and represented graphically in Figure 8. At station 1, the nitrate-nitrogen content was ranged from 1.57 µg-at/l in June to 18.60 µg-at/l in April. At station 2 and 3, nitrate-nitrogen content varied from 1.42 µg-at/l in June to 20.97 µg-at/l in July; whereas at station 4 and 5, the nitrate-nitrogen varied from 1.40 µg-at/l in November to 16.60 µg-at/l in July.

4.3.2. Phosphate-phosphorus

The monthly variation of phosphate-phosphorus concentration in the surface water at different stations is presented in Table 10 and depicted graphically in Figure 9. The surface water phosphate-phosphorus concentration varied from 0.24 µg-at/l in January and 6.87 µg-at/l in July at station 1. At station 2 and 3, it fluctuated from minimum of 0.57 µg-at/l in January to maximum of 9.34 µg-at/l in July; whereas at station 4 and 5, it varied from minimum of 0.48 µg-at/l in January to maximum of 6.80 µg-at/l in July.

4.3.3. Silicate-silicon

The silicate content of surface water at different stations during the present study is presented in Table 11 and depicted graphically in Figure 10. At station 1, the surface water silicate-silicon fluctuated between 0.36 µg-at/l in October and 84.48 µg-at/l in December. At station 2 and 3, the silicate-silicon varied from 4.61 µg-at/l in April to 78.72 µg-at/l in December. Whereas at station 4 and 5, the silicate content fluctuated from 1.25 µg-at/l in March to 91.14 µg-at/l in November.

4.4. Phytoplankton pigments

4.4.1. Chlorophyll-a

The distribution of chlorophyll-a at selected stations in Haladi-Chakra estuarine complex are presented in Table 12 and depicted graphically in Figure
11. The chlorophyll-a content at station 1 fluctuated from 1.08 mg/m$^3$ in February, June July, September and November to 22.44 mg/m$^3$ in October. At station 2 and 3, the chlorophyll-a ranged from 0.54 mg/m$^3$ in April to 50.21 mg/m$^3$ in October; while at station 4 and 5, the chlorophyll-a fluctuated from 1.08 mg/m$^3$ in February to 43.80 mg/m$^3$ in November.

4.4.2. Phaeophytin

The trends of distribution of phaeophytin at selected stations in Haladi-Chakra estuarine complex are presented in Table 13 and depicted graphically in Figure 12. At station 1, the minimum phaeophytin content was 1.83 mg/m$^3$ in February/June/July/ September and November and the maximum was 38.14 mg/m$^3$ in October. At station 2 and 3, the minimum phaeophytin content was 0.92 mg/m$^3$ in April and the maximum was 54.34 mg/m$^3$ in October. While at station 4 and 5, the phaeophytin content varied from 1.83 mg/m$^3$ in February/October to 45.45 mg/m$^3$ in November.

4.5. Sediment analysis

4.5.1. Sediment temperature

The distribution of sediment temperature at different stations in the Haladi-Chakra estuarine complex is presented in Table 14 and depicted graphically in Figure 13. The sediment temperature varied from 25.5$^\circ$C in August and 32.5$^\circ$C in March at station 1, near the confluence. At station 2 and 3, in the Haladi estuarine stretch it varied from 26.5$^\circ$C in September to 32.6$^\circ$C in May and July. At station 4 and 5, located at Chakra estuarine stretch have registered a low temperature of 26.1$^\circ$C in August and high temperature of 32.1$^\circ$C in October.

4.5.2. Sediment pH

Sediment pH at different stations in the Haladi-Chakra estuarine complex during the study period is presented in Table 15 and depicted graphically in Figure 14. At station 1, the sediment pH fluctuated from 8.07 in December to 9.19 in
June. The sediment pH at station 2 and 3, in the Haladi estuarine strech varied from 6.18 in August to 8.59 in March. At station 4 and 5, located in the Chakra estuarine strech have registered a low pH of 7.84 in April and as high as 8.65 in September.

4.5.3. Sediment texture

Sediment texture in terms of percentage of sand, silt and clay is presented in Table 16 and depicted graphically from Figure 15 to 17.

In the confluence at station 1, the sand percentage varied from 89.43% in November to 99.16% in July and the silt varied from 0.82% in July to 10.55% in November and the clay varied from 0.02% in April/July/November and December to 0.25 % in September respectively. At station 2 and 3, in the Haladi estuarine strech the sand percentage varied from 42.70% in December to 99.08% in February, silt varied from 0.90% in June to 57.26% in December and clay varied from 0.01% in February to 0.10% in August respectively.

Whereas at station 4 and 5, in Chakra estuarine strech the sand percentage varied from 53.06% in January to 98.60% in November, the silt varied from 1.38% in November to 46.89% in January and clay varied from 0.01% in June/September to 1.25% in July respectively.

4.5.4. Sediment organic carbon

Distribution of sediment organic carbon at different stations in the study area is given in Table 17 and represented graphically in Figure 18. At station 1, near the confluence the sediment organic carbon values ranged from 0.036% in April to 0.40% in March. At station 2 and 3, the organic carbon content fluctuated from 0.036% in July to 0.96% in August. Whereas at station 4 and 5, the organic carbon ranges from 0.03% in April to 1.67% in July.
4.6. Phytoplankton

4.6.1. Qualitative distribution

The monthly variation in the quality composition of phytoplankton population at different stations in different months is presented in Table 18 to 22 and depicted graphically from Figure 19 to 33.

The qualitative analysis of the phytoplankton sample revealed the presence of a large number of phytoplankton species, belonging to different genera during the present investigation and those phytoplankton, which occurred in more than 50% of the observation are depicted graphically by taking Log\(_{10}\) of phytoplankton numbers against months.

4.6.1.1. Station 1

Wide fluctuation in the qualitative composition and abundance of total phytoplankton population was observed during different months in station 1 near the confluence. The maximum number of phytoplankton was recorded in February month with total number of 4700657 cells/m\(^3\) and minimum number of 106114 cells/m\(^3\) was recorded in November. The major groups of phytoplankton recorded were Cyanophyceae, Chlorophyceae, Bacillariophyceae and Dinophyceae (Table 18, Figure: 20, 23, 26, 31).

Cyanophyceae

The number of blue green algae at this station varied from 247 cells/m\(^3\) to 196813 cells/m\(^3\) with minimum in March and maximum in June month. Most of the genera belonging to this group were recorded in pre-monsoon season. Dominant forms belonging to this group are Oscillatoria, Trichodesmium, Merismopedia and to some extent Anabaena and Lyngbya were also contributed to this group.
**Anabaena**

*Anabaena* was documented only in May with a cell count of 13732 cells/m³.

**Lyngbya**

Not much variation in *lyngbya* was noticed, but was found to be only with sporadic occurrence in April/May and August/December months. The cell numbers varied between 485 cells/m³ in the month of December and 578 cells/m³ with maximum in the month of May.

**Merismopedia**

*Merismopedia* was recorded in pre and post-monsoon season. The maximum cell counts were recorded in the June month of monsoon season with cell counts of 92411 cells/m³ and minimum in March month with 247 cells/m³.

**Oscillatoria**

*Oscillatoria* was observed in most of the months with a minimum of 17287 cells/m³ in the month of October and maximum of 65254 cells/m³ in September month. In general *Oscillatoria* were abundant in monsoon season.

**Trichodesmium**

Contribution of *Trichodesmium* to Cyanophyceae was significant. The maximum number of *Trichodesmium* was recorded in the monsoon season with 62077 cells/m³ in the month of June, while the minimum number was recorded in the post-monsoon season with 246 cells/m³ in month of October. Other BGA’s like *spirulina* were documented only in the month of July with 158 cells/m³.
**Chlorophyceae**

Total Chlorophyceae diversity was highest at all the stations in monsoon season except at station 1. The number of Chlorophyceae at this station was recorded highest in the month of July accounting 23430 cells/m$^3$ and lowest of 642 cells/m$^3$ in the month of April.

The dominant groups were few with major contributions from *Closterium*, *Mougeotia*, *Sphaerocystis* and *Zygmena*. Other genera that occurred were *Chlorochoccus*, *Dichthyocha*, *Staurastrum*, *Pediastrum* and *Spirogyra*.

**Closterium**

It was recorded only during pre-monsoon month with minimum of 280 cells/m$^3$ in the month of May and a maximum of 1696 cells/m$^3$ in the month of March.

**Mougeotia**

It occurred maximum and minimum number in pre-monsoon season with 2435 cells/m$^3$ in the month of May and 243 cells/m$^3$ in the month of March respectively.

**Sphaerocystis**

Their occurrence was totally absent in post-monsoon season and minimum during monsoon season. The maximum number of cells was recorded in the month of March with 1470 cells/m$^3$ and minimum of 328 cells/m$^3$ in the month of August.

**Zygmena**
They were present only in monsoon and post-monsoon season and were completely absent in pre-monsoon season. The total cell numbers were varied between 1629 cells/m$^3$ in the month of August to 14813 cells/m$^3$ in the month of October.

**Bacillariophyceae**

Bacillariophyceae is the major phytoplankton group documented at the station 1 of Haladi-Chakra estuarine complex.

Bacillariophyceae was contributed by major genera such as *Biddulphia*, *Chaetoceros*, *Coscinodiscus*, *Campylodiscus*, *Ditylum*, *Fragillaria*, *Melosira*, *Nitzschia*, *Pleurosigma*, *Rhizosolenia*, *Streptothecae* and *Triceratium*. The other groups do include *Cyclotella*, *Leptocylindricus* and *Planktoniella* etc. Bacillariophyceae in general found to be maximum with 4653217 cells/m$^3$ in the month of February and minimum of 55093 cells/m$^3$ in the month of July. Thus they were documented maximum in pre-monsoon and minimum in monsoon season.

**Biddulphia**

The minimum number of *Biddulphia* observed in the month of August and was totally absent in the month of April. The maximum number occurred in the month of March. They ranged from 13682 cells/m$^3$ to 176357 cells/m$^3$. The number was noticed higher in pre-monsoon season and lower in monsoon season.

**Campylodiscus**

The minimum and maximum numbers were 469 cells/m$^3$ in the month of July and 65172 cells/m$^3$ in the month of November respectively. They were dominant in post-monsoon and minimum were recorded in pre-monsoon season.
**Chaetoceros**

The minimum and maximum numbers were 775 cells/m³ in the month of November to 903831 cells/m³ in the month of March respectively. Thus pre-monsoon season documented the highest *Chaetoceros* compared to post-monsoon and monsoon season.

**Coscinodiscus**

*Coscinodiscus* was recorded in the estuary with a total variation of 9390 cells/m³ to 1015931 cells/m³ in the month of July and September respectively. Thus showing maximum number during monsoon season.

**Ditylum**

*Ditylum* recorded its maximum in the month of March and minimum in the month of November with a count of 51437 cells/m³ and 343 cells/m³ respectively. The total *Ditylum* was shown maximum number during pre-monsoon season.

**Fragillaria**

*Fragillaria* was recorded maximum in the month of October with 155548 cells/m³ and minimum of 779 cells/m³ in the month of November during post-monsoon season.

**Melosira**

*Melosira* accounted minimum in the month of June with 708 cells/m³ and maximum in the month of October month with 138264 cells/m³. Thus they were occurred maximum in post-monsoon season and minimum in monsoon season.

**Nitzschia**
Nitzschia recorded a minimum of 655 cells/m\(^3\) in the month of December and a maximum of 3233225 cells/m\(^3\) in the month of January.

**Pleurosigma**

Pleurosigma has shown maximum and minimum during pre-monsoon season. It showed minimum in the month of April with 735 cells/m\(^3\) and maximum in the month of March with 58789 cells/m\(^3\) respectively.

**Streptothecae**

Streptothecae has shown a minimum of 625 cells/m\(^3\) in the month of July in monsoon season and maximum of 29181 cells/m\(^3\) in the month of May in pre-monsoon season.

**Triceratium**

Triceratium was minimum during monsoon season and maximum during pre-monsoon season with 163 cells/m\(^3\) in the month of July to 6867 cells/m\(^3\) in the month of May respectively.

**Dinophyceae**

The major group was Peridinum and other groups were Ceratium and Periperidinium observed in this station. Dinophyceae in general were maximum in the month of March with 23517 cells/m\(^3\) and minimum in the month of December with 662 cells/m\(^3\). The maximum diversity of Dinophyceae was noticed in pre-monsoon season.

**Periperidinium**

They were present only during pre-monsoon season with maximum in the month of May and minimum in the month of March with 10299 cells/m\(^3\) and 2941 cells/m\(^3\) respectively. They were absent in monsoon and pre-monsoon season.
**Peridinum**

*Peridinum* accounted with a maximum of 11581 cells/m³ in the month of November and minimum of 662 cells/m³ in the month of December. The maximum and minimum numbers were recorded in the post-monsoon season.

**Ceratium**

*Ceratium* were occurred maximum with 14697 cells/m³ in the month of March during pre-monsoon season and minimum with 977 cells/m³ in the month of August during monsoon season. They were completely absent in post-monsoon season.

**4.6.1.2. Station 2**

The major groups of phytoplankton include Cyanophyceae, Chlorophyceae, Bacillariophyceae and Dinophyceae (Table 19, Figure: 21, 24, 27, 32).

This station documented a wide fluctuation in total phytoplankton. A maximum of 15733861 cells/m³ was documented in March month of pre-monsoon season and minimum was recorded in June month as 92911 cells/m³ of monsoon season. On whole pre-monsoon season was documented with a maximum number of phytoplankton and monsoon season with minimum number.

**Cyanophyceae**

Cyanophyceae group at this station varied from 1411 cells/m³ to 6567550 cells/m³ as minimum and maximum. The maximum number was documented during January month and minimum was during December month. The BGA were found to be maximum in pre-monsoon season and minimum during monsoon season.
The major genera documented were *Anabaena*, *Merismopedia*, *Oscillatoria*, *Trichodesmium*, *Lyngbya*, *Nostoc* and *Spirulina* in few numbers.

**Anabaena**

*Anabaena* was maximum in the month of March in pre-monsoon season and minimum during in the month of December of post-monsoon season. The total numbers ranged from 236 cells/m$^3$ to 293928 cells/m$^3$.

**Merismopedia**

*Merismopedia* cells were found with a minimum of 257 cells/m$^3$ in the month of October to a maximum of 1910538 cells/m$^3$ in the month of March.

**Oscillatoria**

The minimum and maximum number of *Oscillatoria* was found to be between 1175 to 6567550 cells/m$^3$. The minimum and maximum numbers were documented in the month of December and January of post-monsoon season respectively. *Oscillatoria* was the most dominant among Cyanophyceae group.

**Trichodesmium**

The minimum and maximum counts of *Trichodesmium*, ranged between 1379 cells/m$^3$ in the month of May to 95379 cells/m$^3$ in the month of October.

**Chlorophyceae**
The Chlorophyceae counts ranged between minimum counts of 2134 cells/m$^3$ in the month of December to maximum counts of 263360 cells/m$^3$ in the month of January respectively. Total chlorophyceae diversity was maximum in monsoon season and minimum in post-monsoon season.

Chlorophyceae in the present study was represented by sporadic appearance of nearly 12 genera like Mougeotia, Staurastrum, Pediastrum, Sphaerocystis, Ulothrix, other genera that occurred were Closterium, Dichthyocha, Spirogyra, Zygnema etc.

**Mougeotia**

The minimum and maximum numbers occurred in the month of May and March of pre-monsoon season with 194 cells/m$^3$ to 607 cells/m$^3$ respectively. Contributing major portion in monsoon season and totally absent in the post-monsoon season.

**Pediastrum**

It has shown a minimum of 211 cells/m$^3$ in the month of June in monsoon season and maximum of 4335 cells/m$^3$ in the month of February in pre-monsoon season.

**Sphaerocystis**

*Sphaerocystis* cells were documented only in 3 months with maximum of 73481 cells/m$^3$ in the month of March in pre-monsoon season and a minimum of 266 cells/m$^3$ in the month of August in monsoon season.

**Staurastrum**
The minimum and maximum of *Staurastrum* was noticed in the month of August and in the month of April with cell counts of 486 cells/m$^3$ to 11756 cells/m$^3$ respectively.

*Ulothrix*

*Ulothrix* was a major group representing the Chlorophyceae with maximum in the month of January in post-monsoon season with 263360 cells/m$^3$ and minimum of 1134 cells/m$^3$ in the month of August in monsoon season.

*Bacillariophyceae*

Bacillariophyceae was represented by major genera such as *Biddulphia, Coscinodiscus, Chaetoceros, Cyclotella, Ditylum, Fragillaria, Melosira, Nitzschia, Pleurosigma* and minor genera like *Campylodiscus, Streptothecae* etc.

Bacillariophyceae is a major group among phytoplankton was recorded with minimum of 5866 cells/m$^3$ in the month of July and maximum of 10457246 cells/m$^3$ in the month of March. Majority of them was dominated in post-monsoon season.

*Biddulphia*

The minimum and maximum numbers were recorded in the month of March and July and their number ranged from 312 cells/m$^3$ to 146964 cells/m$^3$ respectively.

*Chaetoceros*

*Chaetoceros* was minimum during June month and maximum during March month and they varied from 855 to 3571242 cells/m$^3$. The maximum number of *Chaetoceros* was recorded in pre-monsoon season and minimum during monsoon season.

*Coscinodiscus*
Coscinodiscus was observed minimum in the month of July with 866 cells/m$^3$ in monsoon season and maximum in the month of March with 5390000 cells/m$^3$ in pre-monsoon season.

**Cyclotella**

The maximum and minimum number of *Cyclotella* was recorded with 3468 cells/m$^3$ to 38148 cells/m$^3$ during the month of October and May respectively.

**Ditylum**

The maximum number of *Ditylum* occurred in the month of December with 84651 cells/m$^3$ and minimum in the month of July with 167 cells/m$^3$.

**Fragillaria**

The maximum number accounted was 687500 cells/m$^3$ in the month of March and minimum was 343 cells/m$^3$ in the month of July.

**Melosira**

*Melosira* recorded with a minimum of 281 cells/m$^3$ in the month of June in monsoon season and maximum of 220115 cells/m$^3$ in the month of April in pre-monsoon season. In post-monsoon season, it occurred in all months.

**Nitzschia**

The *Nitzschia* varied with a maximum of 1820890 cells/m$^3$ in the month of February in pre-monsoon season and a minimum of 276 cells/m$^3$ the month of August in monsoon season. In pre-monsoon season, they were more abundant and occurred in all months.

**Pleurosigma**
The maximum number was recorded in the month of March in pre-monsoon season with 88179 cells/m$^3$ and minimum with 248 cells/m$^3$ in the month of August in monsoon season. *Pleurosigma* occurred throughout the year with little fluctuation in their abundance.

**Dinophyceae**

Dinophyceae occurrence was observed with maximum and minimum during in the month of September and December respectively. The total Dinophyceae ranged from 254 cells/m$^3$ to 236613 cells/m$^3$. The maximum diversity was recorded in monsoon season and minimum in pre-monsoon season.

* Ceratium, Periperidinium and Peridinium represented the Dinophyceae group of station 2. All genera occurred in sporadically with low density.

**Ceratium**

*Ceratium* occurred only during May, November and December. The maximum number was recorded in the month of May with 1703 cells/m$^3$ in pre-monsoon season and minimum with 254 cells/m$^3$ in the month of December in post-monsoon season.

**Periperidinium**

The maximum number recorded was 44075 cells/ m$^3$ in the month of March and minimum was 1700 cells/ m$^3$ in the month of May.

**Peridinium**

*Peridinium* was recorded in the month of March, May and January of pre-monsoon season and post-monsoon season respectively. The number varied with maximum of 14696 cells/ m$^3$ in the month of March to a minimum of 9875 cells/ m$^3$ in the month of January.
4.6.1.3. Station 3

The phytoplankton in this station was represented by blue green algae, green algae, diatom and dinoflagellates (Table 20, Figure: 21, 24, 28, 32).

Total phytoplankton at this station showed a wide variation with a minimum of 39040 cells/m$^3$ in August and maximum of 2035607 cells/m$^3$ in January. Thus monsoon season showed minimum and post-monsoon season has shown maximum abundance of phytoplankton.

**Cyanophyceae**

Total Cyanophyceae count was recorded maximum in January month with 1998717 cells/m$^3$ in post-monsoon season and minimum with 573 cells/m$^3$ in February month in pre-monsoon season. Cyanophyceae was represented at station 3 by Lyngbya, Merismopedia, Oscillatoria and Trichodesmium and the lower numbers of Anabaena and Spirulina. The monsoon season recorded maximum diversity and pre-monsoon season recorded the minimum diversity.

**Lyngbya**

*Lyngbya* was present only in the month of April, May, August and November. The maximum number was recorded in the month of November with 2656 cells/m$^3$ and minimum with 235 cells/m$^3$ in August.

**Merismopedia**

*Merismopedia* occurred with minimum of 1175 cells/m$^3$ in the June month and maximum of 564344 cells/m$^3$ in September month. They are dominated in monsoon season.

**Oscillatoria**
The minimum number of Oscillatoria was found in February month with 573 cells/m³ and maximum was found in January month with 1998717 cells/m³. The occurrence of Oscillatoria was maximum during post-monsoon and minimum during pre-monsoon season.

Chlorophyceae

Green algae were represented only by few species with very less density. The number of Chlorophyceae varied between minimum of 279 cells/m³ in September month to a maximum of 624540 cells/m³ in January month respectively. Among Chlorophyceae more diversity and less number was observed in monsoon season. Dinobryon, Mougeotia, Pediastrum, Spirogyra, Ulothrix, Staurastrum and Zygnema were represented Chlorophyceae at this station.

Mougeotia

Mougeotia were recorded in the month of April, May, September and October and it varied with maximum of 687 cells/m³ in April month to a minimum of 279 cells/m³ in September month.

Ulothrix

The minimum number of Ulothrix registered was 620 cells/m³ in the month of August in monsoon season and maximum number recorded was 620778 cells/m³ in the month of January in post-monsoon season.

Zygnema

The maximum number of Zygnema recorded was 3762 cells/m³ in January month and minimum number registered was 488 cells/m³ in August month. As a whole Zygnema were maximum in post-monsoon season and minimum during monsoon season.

Dinobryon
Dinobryon were recorded with their occurrence only during pre-monsoon season with maximum of 4468 cells/m$^3$ in March month and minimum of 2939 cells/m$^3$ in February month.

**Bacillariophyceae**

Biddulphia, Chaetoceros, Coscinodiscus, Fragillaria, Melosira, Nitzschia, Pleurosigma and Triceratium represented Bacillariophyceae in this station as major groups and minor groups as Campylodiscus, Cyclotella, Ditylum, Lauderia, Streptothecae, Thalassiothrix and Rhizosolenia.

The maximum number of Bacillariophyceae registered was 17148584 cells/m$^3$ in January month and minimum of 10533 cells/m$^3$ in July month. Post-monsoon season was recorded with maximum numbers and monsoon season with minimum numbers.

**Biddulphia**

The maximum number of Biddulphia registered was 477634 cells/m$^3$ in March month and minimum of 167 cells/m$^3$ in July month. The maximum number was recorded in pre-monsoon and minimum numbers was recorded in monsoon season.

**Chaetoceros**

The minimum number of Chaetoceros recorded was 727 cells/m$^3$ in November month and maximum of 1851753 cells/m$^3$ in March month. The Chaetoceros were more abundant in pre-monsoon season and low in monsoon season.

**Coscinodiscus**
Coscinodiscus registered with a maximum of 3027469 cells/m$^3$ in March month of pre-monsoon season. The minimum number recorded was 3682 cells/m$^3$ in July month of monsoon season.

Fragillaria

The Fragillaria varied from a maximum of 120393 cells/m$^3$ in January month of post-monsoon season and minimum of 609 cells/m$^3$ in June month of monsoon season.

Melosira

Melosira recorded with a maximum and minimum of 124067 cells/m$^3$ in November month and 151 cells/m$^3$ in August month respectively. The post-monsoon season documented the maximum number of cells and monsoon season with minimum number of cells.

Nitzschia

The maximum and minimum number of Nitzschia documented was 15049166 cells/m$^3$ in January month and 463 cells/m$^3$ in August month respectively. As a whole the Nitzschia were present in large numbers during post-monsoon season and less during monsoon season.

Pleurosigma

The maximum and minimum number of Pleurosigma was documented during monsoon season in the month of September with 54671 cells/m$^3$ and in the month of August with 1175 cells/m$^3$ respectively.
**Triceratium**

*Triceratium* was observed with a minimum of 321 cells/m$^3$ in October month of post-monsoon season and maximum of 38210 cells/m$^3$ in February month of pre-monsoon season.

**Dinophyceae**

Dinophyceae group was recorded with a maximum of 583766 cells/m$^3$ in January month and minimum of 490 cells/m$^3$ in December month. The monsoon season recorded minimum occurrence of Dinophyceae and pre-monsoon season recorded maximum diversity.

The main genera contributing to Dinophyceae group are *Ceratium*, *Peridinium* and others like *Noctiluca*, *Dinophysis* and *Periperidinium*.

**Ceratium**

The maximum and minimum number of *Ceratium* was recorded in January month and December month of post-monsoon season with 63655 cells/m$^3$ and 490 cells/m$^3$ respectively. But the numbers were totally absent in monsoon season and dominate in pre-monsoon season.

**Peridinium**

The maximum number of *Peridinium* registered was 39612 cells/m$^3$ in January month and minimum was 5893 cells/m$^3$ in February. In general the *peridinium* were absent in monsoon season and they are nearly equal in total number in both pre-monsoon season and post-monsoon season.
4.6.1.4. Station 4

The station 4 was represented by major groups of phytoplankton such as Cyanophyceae, Chlorophyceae, Bacillariophyceae and Dinophyceae (Table 21, Figure: 22, 25, 29, 33).

Most abundant group in station 4 was Bacillariophyceae. The maximum number of total phytoplankton recorded was 12229855 cells/m$^3$ in January month and minimum was 32324 cells/m$^3$ in June month respectively. The total phytoplankton cells were recorded high in post-monsoon season and low during monsoon season.

**Cyanophyceae**

The BGA was found to be dominant in May month with 740825 cells/m$^3$ and minimum was recorded during August month with 998 cells/m$^3$. The maximum Cyanophyceae richness in terms of diversity was documented in pre-monsoon season and minimum was documented during monsoon season.

Major genera representing BGA in this station were *Anabaena*, *Merismopedia*, *Oscillatoria* and *Trichodesmium*.

*Anabaena*

The maximum number of *Anabaena* recorded was 17638 cells/m$^3$ in April month and minimum with 1329 cells/m$^3$ in May month. *Anabaena* as a whole was minimum during post-monsoon season and maximum during pre-monsoon season.

*Merismopedia*

*Merismopedia* accounted with a minimum of 236 cells/m$^3$ in December month and a maximum of 235143 cells/m$^3$ in March month. *Merismopedia* was
abundant in pre-monsoon season and recorded lower numbers in post-monsoon season.

**Oscillatoria**

In the month of May *Oscillatoria* registered a maximum number of 709563 cells/m$^3$ and minimum of 275 cells/m$^3$ in the month of August. *Oscillatoria* was maximum in pre-monsoon season and minimum in monsoon season.

**Trichodesmium**

*Trichodesmium* was noted with a maximum of 15207 cells/m$^3$ in May month of pre-monsoon season and minimum of 247 cells/m$^3$ in December of post-monsoon period. The total *Trichodesmium* showed minimum during monsoon season and maximum during pre-monsoon season.

**Chlorophyceae**

The genera like *Aphanizomenon*, *Pediastrum*, *Staurastrum* and *Ulothrix* represented Chlorophyceae in this station.

Chlorophyceae showed a maximum number of 131866 cells/m$^3$ in October month and a minimum of 1174 cells/m$^3$ in March month. The total Chlorophyceae in monsoon season were found to be more diversified and the pre-monsoon season was found to be less diversified.

**Aphanizomenon**

*Aphanizomenon* was documented only during April, May, June and July month throughout the study period. The maximum was during May month of pre-monsoon season with 5337 cells/m$^3$ and minimum of 265 cells/m$^3$ in the July month of monsoon season.
**Pediastrum**

The maximum number of *Pediastrum* was recorded in October month with 3466 cells/m³ and minimum in the month of July with 129 cells/m³. Thus *Pediastrum* was occurring in almost all the months in monsoon season except June, compare to pre-monsoon and post-monsoon season.

**Staurastrum**

The minimum number of *Staurastrum* was noticed in April month with 592 cells/m³ and maximum of 1186 cells/m³ in December month.

**Ulothrix**

The *Ulothrix* occurred maximum number in May month with 106898 cells/m³ of pre-monsoon season and minimum number were recorded in August month with 1205 cells/m³ of monsoon season.

**Bacillariophyceae**

Bacillariophyceae group was observed with a maximum of 1946448 cells/m³ in May month of pre-monsoon season and minimum of 15224 cells/m³ in July month of monsoon season.

The groups of *Biddulphia, Campylodiscus, Chaetoceros, Coscinodiscus, Ditylum, Fragillaria, Melosira, Nitzschia, Pleurosigma* and *Streptothecae* represented the Bacillariophyceae.

**Biddulphia**

The minimum number of *Biddulphia* was recorded in July month with 159 cells/m³ and maximum of 146141 cells/m³ in the month of May respectively. Thus in pre-monsoon season the abundance of *Biddulphia* was maximum and minimum during monsoon season.
**Campylodiscus**

*Campylodiscus* has shown a maximum of 646643 cells/m$^3$ in March month and minimum of 305 cells/m$^3$ in August. *Campylodiscus* has shown its maximum abundance in pre-monsoon season and were represented in all the months in monsoon season with less abundant.

**Chaetoceros**

*Chaetoceros* was minimum in monsoon season and maximum in post-monsoon season. Thus number of *Chaetoceros* varied between 613 cells/m$^3$ in the month of April of pre-monsoon season to 1077543 cells/m$^3$ in January month of post-monsoon season respectively.

**Coscinodiscus**

The maximum number of *Coscinodiscus* recorded in May month and minimum number in July month with 929991 cells/m$^3$ and 1808 cells/m$^3$ respectively. *Coscinodiscus* were found to be registered maximum in pre-monsoon season and minimum during monsoon season.

**Ditylum**

*Ditylum* was recorded with both maximum and minimum in monsoon season. The maximum number was 12943 cells/m$^3$ in September month and minimum number was 332 cells/m$^3$ in June month respectively.

**Fragillaria**

*Fragillaria* was documented with a maximum of 240772 cells/m$^3$ in January month of post-monsoon season and minimum of 1049 cells/m$^3$ in July month of monsoon season.

**Melosira**
The maximum number of *Melosira* was recorded in November month with 43172 cells/m$^3$ and minimum was found to be 717 cells/m$^3$ in September month. The post-monsoon season showed maximum numbers and monsoon season showed minimum numbers.

**Nitzschia**

*Nitzschia* number in this station varied from 463 cells/m$^3$ to 9552703 cells/m$^3$ with August showing minimum numbers and January showing maximum numbers. The post-monsoon season has accounted maximum numbers and monsoon season accounted minimum numbers.

**Pleurosigma**

*Pleurosigma* was observed throughout the year with wide fluctuations. The maximum number was accounted during September month with 187537 cells/m$^3$ and minimum of 588 cells/m$^3$ in April month. The Maximum *Pleurosigma* was noticed during monsoon season and minimum during pre-monsoon season.

**Streptothecae**

*Streptothecae* showed its maximum in pre-monsoon season and minimum during monsoon season with 111600 cells/m$^3$ in May month and 148 cells/m$^3$ in August month respectively.

**Dinophyceae**

Dinophyceae was observed with a maximum of 189990 cells/m$^3$ in May month and minimum of 642 cells/m$^3$ in March month of pre-monsoon season. The maximum Dinophyceae was recorded in pre-monsoon season.
Only *Ceratium, Peridinium, Periperidinium, Noctiluca* and *Dinophysis* represented the Dinophyceae in this station.

**Ceratium**

The maximum number of *Ceratium* was 12046 cells/m$^3$ in February month and a minimum of 487 cells/m$^3$ in September month. In general *Ceratium* showed maximum during pre-monsoon season and minimum during monsoon season.

**Peridinium**

*Peridinium* registered a maximum of 186001 cells/m$^3$ in May month and a minimum of 709 cells/m$^3$ in December month.

**4.6.1.5. Station 5**

Major groups such as blue green algae, green algae, diatoms and dinoflagellates were represented at station 5 (Table 22, Figure: 22, 25, 30, 33). *The Bacillariophyceae was found to be the dominant and most diversified group.*

The phytoplankton showed wide fluctuation with a maximum of 15713513 cells/m$^3$ in March month and minimum of 14524 cells/m$^3$ in April month. Both maximum and minimum occurred in pre-monsoon season. The total phytoplankton was found to be maximum in pre-monsoon season and minimum in monsoon season.

**Cyanophyceae**

*Merismopedia, Oscillatoria* and *Trichodesmium* have represented the Cyanophyceae along with *Anabaena, Lyngbya* and *Nostoc* in some months. The maximum number of Cyanophyceae accounted was 1065850 cells/m$^3$ in January month and minimum of 6385 cells/m$^3$ in August month. Cyanophyceae diversity
was maximum in pre-monsoon season and minimum in monsoon season. The different genera recorded were not present throughout the year.

**Merismopedia**

*Merismopedia* registered its minimum in April month with 298 cells/m$^3$ and maximum in February month with 229264 cells/m$^3$ in pre-monsoon season. *Merismopedia* were found to be maximum in pre-monsoon season and minimum in monsoon season.

**Oscillatoria**

The maximum number of *Oscillatoria* was recorded in the month of January with 1065493 cells/m$^3$ and minimum in the month of April with 441 cells/m$^3$. *Oscillatoria* was observed maximum in post-monsoon season and minimum in monsoon season.

**Trichodesmium**

*Trichodesmium* was documented with a maximum of 62077 cells/m$^3$ in June month and minimum of 243 cells/m$^3$ in April month. The monsoon season was found to be record a maximum number. Whereas in post-monsoon season, recorded a minimum number of *Trichodesmium*.

**Chlorophyceae**

*Chlorophyceae* was recorded maximum with 227924 cells/m$^3$ in January month and minimum with 216 cells/m$^3$ in September month. The monsoon season recorded the maximum *Chlorophyceae* diversity.
Many groups were represented the BGA where majority of them occurring only few months. Among BGA, the major groups representing are *Mougeotia*, *Staurastrum* and *Ulothrix*. The minor groups were *Closterium*, *Dichthyocha*, *Dinobryon*, *Eutreptia*, *Microsterias*, *Pediastrum*, *Skujaella*, *Sphaerocystis* and *Spirogyra*.

**Mougeotia**

*Mougeotia* were recorded only in March, April, June and December with maximum of 719 cells/m$^3$ in March month of pre-monsoon season and a minimum of 246 cells/m$^3$ in June month of monsoon season.

**Staurastrum**

*Staurastrum* was abundant in June and August month of monsoon season. It varied from 327 cells/m$^3$ to 150 cells/m$^3$ in June month of monsoon season and April month of pre-monsoon season respectively. They were absent in post-monsoon season and overall occurred only in April, June and August months.

**Ulothrix**

The maximum number of *Ulothrix* was observed in January month with 220485 cells/m$^3$ and minimum number in November month with 972 cells/m$^3$. In post-monsoon season, the *Ulothrix* was found to be abundant and minimum numbers in monsoon season. They were found to be absent in pre-monsoon season.

**Bacillariophyceae**

The group *Bacillariophyceae* were represented by *Biddulphia*, Fragillaria, Chaetoceros, Coscinodiscus, Ditylum, Melosira, Nitzschia, Pleurosigma, Streptothecae, Thalassiothrix and others like *Asterionella*, *Campylodiscus* and *Cyclotella*. The maximum of *Bacillariophyceae* recorded was
15000952 cells/m$^3$ in March and minimum of 66834 cells/m$^3$ in April month. Among different seasons pre-monsoon season recorded a maximum number of cells/m$^3$ and monsoon season recorded a minimum number of cells/m$^3$.

**Biddulphia**

*Biddulphia* was observed with a maximum of 132268 cells/m$^3$ in March month and minimum of 291 cells/m$^3$ in June month. *Biddulphia* were recorded with maximum number in pre-monsoon season and found to be minimum in monsoon season.

**Chaetoceros**

The maximum and minimum number of *Chaetoceros* was documented in pre- monsoon season with 9993586 cells/m$^3$ in March month and 294 cells/m$^3$ in April month. The monsoon season was documented with minimum number of cells and pre-monsoon season recorded maximum number of *Chaetoceros*.

**Coscinodiscus**

The number of *Coscinodiscus* varied from 4408935 cells/m$^3$ in March month to minimum 2645 cells/m$^3$ in April month. Both maximum and minimum was recorded in pre-monsoon season. The pre-monsoon season had the maximum number of cells and the monsoon season recorded minimum number of cells.

**Ditylum**

*Ditylum* recorded its maximum number of cells in January month with 66137 cells/m$^3$ to minimum of 240 cells/m$^3$ in July month.

**Melosira**

The minimum and the maximum number of cells of *Melosira* were varied between 147 cells/m$^3$ in April month and 113164 cells/m$^3$ in November month. In general *Melosira* was maximum in post-monsoon season and minimum during monsoon season.
**Nitzschia**

The maximum number of *Nitzschia* was 712778 cells/m$^3$ in January month and minimum number was 316 cells/m$^3$ in October month. The post-monsoon season showed very high density, whereas monsoon season with very low density.

**Pleurosigma**

The maximum number of *Pleurosigma* was registered with 65840 cells/m$^3$ in September month and minimum was 735 cells/m$^3$ in April month. Monsoon season documented maximum numbers and post-monsoon season recorded minimum number of *Pleurosigma*.

**Streptothecae**

*Streptothecae* was documented with minimum of 347 cells/m$^3$ in June month and a maximum of 21398 cells/m$^3$ in February month. Monsoon season recorded minimum density and pre-monsoon season recorded maximum density of *Streptothecae*.

**Thalassiothrix**

The maximum and minimum number of *Thalassiothrix* was recorded in January with 80830 cells/m$^3$ and 233 cells/m$^3$ in April. The pre-monsoon season had recorded the maximum density of *Thalassiothrix* and in monsoon season it was totally absent.

**Dinophyceae**

Dinophyceae in station 5 was represented by only 2 genera with *Ceratium* and *Peridinium*. January month showed maximum Dinophyceae density with 220446 cells/m$^3$ and October month showed minimum density with 327 cells/m$^3$. 
The monsoon season showed minimum numbers and pre-monsoon season showed maximum Dinophyceae.

**Ceratium**

*Ceratium* showed a maximum of 48910 cells/m$^3$ in February month and minimum of 327 cells/m$^3$ in October month. They were found only in September month of monsoon season.

**Peridinium**

The maximum number of *Peridinium* was 220446 cells/m$^3$ in January month and minimum was 709 cells/m$^3$ in February month. In post-monsoon season *Peridinium* had documented maximum density and they were completely absent in monsoon season.

### 4.7. Zooplankton

#### 4.7.1. Qualitative distribution

The occurrence and the abundance of various groups of zooplankton at different stations during the study period are presented in Tables 23 to 37. The distribution of the dominant groups is also depicted graphically in Figures 34 to 56.

#### 4.7.1.1. Medusae

The seasonal and spatial distribution of medusae are shown in Table 23 and distribution of medusae depicted graphically in Figure 34.

The number of medusae at station 1 near the confluence recorded 01 No/m$^3$ in pre-monsoon season. It varied from 02 to 1663 No/m$^3$ in monsoon season. It ranges from 134 to 269 No/m$^3$ in post-monsoon season.
In Haladi strech at station 2 and 3, the medusae were fluctuated from 01 to 268 No/m$^3$ in pre-monsoon season. They were absent in the month of April. It varied from 01 to 04 No/m$^3$ in the monsoon season. During post-monsoon season, it ranges from 01 to 534 No/m$^3$.

In Chakra stretch at station 4 and 5, the medusae were fluctuated from 04 to 268 No/m$^3$ in pre-monsoon season. It ranges from 01 to 04 No/m$^3$ in monsoon season. While in post-monsoon season, it varied from 01 to 268 No/m$^3$. The medusae were absent in October month.

4.7.1.2. Siphonophores

The seasonal and spatial distribution of siphonophores is shown in Table 23. The siphonophores at station 1, 2 and 3 were completely absent throughout the study period. Whereas the siphonophores at station 4 and 5, occurred 01 No/m$^3$ in pre-monsoon season. The siphonophores were completely absent in monsoon and post-monsoon season.

4.7.1.3. Ctenophores

The seasonal and spatial distribution of ctenophores are shown in Table 24 and depicted graphically in Figure 35. The ctenophores were sole represented by *Pleurobranchia* sp. and *Mnemiopsis* sp.

4.7.1.3.1. *Pleurobranchia* sp.

The *Pleurobranchia* sp. at station 1 occurred 01 No/m$^3$ in pre-monsoon season and absent in April month. It occurred only 04 No/m$^3$ in the month of August in monsoon season. While in post-monsoon season, it occurred 01 No/m$^3$ in the month of December and January respectively. The *Pleurobranchia* sp. were absent in October and November months.
At station 2 and 3, it occurred 01 No/m³ in March of pre-monsoon season and absent in other months. It fluctuated from 01 to 02 No/m³ in monsoon season. In post-monsoon season, it occurred 02 No/m³ in December month and absent in other months.

At station 4 and 5, it observed 01 No/m³ in May of pre-monsoon season and absent in other months. It ranges from 01 to 04 No/m³ in monsoon season and absent in June month. While in post-monsoon season, the *Pleurobranchia* sp. were completely absent in all the months.

4.7.1.3.2. *Mnemiopsis* sp.

The *Mnemiopsis* sp. at station 1 occurred only in May month of pre-monsoon season with 02 No/m³ and absent in remaining months. They were totally absent in monsoon and post-monsoon season. At station 2 and 3, the *Mnemiopsis* sp. were present only in month of April of pre-monsoon season with 01 No/m³ and absent in remaining months. The *Mnemiopsis* sp. were absent in monsoon and post-monsoon season. At station 4 and 5, the *Mnemiopsis* sp. were completely absent throughout the study period.

4.7.1.4. Chaetognaths

Monthly distribution of chaetognaths at selected stations in Haladi-Chakra estuarine complex is shown in Table 25 and represent graphically in Figure 36.

The number of chaetognaths at station 1 varied from 03 to 05 No/m³ of pre-monsoon season with absent in February and April month. In monsoon season, the chaetognaths ranged from 06 to 07 No/m³ and they were absent in the month of June and July. Whereas in post-monsoon season, it fluctuated from 02 to 04 No/m³ with absent in January month.

At station 2 and 3, the chaetognaths varied from 01 to 51 No/m³ of pre-monsoon season. They were not present in the month of February and April. It occurred 02 No/m³ in the month of August and September of monsoon season.
They were absent in June and July. The number of chaetognath fluctuated from 02 to 03 No/m$^3$ of post-monsoon season. They were not occurred in the month of December and January.

At station 4 and 5, the chaetognaths varied from 01 to 05 No/m$^3$ in the pre-monsoon season. They were not present in the month of February and April. In monsoon season, the chaetognaths present only in September with 01 No/m$^3$. While in post-monsoon season, the chaetognaths were occurred in 01 No/m$^3$ in the month of December and January. They were absent in October and November month.

4.7.1.5. Chaetognath larvae

The seasonal and spatial distribution of chaetognath larvae is given in Table 25 and depicted graphically in Figure 37.

The chaetognath larvae at station 1 varied from 02 to 274 No/m$^3$ in pre-monsoon season. They were not recorded in the month of April. In the monsoon season, it fluctuates from 04 to 1104 No/m$^3$. Whereas, it ranges from 04 to 402 No/m$^3$ in the post-monsoon season. They were absent in the month of January.

At station 2 and 3, the chaetognath larvae varied from 01 to 267 No/m$^3$ in pre-monsoon season. They were not recorded in the month of April. It ranges from 01 to 268 No/m$^3$ in monsoon season. In post-monsoon season, the chaetognath larvae fluctuated from 01 to 535 No/m$^3$.

At station 4 and 5, the chaetognath larvae present in almost all the months. It ranges from 02 to 534 No/m$^3$ in pre-monsoon season. In monsoon season, it varied from 02 to 554 No/m$^3$. Whereas in post-monsoon season, it fluctuated from 01 to 801 No/m$^3$.

4.7.1.6. Polycheate
The monthly distribution of polychaete at selected stations in Haladi-Chakra estuarine complex is shown in Table 26 and represent graphically in Figure 38.

The polychaete at station 1 varied from 01 to 04 No/m$^3$ in the pre-monsoon season. While in the monsoon season, the polychaete were present only in September with 16 No/m$^3$. In post-monsoon season, their numbers ranged from 01 to 09 No/m$^3$. They were absent in December month.

The polychaete at station 2 and 3 occurred in 01 No/m$^3$ in all the months of pre-monsoon season. In the monsoon season, their number ranged from 01 to 04 No/m$^3$ in the month of September. They were absent in remaining months. In post-monsoon season, they were varied from 01 to 04 No/m$^3$. They were absent in December month.

The polychaete at station 4 and 5 fluctuated between 01 to 02 No/m$^3$ in the pre-monsoon season with absent in May month. In monsoon season, their numbers varied from 01 to 02 No/m$^3$ in September month. Only 01 No/m$^3$ was observed in post-monsoon season in October and November month respectively.

### 4.7.1.7. Polychaete larvae

The seasonal and spatial distribution of polychaete larvae is given in Table 26 and represented graphically in Figure 39.

The number of polychaete larvae at station 1 varied from 668 to 4049 No/m$^3$ during pre-monsoon season. In the monsoon season, they were ranged from 02 to 5002 No/m$^3$. The number of polychaete larvae fluctuated from 268 to 2407 No/m$^3$ in post-monsoon season.

The polychaete larvae at station 2 and 3 varied from 267 to 19253 No/m$^3$ in pre-monsoon season. In monsoon season, they were ranged from 02 to 1659
In the post-monsoon season, the number of polycheate larvae fluctuated from 134 to 4543 No/m\(^3\).

The number of polycheate larvae at station 4 and 5 ranged from 267 to 6145 No/m\(^3\) in the pre-monsoon season. In the monsoon season, they were varied from 04 to 2764 No/m\(^3\). Their numbers fluctuated from 01 to 2678 No/m\(^3\) in the post-monsoon season.

### 4.7.1.8. Penilia sp.

In the present study, the numerical abundance of important cladoceran species belonging to the genus *Penilia* sp. in space and time is presented in Table 27 and shown graphically in Figure 40.

The number of *Penilia* sp. at station 1 varied from 534 to 4008 No/m\(^3\) in the pre-monsoon season. Their number ranged from 400 to 1657 No/m\(^3\) in the monsoon season. They were absent in June and July month. In the post-monsoon season, their number fluctuated from 668 to 28858 No/m\(^3\).

At station 2 and 3, the number of *Penilia* sp. fluctuated from 534 to 2538 No/m\(^3\) in pre-monsoon season. Their number ranged from 534 to 2209 No/m\(^3\) in the monsoon season. They were not recorded in July month. While in the post-monsoon season, it varied from 534 to 3874 No/m\(^3\).

At station 4 and 5, it varied from 801 to 2751 No/m\(^3\) in the pre-monsoon season. In monsoon season, they were fluctuated from 133 to 2939 No/m\(^3\). They were absent in June and July month. In post-monsoon season, their number ranged from 133 to 4275 No/m\(^3\).

### 4.7.1.9. Evadne sp.

Monthly distribution of *Evadne* sp. at all the stations is presented in Table 27 and shown graphically in Figure 41.

In the present study, the number of *Evadne* sp. at station 1 varied from 133 to 801 No/m\(^3\) in pre-monsoon season. They were ranged from 552 to 1104 No/m\(^3\)
in monsoon season. They were not present in June and September month. In the post-monsoon season, their number fluctuated from 267 to 6412 No/m$^3$.

The number of *Evadne* sp. at station 2 and 3 fluctuated between 133 to 801 No/m$^3$ in the pre-monsoon season. In the monsoon season, they present in September and August month with 133 to 267 No/m$^3$. In the post-monsoon season, the number of *Evadne* sp. ranged from 133 to 935 No/m$^3$. They were not found in month of January.

At station 4 and 5, it varied from 133 to 1336 No/m$^3$ in the pre-monsoon season. In the monsoon season, the *Evadne* sp. were present only in September with 267 No/m$^3$. In post-monsoon season, their number fluctuated from 133 to 2004 No/m$^3$.

### 4.7.1.10. Barnacle nauplii

The seasonal and spatial distribution of barnacle nauplii during the study period is given in Table 28 and represented graphically in Figure 42.

The number of barnacle nauplii at station 1 varied from 133 to 801 No/m$^3$ in pre-monsoon season. In the monsoon season, they were present in August and September and their number varied from 133 to 1104 No/m$^3$. While in the post-monsoon season, the number of barnacle nauplii fluctuated between 534 to 801 No/m$^3$.

The number of barnacle nauplii at station 2 and 3 varied from 133 to 801 No/m$^3$ in the pre-monsoon season. In the monsoon season, they fluctuated between 133 to 1104 No/m$^3$. Whereas in post-monsoon season, the number of barnacle nauplii ranged from 267 to 1603 No/m$^3$. 
At station 4 and 5, it varied from 133 to 1608 No/m³ in the pre-monsoon season. In the monsoon season, it ranged from 22 to 1657 No/m³. While in the post-monsoon season, their number fluctuated from 133 to 1603 No/m³.

### 4.7.1.11. Barnacle cypris

The seasonal and spatial distribution of barnacle cypris is given in Table 28.

The barnacle cypris at station 1 were not observed in both pre-monsoon and post-monsoon season. In the monsoon season, the barnacle cypris were present only in the month of August with 01 No/m³.

The barnacle cypris at station 2 and 3 were completely absent in pre-monsoon, monsoon and post-monsoon season.

During the study period, the barnacle cypris at station 4 and 5 was completely absent in pre-monsoon and post-monsoon season. In the monsoon season, the barnacle cypris were present only in the month of September with 08 No/m³.

### 4.7.1.12. Copepods

Copepods formed the bulk of the zooplankton at all the stations and throughout the period of study. The seasonal and spatial distribution of copepod is given in Table 29 and also graphically shown in Figure 43.

The number of copepods at station 1 varied from 22846 to 106348 No/m³ in the pre-monsoon season. While in the monsoon season, the number ranged from 7182 to 129729 No/m³. In the post-monsoon season, the number of copepod fluctuated between 9218 to 79360 No/m³. The numbers were found lesser in monsoon season compared to pre-monsoon and post-monsoon season.
The number of copepods at station 2 and 3 varied from 4809 to 95660 No/m$^3$ in the pre-monsoon season. In the monsoon season, the copepods fluctuated between 7182 to 180632 No/m$^3$. While their number varied from 13093 to 102073 No/m$^3$ in the post-monsoon season.

The number of copepods at station 4 and 5 ranged from 19506 to 47295 No/m$^3$ during pre-monsoon season. Their number varied from 3867 to 121045 No/m$^3$ in the monsoon season. In the post-monsoon season, their number fluctuated from 18570 to 71879 No/m$^3$.

### 4.7.1.13. Copepod larvae

The seasonal and spatial distribution of copepod larvae is given in Table 30 and represented graphically in Figure 44.

The number of copepod larvae at station 1 varied from 4943 to 37676 No/m$^3$ in the pre-monsoon season. While their number ranged from 552 to 18784 No/m$^3$ in the monsoon season. In the post-monsoon season, their number ranged from 3205 to 19772 No/m$^3$.

The number of copepod larvae at station 2 and 3 varied from 2271 to 44355 No/m$^3$ in the pre-monsoon season. In the monsoon season, their number ranged from 1656 to 21109 No/m$^3$. In the post-monsoon season, their number fluctuated from 4007 to 22712 No/m$^3$.

The number of copepod larvae at station 4 and 5 varied from 1633 to 16833 No/m$^3$ in the pre-monsoon season, 1104 to 14428 No/m$^3$ in monsoon season and 2271 to 16566 No/m$^3$ during post-monsoon season respectively.

### 4.7.1.14. Lucifer

The seasonal and spatial distribution of the species of a pelagic belonging to group lucifer is given in Table 31 and also shown graphically in Figure 45.
The number of lucifer at station 1 occur only in may month with 01 No/m$^3$ of pre-monsoon season, 17 No/m$^3$ in September month of monsoon season and 01 No/m$^3$ in October month of post-monsoon season respectively.

The number of lucifer at station 2 and 3 varied from 02 to 03 No/m$^3$ in the pre-monsoon season, but they were not present in March and April month. In the monsoon season, the lucifer were present only in September month they varied from 01 to 03 No/m$^3$. In the post-monsoon season, the lucifer were completely absent in all the months.

At station 4 and 5, the number varied from 38 to 61 No/m$^3$ in the May month of pre-monsoon season, but they were not observed in the other months. In the monsoon season, the lucifer were occurred only in September month and they ranged from 01 to 45 No/m$^3$, but they were absent in remaining months. In the post-monsoon season, the lucifer occurred only in the month of October with 01 No/m$^3$ and not found in remaining months.

4.7.1.15. Lucifer larvae

The seasonal and spatial distribution of lucifer larvae is given in Table 31 and also shown graphically in Figure 46.

The number of lucifer larvae at station 1 varied from 01 to 06 No/m$^3$ in the pre-monsoon season, but they were not present in month of February and April month. In the monsoon season, it ranged from 01 to 02 No/m$^3$, but they were not observed in June and July month. The lucifer larvae were absent in all the months of post-monsoon season.

The lucifer larvae at station 2 and 3 varied from 02 to 06 No/m$^3$ in pre-monsoon season, but not occured in month of March. They were completely absent during monsoon and post-monsoon season.

At station 4 and 5, it varied from 14 to 18 No/m$^3$ in the month of May of pre-monsoon season, but they were not observed in the other months. In the
monsoon season, it occurred only in September with 02 No/m$^3$, but absent in remaining months. Whereas in post-monsoon season, they were completely absent throughout the study period.

4.7.1.16. Decapod larvae

The seasonal and spatial distribution of decapod larvae is represented in Table 32.

During the present study shrimp nauplii, post larvae of shrimp, protozoea, zoea, mysis, megalopa and elima were the soul representatives of this group.

4.7.1.16.1. Shrimp nauplii

The seasonal and spatial distribution of shrimp nauplii is represented in Table 32.

The shrimp nauplii at station 1 were absent throughout the study period. At station 2 and 3 in pre-monsoon season, it occurred 02 No/m$^3$ in the month of March and May respectively, but they were absent in remaining months. In the monsoon season, their numbers varied from 01 to 02 No/m$^3$, but they were not observed in the month of June and August. The shrimp nauplii were completely absent in the post-monsoon season.

At station 4 and 5, it fluctuated between 01 to 02 No/m$^3$ in the pre-monsoon season, but they were not present in the month of April. While shrimp nauplii were absent in both monsoon and post-monsoon season.

4.7.1.16.2. Post larvae of shrimp

The seasonal and spatial distribution of post larvae of shrimp is shown in Table 32 and represented graphically in the Figure 47.

The number of post larvae of shrimp at station 1 varied from 01 to 03 No/m$^3$ in the pre-monsoon season. While in the monsoon season, they occurred 02
No/m³ in all the months. In post-monsoon season, their number varied from 01 to 03 No/m³.

The number of post larvae of shrimp at station 2 and 3 ranged from 01 to 10 No/m³ in the pre-monsoon season, but they were not present in the month of April and May. In the monsoon season, they occurred 02 No/m³ in all the months, but they were not observed in the month of August. Whereas in the post-monsoon season, they varied from 01 to 09 No/m³.

The number of post larvae of shrimp at station 4 and 5 varied from 01 to 02 No/m³ in the pre-monsoon season, but they were not present in the month of April. In the monsoon season, they were varied from 01 to 02 No/m³ in the September month. In the post-monsoon season, they were fluctuated between 01 to 10 No/m³.

4.7.1.16.3. Protozoa

The distribution of protozoea at different stations during different months are presented in Table 32 and also shown graphically in Figure 48.

The number of protozoea at station 1 varied from 534 to 535 No/m³ in the pre-monsoon season, but they were not found in the month of April and May. In the monsoon season, they were present only in September with 267 No/m³. In the post-monsoon season, they were ranged from 06 to 535 No/m³, but they were absent in the December month.

In pre-monsoon season at station 2 and 3, it fluctuated from 01 to 268 No/m³, they were not found in April month. In the monsoon season, they ranged from 268 to 552 No/m³, but they were not present in month of June and July. Whereas in the post-monsoon season, it varied from 01 to 801 No/m³.

The number of protozoea at station 4 and 5 varied from 01 to 535 No/m³, but they were absent in the month of April. In the monsoon season, it ranged from 268 to 552 No/m³, but absent in the month of June and July. While in the post-monsoon season, the number of protozoea fluctuated from 133 to 268 No/m³.
4.7.1.16.4. Zoea

The abundance and occurrence of zoea in space and time is presented in Table 32 and represented graphically in Figure 49.

The abundance of zoea at station 1 varied from 02 to 534 No/m$^3$ in the pre-monsoon season. The zoea was ranged from 133 to 552 No/m$^3$ in the monsoon season, but absent in the month of June and July. In the post-monsoon season, the number of zoea ranged from 401 to 1265 No/m$^3$, but they were not present in the month of January.

The number of zoea at station 2 and 3 varied from 134 to 535 No/m$^3$ in the pre-monsoon season. In the monsoon season, it ranged from 134 to 552 No/m$^3$, but absent in the month of June and July. During post-monsoon season, the number of zoea fluctuated from 01 to 1640 No/m$^3$.

At station 4 and 5, it ranged from 02 to 801 No/m$^3$ in the pre-monsoon season, but absent in the month of April. In the monsoon season, they were varied from 02 to 1084 No/m$^3$, but not present in the month of August. In the post-monsoon season, the number of zoea fluctuated from 01 to 670 No/m$^3$.

4.7.1.16.5. Mysis

The seasonal and spatial distribution of mysis is presented in Table 32 and shown graphically in Figure 50.

The mysis at station 1 was observed from 02 to 10 No/m$^3$, but they were not found in the month of April in pre-monsoon season. In monsoon season, it ranged from 02 to 137 No/m$^3$, but absent in month of July. In the post-monsoon season, it fluctuated from 03 to 705 No/m$^3$.

The number of mysis at station 2 and 3 ranged from 03 to 400 No/m$^3$ in pre-monsoon season, but not present in the month of May. In the monsoon season, it varied from 134 to 552 No/m$^3$, but they were not present in the month of June.
and July. In the post-monsoon season, the number of mysis fluctuated from 02 to 360 No/m$^3$.

The number of mysis at station 4 and 5 fluctuated from 01 to 268 No/m$^3$ in pre-monsoon season, but absent in the month of April. In the monsoon season, it occurred only in the month of September and it varied from 02 to 06 No/m$^3$. In the post-monsoon season, the number of mysis ranged from 01 to 267 No/m$^3$.

### 4.7.1.16.6. Megalopa

The distribution of megalopa at different stations during different months is presented in Table 32.

The megalopa at station 1 were absent in both pre-monsoon and monsoon season. In post-monsoon season, the number of megalopa varied from 134 to 267 No/m$^3$, but absent in December and January month.

At station 2 and 3, it varied from 01 to 133 No/m$^3$ in the pre-monsoon season, but not present in the month of February and May. In the monsoon season, it occurred only in September with 133 No/m$^3$, but absent in remaining months. In the post-monsoon season, the number of megalopa ranged from 01 to 133 No/m$^3$, but absent in January month.

The megalopa at station 4 and 5 occurred only in April month with 01 No/m$^3$ in pre-monsoon season. In monsoon season, they were completely absent. In the post-monsoon season, the number of megalopa fluctuated between 01 to 133 No/m$^3$ and absent in the month of October and December.

### 4.7.1.16.7. Elima

The abundance and occurrence of elima in space and time is presented in Table 32.
The number of elima at station 1 was present only in December month with 01 No/m³ in post-monsoon season. In the pre-monsoon season and monsoon season, they were completely absent.

The elima were absent in station 2 and 3 in all the seasons throughout the study period. At station 4 and 5, it occurred only in June with 02 No/m³ in monsoon season and absent in remaining months. They were completely absent in pre-monsoon and post-monsoon season.

4.7.1.17. Gastropod larvae

The spatial and seasonal distribution of gastropod larvae in the present investigation is given in Table 33 and shown graphically in Figure 51.

The gastropod larvae at station 1 varied from 267 to 1068 No/m³ in the pre-monsoon season. In the monsoon season, the gastropod larvae ranged from 552 to 1068 No/m³, but absent in the month of July. In the post-monsoon season, the gastropod larvae were fluctuated from 267 to 1336 No/m³.

The number of gastropod larvae at station 2 and 3 fluctuated from 133 to 935 No/m³ in the pre-monsoon season. In the monsoon season, they ranged from 552 to 1870 No/m³. Whereas in the post-monsoon season, the number varied from 133 to 1068 No/m³.

At station 4 and 5, it ranged from 133 to 1068 No/m³ in the pre-monsoon season, 267 to 1870 No/m³ in monsoon season and 133 to 534 No/m³ in post-monsoon season respectively.

4.7.1.18. Bivalve larvae

Monthly abundance of bivalve larvae at selected stations in Haladi-Chakra estuary is presented in Table 34 and also shown graphically in Figure 52.
The number of bivalve larvae at station 1 varied from 267 to 801 No/m$^3$ in the pre-monsoon season. In the monsoon season, the bivalve larvae were observed from 400 to 2209 No/m$^3$, but absent in month of July. In the post-monsoon season, it ranged 400 to 801 No/m$^3$, but not occurred in the month of November.

The number of bivalve larvae at station 2 and 3 varied from 267 to 935 No/m$^3$ in the pre-monsoon season. In the monsoon season, the number of bivalve larvae fluctuated from 400 to 3314 No/m$^3$. It ranged from 133 to 534 No/m$^3$ in the post-monsoon season.

The bivalve larvae at station 4 and 5 ranged from 133 to 935 No/m$^3$ in pre-monsoon season. In the monsoon season, the number of bivalve larvae varied from 400 to 1657 No/m$^3$. Whereas in the post-monsoon season, it fluctuated from 133 to 534 No/m$^3$.

4.7.1.19. Echinoderm larvae

The seasonal and spatial distribution of echinoderm larvae is represented in Table 34 and also shown graphically in Figure 53.

The number of echinoderm larvae at station 1 varied from 267 to 534 No/m$^3$ in pre-monsoon season, but they were not found in the month of February. In the monsoon season, it ranged from 133 to 552 No/m$^3$, but absent in month of June. In the post-monsoon season, the echinoderm larvae fluctuated between 133 to 267 No/m$^3$ and absent in the month of November and January.

At station 2 and 3, the number of echinoderm larvae ranged from 133 to 801 No/m$^3$ in the pre-monsoon season, but not present in the month of February. In the monsoon season, their number observed from 02 to 801 No/m$^3$, but absent in the month of August. In the post-monsoon season, it fluctuated between 267 to 400 No/m$^3$ and not present in November and December month.

The number of echinoderm larvae at station 4 and 5, in the pre-monsoon season ranged from 133 to 400 No/m$^3$, but not found in the month of February and
April. In the monsoon season, the echinoderm larvae were present only in the month of September, it ranged from 133 to 534 No/m\(^3\), but absent in remaining months. In the post-monsoon season, their number fluctuated between 133 to 534 No/m\(^3\), but not present in the month of October.

**4.7.1.20. Planktonic protochordates**

The seasonal and spatial distribution of planktonic protochordates are represented in Table 35.

The occurrence and abundance of planktonic protochordates during the present study were sporadic. During the present study, *Oikopleura* sp., doliolids and salpids were recorded.

**4.7.1.20.1. *Oikopleura* sp.**

The numerical abundance of *Oikopleura* sp. in space and time is presented in Table 35 and represented graphically in Figure 54.

The number of *Oikopleura* sp. at station 1 varied from 267 to 4009 No/m\(^3\) in the pre-monsoon season. In the monsoon season, the *Oikopleura* sp. ranged from 02 to 1104 No/m\(^3\), but not found in September month. In post-monsoon season, the number of *Oikopleura* sp. fluctuated from 134 to 3874 No/m\(^3\).

The number of *Oikopleura* sp. at station 2 and 3 fluctuated from 267 to 6681 No/m\(^3\) in the pre-monsoon season. They were ranged from 267 to 1104 No/m\(^3\) in monsoon season, but not present in month of July and August. In the post-monsoon season, their numbers varied from 134 to 4542 No/m\(^3\).

At station 4 and 5, their number varied from 133 to 1870 No/m\(^3\) in pre-monsoon season. In the monsoon season, it observed from 269 to 1104 No/m\(^3\), but absent in July month. The number of *Oikopleura* sp. ranged from 133 to 3740 No/m\(^3\) in the post-monsoon season.
4.7.1.20.2. Doliolids

The abundance and occurrence of doliolids in space and time is represented in Table 35.

The occurrence and abundance of doliolids during the present study was very low. They were present only in January month with 01 No/m$^3$ at station 1 in post-monsoon season. They were absent in pre-monsoon and monsoon season.

At station 2 and 3, it occurs only 01 No/m$^3$ in May month of pre-monsoon season, but not present in monsoon and post-monsoon season. At station 4 and 5, they were absent throughout the study period.

4.7.1.20.3. Salpids

The abundance and occurrence of salpids in space and time is represented in Table 35.

The abundance and occurrence of salpids during the present study was very low. The number of salpids varied from 02 to 03 No/m$^3$ at station 1 in the pre-monsoon season, but absent in March and April month. They were completely absent in monsoon season. During the post-monsoon season, the number of salpids fluctuated from 01 to 02 No/m$^3$, but absent in the month of October and November.

The number of salpids at station 2 and 3 occurred only in May month with 01 No/m$^3$ in the pre-monsoon season, but not present in remaining months. They were completely absent in monsoon and post-monsoon season.

At station 4 and 5, it varied from 03 to 04 No/m$^3$ in the month of May of pre-monsoon season, but absent in remaining months. Whereas in monsoon and post-monsoon season, they were completely absent in all the months.
4.7.1.21. Fish eggs

The seasonal and spatial distribution of fish eggs are given in Table 36 and also represented graphically in Figure 55.

The number of fish eggs varied from 01 to 135 No/m$^3$ at station 1 in the pre-monsoon season. In the monsoon season, the number of fish eggs ranged from 04 to 552 No/m$^3$, but not present in the month of July. During the post-monsoon season, the number of fish eggs fluctuated from 10 to 39 No/m$^3$, but absent in the month of January.

The number of fish eggs varied from 02 to 534 No/m$^3$ at station 2 and 3 in pre-monsoon season. In the monsoon season, the number ranged from 02 to 552 No/m$^3$, but not occurred in the July month. Whereas in post-monsoon season, their number fluctuated from 01 to 21 No/m$^3$.

The number of fish eggs at station 4 and 5 varied from 03 to 135 No/m$^3$ in the pre-monsoon season. In the monsoon season, it fluctuated from 02 to 11 No/m$^3$, but absent in July. Whereas in post-monsoon season, their number ranged from 01 to 41 No/m$^3$.

4.7.1.22. Fish larvae

In the present study, the spatial and seasonal distribution of fish larvae is given in Table 37 and represented graphically in Figure 56.

The number of fish larvae at station 1 varied from 01 to 267 No/m$^3$ in the pre-monsoon season. Whereas in the monsoon season, it ranged from 02 to 2762 No/m$^3$. While their numbers fluctuated from 01 to 277 No/m$^3$ in post-monsoon season, but absent in January month.

The number of fish larvae at station 2 and 3 ranged from 01 to 537 No/m$^3$ in the pre-monsoon season, whereas the number of fish larvae during monsoon
season varied from 04 to 1659 No/m$^3$. While their number ranged from 01 to 813 No/m$^3$ in post-monsoon season.

The number of fish larvae at station 4 and 5 fluctuated from 01 to 271 No/m$^3$ in the pre-monsoon season. In the monsoon season, it varied from 02 to 1104 No/m$^3$, but absent in August. Whereas in post-monsoon season, their number ranged from 01 to 402 No/m$^3$.

4.8. Macrobenthos

4.8.1. Qualitative distribution

Spatial and temporal distribution of macrobenthos (No.m$^{-2}$) during the period of study is represented in Table 38 to 42 and depicted graphically in Figure 57, 58 and 59.

4.8.1.1. Polychaeta

The class Polychaeta was mainly represented by five families, namely Nepthydae, Nereidae, Glyceridae, Maladanidae and Sabellaridae and their number varied from 20 to 280 m$^{-2}$ during pre-monsoon season. While in monsoon season and the post-monsoon season, the number fluctuated from 20 to 80 m$^{-2}$ at station 1.

At station 2, polychaetes were represented by five families, namely Nepthydae, Nereidae, Glyceridae, Maladanidae and Arenicola and their number during the pre-monsoon season varied from 20 to 140 m$^{-2}$, during the monsoon season the number ranged from 20 to 780 m$^{-2}$ and 40 to 160 m$^{-2}$ were observed during the post-monsoon season respectively.

At station 3, polychaetes were represented by five families, namely Nepthydae, Neridae, Glyceridae, Maladanidae and Arenicola and their number varied from 20 to 680 m$^{-2}$ during pre-monsoon season. During monsoon season,
polychaetes ranged from 20 to 100 m$^2$. In post-monsoon season, their number fluctuated from 20 to 120 m$^2$.

At station 4, six families of polychaetes were identified and their number varied from 20 to 260 m$^2$ in pre-monsoon season. During monsoon season, the number observed from 40 to 960 m$^2$ and 20 to 240 m$^2$ were found during post-monsoon season.

At station 5, polychaetes belonging to five families, namely Nepthydae, Nereidae, Glyceridae, Maladanidae and Arenicola and their number ranged from 20 to 440 m$^2$ in the pre-monsoon season. While in the monsoon season, their numbers varied from 20 to 140 m$^2$ and 20 to 160 m$^2$ were recorded during the post-monsoon season.

### 4.8.1.2. Crustacea

At station 1, no shrimps and crabs were observed throughout the study period. Sporadic representations of crustacean, barnacles settled on the pebbles and on dead shells were reported. In the pre-monsoon season, the barnacles were found 140 m$^2$ in the month of February and April, but absent in remaining months. In the monsoon season, it ranged from 20 to 80 m$^2$. They were absent in the month of June. During post-monsoon season, it registered 20 m$^2$ in the month of December and January, but not found in other months.

The amphipods, which belonging to class Crustacea comprise three main sub orders namely Hyperidea, Caprellidae and Gammaridae. In the pre-monsoon season, their number observed from 60 to 120 m$^2$ in the month of March and May. They were absent in the remaining months. During the monsoon season, it varied from 20 to 40 m$^2$, but absent in September month. Whereas in the post-monsoon season, it ranges from 60 to 160 m$^2$, but absent in January month.

At station 2, shrimps and crabs were totally absent throughout the study period. Barnacle varies from 20 to 40 m$^2$ in the pre-monsoon season. They were not found in the month of March. Whereas in monsoon season, the barnacles were
observed only in July month with 40 m$^2$. They were absent in the remaining months. During post-monsoon season, it ranged from 40 to 160 m$^2$.

The amphipods were observed in almost all the seasons, but they were more in pre and post-monsoon season compared to monsoon season. The amphipods varied from 40 to 180 m$^2$ during pre-monsoon season. Whereas in monsoon season, the numbers ranged from 20 to 920 m$^2$ and 40 to 560 m$^2$ during the post-monsoon season.

At station 3, shrimps were found only during the pre-monsoon season with 40 m$^2$ in the month of March, but these two forms (shrimps and crabs) are totally absent in all the seasons throughout the study period. Barnacles are found in almost all the seasons. The number varied from 160 to 2780 m$^2$ in pre-monsoon season. While in monsoon season, they are reported in June with 80 m$^2$. They were not reported in remaining months. In post-monsoon season their number ranged from 220 to 3040 m$^2$.

Amphipods are dominant in monsoon and post-monsoon season, the number varied from 20 to 1080 m$^2$ and 60 to 260 m$^2$ respectively. During pre-monsoon season, their number fluctuated from 40 to 340 m$^2$. The squilla larvae were found only in the month of December with 40 m$^2$ throughout the study period.

Amphipods were represented by three main sub orders namely Gammaridae, Caprellidae and Orechastredae. Their number varied from 20 to 360 m$^2$ during the pre-monsoon season. Whereas in monsoon season, their
number observed 60 m² in the month of August, but absent in remaining months. During the post-monsoon season, their number fluctuated between 20 to 160 m². The squilla larvae were recorded only in two instances with 80 m² in the month of April of pre-monsoon season and 60 m² in the month of November of post-monsoon season respectively. They were completely absent in monsoon season.

At station 5, both the shrimps and crabs are present in the month of March/April/September/October/November and January. Shrimps were reported in March with 20 m² and January with 40 m². While crabs were reported in April (80 m²), September (180 m²), October (60 m²) and November (40 m²).

Barnacles were present throughout the study period except during the month of March. In pre-monsoon season, their number ranged from 520 to 560 m². In the monsoon season, it varied from 20 to 860 m². While in post-monsoon season, it is observed from 20 to 2640 m². Amphipods varied from 20 to 1140 m². In post-monsoon season, it ranged from 40 to 160 m². The squilla larvae were found only in the month of February with 60 m² throughout the study period.

4.8.1.3. Mollusca

During the present study, the Phylum Mollusca were represented by Gastropoda, Bivalvia, and Scaphopoda. The families Umbonidae, Cerithidea, Turritellidae, Trochidae, Littorinidae and Olividae represented class Gastropoda, class Bivalvia by Donacidae, Arcidae, Mytilidae and Ostreidae and class Scaphopoda by Denticillidae.

During pre-monsoon season at station 1, class Gastropoda was represented by seven families and their number varied from 40 to 1580 m². Bivalvia was represented by four families with their number ranging from 20 to 5180 m². Dentillidae a sole representative of class Scaphopoda was present in all the months except in the month of July, their number varies from 220 to 2320 m².
In the monsoon season, the Gastropoda was represented by six families, their number observed from 40 to 360 m$^{-2}$ and Bivalvia with four families and their number ranging from 40 to 1420 m$^{-2}$. Whereas, Dentalidae fluctuated from 20 to 640 m$^{-2}$. The Gastropoda was represented by six families in the post-monsoon season, their number fluctuated from 20 to 460 m$^{-2}$. While the Bivalvia were occurred with four families and their number varies from 20 to 2180 m$^{-2}$. Dentalidae observed from 180 to 1480 m$^{-2}$.

At station 2, the number of Gastropoda representing five families in the pre-monsoon season and it varies from 40 to 1280 m$^{-2}$. Bivalvia was represented by four families, with their number ranging from 20 to 580 m$^{-2}$. Dentalidae fluctuated from 40 to 80 m$^{-2}$, but they were absent in the month of February and March.

The number of Gastropoda observed from 20 to 120 m$^{-2}$ in the monsoon season with representing from five families and Bivalvia varies from 20 to 320 m$^{-2}$ representing from three families. Whereas, Dentalidae occurred only in the month of August with 40 m$^{-2}$ in the monsoon season. The number of Gastropoda in post-monsoon season represented by five families and their number ranged from 20 to 1540 m$^{-2}$ and the Bivalvia with three families fluctuated from 20 to 340 m$^{-2}$. Dentalidae occurred with 40 m$^{-2}$ in the month of November and January.

At station 3, the five families of Gastropoda were reported with their number varied from 20 to 880 m$^{-2}$ during pre-monsoon season. The Bivalvia representing with four families and their number ranged from 20 to 1220 m$^{-2}$. Whereas, Dentalidae fluctuated from 20 to 60 m$^{-2}$. They were absent in the month of February and March.

During the monsoon season, four families of Gastropoda were found and their number observed from 20 to 240 m$^{-2}$. While the Bivalvia varied from 20 to 180 m$^{-2}$ representing from four families. The Dentalidae were completely absent in all the months. In post-monsoon season, the Gastropoda fluctuated from 20 to 1260 m$^{-2}$ and the Bivalvia varies from 20 to 1240 m$^{-2}$ representing from six and
four families respectively. In both monsoon and post-monsoon season, the Dentallidae were completely absent.

At station 4, six families of Gastropoda were observed during pre-monsoon season with their number varying from 20 to 1340 m$^2$. While Bivalvia were represented by five families, their number ranging from 20 to 4960 m$^2$. The Dentallidea observed from 40 to 140 m$^2$, but absent in the month of March and May.

In the monsoon season, the Gastropoda was represented by four families and their number occurred from 20 to 820 m$^2$. Whereas, Bivalvia represented by four families with 20 to 1740 m$^2$. Dentallidae were present only in the July month with 20 m$^2$, but absent in remaining months. The Gastropoda was represented by three families in the post-monsoon season and their number fluctuated from 20 to 680 m$^2$. While the Bivalvia occurred with three families and their number varies from 20 to 2720 m$^2$. Dentallidae observed only in the month of January with 20 m$^2$, but absent in remaining months.

During pre-monsoon season at station 5, class Gastropoda was represented by five families and their number varied from 20 to 780 m$^2$. Bivalvia was represented by five families with their number ranging from 20 to 4480 m$^2$. Dentallidae fluctuated from 20 to 60 m$^2$.

In the monsoon season, the Gastropoda belonging to four families varied from 20 to 4180 m$^2$ and the Bivalvia representing from four families ranged from 20 to 1320 m$^2$. The family Dentallidae was absent in all the months during monsoon season. The number of Gastropoda in post-monsoon season represented by four families and their number ranged from 20 to 1180 m$^2$. The Bivalvia with four families fluctuated from 20 to 1380 m$^2$. The family Dentallidae occurred only in the month of December with 40 m$^2$, but absent in remaining months.
4.8.1.4. Egg cases

Sporadic representations of egg cases were observed during different seasons throughout the study period.

At station 1, during pre-monsoon season they were varied from 20 to 80 m$^2$, with absent in the month of March and April. In the monsoon season, the egg cases were ranged from 80 to 140 m$^2$, but absent in the month of June. Whereas in the post-monsoon season, it fluctuated from 20 to 40 m$^2$, but absent in the month of December and January.

At station 2, the number of egg cases varied from 160 to 220 m$^2$ were observed during pre-monsoon season. They were not found in the month of March and May. Whereas in monsoon season, they are ranged from 40 to 380 m$^2$ and 80 m$^2$ in the month of January in the post-monsoon season. At station 3, in the pre-monsoon season they were not reported. Whereas in monsoon season, it observed from 20 to 100 m$^2$, but absent in the month of June. In the post-monsoon season, it occurs only in the month of December with 140 m$^2$, but absent in the remaining months.

At station 4, during pre-monsoon season the egg cases ranged from 80 to 260 m$^2$, but absent in the month of February and May. During monsoon season, it varied from 400 to 1480 m$^2$, but absent in the month of September. In the post-monsoon season, it fluctuated from and 20 to 260 m$^2$, but absent in the month of December and January. At station 5, the egg cases were recorded in between 80 to 140 m$^2$ during pre-monsoon season. They were absent in the month of March and May. Their number varied from 40 to 1240 m$^2$ during monsoon season. In post-monsoon season, it varied from 60 to 720 m$^2$. They were not present in the month of November and December.

4.8.1.5. Sand tubes

The sporadic representation of sand tubes were recorded during different seasons throughout the study period.
At station 1, the sand tubes are present during pre-monsoon season and their number varied from 20 to 40 m$^2$. They were absent in the month of February and May. In the monsoon and post-monsoon season, it occurs only in the month of September with 60 m$^2$ and December with 40 m$^2$ respectively.

At station 2, the sand tubes are present in all the seasons throughout the study period. During pre-monsoon season, the number varied from 20 to 640 m$^2$. In monsoon season, they occurred in the month of September with 100 m$^2$ and in post-monsoon season, the number observed from 40 to 280 m$^2$. At station 3, the sand tubes during pre-monsoon season varied from 60 to 280 m$^2$. In monsoon season, it observed only in the month of September with 20 m$^2$. Whereas in post-monsoon season, their number ranged from 20 to 100 m$^2$.

At station 4, the sand tubes are occurred from 60 to 160 m$^2$ in the pre-monsoon season. In monsoon season, it ranged from 40 to 60 m$^2$, but absent in the month of June and July. Whereas in the post-monsoon season, it observed from 60 to 260 m$^2$. At station 5, the sand tubes varied from 20 to 560 m$^2$ during pre-monsoon season. In the monsoon season, it occur only in the month of August with 160 m$^2$. While in post-monsoon season, the number ranged from 20 to 80 m$^2$.

4.8.1.6. Fish

Only one species of cat fish was recorded at stations 3 and 4 during the month of August and April respectively. At station 1, 2 and 5 throughout the study period no fish species was recorded.

4.8.1.7. Annelida tube

The sporadic representations of annelida tubes were observed during different seasons throughout the investigation.
At station 1, in the pre-monsoon season their number varied from 40 to 100 m², with absent in the month of March and April. In the monsoon season, they were completely absent. Whereas in post-monsoon season, it occur only in the month of January with 160 m².

At station 2, throughout the study period no annelida tubes were recorded. At station 3, the annelida tubes during pre-monsoon season varied from 40 to 80 m². They were not occurred in the month of February and May. In monsoon season, it observed only in the month of June with 20 m². In post-monsoon season, they were completely absent.

At station 4, the annelida tubes are occurred from 40 to 140 m² in the pre-monsoon season, but absent in the month of February. In monsoon season, it ranged from 40 to 160 m². They were not recorded in the month of September. While in post-monsoon season, it occur only in the month of January with 60 m².

At station 5, the annelida tubes varied from 40 to 160 m² during pre-monsoon season. In the monsoon season, it occur only in the month of July with 140 m². Whereas in post-monsoon season, it occur only in the month of January with 20 m².

4.9. Statistical Analysis

4.9.1. Phytoplankton

4.9.1.1. Analysis of variance (two way ANOVA)

Two way analysis of variance was carried out (Table 43) for total phytoplankton numbers with respect to stations and months. It was found that there is a significant difference in total phytoplankton numbers due to months, but no significant difference in total phytoplankton due to stations has been observed during the present investigation.
4.9.1.2. Correlation co-efficient

The influence of physical, chemical and biological parameters such as temperature, pH, dissolved oxygen, ammonia, nitrite, nitrate, phosphate, silicate, chlorophyll-a and phaeophytin on total phytoplankton at selected stations is represented in Table 44.

In surface waters, a significant positive correlation was observed between nitrite and phytoplankton at station 1. Further a significant positive correlation was recorded between nitrate and temperature at station 3. Similarly a significant positive correlation was documented between salinity and temperature at station 2, 4 and 5.

A significant negative correlation was recorded between chlorophyll-a and temperature at station 1. Whereas at station 4, a negative correlation was observed between phaeophytin and temperature.

A significant positive correlation was observed between nitrite and pH at station 5. At station 2, 3, 4 and 5, a significant positive correlation was observed between salinity and pH.

A significant negative correlation was recorded between nitrate and pH at station 3. Similarly a significant negative correlation was observed between ammonia and pH at station 3 and 5. Further a significant negative correlation was recorded between phosphate and pH at station 4 and 5. At station 2, in between phaeophytin and pH showed a significant negative correlation. Whereas, a significant negative correlation was observed between silicate and salinity at station 4.

A significant positive correlation was observed between nitrate and ammonia at station 2 and 5. At station 2, 3, 4 and 5, a significant positive correlation was observed between phosphate and ammonia; whereas, a significant positive correlation was recorded between phosphate and nitrate at station 2.
significant negative correlation was observed between chlorophyll-a and nitrate at station 4.

A significant positive correlation was observed between phaeophytin and nitrate at station 2, but a significant negative correlation at station 5. A significant positive correlation was observed between silicate and phosphate at station 5. During the present study the phaeophytin and chlorophyll-a were found to be significantly correlated at all the stations.

4.9.2. Zooplankton

4.9.2.1. Analysis of variance (two way ANOVA)

The result of analysis of variance of polychaete larvae, copepod and copepod larvae after square root transformation is presented in Table 45 to 47. It was found from tables that there is a significant difference in polychaete larvae due to months, but no significant difference due to stations at 5% level of significance. Whereas copepod and copepod larvae showed significant difference due to months and stations at 5% level of significance.

4.9.3. Macrobenthos

4.9.3.1. Analysis of variance (two way ANOVA)

Two way analysis of variance carried out (Table 48) for population density (No.m\(^{-2}\)) for total macrobenthos numbers with respect to stations and months. It was found that there is a significant difference in total macrobenthos numbers due to stations, but no significant difference due to months has been observed during the present study.

4.9.3.2. Correlation co-efficient

The correlation co-efficient between macrobenthos and hydrographical features as well as sediment characteristics are presented in the Table 49 and 50.
The correlation co-efficient between macrobenthos and different hydrographical features (temperature, dissolved oxygen, salinity and pH) were found to be in significant (Table 49). The correlation co-efficient between macrobenthos with salinity at station 1 showed positively correlated.

The correlation co-efficient between macrobenthos and sediment characteristics (sediment temperature, organic carbon, sand, silt and clay) were observed to be in significant (Table 50). Whereas, the correlation co-efficient between macrobenthos with silt and clay at station 5 and 4 respectively showed positive correlation.