

4.3 TEMPORAL DISTRIBUTION OF PHYTOPLANKTON

4.3.1 STATION 1 (ST1)

4.3.1.1 Cells Abundance and Species Composition during High tide

Temporally, phytoplankton's cells abundance fluctuated throughout the sampling periods. The highest peak was recorded in August with the reading of 1.79×10^6 cells/L, which almost 89% of the value was contributed by *Skeletonema costatum* cells density with 1.59×10^6 cells/L (Figure 4.3). Phytoplankton density in June 2009 recorded as the lowest with only 3.4×10^5 cells/L. However, contrarily, the species richness displayed a high value with 35 taxonomic entities were recorded (Figure 4.3). As for species richness, highest value was recorded during the final sampling period which was carried out in March 2010 with 37 species and 1652cells/ml density (Figure 4.3).

The occurrence of pennate diatom *Pinnularia acuminata* in the fourth sampling month in high density (1.08×10^6 cells/L) together with *P. tabellaria* (1.43×10^5 cells/L), inhibited the occurrence of other species thus reducing the species richness steeply to only 9 species (Figure 4.3). In July 2009, genus *Pinnularia* covered almost 98% of total phytoplankton. 3 dominant species of phytoplankton, the chained-forming *Skeletonema costatum*, pennate *Pseudo-nitzschia pungens* and *Thalassiothrix frauenfeldii* that were observed in almost sampling month also found absent from July 2009 sampling, during *Pinnularia acuminata* outstanding occurrence.

Generally, 68 species of phytoplankton were observed and recorded during high tide at ST1 in 12 months samplings. 16 species of phytoplankton which were the *Bacteriastrum comosum*, *Chaetoceros debilis*, *C. delicatulum*, *C. neglectus*, *C. sp3*, *C. sp4*, *Cyclotella meneghiana*, *Fragilaria sp.*, *Mastogloia smithii*, *Melosira nummuloides*, *Stauroneis obtusa*, *S. pusilla*, *Thalassionema nitzshoides*, *Diatoma elongatum*, *Peridinium cinctum* and *Oscillatoria tenuis*, were found absent from the samplings.

The most dominant phytoplankton species was *Skeletonema costatum* which was sampled in 11 out of 12 months of sampling with mean density of 4.53×10^5 cells/L. Followed, were the other 2 species which were also sampled in 11 out of 12 months of seasonal investigation, the *Pseudo-nitzschia pungens* and *Thalassiothrix frauenfeldii* with mean density of 3.25×10^4 cells/L and 1.35×10^4 cells/L respectively. At ST1 during high tide, there were no record of phytoplankton from division Pyrrophyta and Cyanobacteria. *Corethron criophilum* of order Corethrales and *Rhizosolenia alata* of order Rhizosoleniales from division Bacillariophyta were the species those occurred in 10 out of 12 months of sampling, with both mean density of 3×10^4 cells/L.

Phytoplankton species of order Chaetocerotales was normally being sampled during high tide not only at ST1 but also at the other two stations (ST2 and ST3). However, the abundance of these phytoplankton species during low tide could be negligible due to their low density. Surprisingly, the occurrences of the species were relatively high during the early 3 months and final 3 months of sampling (Figure 4.4). Obviously figure 4.4 clearly shows that phytoplankton species of order Chaetocerotales which mainly consists of genus *Chaetoceros* were absent from high tide sampling at ST1 for 6 consecutive months starting from July 2009 until December 2009. However, the cells abundance increased steeply in January 2010 (Figure 4.4).

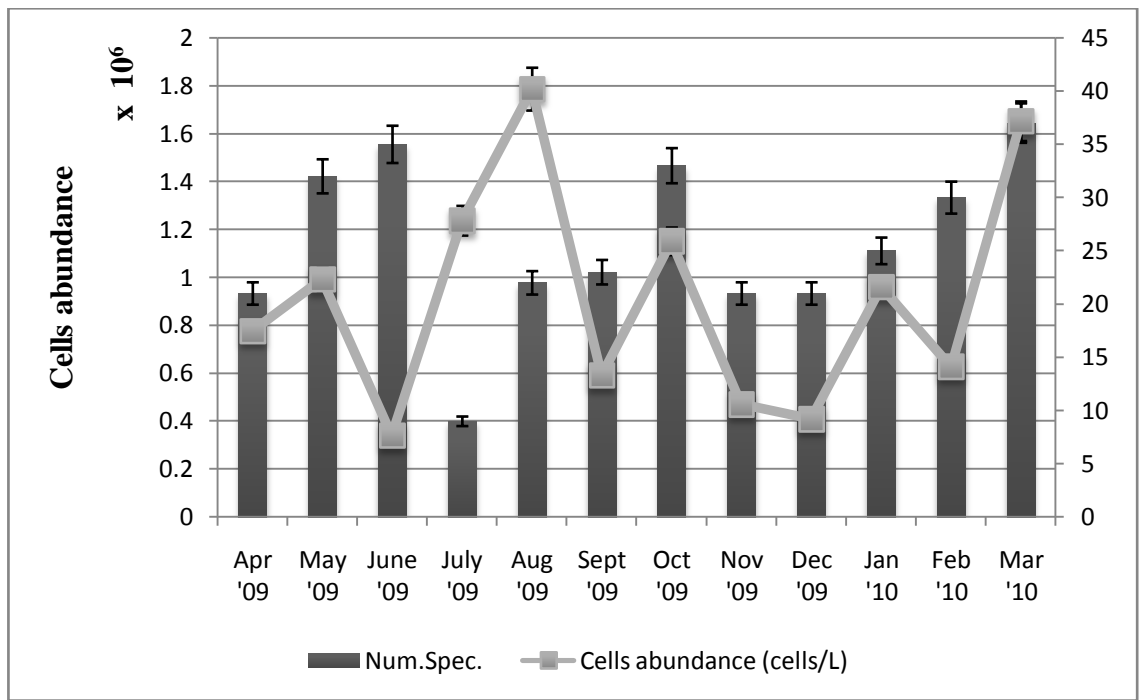


Figure 4.3: The species richness and cells abundance (cells/L) of phytoplankton at ST1 during high tide.

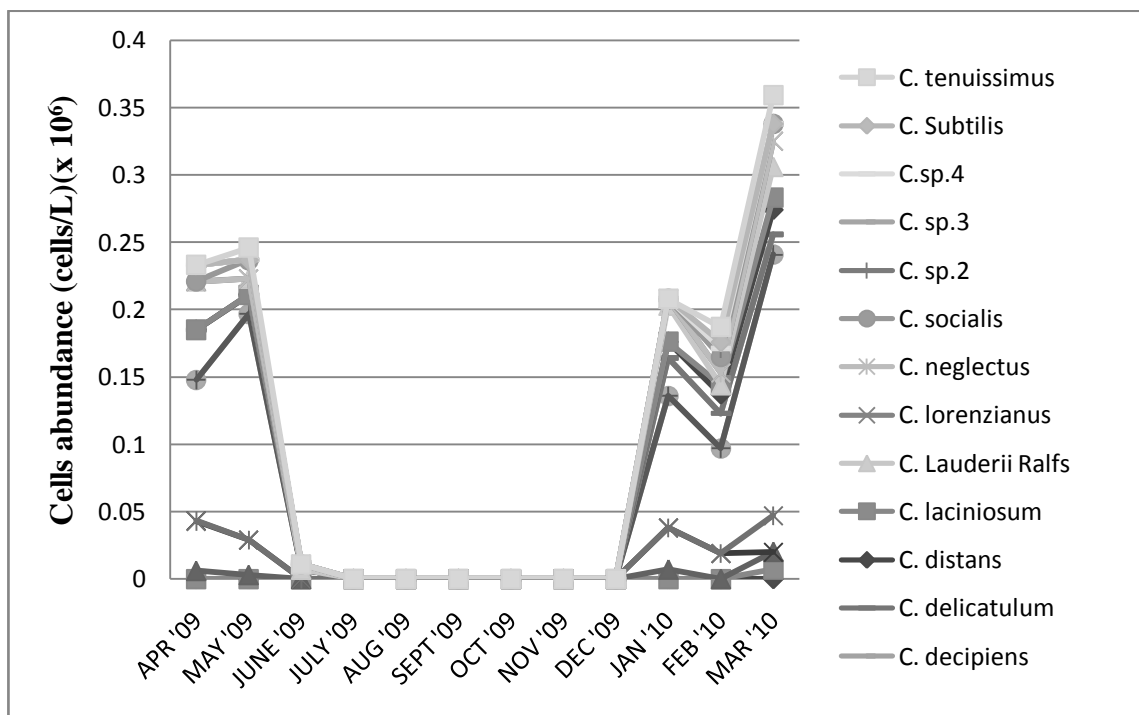


Figure 4.4: Occurrence of some species of order Chaetocerotales at ST1 during high tide.

4.3.1.2 Species Diversity and Evenness during High Tide

The trends of H' and E were fluctuated throughout a year of sampling at ST1 during high tide. Obviously, both H' and E value showed same graph patterns. Highest H' was recorded in February 2010 with the value of 3.528, followed by the value in June 2009 (3.517), March 2010 (3.321) and December 2009 (3.081). H' displayed the lowest value (0.668) in July 2009 during *Pinnularia* bloom.

As for E , the highest value was 0.719 recorded also in February 2010, followed by the value in December 2009 (0.701), June 2009 (0.686) and the fourth higher was in March 2010 (0.637), whereas the lowest E was recorded in August 2009 when the H' value was 0.911.

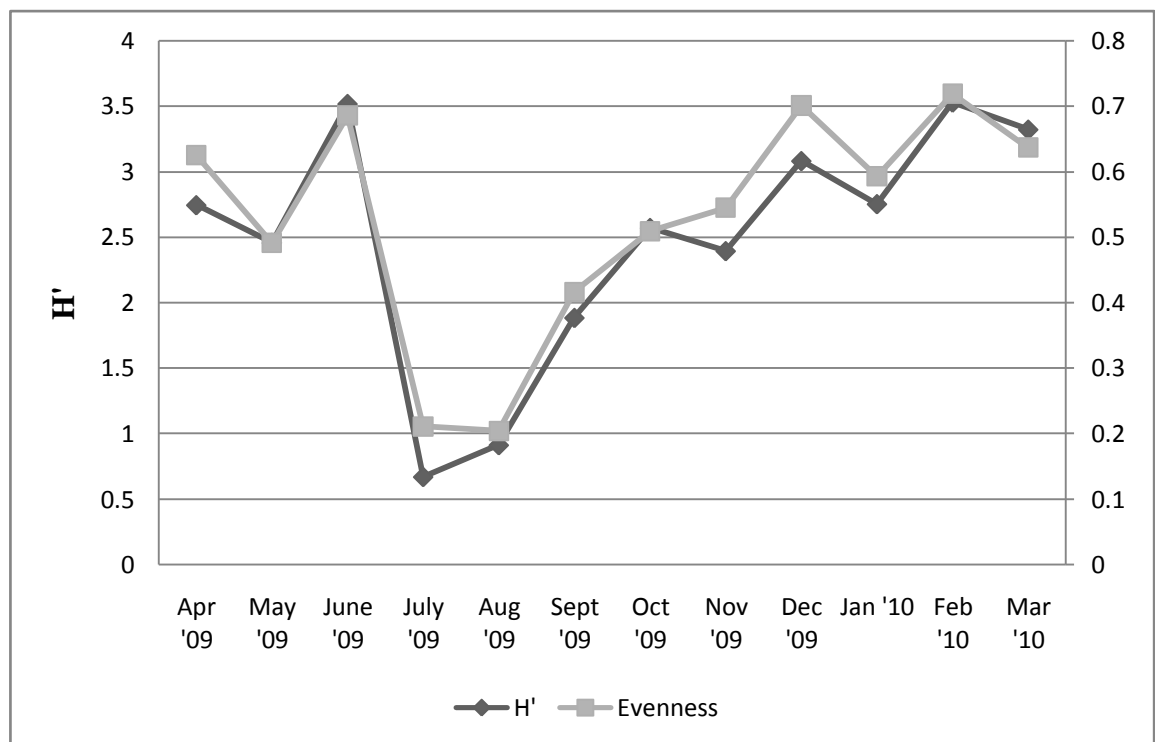


Figure 4.5: The Shannon-Wiener Diversity Index (H') and Evenness (E) of phytoplankton at ST1 during high tide.

4.3.1.3 Cells Abundance and Species Composition during Low Tide

Figure 4.6 shows that the cells abundance and species richness of phytoplankton at ST1 during low tide fluctuated in a year of sampling. Highest cells abundance was recorded in the first month of sampling in April 2009, with the reading of 6.82×10^5 cells/L, whereas the lowest was 7.2×10^4 cells/L recorded in September 2009. Concurrently to the highest cells abundance recorded in April 2009, species richness in this month also displayed the highest value with 20 species, while the lowest species richness was detected in July 2009 with of only 7 species recorded (Figure 4.7). In April 2009, the high cells abundance was contributed majorly by *Pinnularia* sp. which covered 24.8% of total density.

Overall, only 54 species of phytoplankton from 3 divisions which were the Bacillariophyta, Chlorophyta and Cyanobacteria occurred at ST1 during low tide. 30 species of phytoplankton were absent from low tide sampling at ST1. *Diatoma elongatum*, *Fragilaria* sp., *Stauroneis obtusa*, *S. pusilla* and *Oscillatoria tenuis* were sampled during low tide whereas, absent from high tide sampling at ST1. Temporal low tide sampling at ST1 displayed *Campylodiscus daemilianus* of order Surirellales as the most common species that was sampled throughout the 12 sampling months with mean density of 3.0×10^4 cells/L. The species occurred in 10 out of 12 sampling months, while absent from November 2009 and March 2010 samplings.

Genus *Coscinodiscus* was also one of common phytoplankton inhabited ST1 during low tide. *Coscinodiscus concinnus* was sampled in 9 sampling months, followed by *C. lineatus* (6), *C. rothii* (4), *C. sp.* (4), *C. centralis* (3) and finally *C. asteromphalus* (2). *Skeletonema costatum* was the species that was sampled in both tides, though the density was not as high as it was in high tide. The species was sampled in 8 out of 12 months of sampling, with mean density of 2.38×10^4 cells/L. *Oscillatoria tenuis* of

division Cyanobacteria that was absent from ST1 in high tide, was sampled during low tide in 4 sampling months (April 2009, May 2009, Jun 2009 and January 2010), with mean density of 9.52×10^4 cells/L.

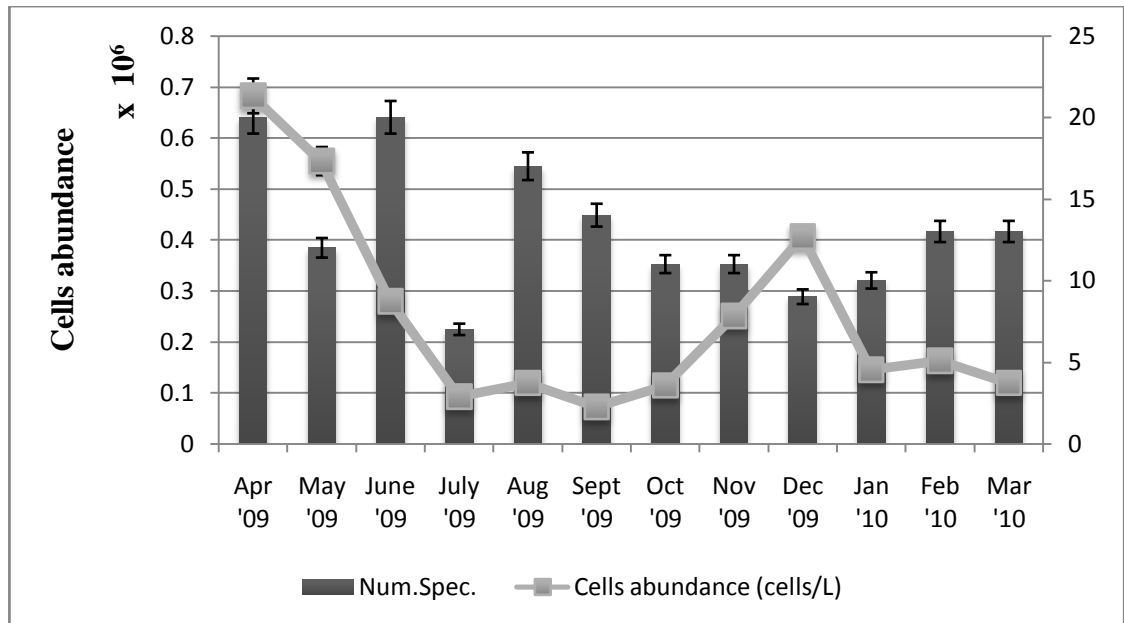


Figure 4.6: The species richness and cells abundance (cells/L) of phytoplankton at ST1 during low tide.

4.3.1.4 Species Diversity and Evenness during Low Tide

Figure 4.7 shows the trend of both H' and E values of phytoplankton community at ST1 during low tide which changed markedly between months. H' values were ranged between 1.300 and 3.200. The highest H' was in September 2009 (3.106), whereas the lowest H' was recorded during the fourth sampling in November 2009 with value of only 1.317 which was relatively low. However, after September 2009, H' value decreased steeply for 2 consecutive months until the lowest value of H' was recorded in November 2009.

As for E , similar to H' value, the highest was recorded in September 2009 (0.816) (Figure 4.8), in which the highest H' value was also recorded, whereas the lowest E was 0.381 in November 2009.

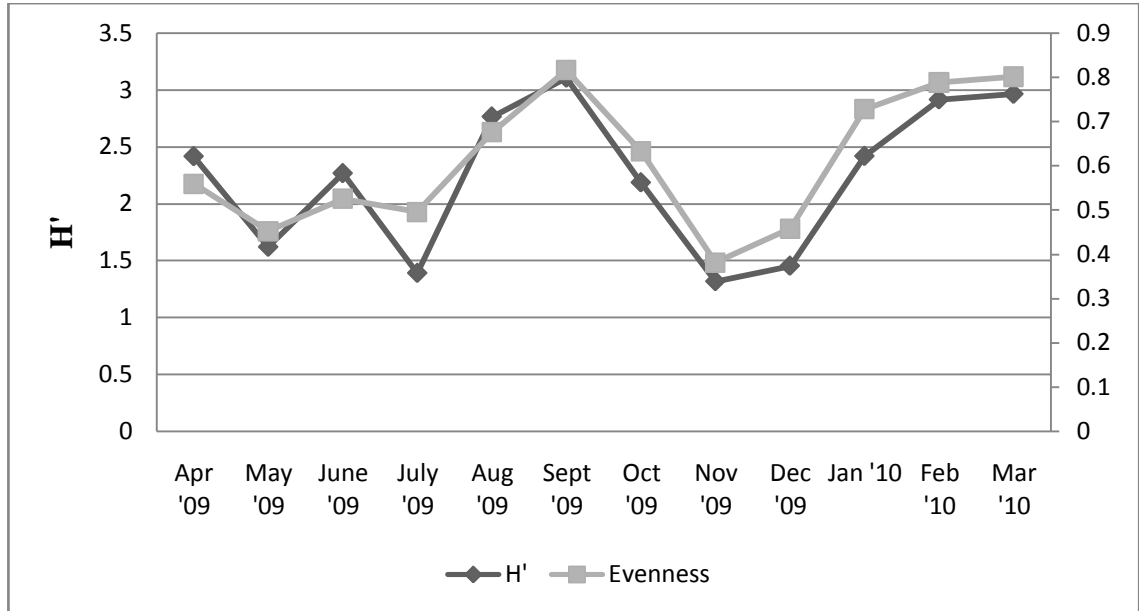


Figure 4.7: The Shannon-Wiener Diversity Index (H') and Evenness (E) of phytoplankton at ST1 during low tide.

4.3.2 STATION 2 (ST2)

4.3.2.1 Cells Abundance and Species Composition during High Tide

Figure 4.8 shows seasonal variation of phytoplankton at ST2 during high tide based on species richness and cells abundance. Cells abundance showed its highest peak in the first sampling in April 2009 with the value of 2.67×10^6 cells/L, while the peak decreased to 2.56×10^6 cells/L in May 2009 during the second sampling month. There was a steep decrease in the temporal trend in the third month (Figure 4.10). The trend continued to increase until the cells abundance dropped to its lowest value in July 2009 with only 3.55×10^5 cells/L. In August, the abundance increased (1.34×10^6 cells/L), and showed fluctuated trend until the final sampling month in March 2010 (Figure 4.8).

As for species richness, contrarily to the cells abundance that was relatively low in June 2009, it displayed the highest value in this third sampling month with 44 species recorded (Figure 4.8). The species richness in June 2009 was followed by the value in May 2009 (38 species) and April 2009 (33 species). Figure 4.8 shows that the first 3 months of sampling were the months in which the number of species was relatively high compared to other sampling months. However, the value decreased markedly in July 2009 with only 12 species recorded. From August 2009 to final sampling in March 2010, the number of species of phytoplankton at ST2 showed quite constant trends (Figure 4.8). In both February and March 2010, same number of species was recorded with 26 species in both months.

Overall, 73 species of phytoplankton were found to occur at ST2 during high tide. However, species from division Cyanobacteria was absent from the samples. 11 species of phytoplankton were absent from ST2 during high tide which were the *Amphiphora alata*, *Campylodiscus daemilianus*, *Chaetoceros* sp. 3, *C.* sp.4, *Cyclotella meneghiana*,

Frustulia vulgaris, *Melosira nummuloides*, *Pinnularia tabellaria*, *Mougeotia* sp., *Cosmarium humile* and *Oscillatoria tenuis*.

Similar to ST1 during high tide sampling, at ST2, *Skeletonema costatum* was the most dominant species with the occurrence in 11 out of 12 sampling months, with a relatively high mean density of 6.92×10^5 cell/L. The statistic followed by *Thalassiothrix frauenfeldii* which was also sampled in 11 months and *Pseudo-nitzschia pungens* occurred in 10 months with mean density of 1.67×10^4 cells/L and 8.16×10^4 cells/L, respectively. Nevertheless, *Leptocylindrus danicus* of order Leptocylindrales was quite dominant species where it was sampled in 9 sampling months with mean density of 2.05×10^4 cells/L. There was no record of *Pinnularia* bloom at ST2 during high tide sampling.

At ST2 during high tide, order Chaetocerotales did show similar trend with its abundance at ST1 during high tide (Figure 4.9). High cells abundance decreased markedly in the third sampling month, which was carried out in June 2009 to 0.00 cells/L. However, contrarily from the trend at ST1, at ST2, there was occurrence of some species of order Chaetocerotales in August 2009, which were the *Bacteriastrum delicatulum* (1.50×10^4 cells/L), *Chaetoceros constrictus* (6.00×10^3 cells/L) and *C. lorenzianus* (2.2×10^4 cells/L). The abundance of order Chaetocerotales returned to 0.00 cells/L in the following 4 months until January 2010, in which more than halves of recorded Chaetocerotales species increased its number toward final sampling month in March 2010, with slight decrement in February 2010 (Figure 4.9).

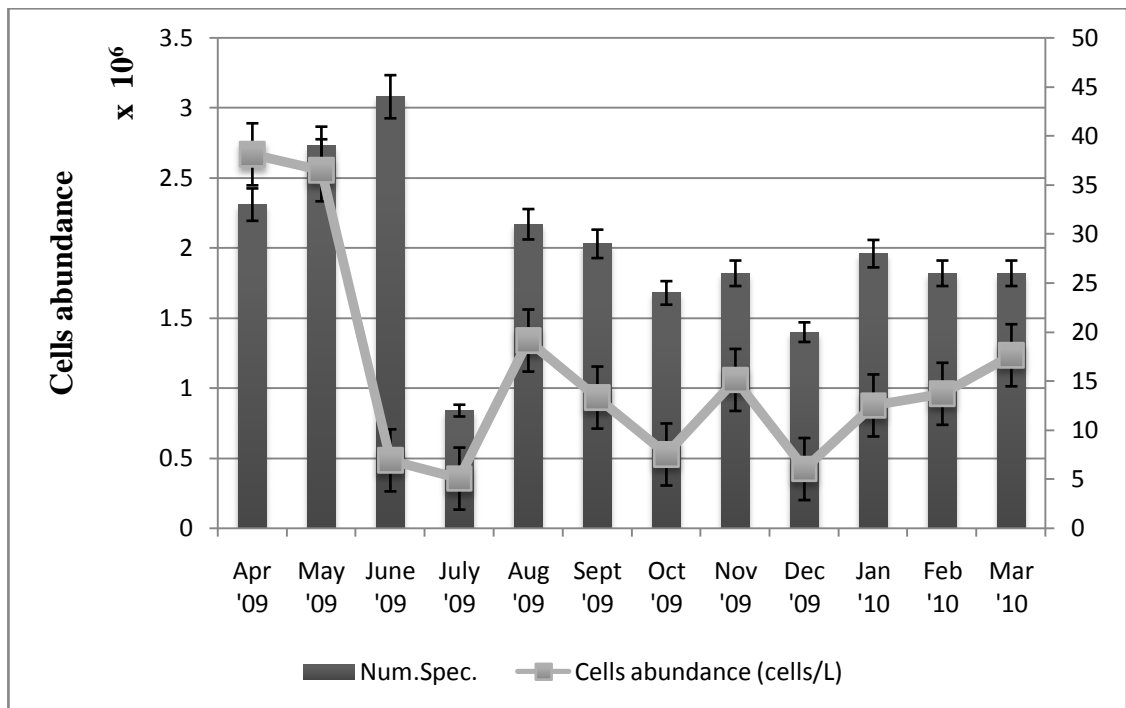


Figure 4.8: The species richness and cells abundance (cells/L) of phytoplankton at ST2 during high tide.

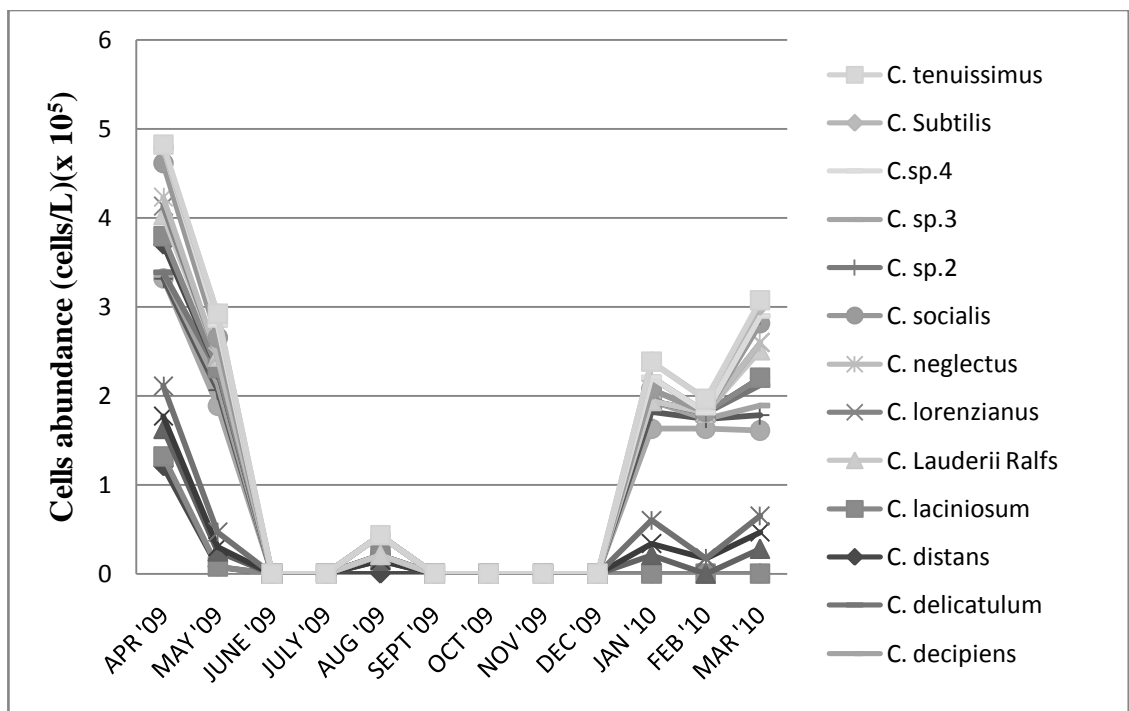


Figure 4.9: Occurrence of some species of order Chaetocerotales at ST2 during high tide.

4.3.2.2 Species Diversity and Evenness during High Tide

Figure 4.10 shows both H' and E values of phytoplankton at ST2 during high tide were fluctuated throughout sampling period. As for H' , the value in the third sampling month which was carried out in June 2009 displayed the highest peak with the record of 3.732. Whereas, the H' values for the other 11 months were recorded below 3.000. From Figure 4.10, obviously shows there was a steep increment of H' from May 2009 (1.637) to June 2009, while in July 2009, the value dropped markedly to 1.877, and the value was continuously decreased to the lowest value that was recorded in August 2009 (1.476). However, the H' value for the following 7 months increased with slight decrement in some months, for instance in November 2009 and February 2010 (Figure 4.10).

Similar to H' , the highest E was also recorded in June 2009, with the value of 0.684, followed by the other E values which were recorded in January 2010 (0.621), December 2009 (0.578), March 2010 (0.572) and finally February 2010 (0.553) (Figure 4.10), whereas the lowest E was recorded in August 2009 with the value of 0.298.

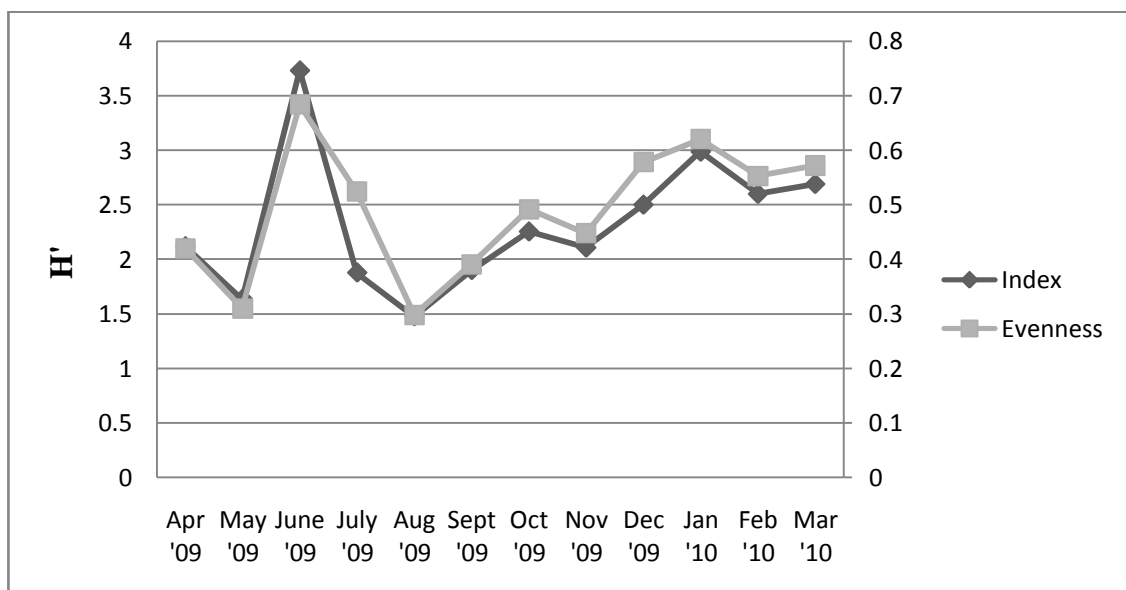


Figure 4.10: The Shannon-Wiener Diversity Index (H') and Evenness (E) of phytoplankton at ST2 during high tide.

4.3.2.3 Cells Abundance and Species Composition during Low Tide

Seasonal variations of phytoplankton at ST2 during low tide displayed a fluctuated trend throughout 12 months sampling period (Figure 4.11). There were steep increment and decrement to phytoplankton's cells abundance in the early months of sampling (Figure 4.11). For instance, in May 2009, the abundance dropped from 4.35×10^5 cells/L in April 2009 to 1.54×10^5 cells/L and increased to the highest value in June 2009 (4.76×10^5 cells/L). However, in July 2009, the abundance decreased markedly from the highest value in June 2009 to the lowest value with cells abundance of only 7.80×10^4 cells/L.

The cells abundance increased from relatively low values in both July and August 2009 in the sixth sampling month which was carried out in September 2009 with the abundance of 3.99×10^5 cells/L (Figure 4.11). Values of cells abundance continued to fluctuate until January 2010 and February 2010 in which the abundance were nearly the same with the recorded abundance 2.60×10^5 cells/L and 2.52×10^5 cells/L respectively. In final sampling month in March 2010, the abundance decreased at relatively low value of 1.05×10^5 cells/L.

As for species richness, the highest record was in August 2009 (17), in which the cells abundance was relatively low (Figure 4.11). Sampling in June 2009 and March 2010 shared same number of species with both recorded the occurrence of 16 species. The lowest species richness was recorded in both November and December 2009, with only 9 species recorded during the sampling (Figure 4.11).

Generally, there was 53 species of phytoplankton from divisions of Bacillariophyta, Chlorophyta and Cyanobacteria were recorded at ST2 during low tide, whereas 31 species were found absent. *Skeletonema costatum* was the most dominant species with occurrence in 9 out of 12 sampling months with mean density of 2.69×10^4

cells/L. *Campylodiscus daemilianus*, the most abundant species at ST1 during low tide also was also commonly sampled during low tide at ST2. The species occurred in 8 sampling months in which it absent from June, August, and September 2009 and in final sampling month, March 2010, with mean density of 1.09×10^4 cells/L. The third most common phytoplankton species occurred was *Pseudo-nitzshia pungens* that was sampled in 7 months in a year of sampling, with mean density of 9.91×10^3 cells/L.

There were 6 phytoplankton species that only occurred at ST2 during low tide, whereas absent in high tide sampling, which were the *Amphiphora alata* of order Thalassiophysales, *Campylodiscus daemilianus* of order Surirellales, *Cyclotella meneghiana* of order Thalassiosirales, *Frustulia vulgaris* of order Naviculales, *Cosmarium humile* of order Desmidiiales and *Oscillatoria tenuis* of order Oscillatoriales.

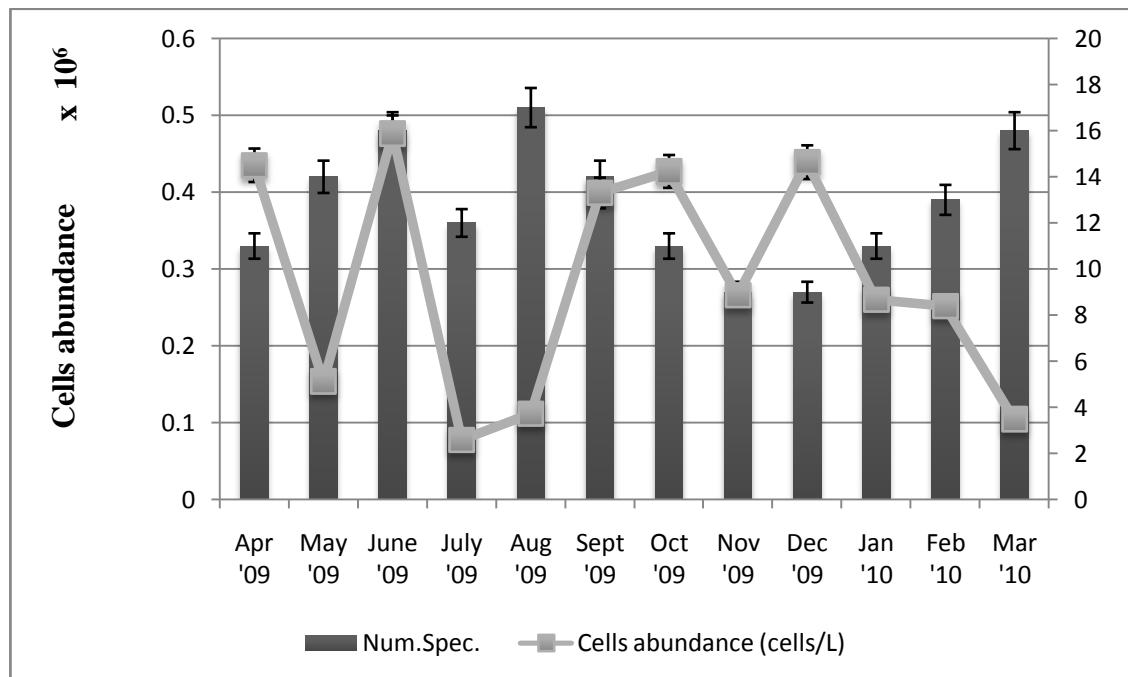


Figure 4.11: The species richness and cells abundance (cells/L) of phytoplankton at ST2 during low tide.

4.3.2.4 Species Diversity and Evenness during Low Tide

Both H' and E values of phytoplankton at ST2 in low tide sampling demonstrated similar fluctuated patterns (Figure 4.12). The lowest H' was recorded in the first sampling month, April 2009 with a relatively low value, 0.706, whereas final sampling month in March 2010 had the highest value of H' (3.592). H' value increased steeply in May 2009 (2.915) from lowest value in April 2009 and in July 2009 (2.931) from relatively low value in previous month, June 2009 (0.994) (Figure 4.12). While in June 2009 and September 2009, the value demonstrated markedly decrement with the values of 0.994 and 0.833 respectively. H' value continued to increase after September 2009 until the highest H' value was recorded in March 2010, with a slight decrement in February 2009 (Figure 4.12).

Similar to the value of H' , the highest E was also recorded in March 2009 with the value of 0.898, whereas the lowest was in April 2009 (0.204). Concurrently to H' value, E decreased steeply in both June and September 2009 with the values of 0.248 and 0.219 respectively (Figure 4.12).

In addition to the highest level in March 2010, E in these 4 months also displayed relatively high values, May 2009 (0.766), July 2009 (0.818), January 2010 (0.858) and February 2010 (0.763).

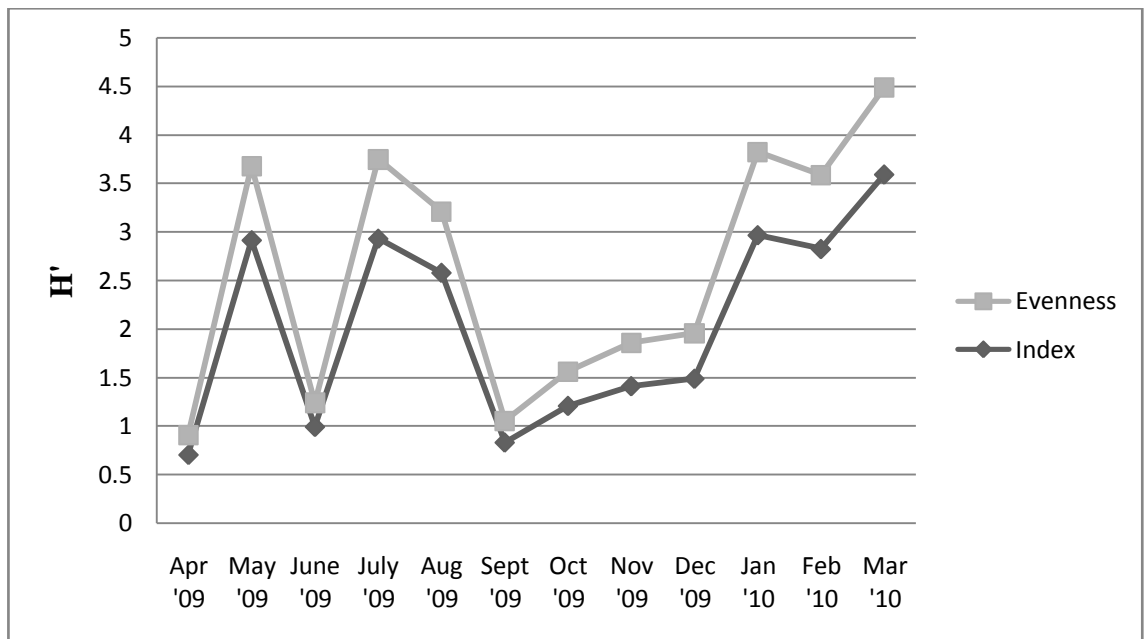


Figure 4.12: The Shannon-Wiener Diversity Index (H') and Evenness (E) of phytoplankton at ST2 during low tide.

4.3.3 STATION 3 (ST3)

4.3.3.1 Cells Abundance and Species Composition during High Tide

Figure 4.13 shows that both cells abundance and species richness were contrarily correlated to each other. For instance, in July 2009, in which the highest phytoplankton abundance was recorded (4.03×10^6 cells/L), species number displayed its lowest value of only 7 species. In June 2009, the highest species number was recorded with 50 species, while on the other hand, the lowest cells abundance recorded in this month with only 597 cells/ml of phytoplankton was sampled (Figure 4.13).

From figure 4.13, shows that both cells abundance and number of species at ST3 during high tide fluctuated markedly at the beginning of sampling months, however, the values started to show uniform pattern in September 2009 until March 2010.

Overall, there was a high occurrence of phytoplankton species with 78 species of phytoplankton recorded while 6 species were absent. The absent species were *Chaetoceros* sp. 3, *Chaetoceros* sp. 4, *Corethron criophilum*, *Melosira moniliformis*, *Saturoneis pusilla* and *Oscillatoria tenuis*.

Skeletonema costatum was the most dominant species to inhabit ST3 during high tide in which it occurred in 11 months of sampling with a high mean density of 9.61×10^5 cells/L. *Thalassiothrix frauenfeldii* was the second dominance species, though occurred also in 11 months, the mean density was relatively low compared to *S. costatum*, which was only 1.63×10^4 cells/L. *Pseudo-nitzschia pungens* and *Lauderia borealis* were the species that were sampled in 10 out of 12 months sampling period with mean density of 7.43×10^4 cells/L and 2.65 cells/L respectively. Apart from that, species from genus *Coscinodiscus* also found common at ST3, for instance the *Coscinodiscus concinnus*, *C. asteromphalus* and *C. centralis* in which were sampled in 9th, 7th and 5th months of sampling respectively.

Similar to ST1 during high tide, at ST3, there was also outstanding occurrence of genus *Pinnularia* in the fourth sampling month, which was carried out in July 2009. However, at ST3, there were two responsible species involved which were *Pinnularia tabellaria* and *P. acuminata* with abundance of 1.53×10^6 cells/L and 1.62×10^6 cells/L respectively. In this month, as mentioned earlier, the number of species dropped dramatically to only 7 species. *Melosira nummuloides* and *Cosmarium humile* both from division Bacillariophyta were 2 of the common species to also inhabit ST3 in July 2009 with abundance of 7.32×10^5 cells/L and 2.00×10^4 cells/L respectively.

Figure 4.14, obviously shows the abundance of order Chaetocerotales at ST3 has a similar pattern with ST2 during high tide sampling. High cells abundance of this order was sampled in the first sampling month in April 2009 (Figure 4.14). However, the number decreased steeply in June 2009 before sudden increasing of 5 species of order Chaetocerotales in August 2009, which were *Chaetoceros constrictum*, *C. debilis*, *C. decipiens*, *C. Lauderii* and *C. lorenzianus*. After September 2009, there was 0.00 cells/L occurrence of order Chaetocerotales until December 2009. In early 2010, which were in January 2010, the abundances increased until March 2010 with slight decrement in February 2010 (Figure 4.14).

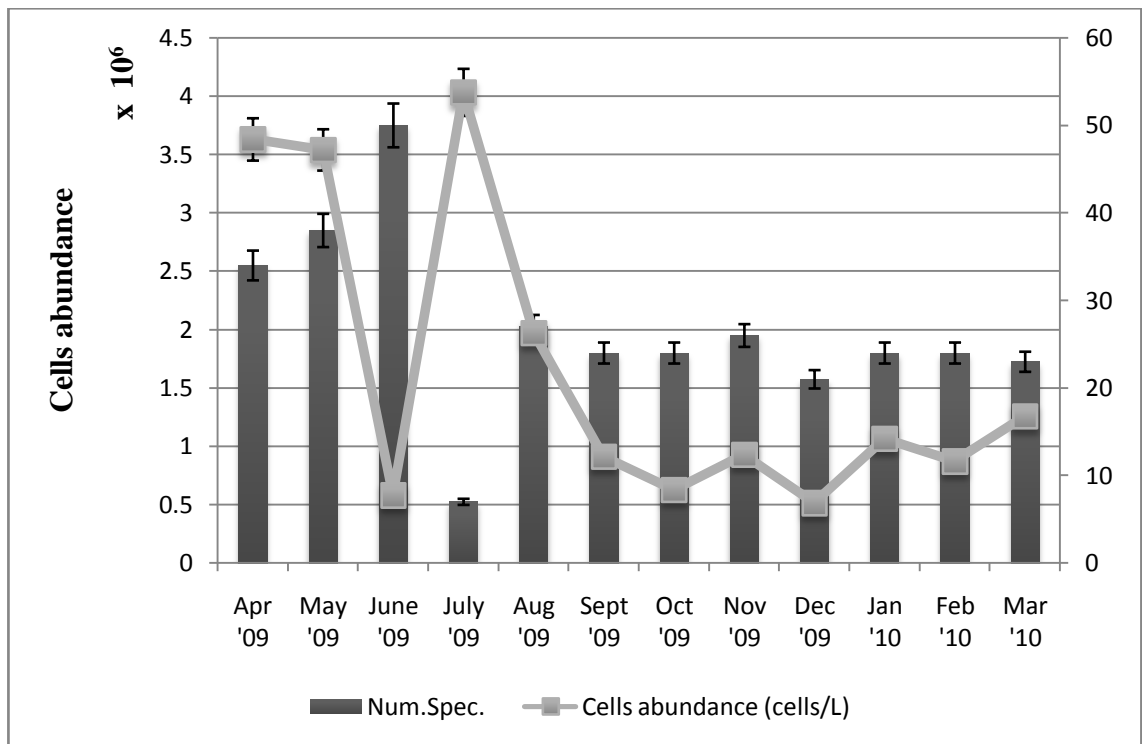


Figure 4.13: The species richness and cells abundance (cells/L) of phytoplankton at ST3 during high tide.

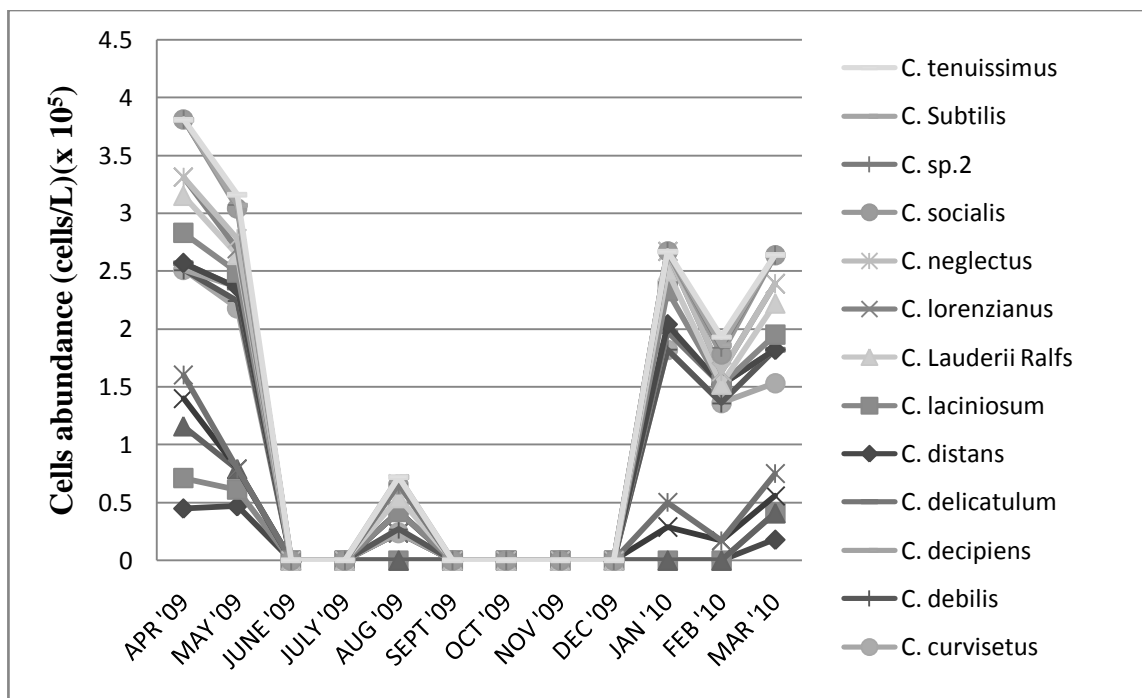


Figure 4.14: Occurrence of some species of order Chaetocerotales at ST3 during high tide.

4.3.3.2 Species Diversity and Evenness during High Tide

Both H' and E started with relatively low values until they increased steeply to the highest level in June 2009 with the reading of 3.924 and 0.695 respectively (Figure 4.15). However, the values decreased to the lowest level in August 2009 with the record of H' was 1.059 and E was 0.223. After their lowest values in August 2009, both H' and E increased moderately in October 2009 with the values of H' and E were 2.52 and 0.55 respectively. Both H' and E showed uniform trends until the end of sampling month with slight decreased in November 2009 with the values of 1.707 and 0.363 respectively.

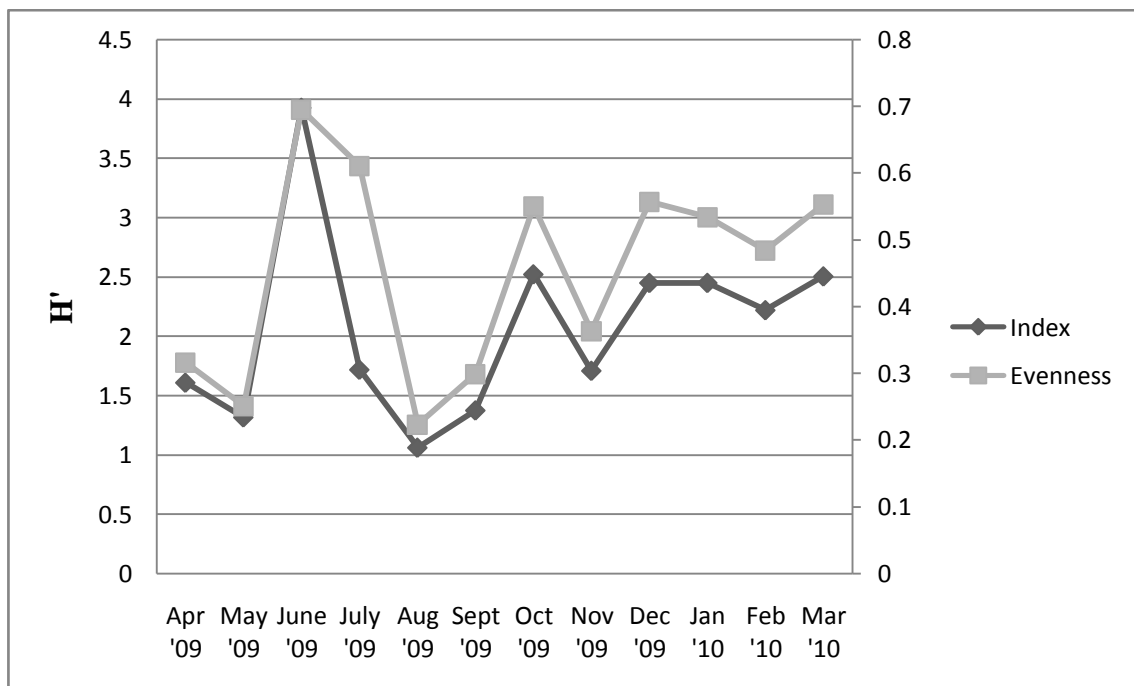


Figure 4.15: The Shannon-Wiener Diversity Index (H') and Evenness (E) of phytoplankton at ST3 during high tide.

4.3.3.3 Cells Abundance and Species Composition during Low Tide

Figure 4.16 shows that both cells abundance and species richness of phytoplankton at ST3 during low tide fluctuated throughout a year of sampling. As for the cells abundance, the value started at a relatively high level in April 2009 in which the highest value was recorded (4.98×10^5 cells/L). However, the value dropped until the lowest abundance was recorded in September 2009 (5.2×10^4 cells/L) and increased in October 2009 with the value of 2.49×10^5 cells/L. The cells abundance showed uniformity after October 2009, until March 2010 in which it dropped to a relatively low value of 1.13×10^5 cells/L (Figure 4.16).

Contrarily to cells abundance, the highest phytoplankton number of species was recorded in the final sampling which was carried out in March 2010 with the record of 18 species. Phytoplankton species richness at ST3 in low tide, increased from 8 species in the first sampling month (April 2009) to 14 species in Jun 2009 before the number decreasing to the lowest value of only 6 species in July 2009.

During low tide sampling, 53 species of phytoplankton were found to occur at the research area, ST3. *Pseudo-nitzschia seriata* was the most common species to be sampled with the occurrence in 9 out of the 12 sampling months with the mean density of 1.23×10^4 cells/L. Followed, was *Skletonema costatum*, which had been sampled in 8 sampling months with mean density of 2.68×10^4 cells/L.

There were 3 phytoplankton species which occurred only in low tide and absent from high tide which were *Oscillatoria tenuis* of order Oscillatoriales, *Melosira nummuloides* of order Melosirales and finally *Stauroneis pusilla* of order Naviculales.

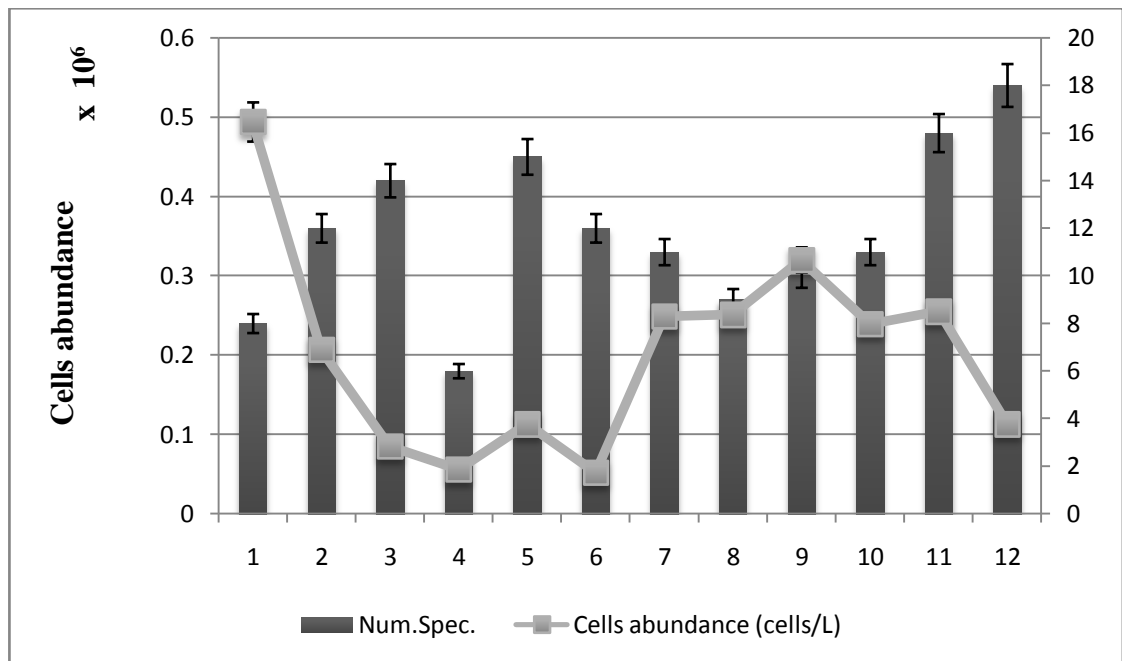


Figure 4.16: The species richness and cells abundance (cells/L) of phytoplankton at ST3 during low tide.

4.3.3.4 Species Diversity and Evenness during Low Tide

Figure 4.17 shows that both H' and E values of phytoplankton at ST3 during low tide fluctuated throughout sampling year. H' started with the lowest value of only 0.618 in April 2009. However, the value showed an increment in the following months until it reached at relatively high value of 3.262 in September 2009 with minor decrement in July 2009, in which the value dropped from 2.353 in June 2009 to 1.968. In October 2009, the H' value dropped quite steeply until November 2009 to a value of 1.527, before increasing to the highest value in March 2010 (3.466) (Figure 4.17).

Similar to H' trend, the E value of the phytoplankton started with its lowest value in the first sampling month with the value of 0.206 (Figure 4.17). There was an increment to the value until it's reached a relatively high value in September 2009 of 0.761 before decreasing to a value of 0.482 in November 2009 (Figure 4.17). The E value increased steeply until the highest value was recorded in to January 2010 with the value 0.891.

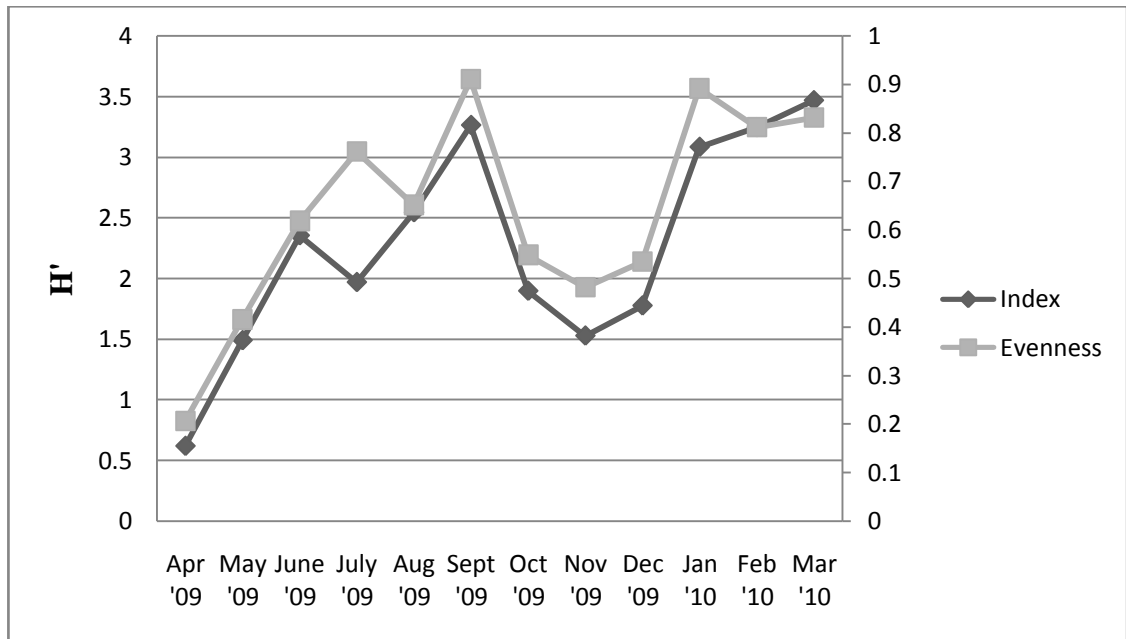


Figure 4.17: The Shannon-Wiener Diversity Index (H') and Evenness (E) of phytoplankton at ST3 during high tide.

4.3.4 CLUSTER ANALYSIS

4.3.4.1 Cluster Analysis of Phytoplankton Community during High Tide

UPGMA Modified Morisita's Similarity obviously clustered phytoplankton's composition into 3 major groups (Figure 4.18). Group 1 was solely consists of July 2009 and the species composition in this month had 0% similarity to both group 1 and group 2.

Group 2 displayed a connection of phytoplankton species composition of 3 final sampling months which were December 2009, January 2010 and February 2010 with December 2009 and June 2009, whereas, in group 3, the dendrogram shows the relatedness between the species composition in September, October and November 2009 with the composition in April, May and August 2009.

In group 2, phytoplankton in January 2010 and the following February 2010 shared a relatively high species composition with the percentage of 99%. Both months shared 94% similarity with the composition of final sampling month in March 2010 (Figure 4.18). While species composition of June 2009 had 94% overlapped species with the composition of phytoplankton in 3 sampling months in 2010. Finally, all the species composition of 4 mentioned months in group 2 were linked to composition in December 2009 with the percentage of 88%.

As for group 3, the first subgroup was comprised of months of October, November and September 2009. The composition of phytoplankton in November 2009 and September 2009 were similar at the percentage of 99%. The phytoplankton composition in October 2009 was similar to both months in this group with 96% species overlapped. This first subgroup was connected to the second subgroup of group 3 that comprised of month of April, May and August 2009 with the percentage of 92%. Species composition of phytoplankton in August and May had a similarity of 99% and

both months have species overlapped of about 98% with the first sampling month species composition which was carried out in April 2009.

Dendrogram of similarity obviously shows that most of the species composition of phytoplankton at ST2 during high tide sampling shared relatively high similarity between months except for July 2009. While both group 2 and 3 shared more than 80% similarities.

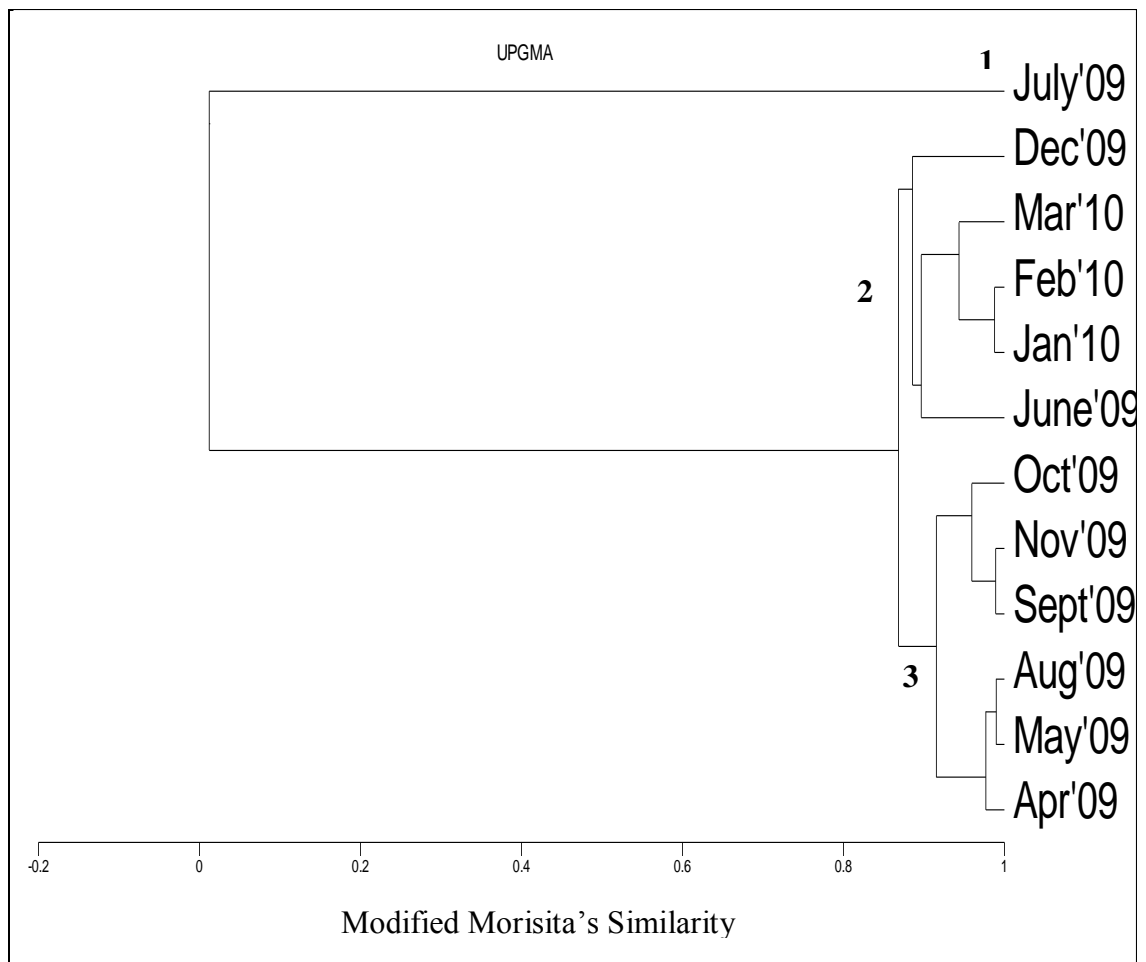


Figure 4.18: Dendrogram of Modified Morisita's Index based on species composition of phytoplankton in different months during high tide.

4.3.4.2 Cluster Analysis of Phytoplankton Community during Low Tide

Dendrogram demonstrates that phytoplankton composition during low tide was grouped into 5 major groups (Figure 4.19). Group 1 (June 2009) and 4 (July 2009) were the 2 groups which comprised of solitary month. Group 2 was built of the composition in December, November and May 2009, whereas group 3 was comprised of 2 subgroups in which the first subgroup consists of species composition in February and January 2010 while the second subgroup showed the relatedness between phytoplankton composition in August 2009 with September 2009 and March 2010. Group 5 shows the linked of species composition in both October and April 2009.

Specifically, in group 2, November 2009 had 95% species overlapped with May 2009, and phytoplankton composition in both months was linked to the composition in December 2009 at the percentage of 93%. In the first subgroup of group 3, both January and February 2010 shared 74% similar species composition, whereas, in the second subgroup, March 2010 and September 2009 shared almost 84% of their species. Both months, had 71% species overlapped with August 2009. Phytoplankton composition in group 3 shared a relatively low species with group 4 (July 2009) at the percentage of 28%. The phytoplankton composition of group 5, in October and April 2009 shared 92% similarity and had a relatively low species overlapped with both group 3 and 4 at the percentage of only 9%. Finally, the solitary June 2009 of group 1 did not have any species similarity with the other 11 months' species composition.

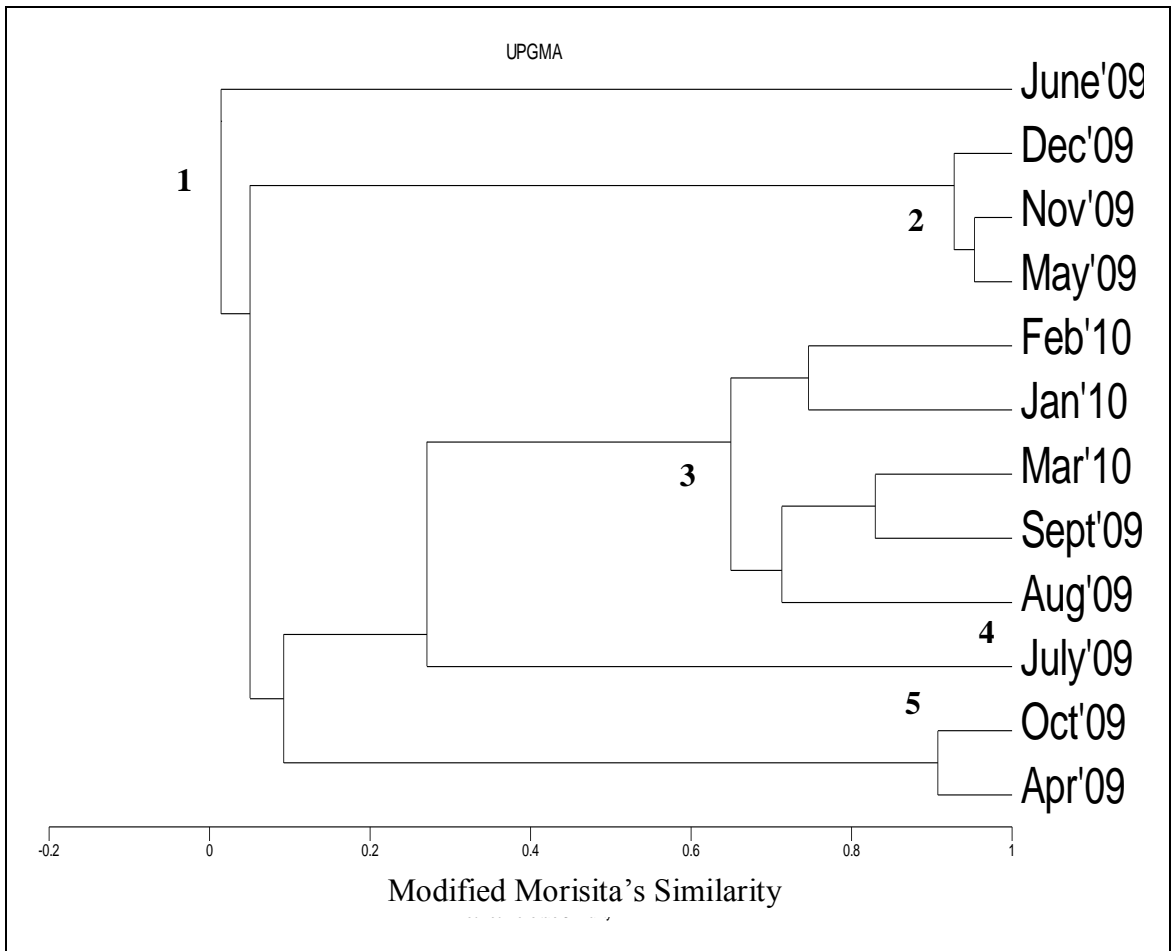


Figure 4.19: Dendrogram of Modified Morisita's Index based on species composition of phytoplankton in different months at during low tide.