4.4 PHYSIOCHEMICAL ANALYSES

4.4.1 *IN SITU* CHEMICAL ANALYSES

4.4.1.1 Nitrate

There was a significant difference in nitrate concentration between months and stations ($p < 0.01$). Exception during high tide in September 2009 and November 2009 (Figure 4.20), nitrate concentration did not show any difference significantly with both mean reading, 0.21 mg/L. The concentration fluctuated throughout a year, which is strongly influenced by runoff which commonly contains fertilizer, pesticides, herbicide and sewage. The highest nitrate concentration was 1.92 mg/L recorded during low tide at ST3 in November 2009 (Figure 4.22) and was below detectable level in June 2009 during high tide (Figure 4.21). Nitrate concentration did not show significant difference between high tide and low tide.

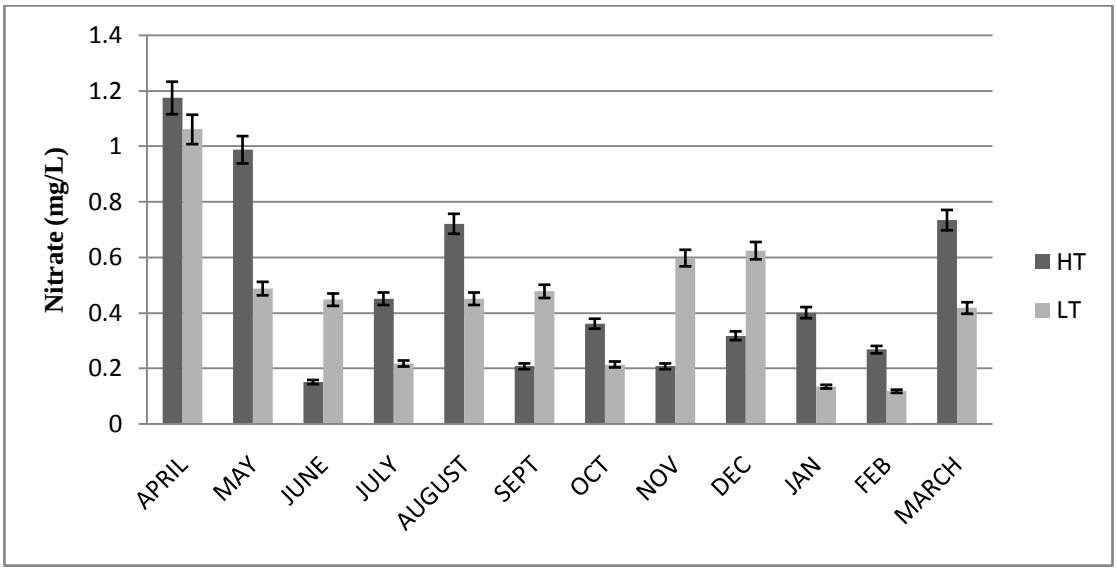

Figure 4.20: Graph mean of nitrate concentration during high tide and low tide.

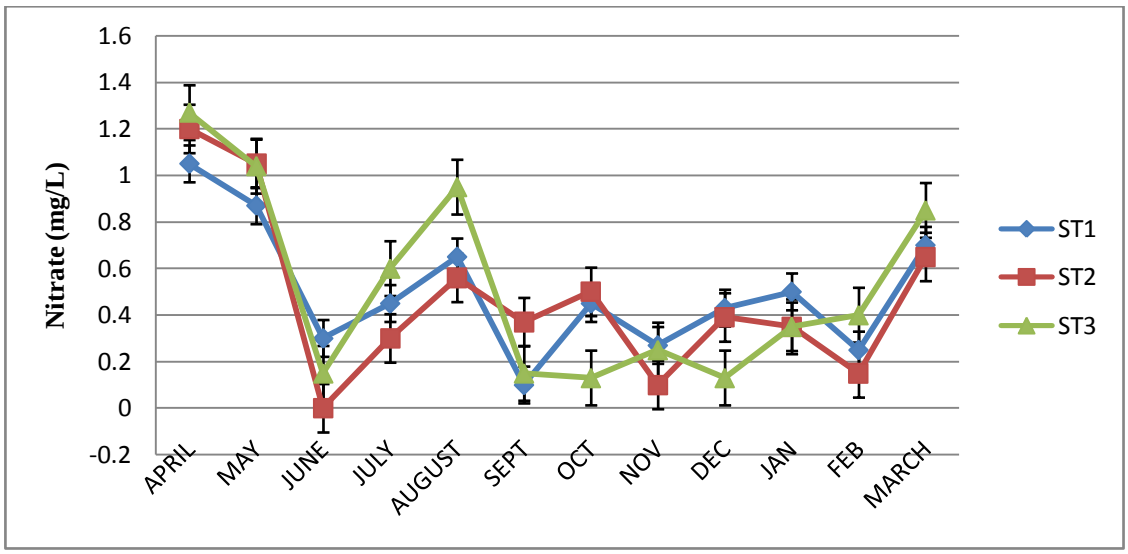

Figure 4.21: Nitrate concentration at all stations during high tide.

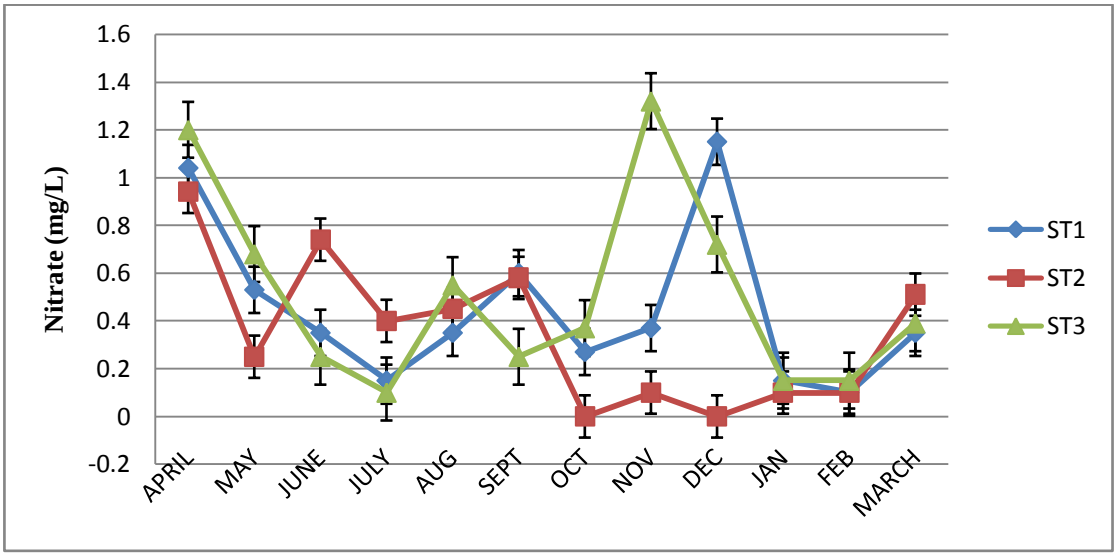

Figure 4.22: Nitrate concentration at all stations during low tide.

4.4.1.2 Phosphate

Phosphate concentration was detected within the range of 0.3 mg/L to 2.22 mg/L during high tide (Figure 4.24) and 0.39 mg/l to 3.59 mg/L in low tide (Figure 4.25). The highest phosphate concentration was recorded in April 2009 during low tide at ST1 with the level of 3.59 mg/L. *2 tailed* t-test proved no significant difference in phosphate concentration between high tide and low tide. In contrast, the concentration was difference significantly between stations ($p < 0.01$) and between months ($p < 0.01$).

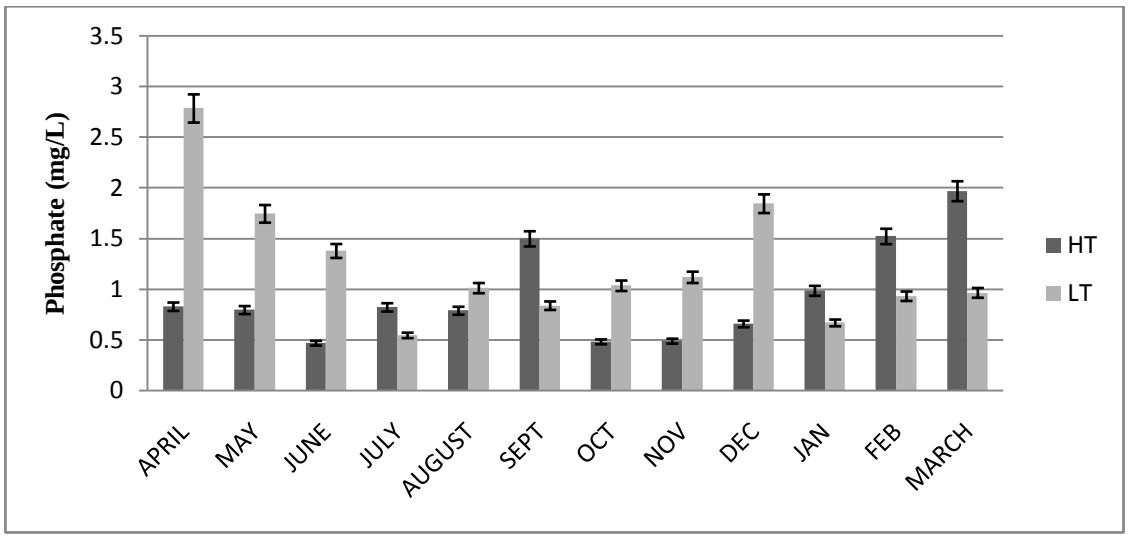

Figure 4.23: Graph mean of phosphate during high tide and low tide.

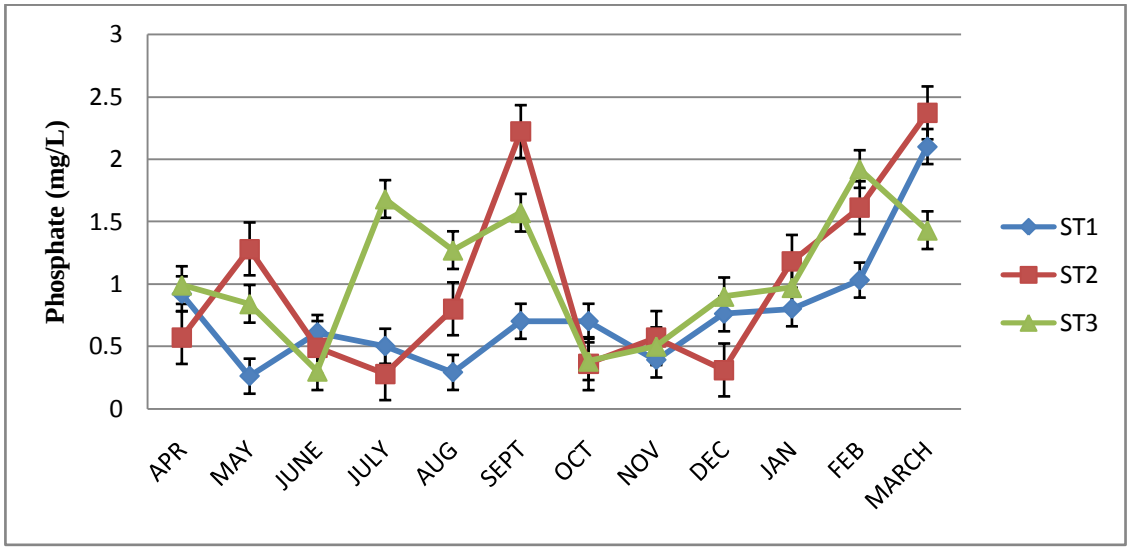

Figure 4.24: Phosphate concentration at all stations during high tide.

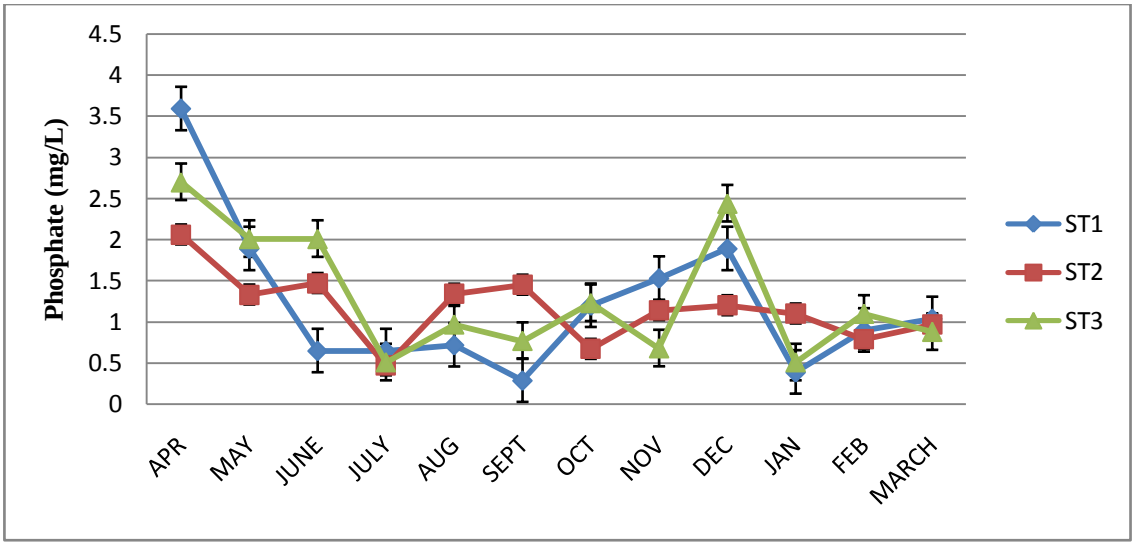

Figure 4.25: Phosphate concentration at all stations during low tide.

4.4.1.3 Silicate

Silicate concentration normally discussed to have strong correlation with diatoms. In research area, silicate showed significant difference between tides ($p < 0.01$), months ($p < 0.01$) (Figure 4.26) and stations ($p < 0.05$). Out of 4 nutrients in chemical parameters, silicate was the only parameter that showed significant difference between tides. Throughout the year, obviously, silicate was found in high concentration during low tide (Figure 4.28). In low tide, silicate concentration ranged within 6 mg/L to 33.50 mg/L, while during high tide, the level was detected within the range of 0.5 mg/L to 8.75 mg/L (Figure 4.27).

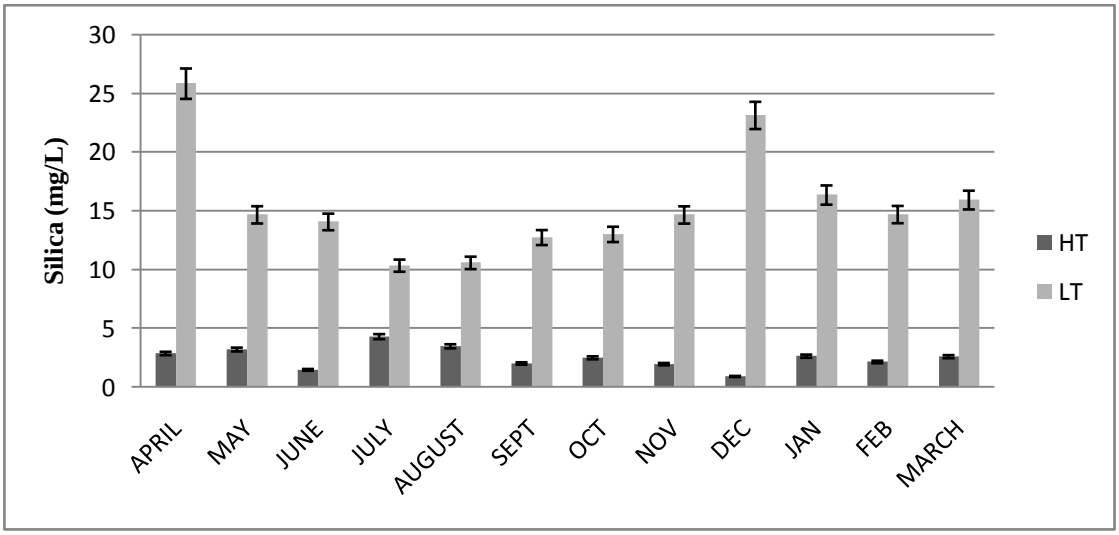

Figure 4.26: Graph mean of silica concentration during high tide and low tide.

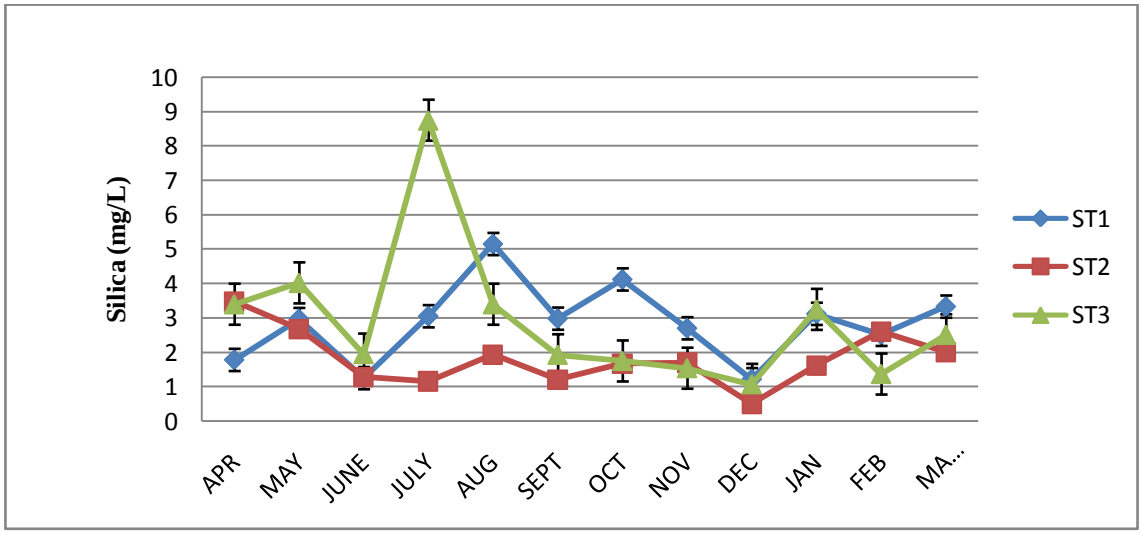

Figure 4.27: Silica concentration at all stations during high tide.

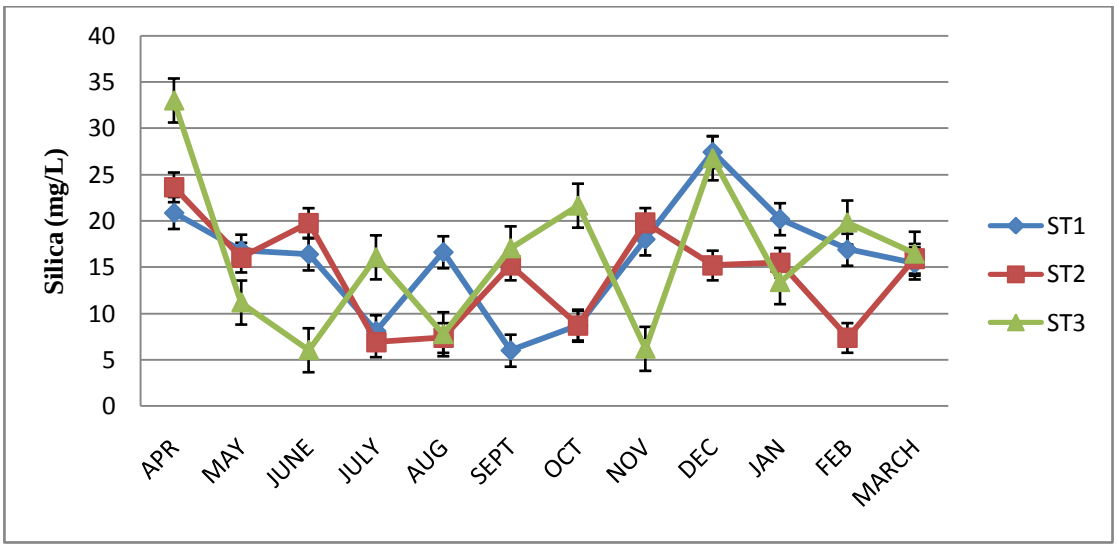

Figure 4.28: Silica concentration at all stations during low tide.

4.4.1.4 Sulfate

Similarly to silicate concentration, sulfate concentration is higher during low tide compared to high tide (Figure 4.29). The highest sulfate concentration in high tide was recorded in May 2009 (Figure 4.30), while for low tide was recorded in April 2009 (Figure 4.31), both at ST2 with readings of 109 mg/L and 407 mg/l respectively. There was significance different in sulfate concentration between months ($p < 0.01$) and stations ($p < 0.01$). However, *2 tailed* t-tests showed no significant difference in this nutrient concentration between tides.

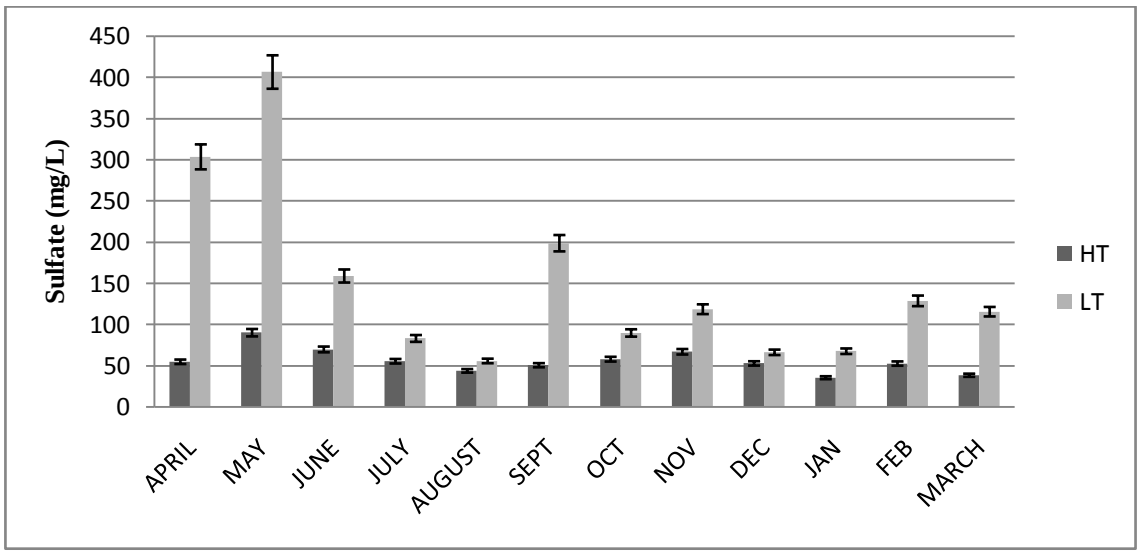

Figure 4.29: Graph mean of sulfate concentration during high tide and low tide.

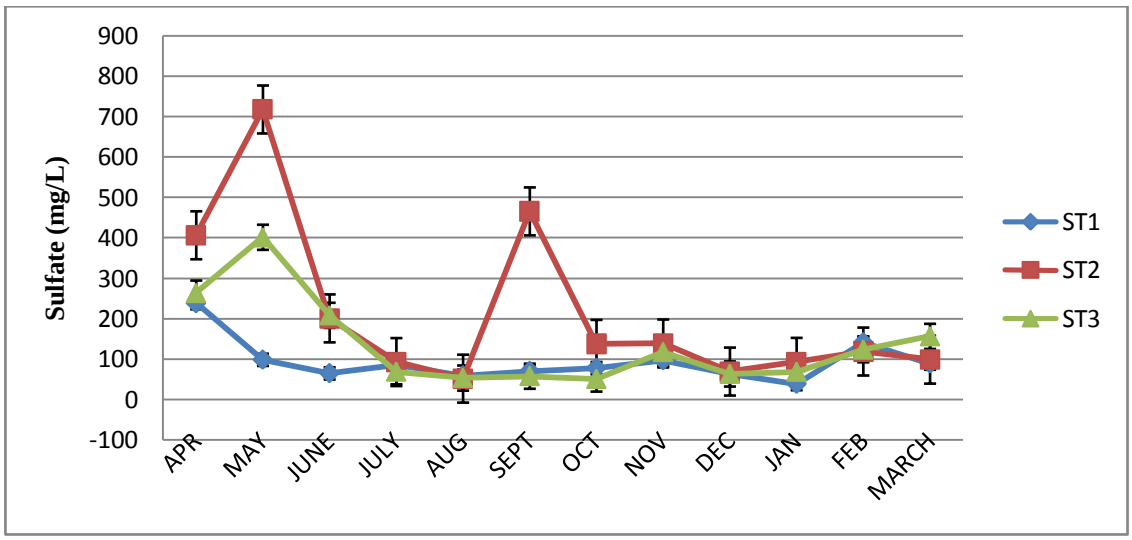

Figure 4.30: Sulfate concentration at all stations during high tide.

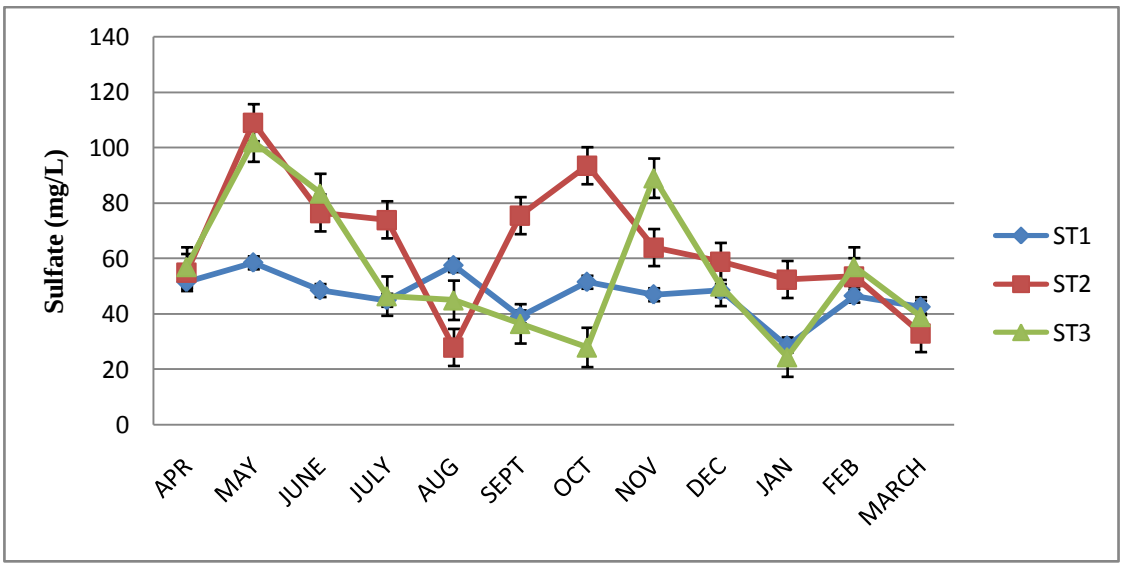

Figure 4.31: Sulfate concentration at all stations during low tide.

4.4.2 *IN SITU* PHYSICAL ANALYSIS

4.4.2.1 Temperature

Data obtained showed daytime water temperature at study sites fluctuated (Figure 4.32) in ± 5°C. The highest temperature during high tide was recorded at ST3 in July 2009 and the lowest was measured in December 2009 with the readings 32.34°C and 27.95°C respectively (Figure 4.33). In low tide, water temperature in April 2009 at ST1, 34.99°C, recorded as the highest, while the lowest was measured 26.01°C at ST3 in January 2010 (Figure 4.34). *Post-Hoc* ANOVA showed significant difference between water temperature between months ($p < 0.01$) and between stations ($p < 0.01$). However, no significant difference in water temperature was recorded between tides.

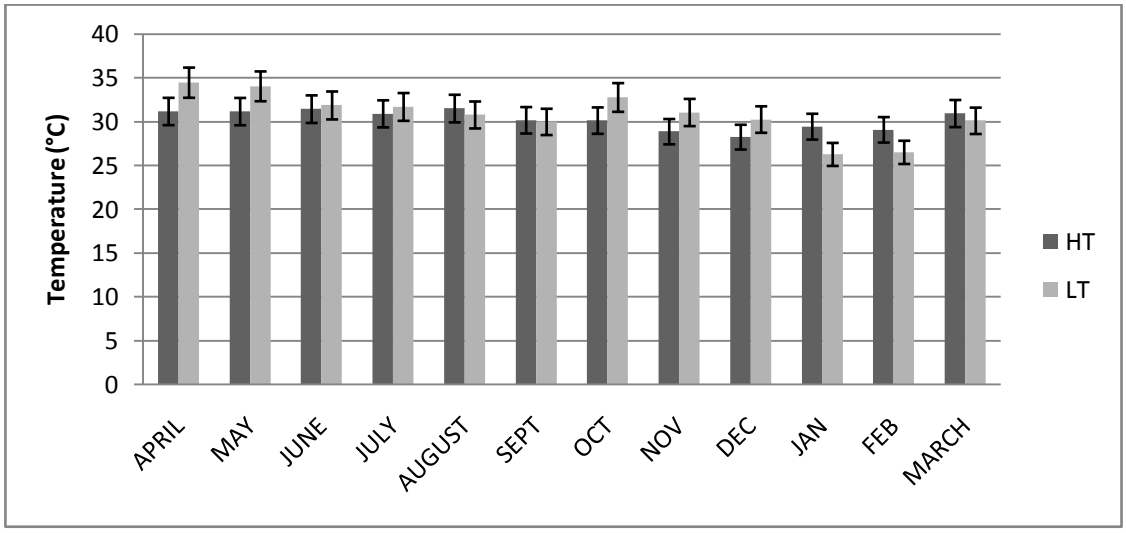

Figure 4.32: Graph mean of water temperature during high tide and low tide.

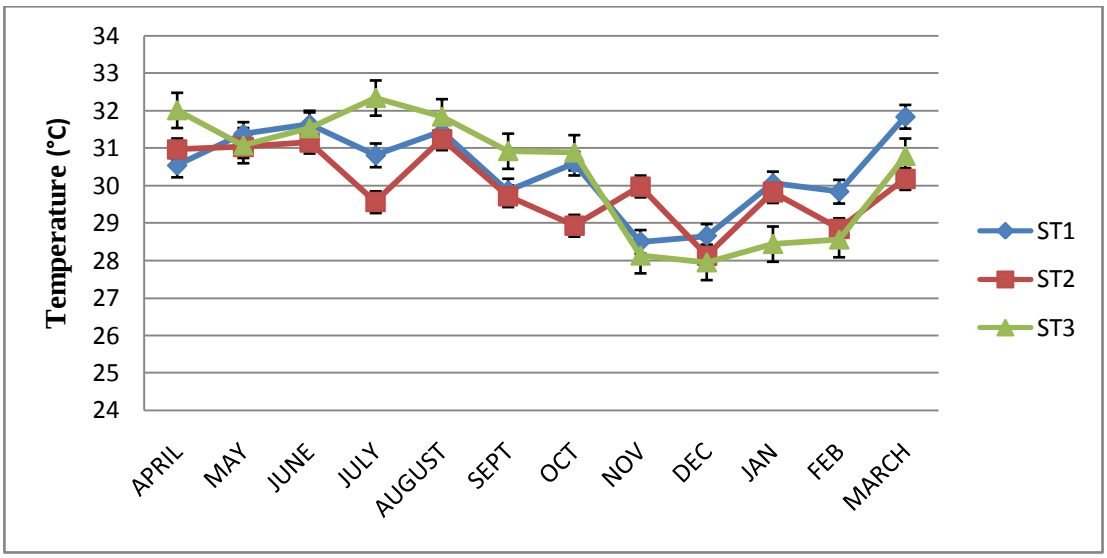

Figure 4.33: Temperature at all stations during high tide

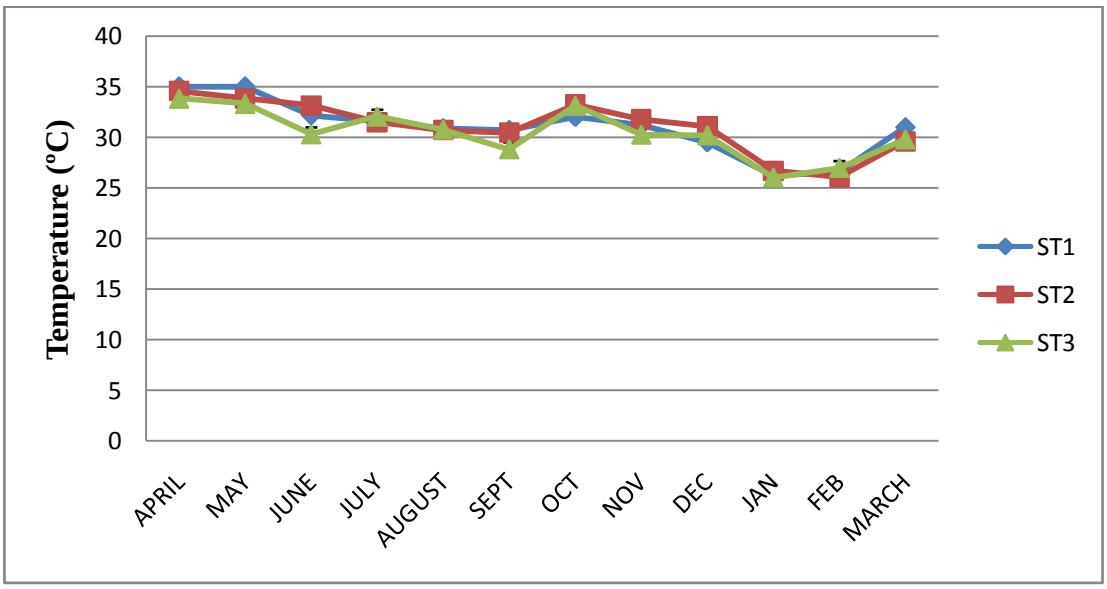

Figure 4.34: Temperature at all stations during low tide.

4.4.2.2 Conductivity

Water conductivity was higher in high tide compared to low tide (Figure 4.35). During high tide, water conductivity level in September 2009 at ST3 was the lowest while at ST1 in January 2010 the highest level was measured with the values 33094 µs/cm and 47356 µs/cm respectively (Figure 4.36). The highest level during low tide was recorded in September 2009 at ST3, 38726 µs/cm while the lowest value was 2433 µs/cm at ST2 in January 2010 (Figure 4.37). There was significant difference in conductivity level between high tide and low tide ($p < 0.01$), stations ($p < 0.01$) and

months ($p < 0.01$). In high tide, the level of conductivity showed uniformity at all stations throughout a year. However, the level was fluctuated during low tide. Conductivity at ST3 was slightly increased in December 2009 at ST3 and in September 2009 at ST1 (Figure 4.41), which values reaching 36884 µs/cm and 38726 µs/cm respectively.

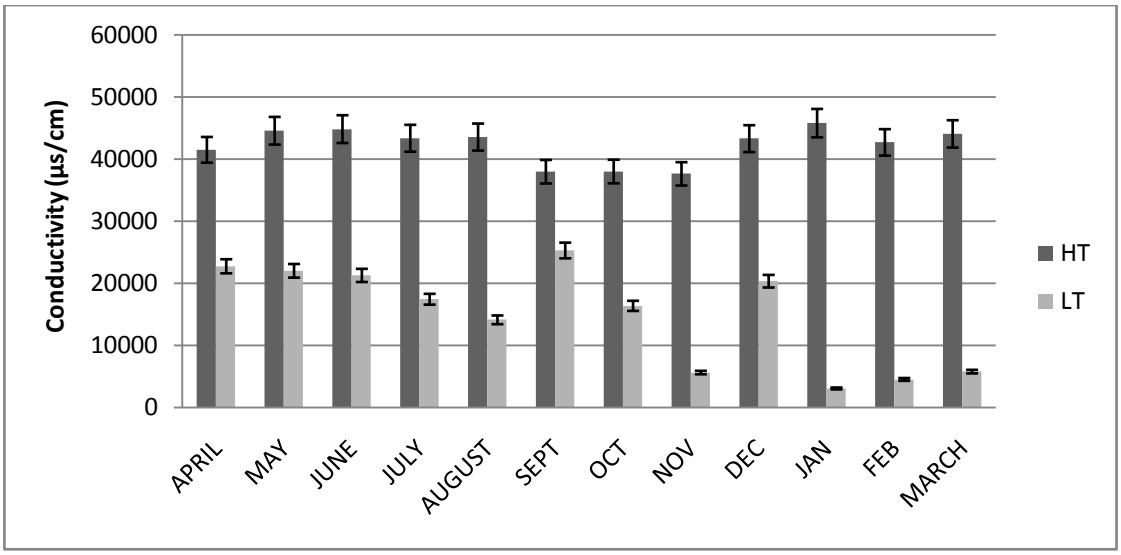

Figure 4.35: Graph mean of conductivity during high tide and low tide.

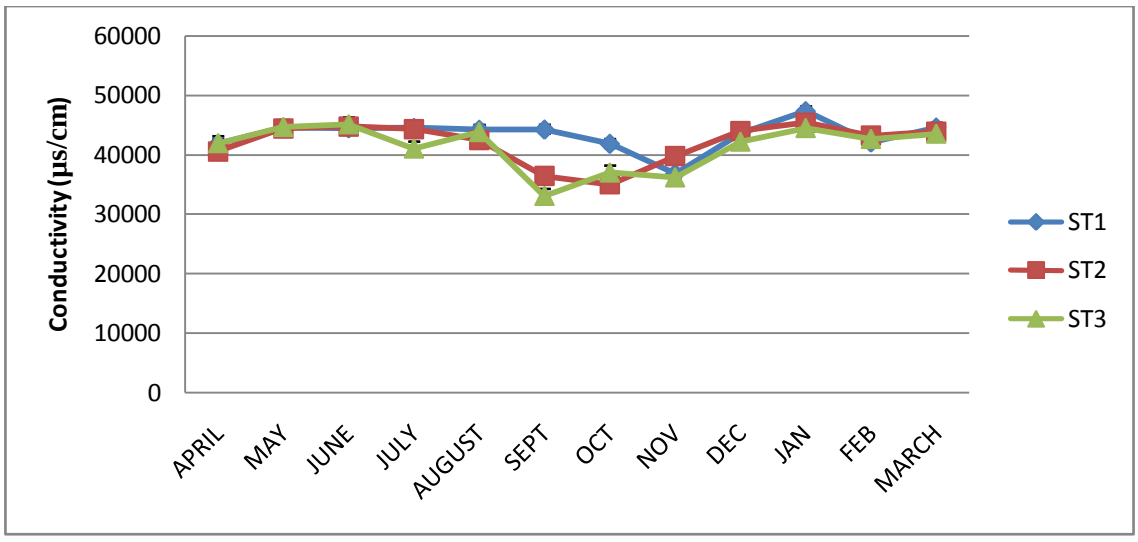

Figure 4.36: Conductivity at all stations during high tide

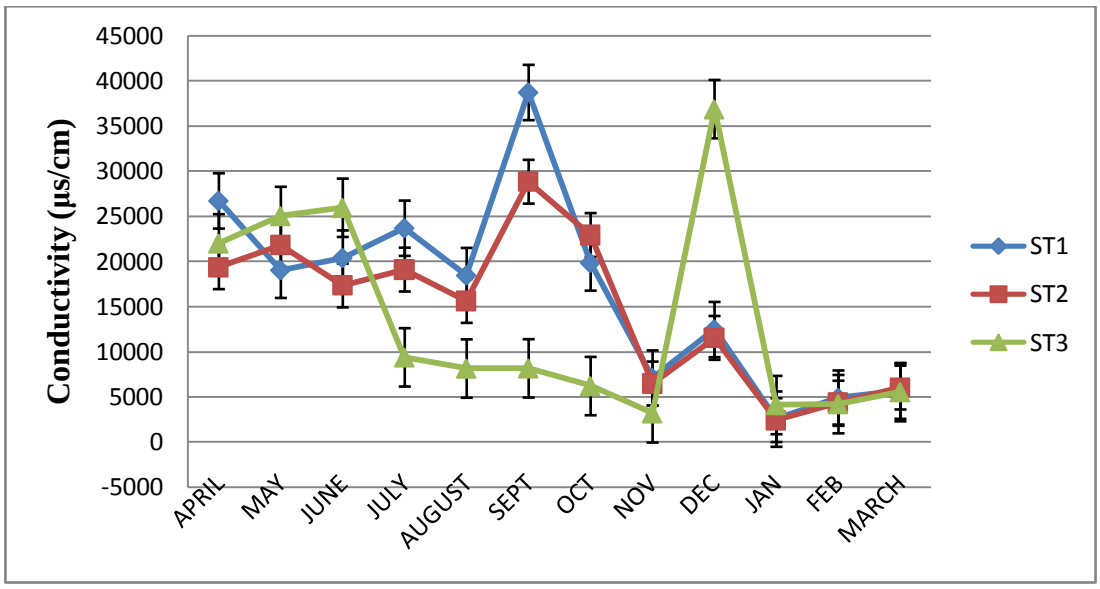

Figure 4.37: Conductivity at all stations during low tide

4.4.2.3 Dissolved oxygen

Dissolved oxygen level showed a fluctuation throughout a year (Figure 4.38), which normally correlated with total density and the number of organisms that utilize oxygen to go on living in the ecosystem. Dissolved oxygen level was higher during low tide compared to high tide (Figure 4.38). Exception in June 2009, the level in high tide showed higher level than low tide. However, the *2 tailed* t -test showed no significant difference between tides in dissolved oxygen level. Nevertheless, *post-hoc* ANOVA proved that there is significance difference between months (p <0.01) and stations (p <0.01) levels throughout sampling period. Dissolved oxygen level was found to be in ranged between 1mg/L to 12mg/L in both tides. During high tide, the lowest level was detected at ST2 in April 2009 with value of 1.2 mg/L, while the highest was in December 2009 (7.19 mg/L) at ST3 (Figure 4.39). At ST1 in July 2009, the highest level during low tide was measured with value of 11.09 mg/L. On the other hand, the lowest dissolved oxygen level during low tide was detected at ST2 in April 2009 at 2.46 mg/L (Figure 4.40). Dissolved oxygen showed a linear negative (r= -0.604, p <0.05) correlation with temperature at research area.

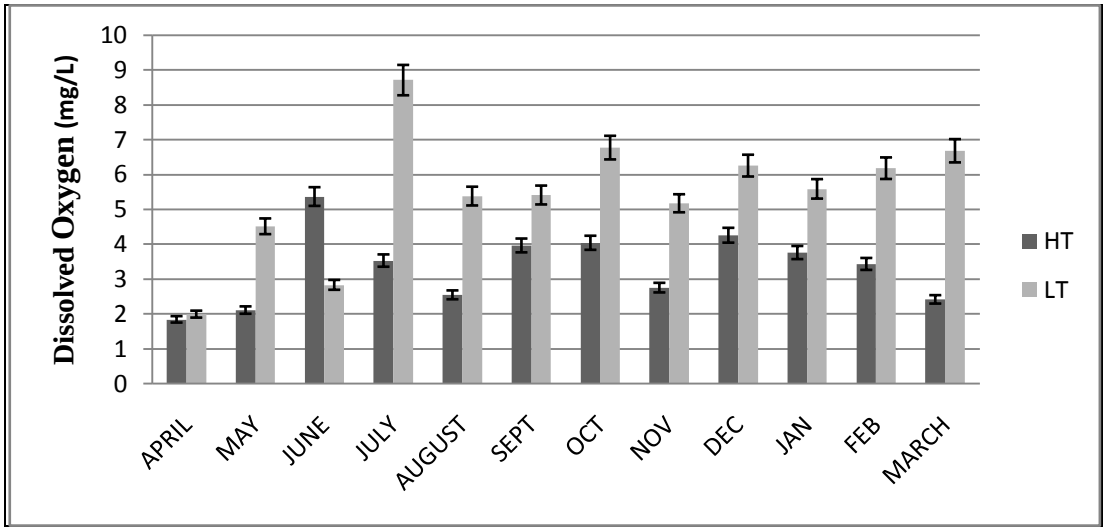

Figure 4.38: Graph mean of dissolved oxygen during high tide and low tide.

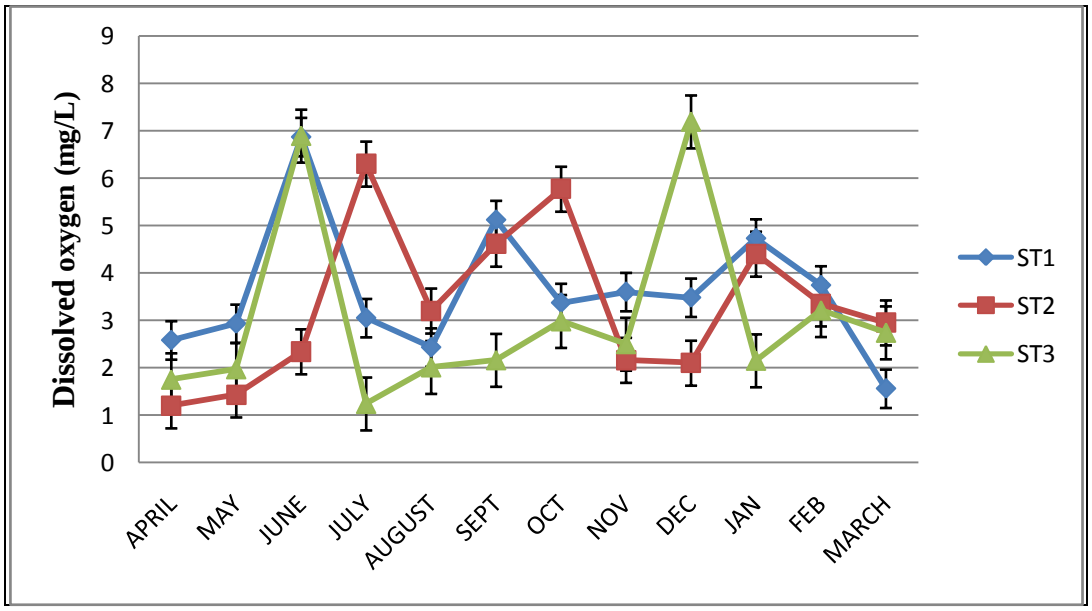

Figure 4.39: Dissolved oxygen at all stations during high tide

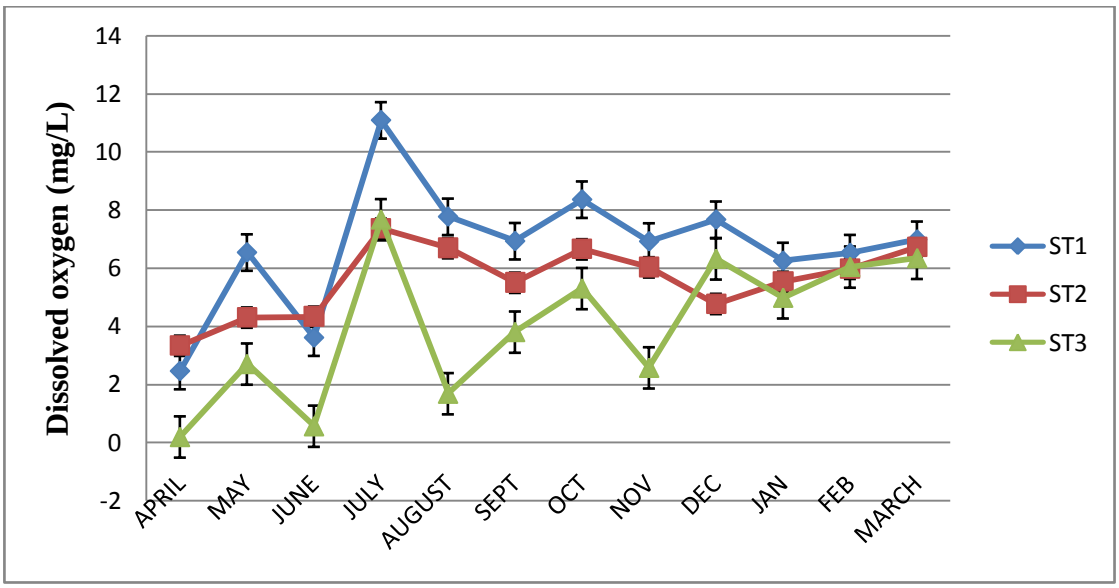

Figure 4.40**:** Dissolved oxygen at all stations during low tide.

4.4.2.4 Total dissolved solid

Total dissolved solid level was higher in high tide compared to low tide (Figure 4.41). The level of total dissolved solid normally has positive correlation to turbidity. Total dissolved solid during high tide was detected in uniformed level throughout sampling period, which was carried out for 12 consecutive months (Figure 4.42). In contrast, the level of total dissolved solid was found fluctuated throughout year during low tide (Figure 4.43). *2 tailed* t-test that was done on the data proved there was significant difference ($p < 0.01$) in the level of total dissolved solid between both tides. There were also significant difference in the value of the total dissolved solid between months ($p < 0.01$) and stations ($p < 0.05$). The highest total dissolved solid levels in both tides were detected in June 2009 with the values of 29.34 mg/L and 29.73 mg/L, respectively. While the lowest level was detected in February 2010 during high tide and in January 2010 during low tide with readings of 23.35 mg/L and 1.626 mg/L respectively. During low tide, in December 2009, there was a steep increment to the level of total dissolved solid after the parameter showed relatively stable value from

July 2009 to November 2009. However, decreasing steeply again in following month (Figure 4.43).

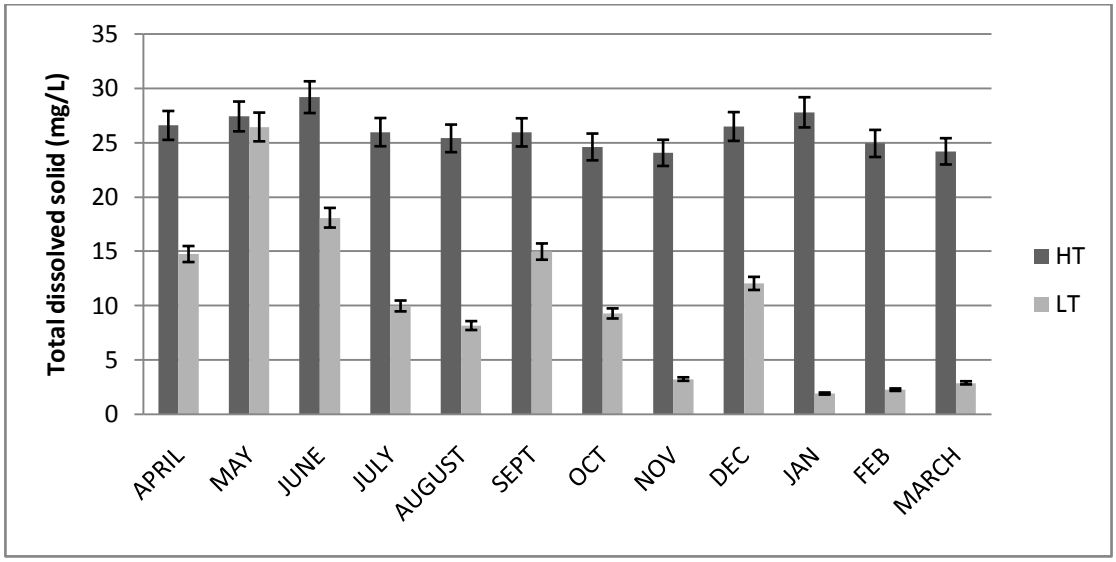

Figure 4.41: Graph mean of total dissolved solid during high tide and low tide.

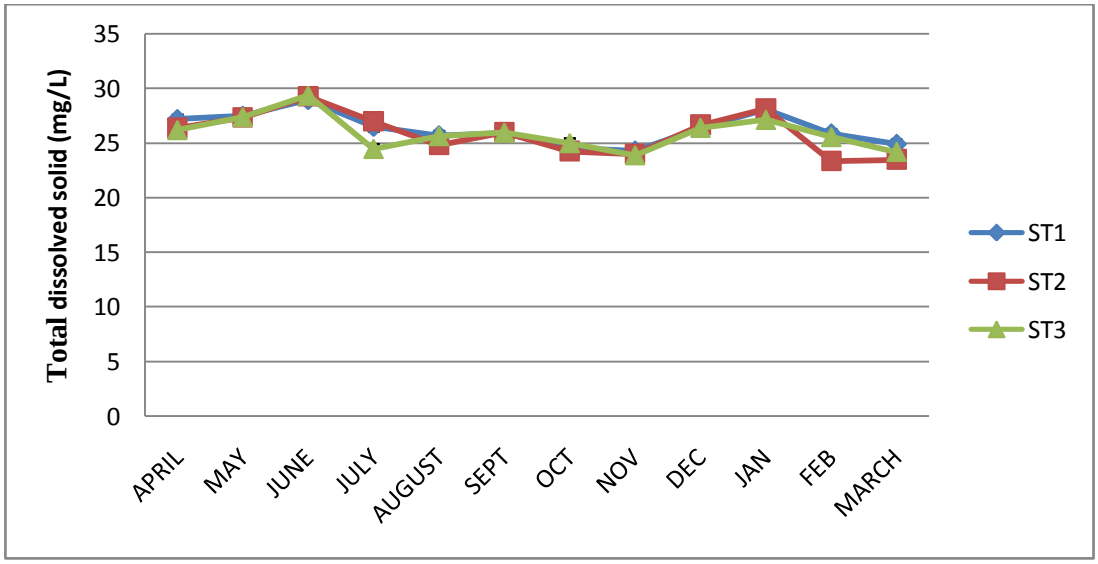

Figure 4.42: Total dissolved solid at all stations during high tide.

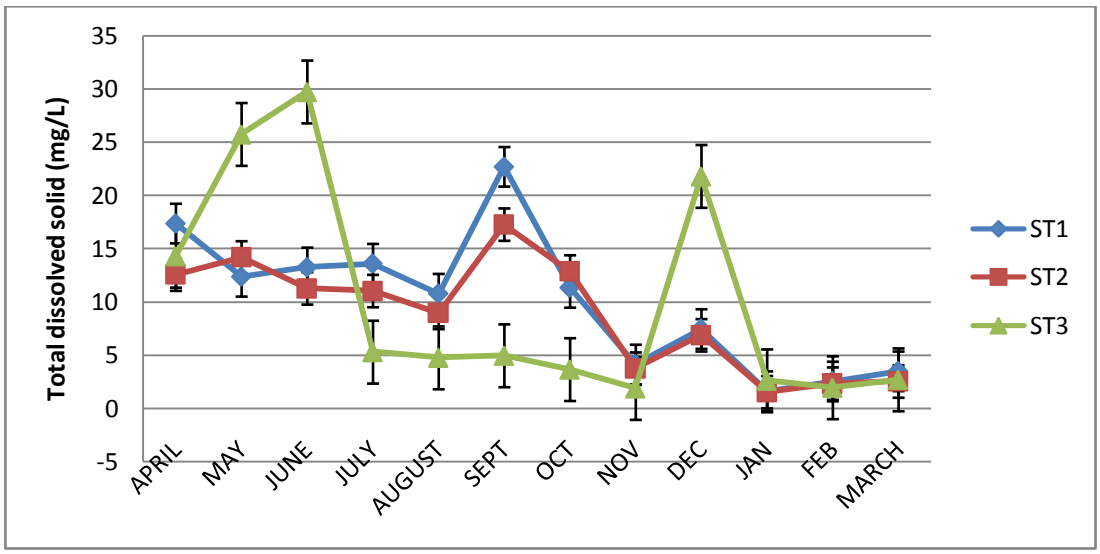

Figure 4.43: Total dissolved solid at all stations during low tide.

4.4.2.5 Salinity

Salinity at research area showed significant difference ($p < 0.01$) between high tide and low tide (Figure 4.44). During high tide, salinity level was relatively stable at all stations throughout a year with the highest level was recorded, in June 2009 while the lowest was in October 2009, both were measured at ST 3 with the values of 29.02 ppt and 19.97 ppt, respectively (Figure 4.45). In contrast, salinity levels during low tide were fluctuated at all stations with steep increment at ST3 in December 2009 (Figure 4.46). The highest salinity level during low tide was recorded in September 2009 at ST1 (21.83 ppt) while the lowest was 1.21ppt, recorded at ST2 in January 2010. *Post- Hoc* ANOVA showed significant difference in salinity between months (p <0.01) and stations ($p < 0.01$). Pearson correlation proved salinity correlated positively (r=0.977, p <0.01) with conductivity in a dependable relationship.

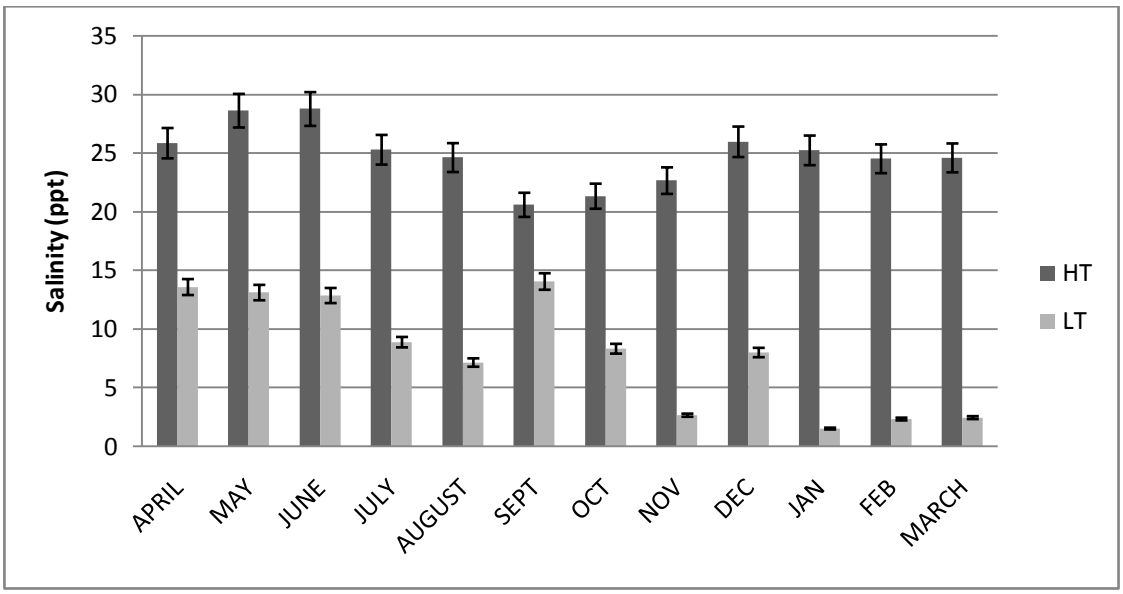

Figure 4.44: Graph mean of salinity during high tide and low tide.

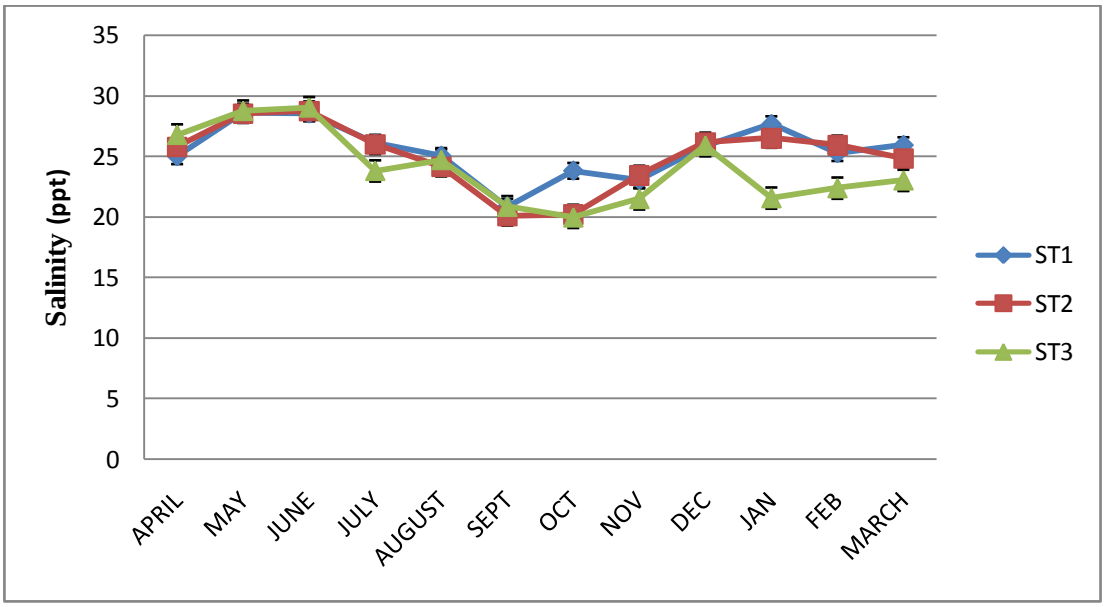

Figure 4.45: Salinity at all stations during high tide.

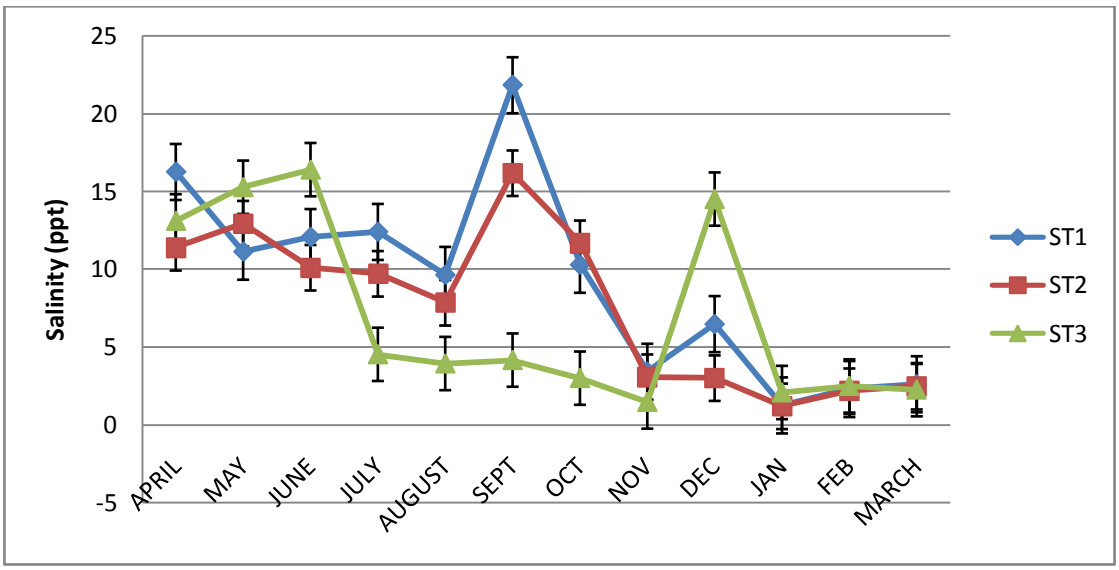

Figure 4.46: Salinity at all stations during low tide.

4.4.2.6 pH

Value of pH ranged from 5.0 to 8.5 throughout 12 months sampling period (Figure 4.47). Measurement of pH was in the lowest level in March 2010 at ST1, during low tide with the value of 5.3 and significantly difference ($p < 0.01$) from ST 2 and ST3 (Figure 4.49). Pertaining to figure 4.48 and figure 4.49 proved that pH level was relatively stable for 12 consecutive months at all stations. The highest pH level was recorded at ST1 during low tide with the reading of 8.12 in April 2009. There was no significant difference in pH level measurement between tides.

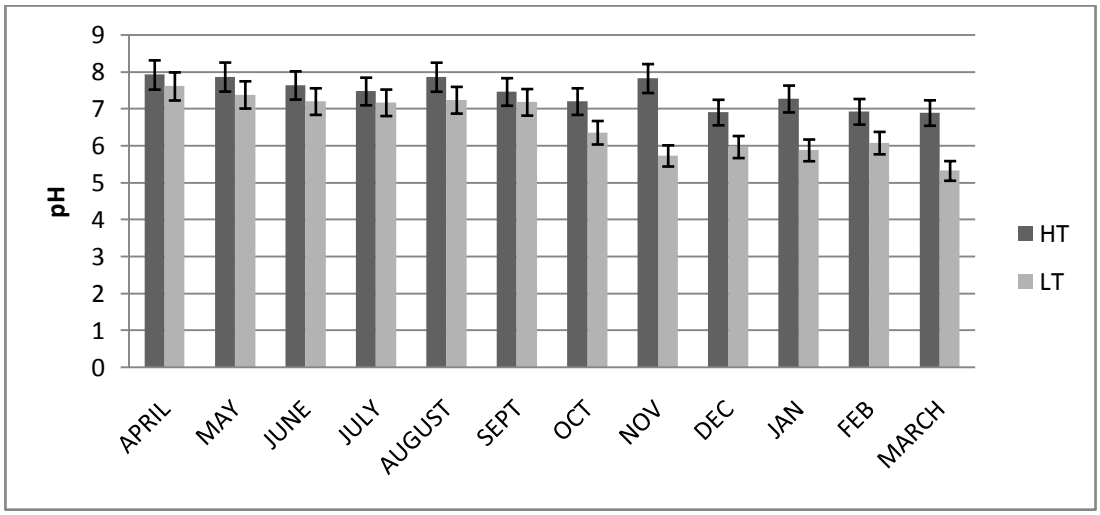

Figure 4.47: Graph mean of pH during high tide and low tide.

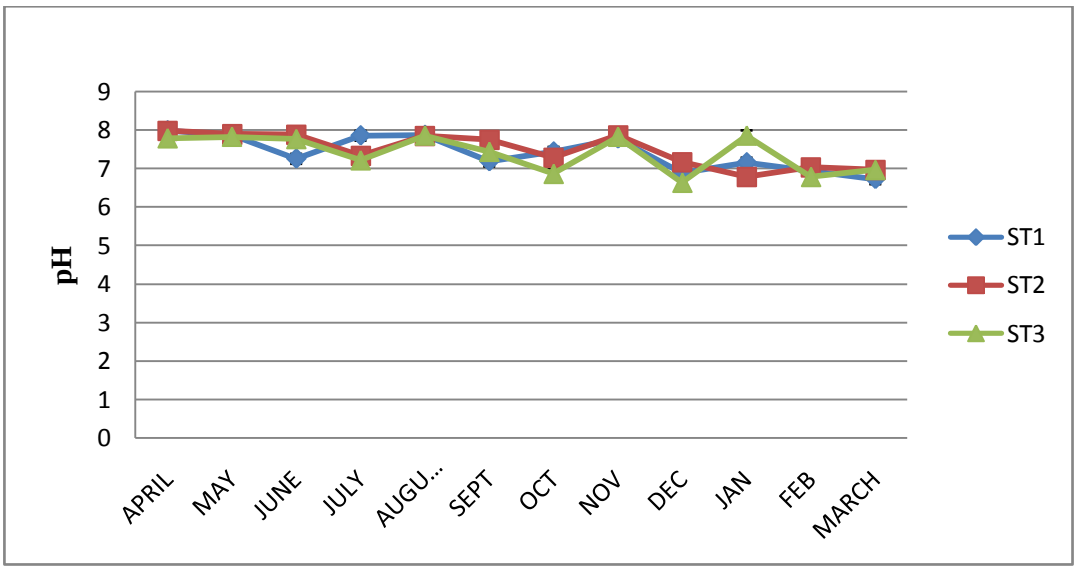

Figure 4.48: pH at all stations during high tide.

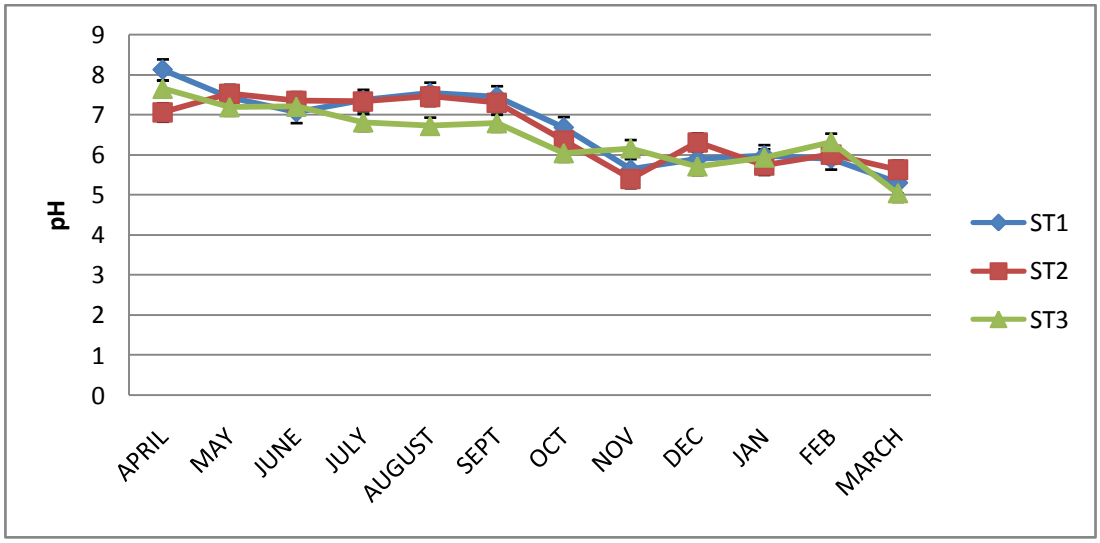

Figure 4.49: pH at all stations during low tide.