Results & Discussion

Intertidal zone at the study site is covered by different types of sea weeds, mainly green algae. During off season dryness and residues of sea weeds were very common. It provides good shelter as well as breeding ground to many intertidal organisms.

During present study, it was observed that entire study area has been occupied by mainly three classes of the algae i.e. Chlorophycea, Rhodophycea and Pheophycea. Among Chlorophycea, *Ulva spp. Caulerpa spp. Chaetomorpha spp. Halimeda spp. etc.* was most common. *Dictyota dichotoma, Padina gymnospora, Padina tetrastromatica, Sargassum johnstonii, Sargassum swartzii, Sargassum cinereum, Hydroclathrus clathratus were* common Pheophycea and *Gracilaria corticata, Champia indica, Galaxaura oblongata* were most abundant Rhodophycea representatives. However, lithographic and physical structure, and wave force at the coast causes variation in distribution (Benedetti-cecchi, 1992) and abundance of flora, hence its occurrence also differs at all the sub-sites. Out of very common 18 species of Algae, 5 species distributed all over the coast, which were found at the all sub-sites, it include two species of *Sargassum,* one species of *Padina* and two species of *Ulva* (Table 1). Bhadja (2010) and Vaghela (2010) recorded 17 species of Chlorophycea, 15 species of Pheophycea and 13 species of Rhodophycea at the Mangrol coast. Animal at this intertidal zone were mainly six groups (Bhadaja, 2010, Vaghela, 2010) Coelenterate, Platyhelminthes, Annelid, Arthropod, Molluscan and Echinoderm. Phylum Coelenterate was represented mainly by Anthozoan like Zoanthids and Actinarians. Phylum Platyhelminthes represented by Pseudoceros, while phylum Annelida represented mainly by some Neries species, Eurythoa species and very few other tube dwellers. Phylum Arthropoda is the largest diverse group (Sen *et al*, 2012, Annadraj *et al*., 2012) and were represented by number of

crab species, Barnacles etc. Phylum Mollusca was second largest animal group after Arthropods (Sen *et al*, 2007, Annadraj *et al*., 2012), it is also the most dominant and diverse group (Morton *et al*, 1968; Menez *et al.*, 2003) of faunal diversity as well utilized as investigation trend for marine biodiversity (Linse, 2006). Among all the classes of the Mollusca, class Gastropod was the most abundant at the coast; and of them most were the grazer that utilized the sea weeds resources as their food as well as shelter. Also the environmental factors were favoring the molluscan diversity status. All these were responsible to provide good breeding ground to sustain population of species. Echinoderms were represented by Starfish, Brittle stars, Sea-urchins etc.

Upper littoral zone is submerged during high tide. It has the transitional zone which is comprised of rocks and sand, but tidal water force generates very clear edge between them. Faunal diversity which prevails and occupies this subzone was mainly by large number of *Celina radiata, Siphonaria siphonaria* (Vakani *et al*., 2014), *Turbo coronetus, Chiton sp*. Cirithedae sp. (Patel, 1984, Trivedi *et al*, 2013) etc. Those species which were tolerating the wider fluctuation (Malli *et al*, 1982) of temperature, salinity (Broitman, 2008) and desiccation condition (Sibaja-cordero, 2008) were abundant at this site. Also these entire area covered by different common flora mainly *Ulva* sp., *Sargassum* sp. and *Padina* sp.

Middle intertidal zone is the most preferable sub-zone for higher biodiversity assemblage due to environmental suitability and other relevant conditions. Recorded most abundant floral species were *Ulva sp, Sarggassum sp, Padina sp, Champia sp, Chollarpa* sp, etc. it was observed that all the nineteen species of algae that were recorded during present work (Table 1) were present in this sub-zone. Faunal diversity of this sub-zone was also exhibits diverse diversity, all the major and minor faunal groups were observed in this sub-zone except *Amphineura spp*. and *Patella spp*. This sub-zone was occupied by mainly six animal groups. Very few representatives of phylum Cnidaria

and Platyhelminthes were recorded. Annelids were represented by *Neries pelegica* and few other chaetopods, while as Arthropods crab were main with Amphibalanus and Barnacles, *Squalla*, etc. Molluscans are mainly represented by Gastropod and Bivalve species, while Echinodermata was represented by *Asterina gibbosa*, *Ophioderma bravispinum* and *Echinus esculantus*.

Lower intertidal zone is exposed only during the low tide otherwise it remains submerged. This sub-zone was occupied by *Caularpa scalpeliformis, Champia indicus, Enteromorpha clathrata, Grancilaria corticata, Padina tetrastomatica, Sargassum ilicifolium, Ulva faciata* etc. Moreover it permits only those species which can survive within submerged conditions as well can survive against the forces of wave action (Broitman, 2008). Most of the faunal diversity which exists in between this sub-zone was Sea anemones, *Pseudoceros susanae, Clibanarius sp, Scallop sp. Octopus valgari, Asterina gibbosa, Ophioderma bravispinum* etc.

Sub-site one (S1) has flat upper intertidal zone, slightly upward middle intertidal zone and sea facing slopy lower intertidal zone. Upper intertidal zone of this sub-site has less dominance and distribution of flora and occupied by *Codium, Dictyopteris, Padina, Sargassum* and *Ulva* etc. Middle intertidal of this sub-site was occupied by *Dictyopteris allstralis, Dictyopteris bartaresiana, Enteromorpha clathrata, Grancilaria corticata, Laurencia papilosa, Padina gymnospora, Padina tetrastomatica, Sargassum ilicifolium, Ulva faciata* but it was lacking some species viz. *Caularpa sertularioder, C. verticillata* and even *Grancilaria corticata* etc. Lower intertidal zone has more floral diversity; it is observed that entire flora which exists in between both upper and middle intertidal zone.

Faunal diversity at sub-site one (S1) was densely populated. All main six phyla assemblage was recorded at this sub site, of them intertidal crab species were recorded in all three intertidal sub-

zones. More ever upper intertidal zone occupied by Cnidarians and represented by Anthozoa and Zooanthus, Arthropod group represented crab sp., Squilla and Barnacles while the Molluscan group were represented by Gastorpods and Amphineura.

Sub-site two (S2) was more elevated with pools, puddles and crevices. In upper intertidal of this sub-site observed most commonly distributed by Sargasuma sp., Ulva sp. and small patches of *Caularpa racemosa.* The middle intertidal zone of this sub-site was represented by the distribution of *Caularpa verticillata, Cystoseria indica, D. allstralis, D. bartaresiana, and Grancilaria corticata, Padina gymnospora, Padina tetrastomatica, Sargassum ilicifolium, Ulva faciata,* but having less distribution of *Caularpa scalpeliformis and Codium elongatum.* Lower intertidal zone showing moderate distribution of *Caularpa racemosa, Caularpa sertularioder, Caularpa verticillata, Codium elongatum, Dictyopteris allstralis, Dictyopteris bartaresiana, , Grancilaria corticata, Hydroclathrus sp., Laurencia papilosa,and Padina gymnospora.*and less distributed were *Padina tetrastomatica, Sargassum ilicifolium, Ulva faciata* etc. The *C. scalpeliformis* was not observed in the entire sub-site.

Faunal diversity of this sub-site was very diversified and specific. Upper intertidal zone was observed densely distributed by *Cellana radiate, Siphonaria lacinosa, Chiton peregrinus*, while less dense were *Certithium* sp., *Clibanarius nathi*, *C. zebra* and some crab sp. Middle intertidal zone of sub-site 2 (S2) has recorded with abundant number of *Cerithidae sp*., *Nerita albicilla* (Tan and Clement, 2008), *Turbo coronatus, T. intercostalis, Astraea stellata, Peronia verruculata, Barnacle sp., Crab sp. Palaemon serratus, C. nathi, C. zebra etc. Squalla sp.* presence was frequent and seasonally *Aplysia oculifera*, *Octopus vulgaris* etc. were recorded. Lower intertidal zone was dominated by molluscan species. More ever, Xenophora solaris observed only at this sub-site. Distribution of Octopus also recorded more at this sub-site.

Sub-site three (S3) posses flat upper and lower intertidal zone but middle intertidal zone was elevated. It was observed that this sub-site is suitable and favorable for flora diversity, more ever upper intertidal zone and lower intertidal zone exhibits similar distribution of flora. These both sub-zones were occupied by different C*aularpa spp., Champia indicus, Codium elongatum, Cystoseria indica,* various *Dictyopteris spp. Enteromorpha clathrata, Grancilaria corticata, Hydroclathrus sp., Laurencia papilosa, Padina gymnospora, Padina tetrastomatica, Sargassum ilicifolium, Ulva faciata.* Middle intertidal zone has heterogeneous distribution of the floral species viz. *Caularpa scalpeliformis, Caularpa verticillata, champia indicu, Codium elongatum, Cystoseria indica, Dictyopteris allstralis, Grancilaria corticata, Laurencia papilosa, Padina gymnospora, Padina tetrastomatica, Sargassum ilicifolium, Ulva faciata.*

This sub-site 3 (S3) has suitable sheltering substratum for various fauna; hence faunal diversity exhibits all the main animal groups. Upper intertidal zone occupied by dense distribution of *Cellina sp. and Siphonaria sp*. Cups and puddles distributed by *Trochus sp*. and Turbo sp. While as *Cerithidae sp. and Peronia sp*. spread out all over the substratum of upper intertidal zone of this sub-site. Middle intertidal zone represented by *Barnacle sp*. Crabs and some Gastropods. Due to elevated area, some bird species recorded here viz. Sea-gull, Reef-heron, Black-neck-Ibis etc. Lower intertidal zone at this sub-site has large size tide pools which were occupied Sea anaemon, *Conus sp., Oliva sp. Crab and Palamon sp*.

Sub-site four (S4) structurally entirely flat areas with slope toward sea-face in between upper intertidal zone. Though floral diversity and distribution was found much even in this area, Upper intertidal zone was distributed by common Algae species viz. *Champia indicus, Grancilaria corticata, Padina gymnospora, Padina tetrastomatica, Sargassum ilicifolium, Ulva faciata.* The middle and lower intertidal zone were distributed by more or less un-even aggregations of

Caularpa sertularioder and *Padina gymnospora* while the *Sargassum* and *Ulva* species were intermittently distributed. Middle intertidal zone is denser for flora than lower intertidal zone.

At sub-site four (S4) we recorded less distribution of faunal diversity compare to other sub-sites may be due to its structural characteristics and wave forces. Upper intertidal zone of this sub-site was represented by *Cellana radiata* and *Chiton sp*. densely spread out *Certhidae sp., Nerita sp. Turbo sp.* and frequently distributed *Astraea sp.* Middle intertidal zone was occupied by Zoanthus, Sea anemone, Crab sp., *Cantharus sp*., *Murex sp*., *Peronia sp*. and Scallops. Lower intertidal zone was more specific and distributed by *Cantharus sp*., *Scallops* and *Tertela sp*., *Tertela terebra* and *Conus galinus* etc.

Sub-site five (S5) has also flat substratum. On this sub-site was observed homogenous floral distribution. Hence upper, middle and lower intertidal zone exhibits equal distribution of flora and observed all major species were evenly distribution except *Enteromorpha intestinalis* and *Laurencia papilosa* that observed more distributed at middle and lower intertidal zone. Though this sub-site has favorable as well as suitable characteristics, major three floral species were recorded absent and these were *C. sertularioder, C. verticillata,* and *E. clathrata*.

The faunal diversity at sub-site five (S5) has extensive specifications. Flattened substratum of this zone fascinated the faunal diversity, hence upper intertidal zone was recorded with all animal phyla, which were exists at all the sib-sites. More ever upper intertidal zone and middle intertidal zone has similarity regarding in their characteristics and floral diversity, which led to similarity occurrence of fauna. All the three sub-zones, upper and middle and lower intertidal zone at this sub-site, were distributed through Anthozoa, *Astraea stellata*, *Chiton parigrinus*, *Cerithium scabridum, Cerithium morus,* crab sp., *Euchelus tricarinata*, *Murex sp., Neries sp., Nerita*

albicilla, Oliva olive., *Peronia verruculata, Pseudocelous, portis*, *Trochus sp*., *Turbo sp*., zoanthus etc. It was observed that *Cellana radiata* was extremely restricted to only upper intertidal zone may be due to more inundated conditions, *Siphonaria siphonaria* observed at upper and lower intertidal zone, Zoanthus, Porites were observed upper and middle intertidal zone, dynamic swifter *Octopus vulgaris* is distributed at all three sub-zones.

Based on general site and sub-sites survey for documentation of flora and fauna, we observed that Phylum Mollusca is quite abundant in respect to diversity, density and distribution. Hence, for population ecology study we considered this phylum and collected data for the same.

3.1 Molluscan Diversity

In general, rocky sea shore is always more diversified by Mollusc (Vanmali and Jadhav, 2015) mainly Gastropods (Menez *et al*., 2003), group, because of their high adaptive ability. The phylum includes mainly five classes, among them, Mangrol coast has been populated by Amphineura, Gastropoda, Bivalvia and Cephalopoda. It was observed that Pelecepoda has less number of representatives at the coast. Of them Gastropods are more abundant and adaptive group with equal distribution at all the sub-sites while, rest of classes were not constant distribution wise at every sub-sites. The high occurrence of Gastropods on the intertidal belt of the Saurashtra coastal region has been previously documented (Patel, 1984; Joshi, 2007; Bhadja, 2010; Vaghela, 2010), the similar observation has been made by us. Amphineurans were widely distributed in upper intertidal zone, where very small size cups and rough surface exist. Bivalves generally found at mid and lower intertidal zone and Cephalopods were also observed similarly in such intertidal zone.

However Gastropod molluscs were distributed all over the Mangrol coast, habitat structure, composition and ecological niche produce micro-disproportion (or micro-unevenness) in

distribution pattern. So, some sub-sites may have less dense pattern, while as same species exhibits high density at other site. This phenomenon leads to make variation in between endemic species at every sub-site. This study show that out of total 59 species (Table 2) of observed molluscs, 34 mollusc species were recorded throughout the year could be considered as key species or native dweller species or resident species (Vermeu, 2008). However, their distribution over the coast was specific to the sub-sites. Environmental attributes, nature of substratum and wave force might be controlling the distribution of the species for particular sub-sites. Sub-site S1 recorded 14 common native dweller species, while 12 species, 13 species, 4 species, 16 species respectively from S2 to S5. (Table 3). Ecologically, physical parameters are also one of the most important regulatory factors for the molluscan distribution. Of them, one such factor is the tidal force which varies so significantly with the locations that has become one of the key controlling factors for the spatial distribution of intertidal molluscs (Vaghela, 2010). Except one sub-site the mid intertidal zone was most apparently suitable for most of species. Entire coast of Mangrol represented by 59 species of the molluscs throughout the year. It was found that those species, which were most highly adaptive to the particular sub-site, were recorded more in number (Salehi, 2015) during all seasons or throughout the year. The seasonal variation was less (Misra and Kundu, 2005) rather than that of average variation except some species like *Aplysia*. Highly populated species were recorded with minute fluctuation as per seasons except their breeding seasons for Peronia and Cerithids. During the study period numbers of individuals of key species per sub-site corresponding to the year are mentioned in Table 4. On sub-site S1 total 3876 molluscan individuals were recorded during entire study period, number of individuals respectively recorded as 506, 1122, 991, 623, 634 individuals. An average was 775.2 molluscan /year. Sub-site S2 has 3652 total molluscan individual respectively year wise it was 598, 757, 1073, 676, 548 individuals and the average 730.4 per year.

At S3 3209 total molluscan was recorded, year wise the counting was 598, 536, 890, 621, 564 individuals per year with average of 641.8 individuals/year. Physical and ecological forces at the Sub-site S4 were more extreme than any other sub-sites, hence the number was quite less i.e., 1716 molluscs during the study period, it was respectively year wise 260, 266, 391, 309 and 490 individuals per year with an average as low as 343.2 individuals/year. S5 seems to be more suitable for the molluscs as it recorded with 4998 molluscs during the entire study period. This sub-site was recorded with 1123, 912, 1291, 864 and 811 individual respective with an average of 999.6 individuals/year.

Saurashtra coast experiences mainly three seasons with many extremes, the summer is dry and hotter, temperature some time reaches up to 42 to 43^0 C, while winter is dry and cool with low temperature may be up to 8° to 9° C. thus, the temperature anomalies (Menesgues and Drews, 1987) has positive relationship with environment. Monsoon period is less but rain fall estimated an average of 40 inches. Thus, the faunal community structure is completely under control of these extreme attributes and population dynamics exhibits seasonal variation in population strength which lead to fluctuation in Density, Frequency and Abundance, too. Hence monthly population counting exhibited much variation as the term of seasonal variation, which also effected by ethologically, too. Most molluscan species were recorded more in number during post monsoon and winter time, while as summer time population strength decreases slightly, which demonstrates minute or micro seasonal variation (Misra and Kundu. 2005).

Entire Mangrol intertidal area has particular pattern of molluscs distribution, study show (Table 5) that in 1^{st} year, the entire intertidal area was exhibited with 2.062 mean values of species richness indices. It was lowest during September month and 1.859 and maximum in October 2.114 (Figure 2). In the 2^{nd} year, diversity indices value was recorded 2.063 mean values, lowest in November;

it was 1.830 and highest in March 2.215 (Figure 3). For the 3rd year molluscan diversity indices was recorded as 2.068 mean value, with lowest in July (1.776) and highest in April (2.405) (Figure 4). In the 4th Year the mean molluscan diversity indices was 2.010 with lowest values 1.859 (July) and highest 2.468 (April) (Figure 5). In the 5th year, the molluscan diversity indices were recorded as mean value 2.169, with lowest in October -1.977 and highest in April-2.705 (Figure 6).

Sub-site S1 was most influence and having with ecological disruptive (Wootton *et al*.2009) intertidal area at the Mangrol coast by local fisherman and tourist. But this site observed with good Molluscan population may be due to its habitat structure. Entirely in five years study period, the sub-site S1 exhibits mean values of 2.303 molluscs as diversity indices where the lowest is in 1st year (2.256) and the highest in 2nd year (2.367). Thus, it was recorded that the indices values were less fluctuated at this sub-site. Similarly, diversity indices at sub-site S2 was with mean value of 2.160 for study period. It exhibits variation of 2.018 as lowest in year 1st year and highest being 2.416 in 5th year. This sub-site has also quite less fluctuation in indices values (Figure 7). At the sub-site S3 the mean value is of 2.033of diversity indices. Here the fluctuation was recorded as 1.957 (lowest) in 4th year and (highest) 2.093 in 5th year. Sub-site S4 has been less influenced by human activities, molluscan distribution was found to be less dense, might be due to coastal structure and physical forces of tide. It was recorded that mean value of 1.447 for diversity indices of Molluscs during the study period of five years. It shows variation from lowest value i.e. 1.387 during 4th year and 1.479 highest values during 1st year. The study show that the sib-site S5 was less polluted than that of the other sub-sites; though being visited by local public, visitors and local fishermen. Its flat substratum gives suitability to the molluscan diversity. Hence this sub-site had good number of species diversity. At this sub-site diversity index of molluscs was 2.367 as mean

value for five year duration. The fluctuation in the diversity indices was 2.203 as lowest in 1st year and 2.498 as highest in 5th year.

3.2 Population ecology of species

Entire study period, it was observed that the intertidal area of the Mangrol coast has been maximally occupied by diverse Molluscan species, mainly Gastropods. Among them some species were recorded regularly during the entire study duration. Hence, population ecology of such molluscan species was studied. From all five sub-sites, it was observed that eight species of Molluscs were dominated and well distributed viz. *Astrea stellata, Bursa granularies, Cellana radiate, Cerithium obeliscus, Nerita albicilla, Peronia verruculata (Cuvier 1830), Turbo coronatus* and *Turbo intercostalis*. Population ecology these species were represented mainly by attributes like density, abundance and frequency. Result of computed data analysis showed that collectively all these eight species exhibits yearly average density of 0.373 no/0.25m^2 in 1st year of the study and respectively it was 0.322, 0.403, 0.294, 0.428 individuals/0.25m^2 for remaining years of the study period. Thus, average density trough the study was 0.364 individuals/0.25m^2 (Table 6, Figure 8). Same way, abundance was recorded 1.775, 1.645, 1.627, 1.480, and 1.641 no/0.25m^2 respectively for five years with an average of 1.634 individuals/0.25m^2 during entire study period (Table 7, Figure 9). Collective for all sub-sites yearly average frequency of occurrence was recorded as 22.109%, 19.553%, 26.576%, 20.484% and 26.335 % for 0.25m^2 quadrate sizes with average 23.071% (Table 8, Figure 10). Population ecology regarding the studied key species were species specific average values of *Astrea stellata* which exhibited 0.31 individual/0.25m^2 density, 1.74 individual/0.25m^2 abundance and 14.63% frequency during the study period. Minimum density value for this species was 0.24 individual/0.25m^2 in 2nd year and maximum 0.48 individual/0.25m^2 in 3rd year. Minimum abundance value was 1.55 individual/0.25m^2 in 1st year

and Maximum 2.04 individual/0.25m^2 in 2nd year, while as frequency was minimum 14.63% in 1st year and 18.27% in 5th year of study period (Table 9, Figure 11). Recorded mean values regarding to density, abundance and frequency of *Bursa granularies* was 0.22 individual/0.25m^2, 1.55 individual/0.25m^2 and 14.48 % respectively. All this three attributes with minimum value were recorded 0.16 individual/0.25m^2 in 2nd year, 1.33 individual/0.25m^2 in 4th year, and 11.17% in 2nd year and maximum 0.28 individual/0.25m^2 in 3rd year, 1.81 individual/0.25m^2 in 3rd year and 15.85% in 1st year during study period (Table 10, Figure 12). Density, abundance and frequency of *Cellana radiata* was recorded mean value with 0.41 individual/0.25m^2, 2.13 , individual/0.25m^2 and 19.64% respectively while as same are respectively minimum with 0.35 individual/0.25m^2 in 4th year, 1.69 individual/0.25m^2 in 4th year and 29.44% in 5th year during the study period and maximum 0.56 individual/0.25m^2 in 5th year, 2.89 individual/0.25m^2 in 5th year and 29.44% in 5th year during study period (Table 11, Figure 13). Density, abundance and frequency of *Cerithium obeliscus* was recorded mean value with 0.36 individual/0.25m^2, 1.72 individual/0.25m^2 and 21.21% respectively while as same are respectively minimum with 0.27 individual/0.25m^2 in 2nd year, 1.15 individual/0.25m^2 in 4th year and 14.52% in 2nd year during the study period and maximum 0.43 individual/0.25m^2 in 3rd year, 2.17 individual/0.25m^2 in 1st year and 26.64% in 5th year during study period (Table 12, Figure 16). Recorded mean values regarding to density, abundance and frequency of *Nerita albicilla* was 0.28 individual/0.25m^2, 1.41 individual/0.25m^2 and 20.35 % respectively. All this three attributes with minimum value were recorded 0.27 individual/0.25m^2 in 2nd year and same in 5th year, 1.28 individual/0.25m^2 in 5th year, and 18.99% in 2nd year and maximum 0.31 individual/0.25m^2 in 1st year, 1.58 individual/0.25m^2 in 4th year and 23.1% in 3th year during study period (Table13, Figure 17). Recorded mean values regarding to density, abundance and frequency of *Onchidium verriculatum was* 0.49 individual/0.25m^2, 1.47

individual/0.25m^2 and 33.65 % respectively. All this three attributes with minimum value were recorded 0.32 individual/0.25m^2 in 4th year, 1.13 individual/0.25m^2 in 5th year, and 26.64% in 4th year and maximum 0.56 individual/0.25m^2 in 5th year, 1.73 individual/0.25m^2 in 1st year and 47.47% in 4th year during study period (Table14, Figure 18). Density, abundance and frequency of *Turbo coronatus* was recorded mean value with 0.37 individual/0.25m^2, 1.49 individual/0.25m^2 and 25.3% respectively while as same are respectively minimum with 0.33 individual/0.25m^2 in 1st and 4th year, 1.18 individual/0.25m^2 in 1st year and 17.88% in 4th year during the study period and maximum 0.59 individual/0.25m^2 in 5th year, 1.5 individual/0.25m^2 in 2nd year and 41.62% in 5th year during study period (Table 15, .Figure 17). These three attributes for *Turbo intercostalis* were recorded mean value with 0.37 individual/0.25m^2, 1.35 individual/0.25m^2 and 27.95% respectively while as same are respectively minimum with 0.26 individual/0.25m^2 in 4th year, 1.12 individual/0.25m^2 in 4th year and 22.72% in 2nd year, more ever these attributes are respectively maximum 0.49 individual/0.25m^2 in 5th, 1.72 individual/0.25m^2 in 2nd and 33.19% in 3rd year during the study period (Table 16, Figure 18).

During the entire study, after completion of first year, it was recorded that minimum density was exhibited by *Bursa granularies* with 0.25 individuals/0.25 m^2, and maximum density was exhibited by *Onchidium verriculatum* with 0.54 individuals/0.25 m^2. After completion of the first year study, minimum abundance was exhibited by *Nerita albicilla* with 1.43 and maximum abundance was exhibited by *Cellana radiata* with 2.89 individuals/0.25 m^2. While as minimum frequency was exhibited by *Astrea stellata* with 14.63% and maximum frequency was exhibited by *Onchidium verriculatum* and *Turbo intercostalis* with 31.7% (Figure 19)

During the entire study after completion of second year, it was recorded that particular for second year minimum density was exhibited by *Bursa granularies* with 0.16 individuals/0.25 m^2, and

maximum density was exhibited by *Onchidium verriculatum* with 0.54 individuals/0.25 m^2. For the second year, minimum abundance was exhibited by *Nerita albicilla* with 1.44 and maximum abundance was exhibited by *Onchidium verriculatum* with 1.88 individuals/0.25 m^2. While as minimum frequency was exhibited by *Bursa granularies* with 11.17% and maximum frequency was exhibited by *Turbo coronatus* with 22.9% (Figure 20).

During the entire study after completion of three year, it was recorded that particular for third year minimum density was exhibited by *Bursa granularies* with 0.28 individuals/0.25 m^2, and maximum density was exhibited by *Onchidium verriculatum* with 0.53 individuals/0.25 m^2. For the third year, minimum abundance was exhibited by *Nerita albicilla* with 1.13 and maximum abundance was exhibited by *Cellana radiate* with 2.47 individuals/0.25 m^2. While as minimum frequency was exhibited by *Bursa granularies* with 15.54% and maximum frequency was exhibited by *Onchidium verriculatum* with 47.47% (Figure 21).

During the entire study after completion of fourth year, it was recorded that particular for fourth year minimum density was exhibited by *Bursa granularies* with 0.2 individuals/0.25 m^2, and maximum density was exhibited by *Cellana radiate* with 0.35 individuals/0.25 m^2. For the fourt year, minimum abundance was exhibited by *Turbo intercostalis* with 1.12 and maximum abundance was exhibited by *Astrea stellata, Turbo coronatus* with 1.87 individuals/0.25 m^2. While as minimum frequency was exhibited by *Astrea stellata* with 14.96% and maximum frequency was exhibited by *Onchidium verriculatum* and *Cerithium obeliscus* with 26.64% (Figure 22).

During the entire study, after completion of fifth year, it was recorded that particular for fifth year minimum density was exhibited by *Bursa granularies* with 0.24 individuals/0.25 m^2, and maximum density was exhibited by *Turbo coronatus* with 0.59 individuals/0.25 m^2. For the fifth

year, minimum abundance was exhibited by *Nerita albicilla* with 1.28 and maximum abundance was exhibited by *Cerithium obeliscus* with 2.16 individuals/0.25 m^2. While as minimum frequency was exhibited by *Bursa granularies* with 15.27% and maximum frequency was exhibited by *Turbo coronatus* with 41.42% (Figure 23).

3.3 Abiotic Factors

Each and every ecosystem is always under control of surrounding environment and medium, further it is supported by number of physic-chemical parameters that are responsible to maintain the cyclic phenomena of particular ecosystem. In the present study, sea water analysis has been carried out for some important such parameters i.e. Salinity, pH, Ca^{++} hardness, Mg^{++} hardness, Total hardness, Potassium, Sulphates, Dissolved Oxygen etc. Mainly these parameters are responsible to maintain the local environment and faunal distribution and population dynamics, too.

Salinity is the most prominent physicochemical parameter for marine ecosystem. At Mangrol coast, mean salinity value for the study period was 35.23 ppt. Yearly the average values were resulted as 34.77, 35.05, 35.16, 35.33 and 35.93 ppt for study period (Table 17, Figure 24). pH refers to nature of water either acidic, basic or neutral. The result for this parameter at the Mangrol coast was 7.55 mean values. Respectively yearly it was recorded as 7.58, 7.55, 7.57, 7.51and 7.55. (Table 18, Figure 25).

Ca^{++} hardness content generally found more in composition of sea water, hence was estimated for the study. It is more important for the molluscan species mainly Gastropods, for formation of the shell. The result was 431.92 ppm mean value and 432, 435.4, 425.2, 436.4 and 430.6 ppm respective values for fiver year of the study. (Table 19, Figure 26). Generally sea water contain

more amount of Mg^{++} per litter, it is also same important regulatory physic-chemical parameter at the intertidal zone. At the study site, the Mg hardness contains mean value of 1253.6 ppm during the study period, while respectively result was 1204.72, 1221.23, 1203.28, 1240.17 and 1231.93 for years sequentially (Table 20, Figure 27). Total hardness is the sum total result of Ca and Mg hardness; combination might change the nature of water. Hence the analysis was carried out for this parameter, it was recorded as an average value 1618.43 ppm during five year study period respectively, and it was 1639.28, 1653.47, 1625.07, 1586.67 and 1587.67 ppm. for other study period (Table 21, Figure 28).

To overcome stress and execute adaptation physiological variation requires being imparted hence Potassium was considered as one of the major factors responsible for coordination. The mean value resulted was 369.54 ppm and respective values were 370.41, 382.36, 376.83, 354.8 and 363.31 ppm for entire study period yearly (Table 22, Figure 29). Sulphate content is the most important abiotic factor to maintain the ecosystem and its trophic levels. At the study site Mangrol, intertidal pool water was tested for quantity of sulphate and the mean value for the entire period was 2701.04 ppm and respectively for other years estimated as 2735.12, 2706.05, 2718.98, 2663.82 and 2681.25 ppm during study period (Table 23, Figure 30). Dissolved oxygen is the most essential parameter in between five years of study period had the mean value of 4.89 mg/ml and respectively it was 5.1, 4.63, 4.98, 4.83 and 4.85 (Table 24, Figure 31).