CHAPTER 9

DISCUSSION AND INTERPRETATION

The research work is outlined with definite objectives and identified gap in research with national and international review of literature. The objectives of the research work is to (i) investigate the quantitative and qualitative analysis of foraminifera assemblage in Ashtamudi estuary, Kollam offshore and coastal plains, Kayamkulam lagoon and offshore area and its implications to shoreline changes, (ii) to correlate the diversified coastal and sea environment properties using foraminifera assemblages and (iii) to record the relationship of heavy metals concentration and its responses to the foraminifera and implication to pollution along the study area. The significance and need for this research is discussed and the research work is presented in 9 chapters of information by introduce the study area with preamble of information, reviewed literature analysis, standard protocol methodology of separation of foraminifera, sediment characteristics and heavy metal analysis. The sediment particle relationship and its proportion of fractionalization in response to the sedimentation process in the shallow sediment core lithofacies are discussed to investigate the sediment type, substrate nature and its influence in faunal distribution. The detailed stock of foraminiferal assemblages is presented in estuary, coastal plain, lagoon and offshore environments. The physical properties of oceanic circulation, transgression-regression in tectonic setting signatures, the evolution of Ashtamudi estuary and Holocene sea level and environment are discussed. The abundances of foraminifera were statistically reviewed to understand its
high resolution mode of distribution and relationship among species in accordance with environment, sedimentation and energy. The concentration of heavy metals are discussed in estuary environment and correlated with three shallow cores. The pollution index, biological effect, enrichment factors are presented in the work. This will be a scientific document of the study area as literature records reveals of gap in foraminiferal studies of Ashtamudi and Kollam area of Kerala state.

Kerala coast has been shifting westward and eastward, particularly during the last 25,000-30,000 years. The Quaternary period was characterized by fluctuations of sea level, which continuously changed the shoreline from its present position. The radiocarbon dates infers that the estuaries along the Kerala coast were not syngenetic. During the Holocene, the transgression event around 8,000-6,000 years B.P shifted the shoreline much to the east of the present shoreline. It has been reported that during last 20,000 years B.P., the sea level along this coast was 60 to 100 m below present MSL. The sea level rose to 4 to 6 m above the present MSL around 6,000 years BP. The regressive phase, following this event might have resulted in the formations of the barrier beach to the north of Neendakara. The laterite escarpment capping and fresh water lake along the eastern fringes of the Ashtamudi estuary are suggestive of the existence of uplifted prograded coastal margin followed by subsiding interiors marked by backwater channels. There are three transgression-regression episodic features (sand ridges) is marked on the traverse from Cochin mouth to the Kayamkulam (Suchindan and Mallik, 1984). Submerged terraces at depth from 10 to 55 m belonging to Holocene period (11,000-9,000 YBP) in the west coast (Soman 1997) may be continuation of the strand lines. It has been reported that Ashtamudi estuary is associated with horst and graben topography which is initiated the mouth of Kallada River. The ridge in the offshore adjoining to the Ashtamudi estuary opening bears testimony of this down faulting.
To address the evolution of these features are required for an understanding of the associated processes, faunal signatures, sediments on the surface of the earth, which provides the clues to reconstruct the paleoenvironment. The comparative study of continental and marine foraminifers’ distribution, its relationship provides the clue on the Holocene environment.

The exhaustive data on lithofacies, foraminiferal abundance and species diversity of 4 shallow cores and surface grab samples of Ashtamudi estuary with available \(^{14}\text{C}\) isotope dates on age are integrated to understand the paleoenvironment and evolution of the study area around Kollam coastal plain, Kayamkulam lagoon and Ashtamudi estuary, in southern Kerala.

### 9.1 Lithofacies Distribution

The surficial sediments in the Ashtamudi show various lithology in its different Kayals. The different activities concentrated in and around the estuary are reflected in the bottom sediment characteristics as well in some of the kayals. The southern kayal is shallow at <1m depth, reveals the dominance of silt (30-85%) followed by clayey silt. In these kayal sediments are rich in organic matter content, possibly owing to entry of municipal waste. Coir retting is another major activity in the southern and western kayals (Prakash et al 2001). The organic richness in this part of the estuary is attributed mainly to anthropogenic activity. The eastern kayal is deeper at about 14m water depth and consists of the dominance of clayey silt and silt. This part of the Kayal receives considerable fine sediments due to washings from the clay factory situated in the hinterland of the region. The northern central kayal reaches up to 10 m in depth. The main trunk of the estuary covered with particles of different size grades except on the northern side, where it becomes sandy. At the estuarine entrance, it is the sand which is the dominant lithology. It is clearly visible that laterally the lithofacies grade from
sand dominance at entrance and northern kayal, to silt and clayey silt dominance at western Kayal in the Ashtamudi estuary

9.1.1 Shallow Sediment Core in Ashtamudi Estuary (A-15)

This core has a length of 45cm and divisible into 2 distinct units. The depth interval of lower unit (L-1) from 45-10cm contains silt (52.35-45.05%), followed by clay (29.63-33.47%) and sand (18.02-24.01%). The organic matter (OM) and CaCO$_3$ varies from 3.3-9.6% and 3.88-4.29% respectively. In the upper unit (L-2), this ratio changes to sand (53.1-53.8%), silt (23.76-23.15%) and clay (23.05-23.07%), while OM and CaCO$_3$ varies from 7.8-9.6% and 0.77-0.65% respectively. A sharp turnaround in sand content is marked at 10cm depth. This lithological break is also reflected in OM and CaCO$_3$ values as well.

9.1.2 Shallow Sediment Core in Kayamkulam Lagoon (K-1)

This short core has a length of 25cm. This core is divisible into 2 discrete units. The lower unit (L-1) covers the depth interval from 25-15cm and predominantly consists of clayey silt lithology wherein silt (33.73-72.5%), clay (19.24-59.78%), sand (6.48-10.08%) and CaCO$_3$ (6.27-7.7%) are present. In the upper unit (L-2), there is a drastic increase in sand (44.75-79.87%) content and reduced silt (24.16-11.75%), clay (31.09-8.38%). CaCO$_3$ does not much vertical variation across the sharp break marked at 15 cm. depths, where sand content shows big turnaround.

9.1.3 Shallow Sediment Core of Kayamkulam Offshore (KO-5)

This has a length of 55cm and located in Kayamkulam offshore at a water depth of 14m. The lithology shows a trend change at 30cm, where % content of sand, silt and clay do vary considerably across this boundary. One
depth interval 25-30cm is transitional and shows very low sand content (8.48%), silt (47.39%) and clay (44.18%). The interval below this (L-1: 55-30cm) contains, sand (80.83-60.23%), silt (5.64-1922%), clay (10.13-20.55%), OM (1.12-2.29%) and CaCO3 (5.6-8.0%). The upper unit (L-2: 25-0cm) consists of sand (29.04-41.41%), silt (45.23-36.23%), clay (22.36-35.9%), OM (2.09-2.85%) and CaCO3 (11.4-15.4%).

9.1.4 Shallow Sediment Core of Kollam Offshore (QO-1)

This site located further into offshore at a water depth of 18m. This core has a length of 85 cm represented dominantly by clayey silt lithology. Considering sand and clay content it is possible to demarcate a lithological break at 60cm. Silt content do not show such a change. Depth interval from 85-60cm (L-1 unit) contains sand (22.3-12.82), silt (58.59-68.31%), clay (16.88-20.09%), OM (0.61-2.72%) and CaCO3 (12.6-14.0%). The upper litho unit (L-2) from 60-0cm consists of sand (9.23-0.31%), silt (54.46-82.52%), clay (13.66-45.23%), OM (2.53-5.02%), CaCO3 (9-13.8%).

Figure shows the lithological correlation of all 4 sedimentary cores of Kollam area. At all the core sites, a sharp break was found in litho content dividing the core into two distinct litho units (L-1 &L-2). The bottom core (L-1) at site QO-1 located at 18m water depth contains silty clay, while at KO-5 placed at 14m water depth, contains sandy lithology at the bottom. The on land sites K-1 and A-15 predominantly contain silty clay and clayey silt lithology. Whereas litho unit (L-2) contains silty clay at QO-1 and KO-5 and sandy substrate at all three land ward sites K-1 and A-15. Besides, lateral lithofacies gradation in both litho units is distinct from offshore to on land sites. In the L-1 unit, the core QO-1 shows silty which grades into sandy at KO-5 further altering into silty and clayey in on land sites, while in L-2 unit, both offshore sites covered by silty clay and dominantly sand deposited at all three on land sites.
The organic matter content (OM) correlating positively with increased clay content at all sites while CaCO$_3$ content shows irregular correlation with grain size, but shows decreasing trend in upcore at A-15 and KO-5, while decreasing trend at QO-1. It shows uniform values at K-1 site. The vertical variation of lithofacies shows marked changes in upcore direction in all the four shallow sediment cores studied for this work. Lateral migration of sandy facies from KO-1 into landward sites at K-1 and A-15 further reinforces to infer that transgression commenced during the deposition of L-2 unit. The vertical and lateral gradation of lithofacies clearly point to conclude that sedimentation through upcore occurred in a transgressive phase.

9.2 FORAMINIFERAL ABUNDANCE AND SPECIES DIVERSITY

9.2.1 Ashtamudi Estuary Surface Sediments

There are 32 Benthic foraminifera species are identified in the five Kayals of Ashtamudi estuary are; Ammonia beccari, Ammonia dentata, Ammobaculites sp., Bolivina earlandi, Brizalina striatula, Bulimina marginata, Caribeanella polystoma, Cancris oblongus, Cibicides lobatulus, Dyocibicides sp., Elphidium crispium, Elphidium excavatum, Elphidium discoidale, Elphidium hispidulum, Eponides repandus, Globigerina bulloides, Globorotalia angulata, Globigerinoides ruber, Globulina gibba, Loxostomum lobatum, Nonion boueana, Nonion grateloupi, Nonion scaphum, Nonion sp., Pararotalia nipponica, poroeponides lateralis, Quinqueloculina agglutinans, Quinqueloculina boueana, Quoqueloculina seminula, Rolshausenia rolshauseni, Textularia agglutinans, Virgulina riggii.

Ammonia beccarii is ubiquitous and dominant in all the coastal water bodies like lagoons and estuaries along the TamilNadu and Kerala coasts (Ramanathan 1970; Reddy & Reddy 1982; Jayaraju and Reddy 1992;
Kumar et al 1996; Gandhi et al 2002; Nagendra et al 2011). These taxa reported to occur abundantly in lower estuarine zone of Ashtamudi estuary of southern Kerala coast (Nagendra et al 2011). The water depth in the lower estuary of Ashtamudi is about 4m and the predominant lithology represented by sand. *N.scaphum* was associated with *A.beccarii* in the middle estuarine zone (central and western Kayals) of Ashtamudi estuary where water depth ranges from 2-4m and lithology mainly represented by clay and silt. In the central and western Kayals of Ashtamudi abundance of *A.beccarii* and *N.scaphum* account to about 60% and 25-30% respectively.

**9.2.2 Ashtamudi Estuary Sedimentary Core A-15**

The A-15 sediments were yielded 29 benthic foraminifera species, they are *Ammonia beccarii, Ammonia dentate, Ammonia tepida, Amphicoryna sublineata, Amphistegina quoyii, Bolivina spathulata, Brizalina subaenariensis Cancris oblongu, Elphidium advenum, Elphidium crispum, Elphidium discoidale, Elphidium craticulatum, Elphidium macellum, Fissurina alveolata, Fursenkoina texturata, Lobatula lobatula, Nonion boueaneum, Nonion scaphum, Protelohidium sp., Pyrgo oblonga, Quinqueloculina sp.,Quinqueloculina seminula, Quinqueloculina vulgaris Spiroloculina henbesti, Spiroplectammina sagittula, spiroloculina sp., Tretomphaloides concinnus, Triloculina sp., Virgulina sp.* Two planktic forms; *Globigerina bulloides, Globigerinoides ruber* are recorded in these sediments.

The total foraminiferal abundance (1125-1498) shows gradual increase from bottom to 10cm depth in L-1 unit. Similar trends are exhibited in species diversity (3-19), whereas in L-2 unit these trends are reversed. But absolute values are higher in L-2 compared to L-1, indicating a general increase in water depth through upcore.
A. beccari is the most dominant species ranging from 36-99.7%. Other important species A. tepida, E. discoidale and N. scaphum contributes to total abundance in the upper part of the core. A. beccarii shows maximum absolute abundance (460-1426/10g. dry sediment) at this site. The absolute abundance shows increasing trend while relative abundance exhibits opposite trend, because other species A. beccarii, E. discoidale and N. scaphum contributes significantly to relative abundance in the upper part of the core. The species diversity (03-22) shows a gradual increasing trend in upcore direction.

9.2.3 Kayamkulam Lagoon Sedimentary Core K-1

The K-1 core is sub-sampled in to 5 units at an interval of every 5cm. These sediments were yielded foraminiferal species of Ammonia beccarii, Ammonia tepida, Bolivina spathulata, Cancris oblongus, Elphidium advenum, Elphidium crispum, Elphidium discoidale, Globigerinoides ruber, Nonion boueannum, Nonion scaphum, Spiroloculina henbesti, Textularia sagitula, Virgulina sp.

The total foraminiferal abundance (2-841) shows gradual increase from bottom 25 cm to surface. The L-1 unit trends are exhibited in species diversity (1-4), whereas in L-2 unit these trends are increased in the diversity (7-8). But absolute values are higher in L-2 compared to L-1, indicating a general increase in water depth through upcore. A. beccarii is predominant species distributed throughout the core.

In this core, A. beccarii is the most dominant ranging in its relative abundance from 84.6-100%. Its relative abundance decreases in upcore in L-1 unit, and increases in L-2 unit. Similar trends are observed in its absolute abundance as well. However, the increase in abundance above the lithological break at 10cm is drastic. Species diversity shows a gradual increase from 2-8 in upcore.
9.2.4 Kayamkulam Offshore Sedimentary Core KO-5

In this offshore identified 17 foraminiferal species. *Ammonia beccarii, Ammonia dentate, Ammonia tepida, Amphistegina quoyii, Bulimina sp., Bolivina spathulata, Brizalina subaenariensis, Cancris oblongus, Elphidium crispum, Elphidium discoidale, Globigerina bulloides, Globigerinoides ruber, Nonion boueanum, Nonion boueanum, Nonion scaphum, Protelphidium sp., Quinqueloculina sp., Spiroplectammina sagittula.*

The total foraminiferal abundance (108-1266) shows gradual increase from bottom 25 cm to surface. The L-1 unit trends are exhibited in species diversity (6-10), whereas in L-2 unit these trends are increased in the diversity (9-11). But absolute values varies in L-1(212-1266) and L-2 (108-459), indicating a transitional zone at 25-30cm. *A.beccarii* is predominant species distributed throughout the core.

Foraminiferal taxa *A.beccarii* is the dominant throughout the core ranging in its relative abundance from 48.5-87.4%. Both relative and absolute abundances of this taxa show a gradual decreasing trend in upcore. But species diversity shows a gradual increasing trend (6-11) from 25cm to top of the core in L-2 unit, while in L-1 unit, this trend in species diversity is opposite (12-6).

9.2.5 Kollam Offshore Sedimentary Core QO-1

The sediment core (QO-1) sub-sampled to 18 units from 88cm length of the core. This sediment yielded 30 foraminifera species. *Ammonia beccarii, Ammonia dentate, Ammonia tepida, Amphistegina quoyii?, Bolivina spathulata, Brizalina subbrizalina subaenariensis, Bulimina gibba, Cancris oblongus, Elphidium advenum, Elphidium crispum, Elphidium discoidale,*
Eponides repandus, Fursenkoina davi, Fursenkoina texturata, Globigerina bulloides Globigerinoides ruber, Nonian boueanum, Nonion scaphum, Oolina globosa, Protelphidium sp., Quinqueloculina lata, Quinqueloculina seminula, Quinqueloculina sp., Reussoolina laevis, Rolshausenia rolshauseni, Spiroloculina henbesti, spiroloculina sp., Tretomphaloides concinnus, Virgulina riggii, Virgulina sp.

The total foraminiferal abundance (45-1064) shows not defined trend from bottom 85 cm to 0. The L-1 unit (85-60) trends are exhibited in species diversity (3-18), whereas in L-2 unit 960-0cm) trends are increased in the diversity (12-19). But absolute values varies in L-1(84-1064) and L-2 (45-753), indicating a general increase in water depth through upcore. A.beccarii, Elphidium discoidale, Nonian scaphum and Nonian boueanum is predominant species distributed throughout the core.

A.beccarii and A.tepida constitute >50-85% of total abundance at all core depths. The absolute abundance shows a decreasing trend from bottom to top of the L-1 unit, and increasing trend from towards top in L-2 unit. While species diversity shows regular increasing trend from bottom (6) to top (19) of the core.

The total foraminiferal composition recorded in all the 4 cores shows remarkable similarity with faunal assemblages characteristic of near shore and estuarine complex. The foraminiferal abundance demonstrate gradual increasing trends with few intermittent fluctuations in upcore, but species diversity shows general increasing trend in upcore at all sites The genus Ammonia mainly represented by A.beccarii and A.tepida, is the most abundant at all the sites, and dominates (>50%) at all depths. A.beccarii is the most tolerant species and occurs predominantly in all the coastal water bodies either in polluted or natural environments revealing its high tolerance and adaptability to changing environmental variables (Buzas et al.2003). The
general increase in abundance and diversity of total foraminifera and dominance of *Ammonia beccarii* is a pointer to increasing water depth through upcore.

9.3 **AGE DATING OF CORE SEDIMENTS BASED ON $^{14}$C ISOTOPE**

The carbon isotope dates available for the drill cores in the vicinity of Ashtamudi estuary and Kayamkulam lagoon are given table 6.5 (Tiju 2013). However no carbon dating is available for short cores used in this study. However the date points are extended by tying up with lithology or lithological contacts. The $^{14}$C isotope date available for sedimentary core: BH-2 adjacent to shallow core A15 gave 940 cal years at 1.0-1.08m depth. All the 4 shallow sediment cores utilized in this study are less than 1.0m length and are proximal to BH-2. Therefore the age date of BH-2 (940m cal years at 1.0m depth) is extended with confidence into all study sites at around the same depth. Although age control is available only at one point, it was found good enough for the correlation of 4 core sites, because dating point is 1m below the surface.

9.3.1 **Holocene Sea Level Changes**

Holocene sea level changes documented by Woodroff & Horton (2005) reveal broad similarity in all the locations in the Indo-Pacific region. However, these authors believe that differences do exist, in the timing and magnitude of the Mid-Holocene High Stand (MHHS) and the nature of late Holocene sea level fall across the region. This is probably due to lack of consistent methodology throughout the Indo-Pacific for the analysis of sea level change. When the Indo-Pacific is subdivided into smaller regions, these discrepancies do not disappear, and in some cases the discrepancies are large within a single coastline.
Banerjee (2000) reconstructed mid Holocene sea level changes for the east coast of India using Radiocarbon and Uranium series methods by dating beach ridges, *Porites* coral colony and intertidal shells at 5 locations. He recognized 1<sup>st</sup> highstand of sea level at 7300-5660cal years and 2<sup>nd</sup> highstand at 4330-2500cal years BP. Katupotha and Fujiwara (1988) used radiocarbon dating of corals and marine shells at 4 locations along Srilankan coast and recognized 1st highstand sea level at 6485-5370cal years BP and 2<sup>nd</sup> HS at 2902-1558 cal years BP in mid Holocene.

Ramsay (1995) produced a 9000 year record showing early Holocene RSL rise to a mid-Holocene high stand of +3.5 m at 4650 14C yrs BP with RSL subsequently falling below present levels, but also shows a secondary high stand at 1610 14C yrs BP (+1.5 m) before mean sea level is attained at 900 14C yrs BP. The sea-level observations are taken from a 180 km long stretch of coastline in eastern South Africa, thus reflecting regional RSL influences. It may be observed here that Holocene sea level changes of the South African and Srilankan coasts shows close similarity. Since the present study area is in close geographic enclosure with Srilankan coast, it is prudent to extrapolate Holocene sea level changes to the present study area on the west coast of India. Pluet & Pirazzoli (1991) reconstructed sea level changes during Holocene for both stable and Delta regions throughout the world. The world Atlas of Holocene sea level changes (Pluet&Pirazzoli,1991) indicates that sea level highstand around 1200 years and since gradual transgression which led to attain present mean sea levels around 900 years ago. By correlating with age dates of 940years at 1-1.08m in BH-2, all the study sites at their bottom depths likely fall in the transgressive phase of late Holocene sea level.

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9.4 HEAVY METAL RELATIONSHIP WITH FORAMINIFERA

The extent of pollution by trace metals has been assessed by employing the method based on Pollution Load Index (PLI) developed by Thomilson et al (1980). The contamination factor, the metal base values represents its average concentration in UCC (Wedepohl 1995). PLI provides a simple, comparative means for assessing a site or estuarine quality: a value of 0, 1 and >1 indicates absence, presence of them and progressive deterioration of sediment quality respectively (Tomlinson, 1980). The PLI values on core 1 ranging from 1.56 to 1.95 with an average value of 1.72 and in core 3 the PLI values ranging from 1.62 to 2.07; avg. 1.92 where as core 2 is recorded higher as 1.91 to 3.07; avg. 2.33 which indicates that core 2 sediments are highly polluted that the core sediments core 1 and core 3.

The variation in Enrichment Factor values between the cores is shown in Figure 8.6. The overall, the average enrichment factors of Cr (4.31; 3.47; 4.21 in core 1; 2 and 3 respectively), Ni (3.92; 3.49; 3.42 in Core 1, 2 & 3 respectively) and Cu (3.23 in core 2) are found to be >2, suggesting contamination of these metals in the Ashtamudi estuary sediments.

At elevated concentrations, many heavy metals become highly toxic and have chronic effects on living organisms in aquatic ecosystem. In the present study, various heavy metals in the core sediments of Ashtamudi estuary have been computed to Effects-Range Low (ERL) and Effects-Range Median (ERM) guidelines derived from Long et al. (1995) to evaluate the degree of contamination connected with biological effects. Sediment chemical concentrations below ERL are interpreted as rarely being associated with adverse health effect. Exceedence of ERM values and maximum baseline
values were used to identify metals of ecological concern. The adverse effect of the metals in the core sediments of Ashtamudi estuary indicates that Ni concentration is recorded higher than the ERM values in all the core sediments, i.e. more ecological concern. Cu concentrations in core-2; Pb concentrations in A-15; Cr concentrations in core-3 potentially of greatest concern, in this case are between ERL and ERM with an effect of 93%, 87% and 83% respectively. Cu (in core 1; 3), Cr (in 1; 3), and Zn (in core 2 &3), concentration in all the sediments are recorded lower than the ERL value, whereas Pb concentration in core 1 shows that 13% of samples are recorded lower than the ERL value.

9.5 EVOLUTION OF ESTUARY

The occurrence of Quaternary formations at various elevations along the Kerala coast and formation of a chain of coast-parallel estuaries/lagoons with rivers debouching into them and separated from the sea by spits/bars provides evidence of a progarding coastline through well preserved palaeo records in the sediment column. Padmalal (2011) and Nair et al (2010) studied the sedimentological and palynological analysis of the boreholes samples around the Ashtamudi estuary and deciphered a thick sequence of Holocene sediments (20-35.0 m) containing good archives of landform evolution and climate changes. Further the sediment lithological variations from the above observation and a detailed sedimentological study along with carbon dating carried out by (Tiju Varghese 2013) has brought out clear understanding on the evolution of estuary during Quaternary. In the southern coastal plain bordering the Ashtamudi estuary the results of sediment litholog indicates several deposition as well as erosion episodes. The top 7 m is carpeted with fluvial sand of medium to fine grade of angular to sub angular in nature which is considered to be recent deposition. This is also well documented in the SEM studies. Below 7 to 9 m the sediment has changed the colour from reddish brown to yellow of medium to coarse sand with
occasional gravel and brachiopods shells indicating a change in the deposition scenario of shallow marine to lagoon and swamp/marsh environment (Nair et al 2004). Overpeck et al (1996) concluded that the monsoon strength increased suddenly in two steps, 13-12.5 $^{14}$C Kyr and 10-9.5 $^{14}$C kyr BP (ca.15.3-14.7 and 11.5-10.8 cal kyr BP). Most climatic proxies suggest that the stronger monsoon in the early Holocene was associated with high lake levels; increased flow discharges floods and scouring (Kale et al., 2004). The stronger monsoon during the early Holocene results in the formation incised valley at the entrance of Kallada river. This was followed by the Holocene transgression event submerging the adjacent coastal plain results in the formation of coast perpendicular estuary. The Pleistocene-Holocene boundaries were also encountered in the study area. The Holocene sedimentation was replaced by 7 m recent sediment which is directly overlying the late Pleistocene of 40,000 yrs BP.

9.6 CONCEPTUAL MODEL

The conceptual model illustrating the Late Holocene eustatic sea level changes as observed by Fairbridge (1961) and vertical lithological facies observed at present study sites in Kollam area, displays close correlation between sea level rise and major lithological changes. The relative rise in sea level around 480 years BP seems to have initiated the migration of sandy facies towards landward side. The migration of facies appears to have caused sharp break in lithology at varying time intervals at different sites showing a possible linkage to relative rise in sea level during Late Holocene.

The migration of sandy facies from seaside (KO-1) to landward side (A-15 and K-1 sites) again shows linkage to relative rise in sea level. It is likely that transgressive pulses triggered the migration of sand depocentres in landward side. (Figure 9.1) The model also reveals that Late Holocene transgression initiated about 480 years BP at study area, and continued with minor fluctuations to the present day (Figure 9.2).
Figure 9.1 Migration of sandy facies sea side to landward shows linkage to rise in sea level
Figure 9.2 Conceptual model illustrating the correlation of vertical lithological changes observed at 4 study sites with Late Holocene sea level changes (Fairbridge, 1961), and ^14C isotope dates measured at site A-17 which is in close vicinity to present study site A-15
9.7 SCOPE FOR FURTHER RESEARCH

The shell chemistry and carbon dates of shells update the compositional units of transgression regression history and to place the geological events of this area. Shell deformities, shell surface modifications categorization to lead to record the Pollution Index for the southern Kerala.