CHAPTER 2

PREVIOUS LITERATURE REVIEW

2.1 NATIONAL

The south west coast of India is accounted on sea level changes records with multidisplinary science of stratigraphic, lithological, geochronological and paleontological framework (Jacob & Sastri 1952; Paulose & Narayanaswamy 1968; Ramanujam 1987; Aditya & Sinha, 1976; Raha et al 1983, 1987). Thrivikramji & Ramasarma (1981) inferred a 4 to 5 m fall in sea level during the Holocene period. Sawarkar (1969) has located auriferous alluvial gravels farther inland in the Nilambur valley at an elevation of 150 m above mean sea level. Guzder (1980) attributed the alluvial gravels in Nilambur valley to sea level changes during the early late Pleistocene period. The peat beds that form prominent Quaternary units in Kerala were considered to be developed from the submergence of coastal forests, thereby representing series of transgression and regression events (Powar et al 1983, Rajendran et al 1989). The submerged terraces found at -92 m, -85 m, -75 m and -55 m in the continental shelf of west coast represent four still stands of sea levels of the Holocene age (9,000-11,000 YBP), the period during which the sea was in a transgressive phase (Nair 1974, 1975).

Nair & Hashmi (1980) ascribed the formation of oolitic limestone in the Kerala shelf to warmer conditions and low terrestrial run off during the Holocene period (9000-11000 YBP).
Agarwal (1990) considered the west coast of India to be an emergent type and identified a rise in sea level to the order of 0.3 m during the past 57 years.

Nair et al (1978) and Hashimi et al (1978) identified three distinct sedimentary facies, the first two consisting of sand and mud which are of recent origin, while the third outer shelf relict carbonates sand facies of late Pleistocene formed at the time of low stand of sea level. From the study of carbonate sediments and size of the quartz grains, Nair & Hashimi (1980) inferred a warmer climate and low terrestrial run off during the Holocene (about 10,000 YBP). Further, feldspar content in the sediments has been used to infer the climatic aridity over India around 11,000 years ago (Hashimi & Nair 1986). These evidences indicate contrasting climatic changes in the deposition of the carbonate and clastic sediments on the shelf, thus suggesting rapid changes in climate from arid to humid. A review article by Rao & Wagle (1997) gives an elaborate account of the geomorphology and the surficial sediments of the continental margins of India.

Krishnan Nair (1987) studied the morphostartigraphic Quaternary surface of the Kasargod-Cannanore district and retreated the Payyannur strandline deposit represent palaeo-coastal plain of late Pleistocene to Early Holocene period. Rajendran et al (1989) dated the peat sample of Irinjalakuda to be 7230+ 120 YBP indicating transgression of the sea and lime shell of Payyannur in Cannanore district, estimated an age of 4370+100 YBP indicating the regression of the sea during that time.

Samsuddin et al (1992) considered the strand plain deposits along the northern Kerala coast to be the morphological manifestations of marine transgression/regressions event.
Haneesh (2001) studied sea level variations during the late Quaternary and coastal evolution along the northern Kerala coast. Radiocarbon dating of shell samples collected from a depth of 6.3 m from the Thekkekad Island gave an age of 2830 ± 30 YBP. This shows that the deposition of shells was associated with a regressive phase took place at around 3000 YBP. The radiocarbon dates obtained from the shell and peat samples in dark gray coloured fine and very fine sands from the Onakkunnu transect at a depth of 3.2 m and 10.4 m an age of 5650 ± 110 YBP and >30000 YBP respectively. The chrono-stratigraphy illustrates eight episodes of regressive events corresponding to eight sets of ridges and swales. The inner most ridge event took place around 6000 YBP and the dune adjacent to the beach is a morphologic continuum since 1000 YBP. From the morphotostratigraphic study of strandlines, the innermost ridges are the morphological manifestation of sea level maxima during mid-Holocene (Suchindan et al 1996). An earlier report on the origin of sand bar along this coast is attributed to the regression of the sea during 5000-3000 YBP (Rajendran et al 1989). Sedimentological studies demonstrate that a palaeo-beach that existed off Kerala coast during late Quaternary low stand of sea level, which, at present, remain detached from the mainland due to the subsequent transgression. The expanse of sandy sediments at a water depth of 40 m in the mid-shelf has an age bracket of 7000-8000 YBP. Radio carbon dating on shells from the inner shelf and outer shelf cores collected at 40 m and 150 m water depths, indicates a sedimentation rate of 0.12 mm/yr for the inner shelf and 0.05 mm/yr for the outer shelf. Relict terrigeneous sediments in the outer shelf between Mangalore and Cochin imply that the Holocene sedimentation to the outer shelf is minimal and has been unable to cover the Late Pleistocene sediments. This is confirmed by the exposure of terrestrial carbonates such as calcretes and paleosols of Pleistocene age at 50 to 60 m water depth (Rao & Thamban 1997).
The radio carbon dating of decayed wood from carbonaceous clay from Ponnani inferred an age of 8230-10240 YBP indicating transgression of the sea during Early Holocene period (Rajan et al 1992), which ultimately resulted in destruction of the coastal mangroves.

According to Mathai & Nair (1988), the strand lines and linear sand dunes of the Kodungallur area are evidences for a periodic cyclicity in the regression of the sea, indicating dominance of marine forces in the evolution of various land forms. The peat sample in the Irinjalakuda region estimated an age of 6420+120YBP indicating early to middle Holocene (Rajendran et al 1989). The sediment granulometry and quartz grain micro textural features in the outer and near inner shelf zone inferred that the sands are of beach deposits indicating Holocene (Prithviraj & Prakash 1991).

Holocene studies along the Ernakulum area came in to light by Agrawal et al (1970), which studied that the Wellington Island near Cochin with an estimated age of 8080+120 YBP indicating Holocene period based on peat. The studies were further strengthened by Agrawal et al 1975, 1979; Agrawal & SheelaKusumgar 1973. Based on the study of satellite images, the striking parallelism of Vembanad Lake with that of the series of strand lines in the central Kerala coast is an example of the transgressive-regressive episodes. Their orientation is controlled by changes in direction of approach of wave front (Mallik & Suchindan 1984).

Narayana et al (2001) have reported the abundance of peat deposits at onshore locations adjacent to the present shoreline of the west coast shows ages between 7200 and 45000 yr BP. A number of parallel strandlines standout as a signature of marine transgression and regression phenomena in the study area and suggest the progradation of the coastline during late Quaternary (Narayana & Priju 2004). The occurrence of strandlines
(Cheniers) along the Cochin coast furthers clarifies a series of marine transgressions and regressions during the Late Quaternary period.

Narayana (2007) studied the environmental and climate change during late Quaternary from the coastal land of Cochin based on peat deposit. The study emphases that peat deposit occurring in association with Quaternary sediments suggests that they originated from the submergence of the coastal tract and consequent transgression of the sea. It is suggested that the flooding is related to transgression occurred likely during 8000-6000 yrs BP destroyed the mangrove vegetation and gave rise to the formation of peat layers. Usually the peat layers occur at 2 m, 6 m, 20 m and 40 m below the surface of the coastal alluvium (Narayana & Priju 2002). The presence of peat suggests intense plant productivity and luxuriant growth of forests in the immediate vicinity.

Priju & Narayana (2007) studied the particle size characterization and late Holocene depositional processes in Vembanad Lagoon based on Tanner’s bivariate plot of grain size parameters.

Reddy et al (1992) studied the clay mineralogy of inner shelf sediments off Cochin west coast of India. Kaolinite and illite are the clay minerals, occurring in decrease order of abundance in Holocene sediments of inner shelf and adjacent coastal environment of Cochin region. Higher proportions of Kaolinite in sediments of outer parts of inner shelf are considered to have been deposited during a lowered sea level in Holocene. The inner shelf sediments off Cochin coast exhibit lens of coarse sands at 30 m water depth which indicates that they have been deposited during a still stand of Holocene transgression at that level and is therefore relict in nature. (Reddy & Rao 1992).
Rajendran et al (1989) estimated an age of 3130±100 YBP in the Muhama region of Alleppey district based on lime shell indicating the regression of sea.

Nair et al (2006) estimated an age of 6740±120 YBP based on sediment at a depth of 8.45 m in the Kalarkod region confirming Holocene period. Based on sedimentological, radiocarbon dating and palynological studies emphasized the presence of a marine and marginal marine environmental complex during Holocene. The oldest Holocene sediments dated 8-7kyBP and those up to approx. 4kyBP with an abundance of terrestrial organic matter were probably supplied during a period of higher-than-normal precipitation. A detailed playnological study in the region indicating occurrence and relative abundance of *Culleniaexarillata* pollen along with other wet evergreen forest members at certain intervals indicate the prevalence of heavy rainfall during early Holocene. This aspect is further complemented by the presence of a large number of fungal remains. In contrast, their scarcity and even absence at higher levels in boreholes point towards relatively dry climate during Late Holocene (Kumaran 2008).

The NE-SW to ENE-WSW trending lineaments marked in the coastal belt is considered to be youngest (Nair 1990; Soman 1997). Chattopadhyay 2001 interpreted 2 sets of regression-transgression sand ridges along the Kayamkulam sector during Holocene. The N-S trending sand ridges are associated with Holocene sea level rise along with tectonic disturbances that had caused further sea level change. The NNW-SSE sand ridges formed as a result of mid Holocene (6000-4000 YBP) sea level changes. Apart from the transgression and regression which cause alternate water logging and fast drainage of the valleys, there are evidences of high rainfall in different spells during early to mid-Holocene (Nair & Hashmi 1980).
Nair & Padmalal (2004) presented that thickest Quaternary sediments exposure in the South Kerala Sedimentary basin which extends from Kollam to Kodungallur in a form of curvilinear area with a maximum width of approx. 25 km and a thickness of approx. 80 m. The basin is divided into central depression flanked by southern block and northern block. The first marine transgression took place around 42,000 years before present (42KyBP). The Holocene marine transgression was experienced by about 7kyBp. This was followed by a regression which left the present landscape of lagoons, wetlands and the ridge-runnel topography.

Jayalakshmi et al (2004) used two bore holes sediments atEruva and Muthukulam near Kayamkulam are used to delineating the late Pleistocene-Holocene history of the southern western Kerala basin. The wood fragments in the Muthukulam core sample (depth zone: 1.27-3.00m) records C\(^{14}\) ages in the range of 3.7 to 7.2 ky BP indicating a Holocene history. This period witnessed aeolian activity modifying the sand ridges in the ridge-runnel systems formed by the Holocene regression. The study linked the Quaternary transgression to abnormally high intensity of Asian summer monsoons.

Limaye et al (2009) reported cyanobacteria from studied Late Quaternary sediments from the boreholes of Panavally and Ayiramthengu of Kollam district.

The Ashtamudi estuary studies was first taken by Prabhakara Rao (1964) in which, discussed the sediments of Ashtamudi and Vatta estuary region of Neendakara-Kayamkulam coast. During the last two decades the study on Ashtamudi estuary studied based on physico-chemical features of water and sediment nutrients (Nair et al 1983), primary productivity, organic carbon (Nair 1984), and calcium carbonate (Sajan & Damodran 1984).
Sajan (1988) studied the mineralogy and geochemistry of Ashtamudi estuary surface sediment of fresh water, brackish and marine water environments. The variations in the mineralogy of the heavy, light and clay minerals attributed for their respective sources. The progressive depletion of feldspars and corresponding enrichment of quartz from the eastern through central to western part attributed to selective abrasion and chemical weathering. The dual source of sediments to the lake is brought out from the mineralogical studies.

Centre for Earth Science Studies (CESS), Trivandrum, India has prepared the Ashtamudi Management Plan based on detailed study of socio-economics, gender, fisheries and tourism in the context of the physical, chemical and biological aspect of the Ashtamudi estuary (Black & Baba 2001). Ashtamudi management plan, technical Report 11, Current measurements were made during monsoon and non-monsoon seasons to understand the seasonal variation in the current pattern and to support numerical modelling study to understand the estuarine hydrodynamics, circulation pattern and flushing and residence time. Current speed reach up to 100 cms at the estuary entrance, but they rapidly diminish in the wider parts further inland where speeds are generally less than 30 cms. Significant differences were observed in currents during the monsoon and non-monsoon seasons, with faster ebb and slower flood flows in the monsoon due to the freshwater inputs. The flood tide duration is shorter during the monsoon in the entrance. Measurements of current speed and direction throughout the water column using an Acoustic Doppler Profiler identified intrusion of ocean water into the estuary in the near-bottom layers at the entrance and intrusion of estuarine water into the Kallada River at the bed, below an out flowing surface flow during the flood tide. Density stratification is more prominent during the monsoon season at all stations except the Kallada River, where it is prominent during the non-monsoon period. Currents in the Ashtamudi Estuary
vary between the monsoons and non-monsoon seasons, primarily due to increased freshwater discharge and precipitation during the monsoon season. Density stratification within the estuary, primarily due to salinity variation, has a major impact on the estuarine circulation patterns.

The geology and surface sediment characteristics of the estuary were documented by Prakash et al (2001) where the silt and clayey silt are the dominant sediment type in the estuary.

Kurian et al (2001) documented the bathymetric survey of the Ashtamudi estuary. The study has further inferred that the major part of the estuary is shallow (<3m) with a maximum depth of 14 m near the Kallada River confluence.

Nair (2010) discussed the sedimentological and palynological analysis of two boreholes sediments collected near the confluence of Kallada River with Ashtamudi estuary to decipher the late Quaternary evolution of this region. The palynoflora reveals that the depositional site is within the tidal limit and deposition occurred under high precipitation and atmospheric humidity. The similarity in $^{14}$C dates of a wood at 5 m bgl (7490 ± 90 yrs BP) and the embedding sediments (7480 ± 80 yrs BP) indicate quick burial of the riparian vegetation. The West Kallada borehole reveals middle to late Holocene sequence of clayey silt (6250 ± 110 yrs BP–3880 ± 80 yrs BP) and sand resting unconformable over greyish white, clayey sand with pebbles and granules derived from laterite provenance. Palynological analysis shows that the Holocene sedimentation took place under marine/nearly marine environment and later changed to brackish water and finally to freshwater environment. Marine transgression approximately 6000 yrs BP coupled with heavy rainfall in the hinterlands was responsible for faster sedimentation in the region. The heavy mineral contents, especially opaque, garnet and sillimanite in the sediment samples of the study area as well as the
bathymetric configuration of the Ashtamudi, Sasthamkotta and Chelupola lakes reiterate the fact that these lakes have been evolved from an embayment consequent to incomplete/partial silting up during early to middle Holocene higher sea levels and high rainfall of the Holocene climatic optimum of around 10,000–7000 yrs.

Balakrishna Nair (1983) studied the ecology of Indian estuaries; distribution of organic carbon in the sediments of Ashtamudi estuary. The organic carbon varies from 0.06 to 4.95%.

Kameswara Rao (1996) studied the distribution of foraminifera in the Cochin estuary in different seasons. The abundance and total number of foraminifer species are poor during SW monsoon when the area becomes less saline due to influx of fresh water through riverine input, but fairly rich in other seasons for prevalence of marine conditions. The sediment texture has a bearing on the faunal density.

Raha studied the mineralogy and micro chemical properties of foraminifera tests of the Quilon Formation in Kerala. Foraminifera test of Quilon Formation indicate that different proportions of calcite, low magnesium calcite, quartz and montmorillonite. Mineralogical and chemical variations in Sr, Ba, Na, K, Mg and other trace elements are reported to understand their usefulness in stratigraphy correlation of paleo environment.

ShajanKuttickat Paul (2001) studies the geochemistry of bottom sediments from a river-estuary-shelf mixing zone on the tropical southwest coast of India and inferred that the higher concentration of Fe, O, Mgo, P, O/, Zn, Ba, Pb, Cd, Bi and Cr in many samples indicates that all the sampling units are anthropologically contaminated, With the Periyar River and its estuarine area showing maximum heavy metal contamination in the study area.
Nagendra et al (2010) documented 28 recent benthic foraminifer species from the Ashtamudi estuary and attributed low faunal diversity and reduced population to the coir retting activities in the estuary proper.

2.2 INTERNATIONAL

The opinion on the eustatic sea level changes during the last 10,000 years (the Holocene) is rather divergent (Jelgersma 1966). Pirazzoli 1991, proposed three possibilities: They are (i) an oscillating eustatic sea level (ii) a steady sea level after 5000 BP and (iii) a continuously rising sea-level. Subsequently, investigators around the world have adhered to one or other of these possibilities. After compilations of age/altitude graphs of sea-level curves from different areas (Morner, 1976b), Hoplely (1978), Edward (1980) recognized considerable range and variety of regional sea-level curves. As a result of eustatic rise in sea level, wide assemblages of bivalves and univalve mollusks got accumulated in the coastal deposits of many part of the world. They are considered as well-known geo-scientific tool in deciphering the palaeosea level stands. In general, the faster the sea level raises, the higher the possibility of bivalve and univalve burial, drowning or destruction. The faster the fall in sea level, probability of the preservation of depositional bodies such as beach ridges and coastal dunes. Utilizing the interplay between the inland marine shells and submerged deposits, Fairbridge (1976) was able to reconstruct episodes of transgression and regression and established the sea level curve for the area.

In Europe, North America, Africa and Australia, a detailed geomorphological, palynological, micropaleontological and geoarchaeological studies of the Quaternary deposits have helped in the reconstruction of different paleogeomorphic environments (Schumm 1977; Goudie 1977; William & Faure 1980; Butzer 1980). Such studies have clearly demonstrated the complexities involved in the interpretation of continental sediments and
identified the problems encountered in establishing the reconstruction of Quaternary Paleogeography. Seminuk (1981) and Eronen et al (1987) utilized the stratigraphic sequences of tidal flats and swampy environments to deduce past climatic conditions and Holocene sea level fluctuations. In their pioneering work, Curray & Moore (1964) illustrated the formation of beach ridges and their importance in elucidating sea level changes. Seminuk (1983) and Tanner (1992, 1993) emphasized the importance of beach ridge in deciphering various stages of evolution of the coastal plain.

YT-Maw Chang (1974) reported the foraminifer *Ammonia beccarii* (Linné) from Holocene environments of the Atlantic coast of the United States in order to define its morphological variation and to determine the possible causes of the variation. 45 morphological characters were measured from each of 221 specimens from two areas located in the northern and the southern portions of the coast. Comparison of characters indicated that many of the characters are inter correlated, and each character has different significance in revealing the geographical variation of morphology. Statistical analysis showed that among the characters measured, proloculus size and umbilicus size have relatively large variation among samples and small variation within samples.

Boltovskoy (1991) studied the morphological variations of benthic foraminifera tests in response to changes in ecological parameters. Recent literature correlating morphological variation in benthic foraminifera with environmental parameters such as temperature, salinity, carbonate solubility, depth, nutrition, substrate, dissolved oxygen, illumination, pollution, water motion, trace elements, and rapid environmental fluctuation is reviewed. The broad trends concern thinning or thickening of carbonate tests with changing carbonate availability, temperature, and salinity.
Longyin Li (2000) worked on Foraminifera response to Holocene environmental changes of a tidal estuary in Victoria, southeastern Australia. The foraminifera fauna show a clear response to these palaeo environmental changes. *Globigerina bulloides* can be used as an indicator for cold water marine environments. The high concentration of this species in these middle Holocene sediments shows a strong cold water influence on the coastal environments which reduced the effect of regional warm currents during this period. The Holocene palaeo environmental changes in the area were controlled by the Holocene sea-level fluctuations associated with the deglaciation history during this period. Similar integrated studies of shallow to marginal marine strata in southern Africa, America and New Zealand will lead to a better understanding of Holocene relative sea-level change and the interplay between Holocene cold and warm water regimes in the southern hemisphere.

Haslett (2001) reported the palaeo environmental implications of the distribution of intertidal foraminifera in a tropical Australian estuary. The modern intertidal foraminifera were investigated in a mangrove-lined micro tidal distributor channel of the Barron River Delta (Cairns, Queensland, Australia). A mono specific assemblage of *Trochammina inflata* characterizes salt marsh environments, inundated tidal flat is dominated (>55%) by *Ammonia beccarii*. Within the tidal flat environment, two foraminifera subdivisions are recognised; a high tidal flat assemblage characterized by >70% *Ammonia beccarii* and low diversity, and a low tidal flat assemblage with 55–65% *Ammonia beccarii* and high diversity (due to the settling out of small allochthonous species transported into the estuary from shelf environments). Foraminifera distributions are compared with tide levels estimated in the field. The foraminifera possess a significant potential in palaeo environmental studies of tropical Australian estuaries as indicators of intertidal environments.
Pinxian Wang (2001) studied the foraminifera as Holocene environmental indicators in the South Alligator River, Northern Australia. The surface sediments and Holocene deposits from the South Alligator River, northern Australia, are examined to evaluate the usefulness of estuarine foraminifers for palaeo environmental interpretation of sediments deposited in tropical macro tidal conditions. Although marine and estuarine foraminifers in the estuarine channel are mixed by strong tidal currents, there are significant trends along the 80km length of the tidal river. The relative proportions of marine and porcellaneous taxa decrease upstream from the mouth, but hyaline taxa and those with brackish affinities increase upstream. Foraminifers in intertidal sediments have distinctly different assemblages in the uppermost intertidal, mid-tidal (mangrove), lower intertidal and sub-tidal zones. Foraminifers are found to improve the precision of palaeo environmental reconstructions made on the basis of sedimentary facies and pollen analyses.

Pascual (2002) studied the late Holocene pollution in the Gernika estuary (southern Bay of Biscay) evidenced by the study of foraminifera and ostracoda The Arketas pier in the Gernika estuary (southern Bay of Biscay) has during summer periods waters with strong hypoxia (<1ml l⁻¹) but curiously bears the richest assemblages of foraminifers and ostracods in the whole estuary. The abundant species in Arketas are: Ammonia beccarii, Cribroephidium williamsoni, Haynesina germanica and Lobatula lobatula (foraminifers) Loxocon chaelliptica and Leptocytherecastanea (ostracods). The benthic foraminifer sub-species A. beccarii tepida exhibits in this estuary three different morphotypes, whose distributions are controlled by changes in the salinity, dissolved oxygen and nutrient content of the waters, and thus could be used as an indicator of environmental alteration caused by those parameters. The study of foraminifera and ostracoda assemblages, species diversity, and A. beccarii tepida morphotypes used to reconstruct the evolution of this part of the estuary over the last 3800 years. During the late
Holocene (up to 3500 years BP), this site was a middle-outer estuarine settlement, euryhaline with low to moderate salinity. This episode ends with a marine transgressive pulsation. After depositional hiatus of unknown duration, recent sediments suggest a modern palaeogeographic position of Arketas located in a lower estuary environment.

Caterina Morigi (2005) published a paper on benthic foraminifera evidence for the formation of the Holocene mud-belt and bathymetrical evolution in the central Adriatic Sea. The modern and fossil benthic foraminifera assemblages are used to reconstruct the environmental changes that occurred between the Last Deglaciation and the Present (last 14 Kyrs); in particular timing and formation of the mud-belt. The modern benthic foraminifera assemblages display a parallel zonation to the Italian coast controlled by the interaction between food/oxygen availability and water depth. The cluster analysis and contemporary distribution patterns of these taxa are used together with ecological preferences of the frequent species to reconstruct the spatial and temporal distribution of the different biofacies in the past. This reveals information about Holocene palaeoenvironmental changes that are related to water depth fluctuations. The benthic assemblage records the transition from an infra littoral environment to deeper marine condition.

Ruiz (2005) reported the correlation between foraminifera and sedimentary environments in recent estuaries of south-western Spain. The author has addressed the multivariate analysis of the foraminifera collected in three estuaries of south-western Spain (Guadiana, Piedras, Tinto-Odiel) and recognized three foraminifera assemblages, with spatial distribution, depending on sedimentary environments, grain size classes and salinity variations. Assemblage 1 (*Trochammina inflata, Jadamminamacrescens*) is typical of salt marsh deposits with high salinity variations and percentages of
important silt. Assemblage 2 (*Ammonia beccarii*, *Ammonia tepida*, *Astrononion stelligerum*, *Elphidium williamsoni*) includes the abundant estuarine species, with increasing densities from the channel margin to the subtidal channel. Assemblage 3 (*Quinqueloculina seminulum*, *Elphidium crispum*) is found in the sandy sediments of the subtidal channels located near the mouth, with normal marine conditions. These results and the sedimentological interpretation of seven drill cores of the Domingo Rubio Channel (Tinto River) reconstruct the palaeogeographic changes of estuary in the last ca. 6500 $^{14}$C years BP. Seven phases were distinguished, with an evolution from an open marine bay to a very restricted channel limited by broad salt marshes.

Luli Gustiantini (2007) reviewed the paleo environmental reconstruction from benthic foraminifera assemblages of early Holocene, shallow marine deposits in Gombong, central Java. A 30m-long sediment core covering the Holocene period was taken from the area of Gombong in the southern part of Central Java. The sediments were deposited in a shallow marine to lagoon environment that was confirmed by the dominance of *Ammonia beccarii* along the core intervals. In addition, the species *Quinqueloculina poeyana*, *Miliolinella lakemacquariensis*, and *Miliolinella subrotunda* were found in the sediments that are typical of normal shallow marine conditions. The decrease and increase in the abundance of these species throughout the core is an expression of sea level change in the area, which results the environmental changes. Low sea level is expressed by the dominance of *Ammonia beccarii*, and the low abundances or absence of the other three species. In contrast, high sea level stands are reflected by the presence of all four species. The high sea level would imply favourable conditions for benthic foraminifera because it would result in normal shallow marine conditions in the area.
In this chapter the foraminifera and its applications in different environment related literature reviewed in national and international research papers and identified the gap of research in the area of distribution of foraminifera and its affiliation to environment and to read the Holocene sedimentation in the study area along Kerala coast covering Ashtamudi estuary, Kayamkulam lagoon, Kayamkulam offshore and Kollam onshore platform, west coast of India.

The foraminifera assemblages in sediments of present day estuary/lagoon, offshore, and coastal plains environments are the direct physical clue in deciphering the geological past, paleoecology, paleoclimate, sea water chemistry, nature of sediment substratum and depositional environment. Concept of present is the key to the past, the recent sediment-faunal assemblages are studied to reconstruct the Holocene environment prevailed in the Ashtamudi estuary, Kayamkulam lagoon and off shore and Kollam coastal plain, part of southern Kerala coast. The qualitative and quantitative studies of foraminifer and its spatio-temporal distribution lead to the geological history and sedimentation system. This science deciphers the evolution of coastal zone landforms with time and space.
**Methodology Adopted for the PhD Thesis Work**

**SPATIAL TEMPORAL DISTRIBUTION OF FORAMINIFERA ASSEMBLAGES IN THE COASTAL PLAIN, ESTUARY AND LAGOON SEDIMENTS OF SOUTHERN KERALA, INDIA**

### Significance and need for the research

1. Literature review reflects the lack of scientific data on foraminifera responses and its implication to understand coastal and sea environment of southern Kerala.
2. The qualitative and quantitative analysis of foraminifera forms are the basic data for evaluation of coastal environment and shoreline changes during Holocene period.
3. Biotic responses to the present day pollution effect along the coastal zone.

### Objectives

1. To investigate the quantitative and qualitative analysis of foraminifera assemblages in Ashtamudi estuary, Kollam coastal plain, Kayamkulam lagoon and offshore area and its implication to shoreline changes.
2. To correlate the diversified coastal and sea environment properties using foraminifera assemblages.
3. To record the relationship of heavy metal concentration and its responses to the foraminifera abundance and modification. Implication to pollution along the shoreline of southern Kerala.

### Study Area

1. Ashtamudi Estuary
   - Core+Grab sample/Borehole (BH-1) Core (K-1)
   - (A+15 + 20 station spatially)

2. Kollam coastal plain
   - Core+Grab sample/Borehole (BH-1) Core (K-1)
   - (A+15 + 20 station spatially)

3. Kayamkulam lagoon
   - Core (QQ-1 and KQ-5)

4. Offshore (Kollam and Kayamkulam)
   - Core (QQ-1 and KQ-5)

### Sediments Characteristics

- Sand, Silt and Clay fractions
- Calcium carbonate
- Organic matter

### Benthic foraminifera records

- Cluster Analysis
- Biotope
- Organic Matter Vs Benthic Foraminifera
- Relationship between CaCO3, OM and TBF

### Heavy metal concentration response to the foraminifera quantitative and qualitative records

- Fe, Co, Cu, Mn, Pb, Cr Analysis
- Relationship between Heavy metal and Foraminifera distribution

### Inference

1. Documentation of Benthic foraminifera for four different environments.
2. Abundance and frequency in relation to sediments, substrate of coastal and sea environments.
3. Evaluation of Estuary and shoreline changes.