4. REVIEW OF LITERATURE

The order Amphipoda is an important group in the zooplankton under the class Crustacea. Rabindranath (1971) investigated the amphipods from the Southern Indian region and identified two new species of haustoriid amphipods. He also studied the gammaridean amphipods especially of the family Ampithoidae (1972), Amphilocheidae (1972), Ampeliscidae (1975) and a new species of Podocerus (1972). Nair (1972) observed a swarm of amphipods along the South West coast of India and studied the distribution and relative abundance of Paraphronimidae (Hyperiidae) in the Indian Ocean. Nair et al. (1973) made a detailed study on the distribution and abundance of planktonic amphipods in the Indian Ocean and investigated the population dynamics of estuarine amphipods in the Cochin backwaters while Nair and Jayalakshmy (1992) studied the distribution of Oxycephalidae in the Indian Ocean. Sivaprakasam (1969 & 1970) observed four new amphipods in the collections from the Gulf of Mannar, he studied Gammaridea and Caprellidea from the East Coast of India. He observed a new species of Idunella demersalis, Atylus processicer from Gulf of Mannar and he also studied the Leucothoid amphipod from the Madras coast. Asari and Myers (1982) made taxonomic studies on the genus Grandidierella and described five species from India, while Asari (1983) studied on two new species of gammarids from Andaman and Nicobar Islands. He studied the biology of brackishwater gammarid amphipods, Eriopisa chilkensis and Idumella chilkensis. The amphipods of the family Hyperiidae for the International Indian Ocean Expedition, 1959-1965 was studied in detail by Thomas and Maura (1982) and they noticed that the family which comprises about 45% of the amphipoda contained 15 species.
4.1. Hydrobiology

Many reports are available on the physico-chemical features of Indian estuaries (Goindasamy et al., 2000; Rajasekar, 2003; Balasubramanian and Kannan, 2005; Paramasivam and Kannan, 2005; Rajaram et al., 2005; Ajithkumar et al., 2006; Asha and Diwakar, 2007, AshokPrabu et al., 2008, Saravanakumar et al., 2008; Gowda et al., 2009; Vengadesh et al., 2009). Many studies have been carried out so far on sediment nutrients from various estuaries of India (Ramani et al., 1980; Murthy and Veerayya, 1981; Sivakumar et al., 1983; Sesamal et al., 1986; Nair et al., 1987; Satyanarayana et al., 1993; Seralathan et al., 1993; Rajasekar et al., 2002). Bragadeeswaran et al. (2007) were studied the sediment texture and nutrients of Arasalar estuary, Karaikal from South East coast of India. Seasonal variations in physico-chemical characteristics of Pichavaram mangroves were studied by Ashokprabu et al. (2008). In different mangrove regions, physico-chemical aspects were noticed by Srilatha et al. (2013).

From the Pondicherry mangroves the seasonal variations in physico-chemical parameters of water and sediment characteristics were studied by Satheeshkumar and Anisa Khan (2009). Asha and Diwakar (2007) explained the hydrobiology of the inshore waters off Tuticorin in the Gulf of Mannar. The assessment of spatial and temporal fluctuations in water quality of a tropical permanent estuarine system from Tapi, West coast of India were studied by Nirmalkumar et al. (2009). Paul (2012) has described the seasonal variation in water temperature on the South East coast of Tamilnadu. Manikannan (2011) explained the seasonal variations of physico-chemical properties of great Vadaranyam Swamp, Point Calimere Wildlife Sanctuary, South East coast of India. Sundaramanickam et al. (2008) have studied the physico-chemical characteristics of water from the Parangipettai and Cuddalore coast.
4.2. Ecology

Raja et al. (2013) have described 44 species belonging to 29 genera and 17 families from the continental shelf sediments of South East coast of India. Satheeshkumar (2011) identified seven amphipods crustaceans from Pondicherry mangroves (South East coast of India comprises of Eriopsia chilkensis, Eriopisella sp., Melita dentada, Grandidierella bonnieroides, G.pathy, Cymadusa pathyi and Isaei montagui. Varadharajan et al. (2010) described nine species of amphipods from Arukkattuthurai to Aiyyampattinam, South East coast of India with seasonal abundance of macro benthic composition and diversity. Mondal et al. (2010) described 29 species of gammarid amphipods collected from Vellar and Uppanar estuaries in different habitats which includes sediments, oyster, seaweed, seagrass and mangrove ecosystem. A detailed study on intertidal amphipods from the Indian coast was carried out by Surya Rao (1972) he dealt with 132 species belonging to 54 genera of gammaridean amphipods in which 111 species are found exclusively in intertidal region, 11 species common to intertidal and plankton, 7 species to intertidal and benthic and three species are common to all the habitats ie. intertidal, pelagic and benthic. Geetha and Nandan (2014) have identified six species of amphipods from Gammarus tigrinus, Corophium volutator, Psammogammarus sp., Eriopisa chilkensis, Microdeutopus sp. and Jassa falcate. Asari (1983) described two new species of gammarids amphipods includes Victoriopisa papiae and Quadrivisio lobata. Nair et al. (1983) studied on population dynamics of estuarine amphipods in Cochin backwaters where they have described 11 gammarid amphipod species belonging to 9 genera. Studies on the amphipods of the Indian and the neighboring waters received the attention of Zoologists only as late as 1885 when reported on the occurrence of two species of amphipods from Bengal. The subsequent works raised the number to 27 by Giles (1958). Barnard (1935) reported amphipods from the collection made from Travancore,
Cochin and Bengal coasts by the Zoological Survey of India, apart from the record of three species of amphipods off the coast of Mahabalipuram by Giles (1958) and a brief note about the occurrence of three species of amphipods at Adyar in Madras, in the last half of previous century, Sivaprakasam (1969) in a series of contributions enriched knowledge on the amphipods of East coast of India and listed 61 species. Nayar (1959) dealt with the amphipods of the Madras coast and Gulf of Mannar. In his monographs on the gammaridean amphipods of the Gulf of Mannar he dealt 78 species of 26 families. Surya Rao (1972) enumerated a detailed account of the intertidal gammarid amphipods from the Indian coasts and listed 132 species pertaining to 54 genera.

Availability of seaweeds and algae is an important determining factor to the species composition and the diversity of gammaridean amphipods in the brackish water environments (Fenchel and Kolding, 1979). Genus *Elasmopus* from Mauritius with description of five new species were described by Appadoo and Myers (2003). Krapp-Schickel *et al.* (2010) were explained the taxonomy and ecology of some gammaridean amphipod species from Tarifa Island from Southern Spain. Information about the tropical brackish water gammarids are scarce in India. Few studies have been performed about tropical gammarids amphipods (Balasubramaniyan, 1961; Sivaprakasam, 1969; Nair *et al.*, 1973; Balasubramaniyan and Srinivasan, 1987).

Barnard (1935) had worked on the amphipods from the waters of Travancore, Cochin and Bengal coasts from the collections of Zoological Survey of India. Life history of amphipods are known to us from the accounts given by Sexton and Mathews (1913) and Sexton (1924). Amphipoda of the Madras coast was studied by Nagappan Nayar (1959). Shyamasundari (1973) studied the effect of salinity and temperature on the tube-building amphipod *Melita zeylonica* in
India. Morine (1978) classified breeding activity and life history into four categories and concluded that low latitude species tend to breed throughout the year and have short life spans. Nair and Anger (1979 a,b) studied the life cycle of *Corophium insidiosum* and *Jassa falcata* using laboratory culture. Nelson (1980) reviewed the reproductive pattern of 65 species of gammaridean amphipods. Asari (1983) has studied the biology of *Eriopisa chilkensis* and *Iduella chilkensis* from mangrove of Pitchavaram. Work done on gammarid amphipods of Cochin backwaters by Nair *et al.* (1983) gives an account of the ecology and population dynamics of this group.

Studies on bottom fauna in India was first made by Annandale (1907), Peterson (1913) and Annandale and Kemp (1915). The benthos of Malabar and Trivandram coasts were studied by Seshappa (1953) and Kurian (1953) respectively. Kurian (1967) has given an account of benthos of South West coast of India. Work on benthos of the mud banks of Kerala coast was done by Damodaran (1973). Macrobenthic polychaetes along the shelfwaters of the West coast of India was studied by Joydas and Damodaran (2001). Macrobenthos of the shelf waters of the West coast of India was studied by Joydas (2002). Kumar *et al.* (2004) has studied the macrobenthos in relation to sediment characteristics of nearshore waters, West coast of India receiving industrial effluents.

The bottom fauna of Cochin backwaters was studied by Desai and Krishnan Kutty (1967). Kurian (1972) has worked on the ecology of benthos in Cochin backwaters. Ansari (1974) has investigated the macrobenthic production in the Vembanad lake. Bottom fauna of the Vembanad lake was studied by Kurian *et al.* (1975). Bottom fauna of north Vembanad lake was studied by Batcha (1984).
The spatial and temporal distribution of benthos in northern limbs of Cochin backwaters was made by Saraladevi and Venugopal (1989). Saraladevi et al. (1991) have given an account of the benthic communities and co-existence of species in the Cochin backwaters. Benthic ecology of the prawn culture fields in the northern and adjoining areas of Cochin backwaters was studied by Aravindakshan et al. (1992). Fauna of the mangrove swamps of Cochin was studied by Sunilkumar (1993). The community study on the community structure and distributional ecology of benthos in the mangrove swamps of Cochin estuary was made by Sunil Kumar (1995). The effect of dredging on benthic fauna in and around Cochin harbour was studied by Rasheed (1997).

*Eriopisa chilkensis*, estuarine gammarid amphipod which was first recorded from Chilka lake by Chilton (1921) and Asari (1983) studied the biology of *E.chilkensis* and reported that they are suspension feeders feeding on organic-rich detritus. Work done on the gammarid amphipods of Cochin backwaters by Nair et al. (1983) gave an account of the ecology and population dynamics of this group.

### 4.3. Amphipods of the East Coast

Studies on the amphipods of the Indian and the neighboring waters received in the attention of zoologists when Giles (1958) published paper on the occurrence of two species of amphipods from Bengal. Along the East coast investigations on amphipods were carried out mainly by Nayar (1966). He made a detailed study on the gammaridean amphipods of the Gulf of Mannar with special reference to those of the pearl and chank beds. In the inshore waters off Mandapam, amphipods occurred during February-May and July-November which were mostly hyperids (Prasad, 1956). The amphipods are found to get associated with seaweeds in nature and a detailed study in this line was carried out by James et al. (1986). They were found associated
with cultured seaweed *Gracilaria edulis* in the coastal waters of the Palk Bay and the Gulf of Mannar. In the stomach contents of fishes and crabs captured from these seaweed culture sites amphipods also were observed. In the inshore waters of Tuticorin, amphipods were noticed during March-June and October-November periods in negligible proportions (Marichamy *et al.*, 1987). The studies on amphipods was extended to Kakinada Bay where they formed less than 0.2%, *Hyperia* spp. and *Corophium* spp. being the common forms (Narasimham *et al.*, 1984).

Anbuchezhian *et al.* (2010) have reported 33 species of nematodes which emphasis the composition and seasonal fluctuations at Palk Bay, South East Coast of India. Seven species of amphipods have been noted from the intertidal seagrass ecosystem from Pulicat Lake by Nesakumari *et al.* (2014). Biodiversity of Vellar and Uppanar estuaries of brackishwater amphipods have studied by Mondal *et al.* (2010) which includes premonsoon and post monsoon season from the sediments, oyster beds, seaweeds, seagrass and mangrove ecosystems and 29 species of amphipods recorded in each areas. The range of species diversity, richness, dominance and evenness also noted. The ecology, diversity and abundance of macrobenthic crustaceans in Cochin estuary studied by Geetha and Nandan (2014) and six species of amphipods viz., *Gammarus tigrinus*, *Corophium volutator*, *Psammogammarus* sp., *Eriopisa chilkensis*, *Microdeutopus* sp. and *Jassa fatcata* were the representative species.

### 4.4. Amphipods of the West Coast

Among the work carried out along the West coast the contributions by George (1958), Pillai and Pillai (1974), Silas and Pillai (1977) and Rajagopalan *et al.* (1992) are remarkable. In the Cochin backwater the more important species noticed were *Corophium triaenonyx*, *Photis longicaudata*, *Periculodes longimanus*, *Eriopisa chilkensis*, *Grandidierella* sp. and *Hyperia* sp. (George, 1958). The abundance of amphipods in the night collections was recorded by Pillai and
Pillai (1974) and this abundance was irrespective of the hydrobiological conditions and the state of the tide. In Cochin backwater, Pillai (1977) studied the macrobenthos and noticed a rich fauna of amphipods and a maximum of 6850/m$^2$ was recorded at a station in December and the dominant from *Grandidierella megnae*. Pillai *et al.* (1977) observed maximum amphipods in the Vembanad lake and adjacent waters during December-January and absence during February-June; while abundance was recorded during post monsoon season, rare during pre monsoon and apparently absent during monsoon (Silas and Pillai, 1977). They observed the amphipod species *Corophium triaenonyx, Photis longicaudata, Perioculoides longimanus, Eriopisa chilkensis, Grandidierella* sp. and *Hyperia* sp. During high tides at Thoppumpady of the Cochin backwater, amphipod was one of the major group which were more in the bottom waters during the full moon days in January (Rengarajan and David Raj, 1984). Rajagopalan *et al.* (1986) observed amphipods in the tidal pools and creeks of the mangrove ecosystem of the Cochin backwaters. Nair *et al.* (1983) recorded 11 species of estuarine amphipods from Cochin backwaters.

Amphipods are found to be one of the major group in the mangrove ecosystems in Cochin area (Shajina and Bala, 1993). On sandy beaches when pursued, amphipods dig rapidly into the sand, head first and disappear quickly (Prasad, 1958). In the coastal waters of Calicut, George (1953) observed amphipods soon after the onset of the monsoon and thereafter only nominally present. The more common forms he observed belonged to the family Hyperiidae. In Vizhinjam also amphipods were sparingly present (Rani *et al.*, 1986). At Colochel, Suseelan *et al.* (1985) noticed *Hyperia* sp. that too negligible numbers. In the shallow waters of Karwar bay a swarm of amphipods *Atylus minikoi* (Walker) is reported (Naomi, 1979) to occur and in the inshore waters of Karwar the common amphipods were gammarids especially during August-October. At Kandla in the Gulf of Kutch region it was present during February-April
Along the Bombay coast, Pillai (1970) observed that the common amphipods present were *Hyperia* sp. and *Primno* sp. The former species being fairly abundant during the months of November, February and March while *Oxycephalus* sp. and *Simorhyncotus* sp. were observed only during the May and February respectively. Month wise occurrence of amphipods in the shelf waters off Bombay showed its availability in October, March, September and November (Radhakrishnan and Pillai, 1985), while Pillai and Bhat (1987) noticed amphipods to form 0.4% of the zooplankton during the post monsoon months along the North West coast of India.

Studies on the diurnal variations in the distribution of amphipods in the mud bank at Purakkad-Thottappally region south of Alleppey in Kerala, during May and August were carried out by Mathew *et al.* (1977) and noticed its presence in moderate numbers in August (0.8%) but during May it was poorly represented.

### 4.5. Amphipods of oceanic regions

Pelagic amphipods under the families Vibiliidae, Paraphronimidae, Hyperiidae, Phronimidae, Phrosinidae, Lycaeopsidae, Proronidae, Lycaeidae, Brachyscelidae and Platyscelidae in the collections of CMFRI made on board R.V.Varuna from Arabian Sea were studied in detail with species wise illustrations and descriptions by Pillai (1966). The occurrence of amphipods in the EEZ of India and adjoining seas was investigated by Revikala *et al.* (1990), based on samples collected during the cruises of FORV Sagar Sampada and the observations were amphipods at an average rate of 2278/1000m$^3$ occurred in the shelf waters off the West coast, only 1501/1000m$^3$ occurred in the same area off the East coast. On the other hand, in the oceanic region the numerical abundance was relatively low being 1014/1000m$^3$ off the West coast and 925/1000m$^3$ off East coast indicating that the amphipods were abundant in the shelf.
waters of the West coast than other organisms. The faunal distribution in the DSL of the EEZ of India was investigated by Revikala (1996). According to her studies the amphipods of this area belonged to 13 families viz. Cystisomatidae, Oxycepalidae, Pronoidae, Anapronoidae, Vibilidae, Lycaedae, Lycaeopsidae, Phronimidae, Platyscelidae, Phrosinidae, Scinidae, Lanceolidae and Hyperiidae. In the lagoons and open sea of Lakshadweep, amphipods constituted less than 1% of the zooplankton in Kadmat, Kiltan, Chetlat, Agatti, Kalpeni, Bangaram, Bitra and Kavaratti islands (Girijavallabhan et al., 1989). But Silas (1972) noticed contribution of amphipods as 2% of the total zooplankton in the deep scattering layers in the Lakshadweep Sea. He also studied the day and night variations and observed 77% at night and rest in daytime collections. In the coastal waters of Andaman and Nicobar islands amphipods were recorded in all collections but only in negligible ratios (Marichamy, 1983). And elaborate study on the quantitative distribution and abundance of amphipods in the Andaman Sea in space and time was carried out by Varghese et al. (1996). The seasonal density was maximum during the North East monsoon and minimum for the South West monsoon and their mean numbers were estimated as 812 and 463 per 1000m$^3$ of water respectively.

4.6. Amphipods of Antarctic waters

CMFRI has participated in the third Antarctic Expedition and amphipods along with other zooplankters in that region were studied. Daily variations in the abundance of amphipods in the coastal waters off Queen Maud Land, Antarctica was investigated from mid summer to the beginning winter. Regarding spatial distribution of amphipods in the Antarctic waters, a highly patchy, with a meager representation of less than 1% of the total zooplankton was observed (Mathew and Vincent, 1986).
4.7. Foreign waters

Lowry (2000) has recorded amphipods of South China Sea comprises of 48 families, 113 genera and 272 species. Based on these studies 31 gammaridean families, 67 genera and 153 species have been recorded from Central Western and North Western South China Sea, these area were Hong Kong, Vietnam and The Philippines. Ingolfsson and Agnarsson (2003) have studied the zonation of amphipods and isopods on rocky shores in South Western Iceland at low tide as well as sampling during high tide. *Anonyx sarsi* was common around in high tides, absent in intertidal low tide. Darakrai and Pholpunthin (2009) explained new species of Tethygeneia and new record of algae-living gammarid amphipods in South Sea islands, Marine National Park, Nakhon Si Thammarat Province from Thailand. Vainola et al. (2008) described the global biodiversity of amphipod species, the distribution and abundance of hyperiid amphipods from the Mexican Carribean sea has studied by Gasca and Morales in 2004.

4.8. Culture

The life cycle of *Corophium insidiosum* was studied by culturing in the laboratory (Nair and Anger, 1979). Shyamasundari (1972, 1973, 1988) studied the salinity, temperature and oxygen consumption in relation to salinity and temperature and the developmental stages of the tube building amphipod *Corophium trianoyx* from Visakhapatinam harbor. Lalitha et al. (1988, 1989, 1990) made detailed studies on the littoral hopper *Talorchestia mariensii* effect of salinity and temperature, the embryonic development and effect of salinity and temperature on the development of eggs. She also studied the annual life cycle of the talitrid amphipod, *Orchestia platensis*.

Laboratory studies on the reproduction and growth of the amphipod (*Gammarus pulex*) was carried out by Welton and Clarke (1980). Life histories of the amphipods *Lempos wessteri*
Bate and *Corophium bonnelli* was studied by Moore (1981). Sainte Marie (1991) reviewed the reproductive binomics of aquatic gammaridean amphipods. Steele and Steele (1991) pointed out that tropical species are characterized by small size, low fecundity, short brood intervals and multivoltine life cycle. Life history traits of 214 amphipod species were reviewed by Sainte Marie (1991) and stated that life history patterns of gammarid amphipods are influenced by latitude, depth and salinity. Life history of the amphipod *Gammarus lacusta* in the Sado estuary was studied by Costa and Costa (1999). Cunha *et al.* (2000) studied the life history and reproductive biology of *Corophium multisetosum* and stated that low-latitude, warm-water amphipods show iteroparous, multivoltine life history patterns. Chandani and Alan (2004) studied the reproductive bionomics and life history traits of three gammaridean amphipods *Cymadusa filose*, *Ampithoe laxipodus* and *Mallacoota schellenbergi* from the tropical Indian Ocean and reported multivoltinism and continuous reproduction.

Amphipod adaptation and continues reproduction in the new environment are the main factors for success. The dependence on adequate natural prey such as mysids, which are expensive to culture, has been one of the bottlenecks for the large scale culture of cephalopods such as cuttlefish. Less expensive live prey could reduce considerably production costs and enable large scale culture. Amphipods (gammarids and caprellids) are among the most adaptable species in the world. Due to their opportunistic feeding, fast growth and reproductive cycles, their culture would be considerably less expensive compared to mysid culture, which requires a constant supply of *Artemia* nauplii for their culture. This would make them good candidates to be used as first live prey for cuttlefish hatchlings and greatly reduce production costs (Baeza-Rojano *et al.*, 2010).
Tsoi and Chu (2005) studied the sexual dimorphism and reproduction of the amphipod *Hyale crassicornis*. Prato *et al.* (2006) observed the postembryonic growth, development and reproduction of *Gammarus aequicauda* in the laboratory culture. The intertidal macroalgae as refuge and food for amphipods in Central Chile was investigated by Bushmann (1990). Agnew and Taylor (1986) observed the effects of oxygen tension, temperature, salinity and humidity on the survival of two intertidal gammarid amphipods. The effects of different salinities on juvenile growth of *Gammarus aequicauda* was carried out by Delgado *et al.* (2011). The influence of temperature and salinity on the duration of embryonic development, fecundity and growth of amphipods *Echinogammarus marinus* has studies by Maranho and Marques (2003). Life history, population dynamics of an estuarine amphipod *Eriopisa chilkensis* was done by Aravind *et al.* (2007).

Few studies have been carried out on the live feed potential of amphipods. Baeza-Rojano *et al.* (2013) studied the culture of amphipod *Caprella scaura*. Amphipods (marine gammarids) also used as a live feed (live prey) for the hatchlings of the *Octopus maya* (Baeza-Rojano *et al.*, 2012). Baeza-Rojano *et al.* (2014) have explained the nutritional analysis of freshwater and marine amphipods from the Strait of Gibraltar and their potential applications.

4.9. Biochemical analysis

Krishnan and John (1974) have observed that the brackish water amphipod *Melita zeylanica* breeds throughout the year in India. Asari (1983) has studied the biology of *Eriopisa chilkensis* and *Idunella chilkensis* from mangroves of Pitchavaram, India and the fodder organisms like amphipods and tanaidaceans, support the growth and production of estuarine fishes and prawns. Seasonal variation in population structure and biochemical composition of *Jassa falcate* was studied by Nair and Anger (1980).
E.chilkensis was first recorded from Chilka Lake by Chilton (1921) and Asari (1983) has studied the biology of E.chilkensis and reported that they are filter feeders feeding on organic rich nutrients. This investigation was designed to find out whether this species could be cultures in large numbers economically to be used as a feed for fish culture. They are detritivores and it is an important food source for many fishes, invertebrates, crabs and many other organisms.

Freshly hatched Artemia salina are the most commonly used source of the food for the culture and crustacean larva. Wickins (1972) found that Artemia nauplii can be converted into valuable source of food for prawn larvae (Palaemon serratus) by feeding the larvae which has been cultured for a maximum of four days on live algae. Rotifer and Artemia are the first feed for fish larvae due to inappropriate size (too large or too little). Moreover, both food items may not elicit a feeding response, are difficult to capture and their swimming behavior makes them less susceptible to predation. Because of these problems, there has been a great interest in the identification of alternative live feeds to increase the variety and survival of aquaculture species that can be cultivated. There have been a number of studies done providing evidence of the effectiveness of copepods as a food item, and many investigators have obtained good growth and survival of fish larvae and crustaceans when fed with copepods as test food organisms.

Steele and Steele (1991) pointed out that tropical species are characterized by small size, low fecundity, short brood intervals and multivoltine life cycle. On the other hand low latitude species are characterized by semi-annual or annual life histories, small body size and high reproductive potentials (Sainte Marie, 1991).

This investigation was designed to find out whether this species could be cultured in large numbers economically to be used as a feed for fish culture. They are detritivores and it is important food source for many fishes, invertebrates, crabs and many other organisms. The
deposit feeding benthic amphipods that were previously classified in the genus *Pontoporeia* (Bousfield, 1989) accumulate lipid. It is an important prey item.

Oil droplets have been observed in the body of *Monoporeia afinis* from the Baltic Sea, *Diporeia hoyi*. Amphipods from obviously the richest group with more than 820 species recorded in the Antarctic and Sub Antarctic regions. These peracarids have colonized a wide variety of ecological niches, in benthic habitats as well as in the water column and have developed a large range of feeding strategies, from suspension feeding to scavenging on big carrion and specialized modes like micor-predatory browsing on invertebrate colonies (Dauby et al., 2001).

The important faunal diversity of amphipod taxocoenoses is likely to indicate a worthwhile significance of these crustaceans in total benthic or pelagic biomasses, and thus their major role in the trophodynamics of Antarctic ecosystems, as well as consumers than as preys. Total biomass data on amphipods are more than scarce, only available for some restricted areas like the Eastern Weddell Sea shelf where amphipods should count for about 5% of the benthic biomass. In the same area their impact as predators on benthic material has been arbitrarily estimated and they feed about 80% on detritus.

This view was recently revised by Dauby et al. (2001) who showed, from an extensive study of stomach contents of the most representative species, that their diet was far more complex, planktonic bodies and crustaceans forming the major part of it. On the another hand, the importance of amphipods, either benthic or pelagic, for Southern Ocean higher trophic levels has never been analysed in a global context.

According to Cunha et al. (2000) warm water amphipods show iteroparous, multivoltine life history patterns. Multivoltinism and continuous reproduction have been reported in many
other species occurring in tropical Indian Ocean (Chandani and Alan, 2004). The amphipods are
the main prey for *S. officinalis* during the first three months. Among these, caprellids and
gammarids could be possible alternative prey to mysids, since they are easier to collect and also
less expensive to culture, as they can feed on suspended organic matter (Caine, 1974) and can be
cultured high densities. So the present study was undertaken to study the mass culture of
amphipods. The biochemical constituents of some faunal components of the Cochin backwaters
were studied by Gopakrishnan *et al.* (1977). Biochemical profiles, mainly fatty acids, have been
analysed in some gammarid species showing that they have high levels of beneficial poly
unsaturated fatty acids, docosahexanoic acid (DHA (22:6(n-3)) and eicosapentaenoic acid (EPA
(20:5(n-3))) and high levels of protein that can be used as alternative protein sources in the
complete diets for farmed fish.

Amphipods constitute an important food source for fishes. Although demersal fishes are
able to adapt their diet to the available prey, they feed primarily on macrobenthic fauna,
especially amphipods, with polychaetes and bivalves being taken as secondary prey items. At
least in the shelf sediments, they could be expected to play a vital role in the diet of many
secondary consumers. The importance of amphipods as nutritional resource appears to be due to
the combines secondary production of several co-inhabiting species. Amphipods exhibits
different types of feeding behavior namely deposit feeding, suspension feeding, deposit feeding
coupled with predation, opportunistic predation, micropredatory browsing, macropredation
coupled with scavenging, opportunistic necrophagy and true necrophagy and hence they have a
wide dietary spectrum.
4.10. Pollution monitoring

Incidence of fish mortality due to industrial pollution from the upper reaches of Cochin backwater was reported by Unnithan et al. (1977). Pillai (1978) has studied the distribution of macrobenthos of the Cochin backwaters. The effect of pollution on benthos was made by Remani (1979). Fish mortality due to ammonia poisoning in Chitrapuzha was reported by Venugopal et al. (1980). Remani et al. (1983) have reported on the indicator species of organic pollution in the Cochin backwaters. Effect of pollution on the benthic communities in Cochin back waters was studied by Saraladevi (1986). Sheeba (2000) studied the benthic fauna in the Cochin backwaters in relation to environmental parameters.

Many investigators studied the heavy metals accumulation in East and West coast of India. Among those, Ouseph (1987) reported the low concentration of Fe and high concentration of Zn and Cu in the Cochin estuary and stated that the high levels of metals may be due to the anthropogenic pressure. The distribution of iron and manganese from the sediments of Tellicherry, Kerala was studied by Thamban et al. (1996) indicating that these constituents are apparently controlled by the spatial variations of the physico-chemical factors of the estuary such as pH, base exchange and adsorption characteristics and the texture of the sediments, tidal influence and proximity to the mangrove vegetation. Rajathy and Jayapaul Azariah (1996) investigated the spatial and seasonal variation of heavy metals in mangrove of Ennore estuary, Madras. Thomas and Fernandez (1997) studied the incidence of heavy metals in the mangrove flora and sediments of Kerala. Kathiresan (2000) reported the heavy metals in Pichavaram mangroves.

The pollution levels of the aquatic environment by heavy metals can be estimated by analyzing water, sediments and marine organisms. Sediments may accumulate contaminants in
concentrations higher than those observed in the water column, producing negative effects to the benthic biota and to the organisms that feed on the benthos or on the sediment. Due to ecological importance and the persistence of pollutants in this environmental compartment, sediments are more appropriate to be monitored in environmental evaluations. Biomonitor have been defined as species which accumulate trace metals in their tissues and may therefore be analysed to monitor the bioavailability of such contaminants in the ecosystems (Rainbow and Philips, 1993). Among crustaceans, barnacles and amphipods appear to have particular promise as cosmopolitan biomonitor (Rainbow and Moore, 1986; Ugolini et al., 2004). Amphipod crustaceans have been proposed as model biomonitor organisms since they are extremely widespread, occur in high densities in some communities, are often the principal food for predatory fishes and birds, and there is considerable potential for metal accumulated by amphipods to be transferred along marine food chains (Marsden and Rainbow, 2004). Amphipods appear to store accumulated trace metals from solutions and food storing the metal accumulated in the ventral caeca of the midgut. So, trace metals accumulated from the diet are detoxified and stored in granules of ventral caecal cells. With more granules present in amphipods from contaminated sites (Rainbow, 2002). Although amphipods are usually proposed as marine bioindicators based on ecological studies of species distribution, the number of studies quantifying the trace metal concentrations in amphipods to test its validity as biomonitor is rather low. In fact, most of the studies only provide measures of heavy metal concentrations in amphipods have not been explored (Guerra-Garcia, 2001; Takeuchi et al., 2001).

The order Amphipoda is an abundant and ecologically important component of soft-bottom marine benthic communities. This high abundance and wide distribution suggest that amphipods could often play major roles in the ecology of these habitats. They are ecologically
and trophically important, numerically dominant, exhibit a high degree of niche specificity, are tolerant to varying physico-chemical characteristics in sediment and water, have relatively low dispersion and mobility capabilities, live in direct contact with the sediment, have a documented sensitivity to pollutants and toxicants compared to other benthic organisms and indeed they have been considered capable of accumulating toxic substances (Reish, 1993; Thomas, 1993; Dauvin and Ruellet, 2009). Reish and Barnard (1979) observed that some amphipod species are more tolerant than others to organic pollution.

Biomonitor species can be identified as any biological species or group of species whose function, population or status can be used to determine the state of the ecosystem of which they are a part (Adams, 2005). Amphipods, in general, are considered suitable biomonitor species, as they are relatively sedentary, and are highly abundant in most ecosystems.

Earlier studies were dealt with many workers from different waters with different species. Siji Thomas and Mohaideen (2014a) explained the analysis of heavy metals in fish, water and sediment from Bay of Bengal. Batravi and Krishnamurthy (2010) described the Cr, Cd and Pb contamination in Pulicat Lake. Kamalakannan et al. (2008) assessed the heavy metals (Cd, Cr & Pb) in water, sediment and seaweed Ulva lactuca in the Pulicat Lake. Population and community level indicator in assessment of heavy metal contamination in seagrass system was done by Rappe (2010). Batravi et al. (2013) has studied the heavy metal accumulation in crab and shrimps from Pulicat Lake, North Chennai coastal region. The heavy metals in two fish species (Carangoidel malabaricus and Belone stronglurus) from Pulicat lake was monitored by Batravi et al. (2008). Heavy metals in water, sediment and macrobenthos in the intertidal zone of Hormozgan province of Iran was done by Manavi (2013). Govindasamy and Azariah (1999) found the seasonal variation of heavy metals in coastal water of the Coromandal coast, Bay of
Bengal, India. Solai et al. (2010) observed the trace elements in surface water off Pondicherry, Bay of Bengal. The seasonal variation of heavy metals in Cochin estuary and adjoining Periyar and Nuvattupuzha rivers, Kerala was done by Kumar et al. (2011). Sureshkumar et al. (2013) explained the heavy metal concentration of seawater and marine organisms in Ennore creek waters. The metal concentration in Vellar estuary, Parangipettai waters was explained by Prabhahar et al. (2011). The seasonal variations in physico-chemical parameters and heavy metals concentration in water and sediment of Kolavoi lake, Chengalpet, Tamilnadu was done by Rameshbabu and Selvanayagam (2013). Jayaprakash et al. (2012) assessed the trace metal contamination of freshwater Buckingham canal, Chennai, India.

The heavy metal distribution in the sediments of Adirampattinam mangrove region was carried out by Hussain Dar et al. (2012). Ennore, Pulicat and Muthukadu estuaries heavy metal contamination was described by Shirlin et al. (2014). Periakali and Padma (1998) have observed the mercury contamination from the Pulicat Lake sediments. Joseph and Srivastava (1993) were analysed the heavy metal contamination from the sediment of estuarine system of Madras. Ravichandran and Manickam (2012) have described the heavy metal distribution in the coastal sediment of Chennai coast. Asha et al. (2010) were given the heavy metal concentration in water, sediment and bivalves off Tuticorin. Distribution and enrichment of trace metals in marine sediments of Bay of Bengal, off Ennore carried out by Muthuraj and Jayaprakash (2007). Anand and Kala (2015) studied the seasonal distribution of heavy metals in the coastal waters and sediments along the major zones of South East coast of India with reference to Mandapam, Tuticorin, Aurumuganeri and Kanyakumari. Raju et al. (2011) assessed the impact of anthropogenic input on physicochemical parameters and trace metals in marine surface
sediments of Bay of Bengal off Chennai, India. Chitrasu et al. (2013) studied the metal analysis of sediment at Ennore estuary.

Guerra-Garcia et al. (2009) have studied the amphipods Caprella penantis and Hyale schmidtii as biomonitors of trace metal contamination in intertidal ecosystems of Algeciras Bay, Southern Spain. Guerra-Garcia et al. (2010) carried out the Na, K, Ca and Mg of intertidal caprellids from Spain waters. Rajkumar et al. (2011) assessed the metals (Cd, Cu, Pb and Zn) in Mugil cephalus, Peaneus indicus and Meretrix meretrix of the Ennore Creek, Tamilnadu. Bioaccumulation of heavy metals in mullet (Mugil cephalus) and oyster (Crassostrea madrasensis) from Pulicat Lake was done by Laxmipriya et al. (2010). Mardsen et al. (2000) assessed the estuarine amphipod Paracorophium excavatum as a bioindicator of contaminated sediment. Hamanaka and Ogi (1984) were studied the Cd and Zn in the Hyperiid amphipod Parathemisto libellula from the Bering Sea. Rainbow et al. (1993) explained the talitrid amphipods as biomonitors of trace metals near Dunedin, New Zealand. Bat (1997) studied the uptake of copper, zinc and cadmium by the amphipod Corophium volutator in the laboratory.