1. GENERAL INTRODUCTION

Brackish water lakes are home to a variety of plants and animals. Coastal lakes are semi-enclosed structure and focal point of inshore activities and often act as natural harbours for trade and commerce. They are effective nutrient traps and provide a vital source of natural resources to man and are used for commercial, industrial and recreational purposes. Coastal lakes are functioning as important sinks and transformers of nutrients, thus altering the quantity and quality of nutrients transported from land to the sea. Thus, by virtue of their natural location and easy accessibility, they are more amenable to anthropogenic influences. They also act as nursery ground for a variety of finfishes and shellfishes. It has been estimated that 60 to 80% of the commercial marine fishery resources depend on brackish water for part of or entire life cycles.

Indian coastal waters have a rich biodiversity of soil dwelling organism called benthos which includes micro, meio and macro forms and reports on these groups are limited to certain areas only. Benthos are identified as organisms living in or on the bottom of any body of water (Bostwick, 1983). In coastal lake systems, the benthic community is primarily dominated by species that burrow into the sediments (infauna), or living within tubes. Taxa dominating in the infaunal groups include small worms (polychaetes and oligochaetes), crustaceans, clams and insects larvae, etc. In addition to infauna there are also a number of epibenthic organisms that reside on the sediment surface which include mysid shrimp, some amphipods and isopods.

Benthic animals are classified according to their size: microfauna - <100μm; meiofauna – 100-500μm; and macrofauna - >500μm. Benthos play a vital role in the marine food chain and in the recycling of essential life sustaining elements like C, N and P in the marine ecosystem. The sedimented organic matter from the water column is effectively consumed and converted into
invertebrate benthic biomass, dissolved organic matter and inorganic nutrients by benthic organisms. Benthic animals generally consume detrital or planktonic food, and are in turn prey for larger fish, shrimp and crabs. Owing to their differential tolerance, benthos have been considered as the best indicator organism of environmental stress or aquatic pollution. Benthic macroinvertebrates are widely used in biomonitoring programmes both as surveillance and compliance in order to assess the health of the environment.

The following environmental factors determine the community structure of benthic organisms. Physico-chemical factors such as temperature, salinity, water currents, tidal exposure, depth, substratum, sediment grain size, oxidation - reduction state, dissolved oxygen, organic content, nutrients and light. Biological factors like food availability, feeding activities, prey-predator relationship, breeding, spawning, dispersal and settlement and behavioural effects (movement, aggregation, growth and mortality).

Benthos play a critical role in the coastal lake. The diverse benthic groups form a major link in the food chain. Filter feeders in the benthic community pump large amount of water through their bodies, and as they do so, they remove sediments and organic matter, cleaning the water. Organic matter that is not used within the water - column is deposited on the bottom. It is then remineralised by benthic organisms into nutrients which are given back into the water column. The remineralisation of organic matter is an important source of nutrients and is critical in maintaining the high primary production rates.

Infaunal organisms either move through the sediment, to capture their prey or to swallow large quantities of organic deposits (eg. Lugworm, *Arenicola marina*) convert into usable organic load. Organisms that move within the sediment or disturb the sediment (ie. cause it to move, suspend, erode or redeposit) during their feeding are called bioturbators (or sediment
destabilisers). These include both sessile (organisms that do not move) or motile organisms like bivalves (eg. Macoma sp.), crustaceans (the mud shrimp, Corophium volutator), polychaete (eg. Lugworm, Arenicola sp.), echinoderms (eg. the deposit-feeder sea cucumber, Molpadia sp.). The benthic organism consumes large proportion of seaweeds and seagrass, leaf litter, detritus matter and consequently produce large amount of processed materials, enriched with primary carbon source which can potentially fuel a coprophagous food chain (Schrijvers et al., 1996). Organisms can also be classified as sediment-stabilisers or sediment-destabilisers, and both categories include deposit-feeders, suspension-feeders and carnivores. Other organisms, like tube-building polychaete (eg. Diopatra neapolitana) tend to consolidate the sedimentary habitat and are therefore called sediment stabilizers. Burrowing deposit feeders tend to be more abundant in fine-grained organic rich sediments. The activity of these organisms create resuspension of fine particles and clog the fine filtering structures of some of the suspension-feeders, making their feeding very difficult.

Distribution and abundance of benthic animals of a region is directly related to the fisheries of that region. Benthos that form an important source of food for demersal fishes can be good indicators of fish stocks. Since, the demersal fishery contributes about 30 to 50% of the total fishery potential of any area, the benthic production plays a major role in deciding the demersal fishery potential. Benthic production in coastal lakes are quite high when compared to other aquatic habitats because of the abundance of food and productivity. In such situations, food becomes readily available to the bottom living animals through sinking and vertical transport. Another reason is their presence of opportunistic species, which produce more generations per year compared to the other slower reproducing fauna.
Benthos is an important part of the food chain, especially for fishes. Many invertebrates feed on algae and bacteria, which are primary consumers. As benthic invertebrates die, they decay, releasing nutrients that are reused by aquatic plants and other animals in the food chain. Benthic communities can be used to determine the effects of point source discharges such as sewage treatment plants and factories. Unlike fish, benthos cannot move around much so they are less able to escape the effects of sediment and other pollutants that diminish water quality. Therefore, benthos can give reliable information on stream and lake water quality. Due to their differential tolerance, they have been considered the best indicators of anthropogenic perturbation. Their long life cycles allow studies conducted by aquatic ecologists to determine any decline in environmental quality. Benthos represents an extremely diverse group of aquatic animals, and the large number of species possess a wide range of responses to stressors such as organic pollutants, sediments and toxicants. Many benthic macroinvertebrates are long lived, allowing detection of past pollution events such as pesticide spills and illegal dumping. Ecologists who evaluate environmental quality using the benthos often consider the following characteristics of a benthic sample to be important indicators of stream, river or lake quality.

Benthos supporting the carbon cycling to circulate nutrients from the ocean floor to the overlying water column. The macrobenthos are an important component of the coastal lake systems. Many of the worms, shrimps, snails and bivalves are an integral part of an ecosystem. Knowing the spatial distribution of benthos, their relative and low levels in distribution is the first step in understanding the human impacts on the benthic community. Chemical changes associated with the change from freshwater to saltwater result in the flocculation of dissolved materials that have been transported in the water down in the river into the estuary. Because of the flow restrictions, suspended particles can settle out of the water into the sediments. These
processes allow pollutants to reach greater concentrations in the sediments than in the water. Because of their close association in the sediment, benthic organisms will respond to these pollutants before the animals in the water column. Thus, benthic community may be first component of the estuarine fauna to show weakening environmental health. The changes brought about by the deposition of pollutants on the bottom greatly affect the bottom fauna and flora by reducing species diversity. The elimination of non-tolerant species is often accompanied by an increase in benthic invertebrates due to lack of predation and competition by changes and simplification of food chain or by the surplus supply of allochthonous source of food for the remaining tolerant species. A reduction in the macrofaunal species due to pollution will have a direct impact on demersal fishes. Effluents from industrial, agricultural, domestic and retting sources have lead to its deterioration. The decreased volume of backwaters with limited exchange with the sea reduces the diluting capacity of the backwaters. The physical alterations also play a role in changing the abundance of flora and fauna (Gopalan et al., 1983).

1.1. Amphipods

Systematics

Kingdom: Animalia

Phylum: Arthropoda

Class: Crustacea

Subclass: Malacostraca

Superorder: Peracarida

Order: Amphipoda

Suborder: Gammaridea
The superorder Peracarida is distinguished from other crustacean groups by the following characters: presence of a single thoracic segment fused to the head, absence of a free living larval stage, incubation of the young by the female in a brood pouch formed by oostegites on the inner base of 2 or more thoracic limbs, and the presence of an articulated accessory incisor process.

**Fig. 1. External morphology of amphipod**

Amongst the Peracaridans the Amphipoda (Fig.1) are separated by the following combination of characters: carapace absent, coxal gills present on the inner base of some thoracic limbs, body typically laterally compressed, eyes sessile and without cuticular facets, the pereon comprises 7 segments and pleon with 6 segments. Of the pleon segments, the anterior 3 pairs forms the pleosome and posterior 3 the urosome. The anterior 2 pairs of pereopods are usually modified and term gnathopods, and to a much lesser extent pereopods 3-4 and pereopods 5-7 are often structurally dissimilar. The extreme posterior end of the body carries a small flap like structure, the telson, attached to the posterodorsal margin of pleon segments 6 above the anus.

Amphipods are extremely diverse, abundant and widespread crustaceans. They are found in nearly all marine and freshwater habitats. They are classified according to habitats as epifaunal, infaunal and demersal planktonic amphipods. Amphipods also play different roles in
the trophodynamic relationship, as primary consumers, omnivores, carnivores and opportunistic feeders, and change feeding modes according to food availability (Wongkamhaeng et al., 2009). Most amphipods are free-living benthic gammaridians that can occur in such high densities that at times they dominate some communities (Cunha et al., 2000). Amphipods are often the main food for predatory fish and birds (Nair, 1971; Beare and Moore, 1997 and Dauby et al., 2001) and there is considerable potential for metal accumulated by amphipods to be transferred along marine food chain. Internationally, amphipods are used widely for sediment testing (Mearns et al., 1986 and Fairey et al., 2001), because they are ecologically relevant, have a short life cycle and are suitable for laboratory experiments. They are also known as biomonitor for trace metals, some species are ecologically sensitive and therefore are potential bioindicators of disturbed communities. Amphipods are selected as biomonitor for trace metal because they are not accumulators of particular metals, relatively sedentary, abundant, easy to identify and resistant to handling stress. The benthic amphipods especially Gammaridea, are an invaluable food source for many economically important fishes (Mason, 1974). Their limited mobility and their sensitivity to environmental changes suggest that their distribution and abundance can be used as an indicator of environmental quality (Albright, 1982).

The amphipods comprises a group of small to medium sized peracarid crustaceans that are widely distributed world over in marine, brackish water and terrestrial environments. Amphipods form an important food item for fishes and other organisms. The amphipods come under four suborders namely Gammaridea, Hyperiidea, Caprellidea and Ingolfiellidea, among which Gammaridea is the most dominant group including 5,700 species embraced in 1060 genera (Barnard and Karaman, 1991). In Indian waters (Gravely, 1927) studied the amphipod fauna of Krusadai Islands in the Gulf of Mannar, the former dealt with gammarids and the latter
with caprellids. Their studies however were brief mentioning the occurrence of about 17 species. Barnard’s (1935) contribution on the brackishwater gammarid amphipods was based on the collection made by Zoological Survey of India from Tamil Nadu, Andhra Pradesh and West Bengal.

Amphipods are highly important in coastal and seagrass ecosystems. They are very significant in not only food for fishes and some larger crustaceans but also play an important role in the decomposition of wastes and in the cycle of nutrients. Since they are endemic in many environments, the biodiversity of amphipods is also used to assess the good health of any biotope. Availability of seaweeds and seagrass ecosystem is an important determining factor to the species composition and the diversity of gammaridean amphipods in the brackish water environments (Fenchel and Kolding, 1979). Informations about the biodiversity of tropical brackishwater amphipods are scarce. Few studies have been performed about the tropical amphipods (Balasubramaniyum, 1961; Sivaprakasam, 1969; Balasubramaniyum and Srinivasan, 1987).

Surya Rao (1972) enumerated a detailed account on the intertidal gammarid amphipods from the Indian coast and listed 132 species pertaining to 54 genera. Raja et al. (2013) have studied the diversity of amphipods in the continental shelf sediments of South East coast of India at various depths (30m, 50m, 75, 100m, 150m and 200m) and recorded 44 species belonging to 29 genera and 17 families. Mondal et al. (2010) studied the gammarid amphipod of Vellar and Uppanar estuaries and found that several physiochemical factors such as salinity, temperature, dissolved oxygen, pH and substrate have a marked effect on the distribution and the relative abundance of amphipods. Satheeshkumar (2011) recorded seven species of amphipod crustaceans from Pondicherry mangroves, South East Coast of India. Lecroy (2002) has brought
out an illustrated identification guide to the nearshore marine and esturaine gammaridean amphipoda of Florida.

The present study was focused on the physico-chemical parameters of water and sediment from four ecosystems of Pulicat lake from January to December, 2013. The research further moved on to the ecology of amphipods, where species composition, percentage composition, population density, Shannon and Wiener’s diversity index (H’), evenness (J) and richness (D) were noticed. The study on culture and nutritional evaluation of amphipod *Ampithoe ramondi* were carried out to show that they could be used as a efficient and alternate live feed for cultured organisms. Investigations on heavy metals (cadmium, chromium, arsenic, mercury and lead) from water, sediment and amphipod samples were carried out to understand the pollution indicator potential of amphipods.