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Distribution of Foraminifera and Ostracoda and their Ecological Conditions in the Beach Sands of Tuticorin, Tamil Nadu, Southeast Coast of India

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Abstract: *In order to study the distribution of Foraminifera and Ostracoda in the beach sands of Tuticorin Coast, Tamil Nadu for an environmental implication, a total of 18 beach sand and water samples were collected along the coast of Tuticorin, from Palayakayal to Tuticorin Old Harbour. The microfauna were separated from the sediments by using standard micropaleontological techniques. Water and sediment parameters were measured in both field and lab from the collected samples. In the present work, a total of 31 species of foraminifera and 16 Ostracoda species were identified. Sand is the only substrate recorded in the study area and it is appears congenial for the population abundance. Predation on foraminiferal tests and change in their color has also noticed in few species. Occurrence of few broken and abraded tests indicates the high amplitude of tidal agitation and comparatively low deposition of sand in the beach environment of Tuticorin coast.*

Keywords: *Foraminifera, Ostracoda, Distrubution, Tuticorin Beach, Tamil Nadu*

1. Introduction

Foraminifera, is one of the major microorganism group which lives in an exclusive marine condition and their studies are generally used to reconstruct paleoclimate and sediment transport etc. These organisms show high sensitivity to minute variations in the physico- chemical characteristics of the ambient environment and their response to the changed environmental conditions is reflected in the variation in abundance and morphology of the test. The test of foraminifers has high preservation potential thus making these microorganisms one of the most useful proxy for the long as well as short term temporal variation in the amount and type of toxins in all kinds of marine environments especially in the near shore coastal areas. Benthic foraminifers are useful in environmental studies because they are easily acquired, live primarily in the uppermost centimeters of sediments [7] and are very abundant in marine and estuarine habitats. There are few research works on foraminifera carried out in the beaches and off shore sediments of Bay of Bengal. Some of them are [24], [31], [20], [29], [9], [21] and [18].

Ostracods are tiny bivalved Crustaceans with two chitinous or calcareous valves called carapace and have been successful inhabitants of all aquatic environments and are largely benthic or nekto-benthonic in habit. Ostracods are comparatively less in abundance than foraminifera in marine environment. Ostracoda live in an environment in which the controlling factors are temperature, bottom topography, depth, salinity, dissolved oxygen, substrate, food supply and sediment organic matter [30]. However, the major controlling factors governing ostracod distribution in estuarine environments and continental shelf zones are salinity, water temperature and substrate [39]. The studies show that although increasing level of pollution result in reduced ostracod abundance and diversity, however, some species are capable of withstanding quite level of contaminations. Coastal zones are very sensitive to environmental changes. While some ostracod species are sensitive to the most subtle changes in their environment, others are capable of withstanding a wide range of conditions, even to the extent of in habiting heavily polluted sites. Good number of research activities on ostracods are carried out at Bay of Bengal which includes [16], [34], [17] and [10] etc.

2. Study Area

The area under the investigation is the beach sands of Tuticorin (between Lat. N 08° 40′ 14″ to N 08° 48′ 26″ and Long. E 78° 07′ 57″ to E 07° 09′ 46″) Tuticorin district, which lies on the east coast of India and forms a part of toposheet number 58L/1 and 58L/2 of the Survey of India. In the Gulf of Mannar, Pearl and Chank beds are situated roughly in line parallel with and at a distance of 11 kms from land [8]. The surface of these beds consists of rocks formed by the consolidation of sand and dead corals *in situ*. The Geology of the area is characterized by Precambrian crystalline rocks. It is mostly hard rock terrain predominantly underlain by garnetiferous biotite gneiss and Khondalite group of rocks, which is covered by a veneer of red and black cotton soils. The

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Khondalite group of rocks are considered be Archaean in age.

The climate in Tuticorin is quite tropical, with extremely hot summers, frequent showers and mild winters. The maximum temperature during the summer months is normally around 37°C and the minimum temperature is around 30°C. The months of May, June and July are the summer months, although temperatures start rising around April. Monsoon in Tuticorin is normally characterized by heavy rains and thunderstorms in the months of August, September and October. The post monsoon or winter months in the city of Tuticorin are the months of November, December and January. The weather during these months is quite pleasant, and the maximum and minimum temperatures will range around 32°C and 26°C.

3. Materials and Methods

In order to study the Ostracoda and Foraminifera along with the surface sediment and water characteristics, a total of 18 beach sediment and water samples (from the intertidal region) have been collected along the coast of Tuticorin, from Palayakayal to Tuticorin Old Harbour (fig. 1) during the month of March, 2013. With the help of GPS, sampling locations were fixed. All the collected sediment samples were subjected to standard micropaleontological techniques. Ostracoda and Foraminifera were separated from a unit weight of 50 ml wet sediment sample under a stereo-binocular microscope and counted. Water parameters like, temperature and pH were measured in the field. Dissolved oxygen content in water was fixed in the field by using Winkler's method as proposed in Strickland and Parsons (1968) [35] for salinity, standard titration method proposed by Knudsen (1901) [22] was adopted. The sediment parameters such as, Calcium carbonate and Organic matter content in the sediment samples were determined by adopting methodology suggested by Muller (1967) [28] and Gaudette et al. (1974) [11], respectively. Sand, silt and clay percentage were calculated using a combination of sieving and pipette procedures given by Krumbein and Pettijohn (1938) [23]. Trilinear plots were prepared and description has been given based on Trefethen (1950) [38] textural nomenclature.

4. Results and Discussion

4.1 Water parameters

Horne (1983) [14] stated that temperature is the main controlling factor for ostracoda population dynamics, although salinity is also influential. Hussain (1998) [16] observed that there is no considerable change in temperature among the different stations during the same season. But, there is a difference in temperature during different seasons in Gulf of Mannar, off Tuticorin. In the present study, temperature is measured in all the 18 stations and it ranges rom 27 to 1 (Table 1).

From the present study, it is observed that the obtained pH values of the water samples are ranging from 8.58 to 9.07 (Table 1). Hence it is concluded that the nature of collected water samples are alkaline in nature. Salinity is considered as the one of the important factor that controlling the environment in which the micro fauna (ostracoda and foraminifera) live. The salinity has a limiting factor in the distribution of living organisms, and its variation caused by dilution and evaporation is most likely influence the population of phytoplankton in the intertidal zone [12]. The salinity content present in the water samples collected from the various stations of Tuticorin coast are ranging from 29 ppt. to 29.90 ppt (Table 1). Production of oxygen by dense extensive patches benthic algae in shallow environments could be of a significantly high order [1]. Low oxygen may be due to the decomposition of organic matter and high silt content in the sediment [19]. Dissolved oxygen in all the stations were measured with an average amount of 2 ml/l. Water parameter result shows that, there is no much difference in parameters, measured for all the stations in the study area.

4.2 Sediment parameters

The study of organic matter and calcium carbonate in coastal environments is important as organic carbon is used as a tool for predicting the impact of pollution [33]. The role of organic matter in the distribution of oramini er's species di ers with local conditions. Sometimes, the change of oxygenated conditions greatly affects the development of assemblages. However, in favorable conditions organic matter acts as a catalyst to enhance the nutrient content in the substrate and such condition favors the multiplication of foraminifera. Subba Rao (1960) [37] recorded 1.05% to 1.34% organic matter content for the sandy sediments collected from a depth of 10-15 fathoms off the east coast of India. Rasheed and Ragothaman (1978) [32] observed that all the samples collected near the shore are poor in organic matter and, as depth increase; a gradual rise in the same is noticed in off Porto Novo (Bay of Bengal). In the present study, the organic matter content in the sediments from beach of Tuticorin ranges from 0.40% to 1.21% (Table 1). The lowest value is recorded in station no.2 and the highest value in station 14. The low organic matter is noticed due to sandy nature of the beach in the study area. The organic matter in all the locations is generally low and it appears that the organic matter is not considered as a controlling factor on the distribution of the microfauna in the study area. From off Tuticorin, Gulf of Mannar, Hussain, et al. (1997) [15] observed a relative decrease in the organic matter content of the sediments favours a maximum population of Ostracoda.

The calcium carbonate content of the sediments is an important parameter governing foraminiferal and ostracod distribution. Subba Rao (1958) [36] stated that the sediments from depths of less than 20 fathoms are, in general, poor in calcium carbonate content from the sediments off the east cost of India. Manivannan et al. (1996) [27] observed that $CaCO_3$ is the extensive component that controls the foraminiferal population in the Gulf of Mannar. Hussain et al. (2007) [17] noticed that higher amount of $CaCO_3$ is one of the significant factors for higher populations of ostracods in various parts of the southeast coast of India. In the present study, it has been found that the calcium carbonate in the beach sands of Tuticorin ranges from 2.05% to 19.75% (Table 1). The lowest value was recorded in station no.18 and the highest value in station 15 and it appears that, higher value of $CaCO_3$ favours the maximum population and distribution of Foraminifera and Ostracoda. Hussain et al. (1997) [15] observed that, a relative decrease in the organic matter with an increase in $CaCO_3$ of the sediments favours a maximum population of ostracoda in the Gulf of Mannar, off Tuticorin.

The nature of bottom sediments such as grain size, sorting coefficient and presence or absence of bottom vegetation has impact on the distribution of foraminifera and ostracoda. Bentley (1988) [3] observed that in the Brisbane area, distribution of Ostracoda is mainly controlled by substrate type followed by salinity. The relative abundance of sand, silt and clay in the beach sediment samples of Tuticorin has been estimated and the analytical values of sand, silt and clay contents with sediment types are shown (Table 1). Sand, silt and clay values are plotted in Trilinear plot diagram, after [38] is shown in fig.2. Sand content varies from 73.40% to 89.92%, silt content varies from 0.64% to 15.45% and clay content varies from 2.75% to 11.65%. From the above observation, it may be inferred that the most favourable sediment type for the population abundance is sand. The distribution of sand in the study area indicates a moderate to high energy environment of deposition due to tidal currents.

4.3 Microfaunal Distribution

The classification proposed by Loeblich and Tappan (1987) [26] has been followed in the present study for Foraminiferal identification and taxonomy, through which 31 species belonging to 22 genera, 16 families, 13 superfamilies and 5 suborders of order Foraminiferida have been identified (Table 2). SEM images of foraminifera are given in fig.3. The classification proposed by Hartmann and Puri (1974) [13] has been followed in the present study through which ostracod taxa of 16 species belonging to 15 genera, 9 families, 2 super-families, and 2 suborders of the order Podocopida have been identified (Table 3). SEM photomicrographs of Ostracoda are given in fig.4.

Only one species of ostracoda, namely *Basslerites liebaui* is endemic to Indian waters i.e., to the east and west coasts of India. Of the 16 species encountered in the study area, most of the forms are either moderately calcified, pitted or highly ornate forms, adopting themselves under a turbulent/agitated tidal environmental conditions. The standing crop (population) of both Foraminifera and Ostracoda is less in occurrence in which the Foraminiferal population was observed more in number when compared to Ostracod population. The substrate of the study area is sand in nature.

4.4 Predation and colour diversity on Foraminiferal test

More direct evidence of predation on foraminifera may be holes made in tests by some other organisms. These holes, which penetrate to the interior of the chambers, are assumed to have given the driller access to protoplasm. The effect of predation is indeed enough to reduce foraminiferal standing crops significantly, as observed from off Baja California [4] and [25]. Representatives from two groups of organisms in particular, gastropods and scaphopods, are known to be selective consumers of benthic foraminifera [2], [5] and [6].

Predation on Foraminiferal tests is noticed in some species. It is found that predation may decrease in the number of species population, and in the present study, some of the foraminifera from the identified species were predated. The predation was identified by the presence of holes and breakages on the surface of foraminifera test. The species of formainifera and ostracoda recorded are characteristic of shallow, innershelf and tropical in nature. No significant pollution impact through the morphological deformities of foraminiferal tests and ostracod carapace is noticed in the study area. The occurrence of few dark coloured foraminiferal tests such as brown and black indicate the amount of pyritisation and the impact of low level pollution. The presence of rest of tests in pale yellow, white and light coloured specimens of foraminifera and ostracod indicate that the sediments are deposited under normal oxygenated environmental conditions.

5. Conclusions

Foraminifera and Ostracoda have been successful inhabitants of every aquatic environment from deep abyssal environment to brackish water lagoons, estuaries and even in freshwater streams, lakes etc. In this study, 31 species belonging to 22 genera, 16 families, 13 superfamilies and 5 suborders of order Foraminiferida, whereas 16 species belonging to 15 genera, 9 families, 2 super-families, and 2 suborders of the order Podocopida have been identified. The reported taxa of Foraminifera and Ostracoda are characteristics of benthic, shallow, inner shelf (inner neritic) to marginal marine, tropical in nature and distributed in these intertidal (beach) sediments due to

tides as well as long shore currents. No considerable change is noticed in salinity and pH of the water samples collected from the various stations of Tuticorin beach and the impact on the distribution of microfauna is less significant. Calcium carbonate varies from 2.05% to 19.75% due to low shell fragments. Organic matter content is generally low in all the samples and it is not considered as a controlling factor on the distribution of the microfauna. From the sand, silt and clay ratio, it is observed that sandy sediment is present along the coast of Tuticorin beach and it indicate medium to high energy condition of deposition. Sandy substrate is more accommodative for the population of foraminifera for the recorded species. From the 16 ostracod species encountered in the study area, most of the forms are either moderately calcified, pitted or highly ornate forms because of the presence of coarser and calcareous sediment, adopting themselves under a turbulent/agitated tidal and beach environmental conditions. In the beach sands of Tuticorin area, few foraminiferal species were predated due to the Naticid gastropods and activities of barnacles. There are no much morphological deformities of foraminiferal tests and ostracod carapace is noticed in the beach sands, however, the occurrence of few brown and black coloured foraminiferal tests indicate the amount of pyritisation and the impact of low level pollution. The rest of the foraminiferal tests and ostracod carapace with pale yellow, white and light coloured specimens indicate that the beach sands are deposited under normal oxygenated environmental conditions.

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Table 1: *Water and Sediment parameters of the beach sands (inter tidal) of the study area*

Sample No.	Longitude	Latitude	Temp. (C^0)	DO (%)	Salinity (ppt)	pH	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Organic Matter (%)
1.	$078^0$07′57″ E	$08^0$40′14″ N	27	2.02	29.50	8.61	87.16	1.39	11.45	10.10	0.51
2.	$078^0$08′01″ E	$08^0$40′46″ N	28	2.02	29.70	8.60	87.03	2.72	10.25	10.30	0.42
3.	$078^0$08′08″ E	$08^0$41′12″ N	28	2.02	29.20	8.58	76.21	12.29	11.50	9.30	0.73
4.	$078^0$08′24″ E	$08^0$41′43″ N	29	2.01	29.70	8.59	82.87	6.13	11.00	9.10	0.82
5.	$078^0$08′57″ E	$08^0$42′12″ N	29	2.00	29.40	8.60	83.80	4.80	11.40	10.20	0.46
6.	$078^0$09′15″ E	$08^0$42′39″ N	29	1.99	29.60	8.67	73.40	15.45	11.15	8.70	0.55
7.	$078^0$09′24″ E	$08^0$43′12″ N	29	2.00	29.30	8.62	89.92	7.33	2.75	9.80	0.90
8.	$078^0$09′32″ E	$08^0$43′38″ N	30	2.00	29.20	8.61	86.00	5.15	8.85	9.40	1.12
9.	$078^0$09′47″ E	$08^0$44′07″ N	28	1.99	29.00	8.63	84.41	5.54	10.05	10.10	0.99
10.	$078^0$10′05″ E	$08^0$44′28″ N	30	2.00	29.30	8.65	85.67	3.48	10.85	10.15	0.99
11.	$078^0$10′31″ E	$08^0$44′48″ N	29	2.05	29.00	8.68	83.11	6.84	10.05	8.25	0.64
12.	$078^0$10′57″ E	$08^0$44′56″ N	29	2.01	29.40	8.70	82.62	7.28	10.10	9.75	0.86
13.	$078^0$11′28″ E	$08^0$44′52″ N	31	1.98	29.80	8.82	84.97	3.38	11.65	9.55	0.42
14.	$078^0$11′55″ E	$08^0$46′03″ N	28	2.00	29.90	8.71	87.22	2.13	10.65	19.45	1.21
15.	$078^0$11′56″ E	$08^0$46′34″ N	30	2.01	29.80	8.96	87.50	2.25	10.25	19.75	1.08
16.	$078^0$11′57″ E	$08^0$47′06″ N	30	1.99	29.60	9.07	86.25	3.65	10.10	15.15	0.56
17.	$078^0$11′33″ E	$08^0$47′17″ N	29	2.00	29.90	8.83	88.98	1.07	9.95	14.25	0.77
18.	$078^0$09′46″ E	$08^0$48′26″ N	30	2.00	29.90	8.85	89.31	0.64	10.05	2.05	0.90
	Min		**27**	**1.98**	**29.0**	**8.58**	**73.40**	**0.64**	**2.75**	**2.05**	**0.42**
	Max		**31**	**2.05**	**29.9**	**9.07**	**89.92**	**15.45**	**11.65**	**19.75**	**1.21**
	Average		**29**	**2.0**	**29.5**	**8.71**	**84.80**	**5.09**	**10.11**	**10.85**	**0.77**

Table 2: *Taxonomic chart of Foraminifera in the Tuticorin beach sands of Tamil Nadu*

Order	Suborder	Superfamily	Family	Genus	Species
FORAMINIFERIDA	Textulariina	Textularioidea	Textulariidae	*Textularia*	*T.bocki*
					T.agglutinans
	Miliolina	Miliolacea	Spiroloculinidae	*Spiroloculina*	*S.communis*
			Hauerinidae	*Hauerina*	*H.fragilissima*
				Miliolinella	*M.circularis*
				Quinqueloculina	*Q.agglutinans*
					Q.lamarckiana
					Q. seminulum
					Q. bicostata
					Q. costata
				Triloculina	*T.tricarinata*
		Soritoidea	Soritidae	*Peneroplis*	*P.planatus*
				Sorites	*S.orbiculus*
		Alveolinoidea	Alveolinidae	*Alveonella*	*Alveonella sp.*
	Lagenina	Lageniacea	Lagenae	*Lagena*	*L.striata*
			Ellipsolagenidae	*Fissurina*	*F.laevigata*
	Globigerinina	Globorotaliacea	Glabrataliidae	*Glabratella*	*G.australensis*
				Globigerinoides	*G.trilobus*
	Rotaliina	Bolivinacea	Bolivinidae	*Bolivina*	*B.nobilis*
		Buliminacea	Siphogenerinoididae	*Loxostomina*	*L.limbata*
				Rectobolivina	*R.raphanus*
		Planorbulinacea	Cibicididae	*Cibicides*	*C.lobatulus*
					C. refulgens
		Chilostomellacea	Amphisteginidae	*Amphistegina*	*A.lessonii*
					A.radiata
		Nonionacea	Nonionidae	*Florilus*	*F.boueanum*
		Rotaliacae	Rotaliadae	*Ammonia*	*A.beccarii*
					A.dentata
					A. tepida
			Elphiidea	*Elphidium*	*E.crispum*
		Nummilitoidea	Nummilitidea	*Operculina*	*O.ammonoides*

Table 3: *Taxonomic chart of Ostracoda in the Tuticorin beach sands of Tamil Nadu*

Order	Suborder	Superfamily	Family	Genus	Species
Podocopida	Platycopa		Cytherellidae	*Cytherelloidea*	*Cytherelloidea sp.*
	Podocopa	Bairdiacea	Bairdiidae	*Bairdoppilata*	*B.alcyonicola*
		Cytheracea	Cytheridea	*Neomonoceratina*	*N.porocostata*
			Trachyleberididae	*Chrysocythere*	*C.keiji*
				Stigmatocythere	*S.indica*
					S.kingmai
				Hemitrachyleberis	*H.siddiqui*
				Basslerites	*B.liebaui*
			Hemicytheridae	*Mutilus*	*M.pentoekensis*
				Caudites	*C.sublevis*
			Loxoconchidae	*Loxoconcha*	*L.gruendeli*
				Loxocorniculum	*L.lilljeborgii*
			Xestoleberididae	*Xestoleberis*	*X.variegata*
				Ornatoleberis	*O.morkhoveni*
			Bythocytheridae	*Bythoceratina*	*B.mandviensis*
			Paradoxostomatidae	*Paradoxostoma*	*P.bhatiai*

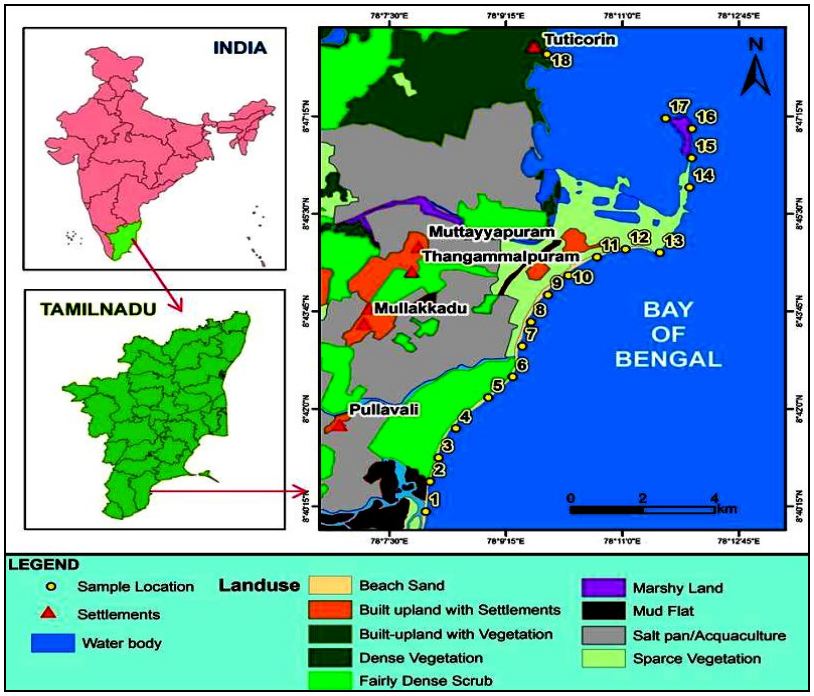

Figure 1. *Study area map showing sample location*

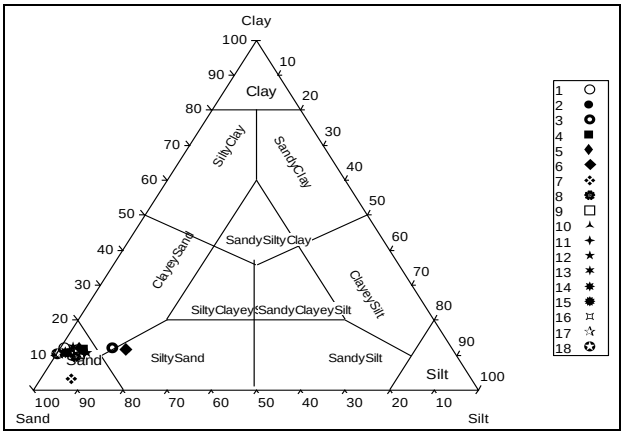

Figure 2. *Trilinear plots of sand, silt and clay ratio, of Tuticorin beach sediment samples (after Trefethen, 1950)*

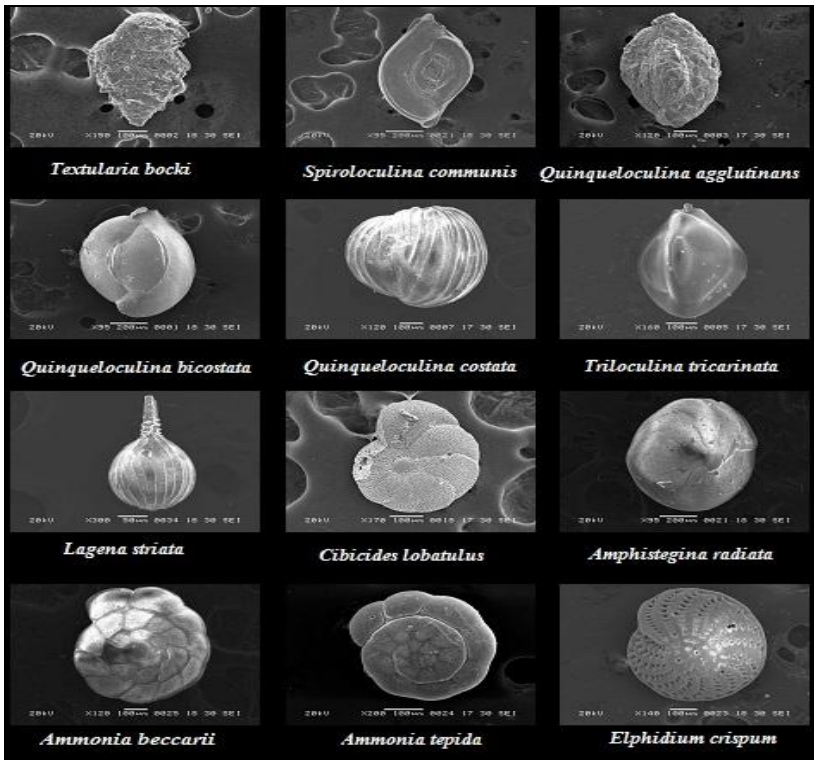

Figure 3. *SEM photogrpahs of Foraminifera (All side views)*

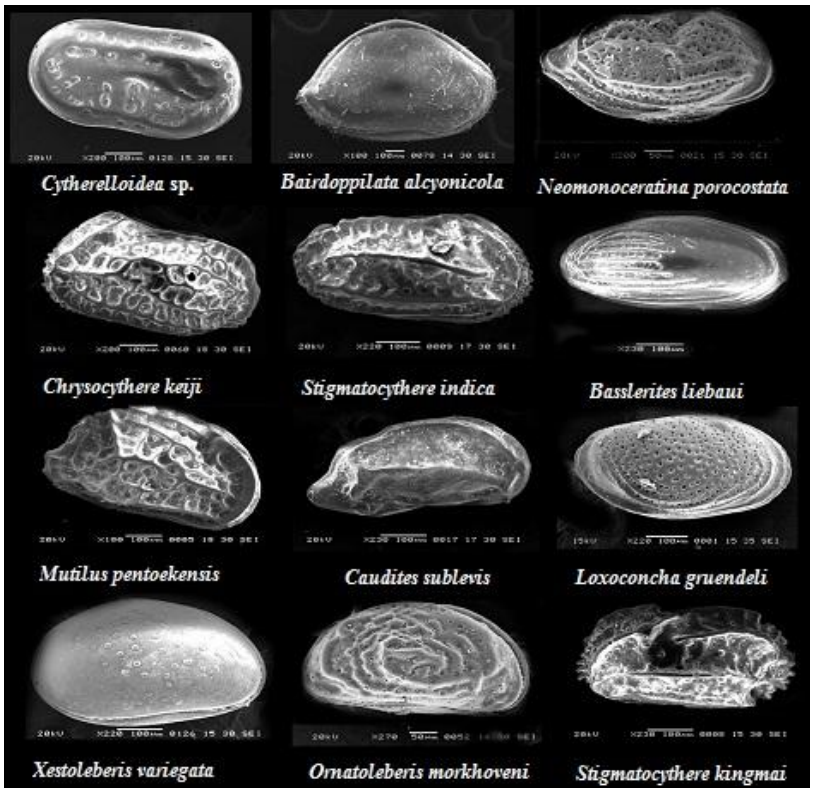

Figure 4. *SEM photogrpahs of Ostracoda (All side views)*