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DISTRIBUTION OF OSTRACODA IN THE SEDIMENTS OF THE NORTHWESTERN PART OF THE BAY OF BENGAL, INDIA - IMPLICATIONS FOR MICROENVIRONMENT

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ABSTRACT

A total of twenty-two surface sediment samples collected through SSK-35 from the coastal region along the northwestern part of the Bay of Bengal were provided to carry out a preliminary study on the distribution of ostracoda. The ostracoda taxa were separated from the sediments applying standard micropaleontolgical techniques, their distribution in individual sample examined and environmental interpretation made. Twenty one species belonging to 18 genera have been identified. Out of these *Echinocythereis species*, *Cytherelloidea leroyi* and *Keijia demissa* are well represented in the samples. From the occurrence and distribution of the ostracod assemblage, it is inferred that the sediments are deposited in a tropical, shallow, inner shelf environment. In the present work, the ratio between the carapaces and open valves has been taken into consideration for determining the comparative rate of sedimentation in the study area. Out of the twenty two samples, as many as 607 ostracod shells were recovered. Among these, 90% specimens were open valves and the remaining 10% were complete carapace. The distribution of carapaces and open valves in the samples of the Bay of Bengal shows that comparatively a slow rate of sedimentation may have prevailed in the locations of study areas of the Bay, probably under normal oxygenated environmental conditions. The ostracod specimens are white to light yellow in colour with a couple of predated species and no pyrite deposit in the ostracoda shells.

Keywords: Distribution, Ostracoda, Northwest Bay of Bengal, sedimentation, environmental implications

INTRODUCTION

The practical value of marine and brackish water microfossils is greatly enhanced by their minute size, abundant occurrence, wide geographic distribution and sensitiveness to the sedimentary environment of all ages. Owing to this, a relatively small sediment sample can obviously yield substantial data for the application of quantitative methods of analysis. Microfossils therefore have a proven potential for usefulness in ecological/ palaeoecological applications.

Ostracods are one of the best documented groups of the animal kingdom, due to many characteristic features of their bodies and a well-calcified, tiny, bivalved carapace which fossilizes easily. They are known to inhabit a wide variety of aquatic environments such as marine, brackish, freshwater, even terrestrial, and also dwell as parasites in the intestines of fishes. Thus, ostracods have an edge over foraminifers in biostratigraphic and ecologic/paleoecologic studies of non-marine strata. Puri (1966) stated that ostracods live in an environment in which the controlling factors are temperature, bottom topography, depth, salinity, pH, alkalinity, dissolved oxygen, food supply, substrate and sediment organic matter content. These forms, which are mostly benthic, exhibit different distributional patterns broadly linked to sediment texture, depth and various physico-chemical characteristics of the environment in which they thrive. Thus, they can be used to delineate changes in the environment.

STUDY AREA AND MATERIALS

The Bay of Bengal, one of the largest bays in the world, forms the northeastern part of the Indian Ocean. Several large rivers, of which the Ganges and its distributaries are important (e.g Padma and Hooghly) debouches continental sediments into the Bay. The Sundarbans' mangrove forest is formed at the delta of the Ganges. Hooghly River, another channel of the Ganga that flows through Kolkata drains into the Bay of Bengal. The Ganga and Brahmaputra rivers contribute nearly 1000 million tons/yr sediment presently. The sediment contributed from these two rivers forms the Bengal Delta and a submarine fan, a vast structure that extends from Bangladesh to south of the Equator is up to 16.5 km thick and contains at least 1130 trillion tonnes of sediment accumulating over the last 17 million years at an average rate of 665 million tons/yr. The fan has buried organic carbon (TOC) at a rate of nearly 1.1 trillion mol/yr since the early Miocene epoch. The two rivers currently contribute nearly 8% of the TOC delivered to the global ocean. Due to high TOC accumulation in the deep seabed of Bay of Bengal, the area is rich in oil and natural gas/gas hydrate reserves (Wasson, 2003). Bangladesh can reclaim land substantially and economically from the sea area by constructing sea dikes/bunds/causeway and trapping the sediment from its rivers (Singh, Indra Bir, 1996). Twenty-two surface sediment samples were collected by using spade corer through Sindhu Sankalp Cruise (Batch SSK-35) from the coastal region (21.1137N; 89.0186E to 19.9140N; 86.4645E) along the northwestern part of the Bay of Bengal. They were provided by Dr. Rajiv Nigam, NIO, Goa for ostracod study (Fig. 1). Salinity and dissolved oxygen values measured on-board were provided along with depth of water sample collection (Table 1). The details are discussed below.The ostracod taxa were handpicked from about 3 gm of sediment samples supplied through standard micropaleontolgical techniques and their distribution individually was studied.

SALINITY VARIATION IN THE STUDY AREA

Salinity has proved to have a direct effect on the number of species and abundance of specimens in marine and marginal marine environments. Normally, there is an increase in number of species with increasing salinity. Zhao *et al.* (1985) found that

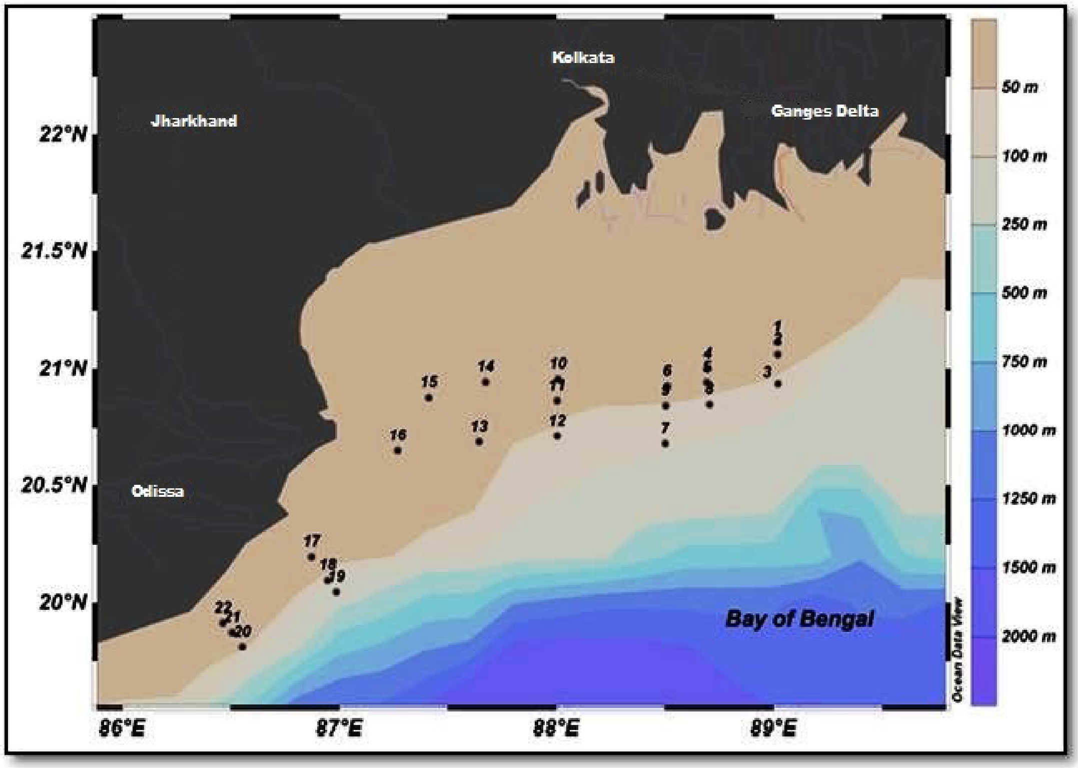


Fig. 1. Study Area Map Showing Sampling Locations.

the abundance in ostracod population and species diversity tend to increase away from the shore with increasing water depth, temperature and salinity. An analysis of earlier work concerning the distribution of shallow marine ostracods throughout the world reveals that the major factors controlling the distribution of ostracods vary from place to place. In the present area, salinity ranges from 32.87% to 34.87‰ (Table 1 & Fig. 2). The lower values of salinity at the river mouths of Odisha Coast and West Bengal (upper part of Bengal fan) Coast may be due to influx of freshwater from the Mahanadi and Ganges rivers, whereas the salinity values noticed are higher away from the coast.

Table 1: Geographical co-ordinates and Salinity and DO values of the surface waters of the study area along with depth of sample collection.

Sample No	Latitude (N)	Longitude (E)	Salinity (psu)	DO %	Water Depth (m)
SC 01	21.1137	89.0186	33.08	3.81	31
SC 02	21.0612	89.0185	33.98	3.44	49
SC 03	20.9372	89.0212	34.80	0.62	104
SC 04	20.9990	88.6967	33.02	3.87	29
SC 05	20.9415	88.6935	33.74	3.56	44
SC 06	20.9255	88.5113	33.36	3.73	35
SC 07	20.6781	88.5018	34.87	0.43	120
SC 08	20.8484	88.7039	34.73	0.9	94
SC 09	20.8425	88.5035	34.59	1.59	78
SC 10	20.9563	88.0078	33.08	3.81	31
SC 11	20.8640	88.0040	34.23	2.79	59
SC 12	20.7117	88.0044	34.63	1.37	83
SC 13	20.6870	87.6433	34.10	3.17	54
SC 14	20.9441	87.6750	33.63	3.62	42
SC 15	20.8765	87.4127	33.37	3.72	36
SC 16	20.6493	87.2698	32.87	3.9	28
SC 17	20.1959	86.8725	33.27	3.75	34
SC 18	20.0964	86.9475	34.10	3.17	54
SC 19	20.0461	86.9875	34.75	0.81	96
SC 20	19.8114	86.5541	34.82	0.57	107
SC 21	19.8733	86.5067	33.93	3.49	47
SC 22	19.9140	86.4645	33.37	3.72	36

DISSOLVED OXYGEN VARIATION IN THE STUDY AREA

A few ostracod species are known to live in environments with low oxygen content or even under anoxic conditions (Elofson, 1941). Most of the marine and brackish water organisms are physiologically well adapted to large variations in oxygen concentration. Rasheed and Ragothaman (1978) stated that dissolved oxygen may also be considered as one of the factors contributing to the abundance in living populations of Foraminifera in the inner shelf sediments off Porto Novo, Bay of Bengal. The dissolved oxygen for 22 stations of marine region ranges from 0.43 to 3.9% (Table 1 & Fig. 3). The higher values of DO at the river mouths of Odisha coast and West Bengal (upper part of Bengal fan) coast may be attributed to the influx of freshwater from the Mahanadi and Ganges rivers, whereas the DO values noticed are lower away from the coast which may be due to the less impact of freshwater influx and evaporation.

DEPTH

The River Ganga strongly influences the Bay's hydrological characteristics by producing a warm, low-salinity, nutrient and oxygen-rich layer to a depth of 100 m that stretches over a distance of 1,500 km from the northern shore. Silt from this river has created large sandbars near the river mouths, which has turned the Bay into a shallow sea, especially off the coast of Bangladesh. Approximately 2.5 billion tonnes of sediments are

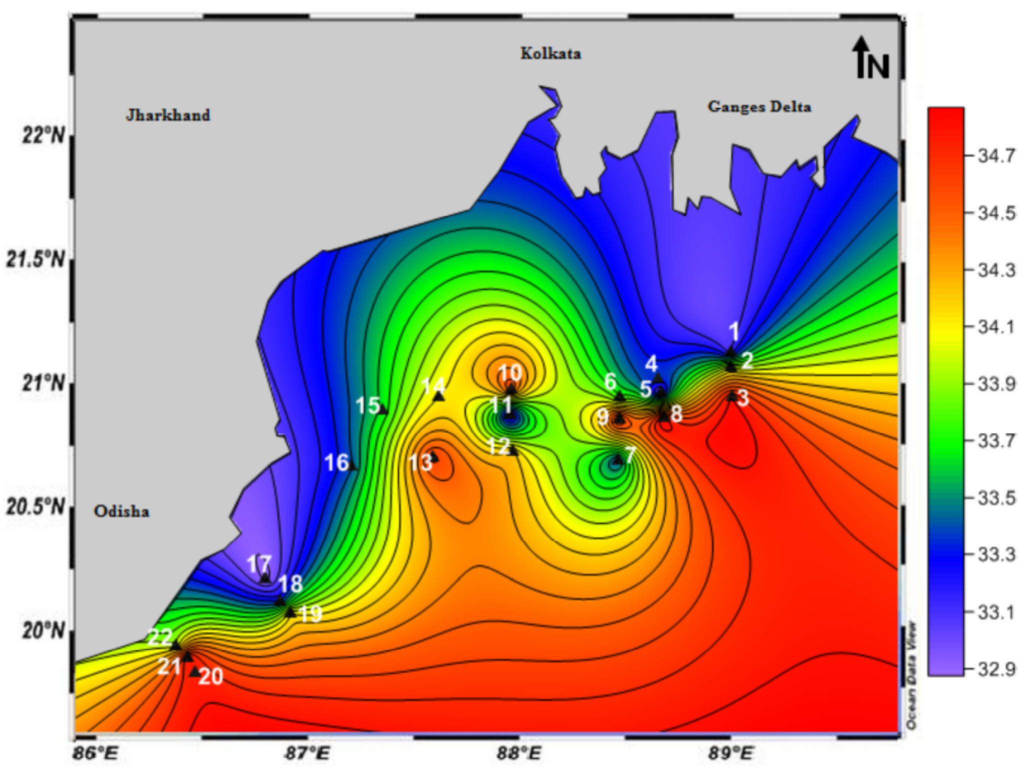


Fig. 2. Spatial distribution of salinity values of the study area.

discharged from the Ganges River annually. In deeper waters, high-salinity, low-temperature and low-oxygen waters persist through the year. In the study area, the depth of the sample collection ranges from 28 to 120 m(Table 1). Depth factor is normally considered to be an important ecological factor, only in the sense that the other variables are directly associated with changes in depth.

CLASSIFICATION OF OSTRACODA

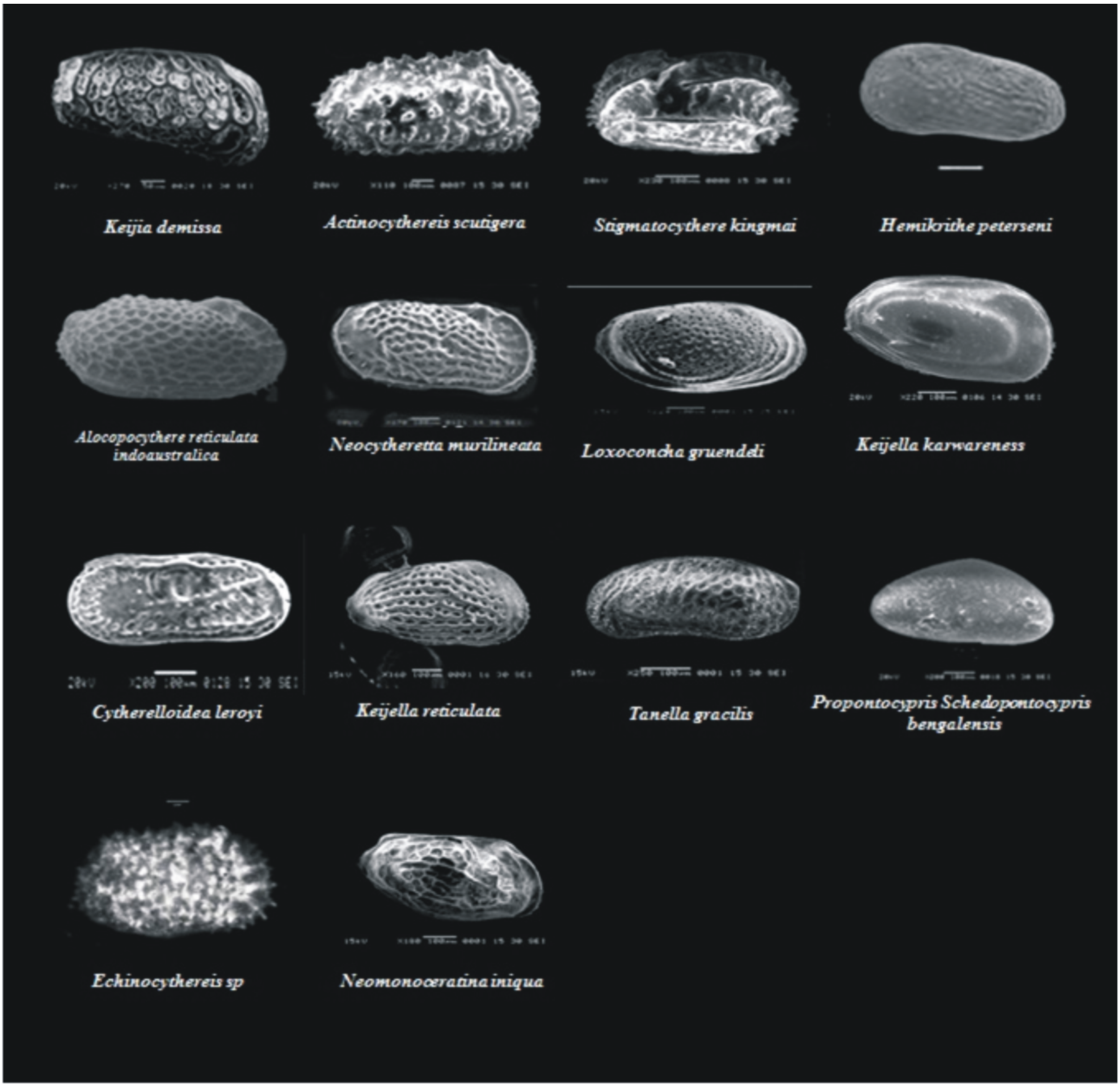
The classification proposed by Hartmann and Puri (1974) has been followed in the present study. Twenty-one ostracod taxa belonging to 18 genera, 13 families, 2 superfamilies, and 2 suborders of the Order PODOCOPIDA have been identified (Table 2). From the occurrence and distribution of the ostracod assemblage, it is inferred that the sediments are deposited in a tropical, shallow, inner shelf environmental conditions. Among these, *Cytherelloidea leroyi* belongs to Suborder PLATYCOPA and the remaining to Suborder PODOCOPA. Out of these species, *Kejia demissa* and *Tanella gracilis* are cosmopolitan in their distribution (Witte, 1993). The SEM photographs of the selected species are given in Plate I. As many as 607 ostracod shells were recovered (specimens of all the 21 species put together) from the 22 surface samples collected in the Bay of Bengal and the individual distribution of the species was presented (Table3).

CARAPACE - VALVE RATIO

The ostracod animal is always enclosed in a bivalve carapace and the carapace is covered by an epicuticle. The first one is to provide protection for the animal and its soft and chitinous skeleton. However, the ostracod carapace is unique in that it is calcified and is an important structure from which the soft body hangs through a series of ligaments, muscles and tissues, the former two leaving frequently prominent scars on the inside of the valves. The most prominent scars are also frequently visible externally because they are the location of muscles, which help close and open the valves. These scar sites are called central muscle scars. The carapaces in ostracods open up and intense bacterial activity separates the valves (Patrick De Deckker, 2002). In an environment where rate of deposition is low, the carapaces are likely to open up by bacterial action. But, in an environment where deposition is very rapid, the carapaces will sink into the soft bottom and will be quickly covered by sediments. Thus, the carapaces will have less chances of opening up, after the destruction of muscles and ligaments.

The application of statistical data on Ostracoda has attained importance, such as juveniles and adults; closed and isolated valves; males and females; right and left valves; smooth and ornamented forms, etc., besides colour variation, pyritisation and predation, to interpret the environment of deposition, rate of deposition and to assess the potentiality of sediments as source rocks for hydrocarbons. The usage of carapace-valve ratio to yield palaeoecological information was pioneered by Pokorny (1965). Oertli (1971) reviewed Pokorny's work and related the carapace-valve ratio to potential information on hydrocarbons. He suggested that when the ratio is high, the sedimentation is rapid, which minimizes disarticulation of carapaces into separate valves. With sufficiently rapid burial, organic matter is not absorbed by mineral particles and so retains potential for conversion into hydrocarbons. Honnappa and Venkatachalapathy (1978) studied the carapace-valve ratio to interpret the rate of deposition of sediments in the Mangalore Harbour area. They found that the separate shells occur more in number than the closed shells (ratio being 24:1). According to them, this is indicative of a slow rate of sedimentation in more agitating waters. McKenzie and Guha (1987) stated that a high

Plate I



percentage of carapaces in the sediments of Eocene/Oligocene from southeastern Australia and India, indicates rapid burial. While studying the Tertiary Ostracoda from the Lindi area, Tanzania, Ahmad *et al*. (1991, p.178), on the basis of valve-carapace ratio, observed a higher rate of sedimentation in the Upper Eocene and Lower Miocene than for the Oligocene.

From a study of the ostracod assemblages in the Pulicat estuarine sediments, Sreenivas *et al*. (1991) found the complete shells in much larger number when compared to the separate ones. According to them, it is an indication of comparatively rapid rate of sedimentation. While studying various aspects of ostracod assemblages in the Gulf of Mannar, off Tuticorin, Hussain *et al*. (2002) observed the ratio between the carapaces and open valves for evaluating the rate of sedimentation and found that the same is faster/rapid. The ratio of carapaces to valves in the inner shelf of the Gulf of Mannar estimated by them (2002) is 4:1. Almost similar estimate was determined by Sridhar *et al.* (1998) from the Palk Bay, where they observed the carapace to valve ratio as 5:1, indicative of a fairly rapid rate of sedimentation. Further, Hussain and Rajeshwara Rao (1996) observed generally larger number of closed carapaces than the open valves along the inner-shelf sediments of east coast, while the number is much less from the sediments off the west coast. From the above observation, they (1996) inferred that the rate of sedimentation is rapid in the east coast while it is slow in the west coast of India; this can be attributed to a larger number of streams/rivers flowing and debouching the sediments into the Bay of Bengal. However, from off Karikkattukuppam, Bay of Bengal, Hussain *et al*. (2004) observed a slow rate of sedimentation in the study area based on C/V ratio.

In the present study, the ratio between the carapaces and open valves has been taken into consideration for determining the comparative rate of sedimentation. Out of the 22 surface samples collected in the Bay of Bengal, as many as 607 ostracod shells were recovered (juvenile and adult specimens of all the 21 species put together) in surface samples. Among these, most of the specimens are open valves (representing about 90%), while the remaining specimens are carapaces. All the ostracod specimens are white to light yellow in colour with couple of species getting predated. No pyritisation of the ostracods is observed in the samples provided. Based on C/V ratio, in the surface samples of the Bay of Bengal, it is inferred that a comparatively slow rate of sedimentation prevails in the study area, under a normal oxygenated environment.

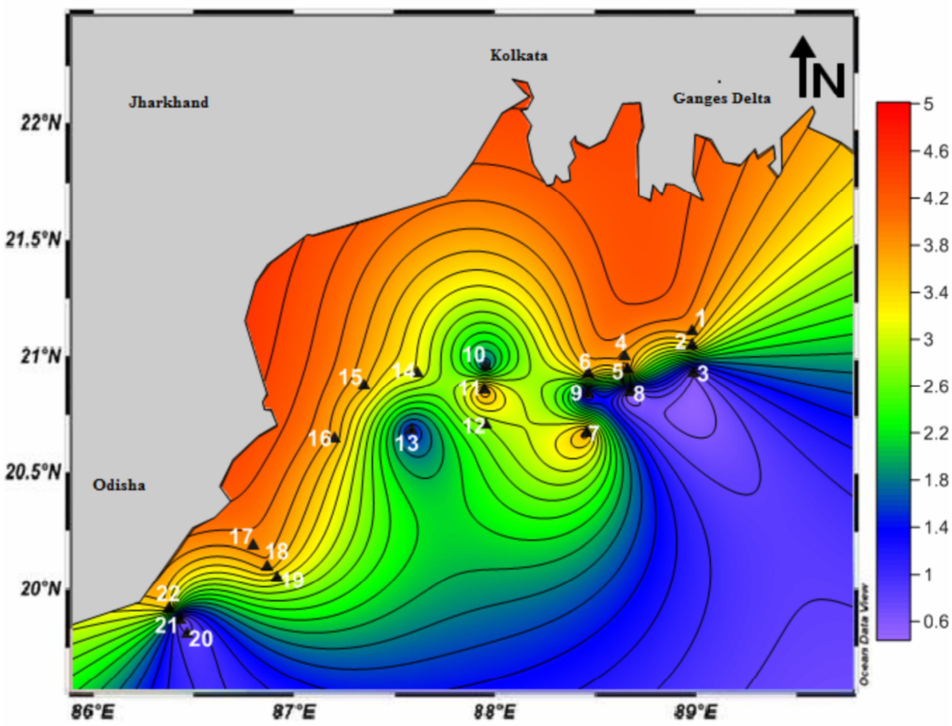


Fig. 3. Spatial distribution of DO values of the study area.

SUMMARY AND CONCLUSIONS

Twenty-one species belonging to 18 genera have been identified from twenty-two surface sediment samples collected through SSK-35 from the coastal region along the northwestern part of the Bay of Bengal. Out of these, *Echinocythereis* sp, *Cytherelloidea leroyi* and *Keijia demissa* occur abundantly. The salinity range from 32.87 to 34.87‰ and DO range from 0.43 to 3.9% appears congenial for the better thriving these species. From the occurrence and distribution of the ostracod assemblage, it is inferred that the sediment are deposited in a tropical, shallow, inner shelf environment. In the present work, the ratio between the carapaces and open valves has been taken into consideration for determining the rate of sedimentation in the study area. Out of the 22 surface samples from the Bay of Bengal, as many as 607 ostracod shells were recovered (including adult and juvenile forms of all the 21 species put together). Among these shells,

Table 2: Taxonomy chart of Ostracoda of the study area.

Order	Sub order	Super family	Family	Genus	Species
Podocopida	Platycopa		Cytherellidae	*Cytherelloidea*	*Cytherelloidea leroyi*
	Podocopa	Cytheracea	Cytheridae	*Neomonoceratina*	*Neomonoceratina iniqua*
					Neomonoceratina spinosa
			Pectocytheridea	*Keijia*	*Keijia demissa*
			Leptocytheridae	*Tanella*	*Tanella gracilis*
			Krithidae	*Hemikrithe*	*Hemikrithe peterseni*
			Trachyleberididae	*Actinocythereis*	*Actionocythereis scutigera*
				Alocopocythere	*Alocopocythere reticulata indoaustralica*
				Echinocythereis	*Echinocythereis sp*
				Keijella	*Keijella karwarensis*
					Keijella reticulata
				Stigmatocythere	*Stigmatocythere kingmai*
			Brachycytheridae	*Chrysocythere*	*Chrysocythere keiji*
				Pterygocythereis	*Pterygocythereis* sp.
			Cytherettidae	*Neocytheretta*	*Neocytheretta murilineata*
					Neocytheretta snellii
			Loxoconchidae	*Loxoconcha*	*Loxoconcha gruendeli*
			Paracytherideidae	*Paracytheridea*	*Paracytheridea* sp.
			Bythocyteridae	*Bythoceratina*	*Bythoceratina mandviensis*
			Cytheruridae	*Cytheropteron*	*Cytheropterons* sp.
		Cypridacea	Pontocypridae	*Propontocypris*	*Propontocypris* sp.

Table 3: Distribution and Population chart of Ostracoda of the study area.

Sample No→	SC01	SC02	SC03	SC04	SC05	SC06	SC07	SC08	SC09	SC10	SC11	SC12	SC13	SC14	SC15	SC16	SC17	SC18	SC19	SC20	SC21	SC22	TOTAL
Species Names ↓																							
Actinocythereis scutigera													13					9		2	10	6	40
Alocopocythere reticulata indoaustralica												1	1	5							1		8
Bythoceratina mandviensis													14	2	2			6					24
Cytherelloidea leroyi									6	4	3		8		12			9			16	8	66
Cytheropteron sp.													8	1	5			1					15
Echinocythereis sp.													22	9	21			7			15		74
Hemikrithe peterseni									2	3			9	3	1					3		6	27
Keijella karwarensis											3	3	1										7
Keijella reticulata										6	3	1	8										18
Keijia demissa													12	13	16			10	5	9			65
Loxoconcha gruendeli												1		6	14						2		23
Neocytheretta murilineata													8								12		20
Neocytheretta snellii													34		7								41
Neomonoceratina iniqua						2				2		2	31										37
Neomonoceratina spinosa						1	4		5	1		5	6					6					28
Paracytheridea sp.							1		3	5			13	9	8			1					40
Propontocypris (Schedopontocypris) bengalensis												1	3	4	2						3		13
Chrysocythere keiji												1											1
Pterygocythereis sp.											1		8										9
Stigmatocythere kingmai												13	2										15
Tanellagracilis													19	7	2			5		2	1		36
																	607						

90% specimens were open valves and the remaining 10% were complete carapace. The distribution of carapaces and open valves in the samples of the Bay of Bengal suggests that comparatively a slow rate of sedimentation prevails in the studied locations of the Bay under normal oxygenated environmental conditions. In the Bay, all the ostracod specimens recorded are white to light yellow in colour with a couple of species appearing predated. No pyritisation was observed in the ostracod shells.

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