



Role of foraminifera and benthic mollusks as biological indicators of the beach environment along the coastal stretches of India

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Available online at: www.isca.in, www.isca.me

Received 24th June 2021, revised 29th October 2021, accepted 28th November 2021

Abstract

Foraminifera are generally found in the shallow waters of intertidal beach and the sandy bottom with subordinate silt and clay. Possessing a similar environment, the coastal stretches of the Bay of Bengal and the Arabian Sea are found suitable for the flourishing of foraminifera and mollusks that play an important role as biological indicators. Foraminifera as well as the benthic molluscan community found in the intertidal zone along the coastlines of peninsular India are also considered as the biological indicators for beach erosion. All these micro- and macroinvertebrates are environment sensitive taxa and act as pollution indicators. Among foraminiferal communities, Ammonia sp. found in the majority is concentrated at beach sands. In general, Ammonia sp., an abundantly occurring foraminifera in the east coast of India, is almost scarce in the beach sands inundated twice daily by the polluted coastal waters.

Keywords: Foraminifera, mollusks, biological indicators, water quality, beach sand characteristics.

Introduction

Benthic genera from the beach sediments are normally considered to prefer shallow, low energy habitats¹. Foraminifera like *Quinqueloculina*, *Triloculina*, and other miliolids are indicative of inshore open shelf margin environments. If, on the other hand, and despite shallowing, the miliolids were representative of mass displacement of inshore deposits onto pelagic oozes, the occurrence of a fine fraction fauna may be a result of resuspension in the water column at depth by debris flows and subsequent mixing with the shallow water sands^{2,3}. In general, all beach materials of the Indian coastlines are sandy to gravelly sands. Occasionally the occurrences of gravelly sands in the lower intertidal zone of Mumbai and Kasaragod of west coast are due to the presence of shell fragments resulting after the heavy biogenic reworking for wave action.

Life cycle of foraminifera is generally shorter in comparison to other macroinvertebrates of the coastal areas and their swift responses to the changing environmental parameters like pH, salinity, temperature, and the degree of pollutants in the surroundings recognize them as an excellent biological indicator around the encompassing environment⁴. Occurrence of foraminifera and mollusks along the coastal stretches of peninsular India as well as their significance as the environmental parameters is the objective of the present study.

Materials and methods

About 32 sediment samples were collected from the intertidal beach zones of Chandrabhaga, Puri, Visakhapatnam, and Chennai from the east coast and Kovalam, Kasaragod, and

Mumbai from the west coast of India for the micropaleontological study. The sediment samples, dried in sunlight, were processed following the standard methods. The coarser fraction of the bulk sediments was considered for the micropaleontological studies, which were retained in the +230 ASTM mesh sieve. To identify the taxonomic position of the foraminifera, mainly picking up and mounting specimens on micropalaeontological slides were done. Gravelly sands of seabeach were studied on a petrological microscope. Biostatic components were studied under a binocular microscope after treating the samples with sodium carbonate solution. Different fractions of sediment samples from the beach areas were collected followed by mechanical sieving and those fractions of different grain size retained in the sieve were considered for the micropalaeontological studies⁵. Major fauna including foraminifera were found from the +35 fraction to +120 fractions of the mechanically sieved samples.

As the collected and processed sediment samples from different coastal zones along different transects from supratidal to the intertidal zones were mostly above silt sizes, different fractions of the samples were separated using the sieving method. The fractions of the samples of Indian coast are scanned under binocular microscope on the biogenic point of view especially of foraminifera which were properly identified by the micropaleontological experts of the Marine Wing Division of Geological Survey of India. Molluscan specimens comprising both gastropods and bivalves were collected from the selected beaches of east and west coasts of peninsular India, and they were properly identified by the experts of Mollusca section of the Zoological Survey of India.

Results and discussion

Examination of samples for the micropaleontological studies reveal that the samples of eastern coast are almost devoid of any biogenic taxa except presence of sporadic ill preserved foraminifera viz. *Ammonia beccarii* in the locations of Chandrabhaga, Puri, and Visakhapatnam. Sediment samples from the supratidal zone of Visakhapatnam do not contain any biogenic taxon. In the west coast, rare biogenic with few grains of foraminifera *Elphidium crispum* are found in the intertidal sand samples of Mumbai contain 8 to 30% biogenic with 2 to 5 % foraminifera; ill preserved *Ammonia beccarii* is observed in the coast. In contrast to the other areas, supratidal gravelly sand samples of Mumbai contain about 80 to 90% biogenic materials with shell fragment content. The foraminifera estimated is about 5% of the total fauna. The taxa encountered are *Ammonia beccarii*, *Elphidium crispum*, *Elphidium advena*, *Smoutina* sp. and *Quinqueloculina* sp. The preservation is rather good. The significantly low content of biogenic taxa including foraminifera in the east coast and southern part of west coast is probably due to low productivity, improper preservation

conditions, and high energy conditions. The extraordinarily high concentration of biogenic taxa in and around Mumbai supratidal beach sand samples is incredibly significant. The biota and fragmentation nature indicate that the salinity temperature and nutrient condition is favourable for generation of biota near Mumbai area. The scarcity of foraminifera in the biogenic is partly due to excessive growth of macroinvertebrates, gastropods etc. which consume foraminifera and partly due to destruction by repeated reworking after death of fauna. Sediment samples from the lower intertidal zone of Chennai, Puri, Chandrabhaga, Kovalam, Kasaragod beaches did not contain either benthic or pelagic foraminifera, and no planktonic species could be found in samples from the lower intertidal beach sands.

The fractions of the beach sand samples of Indian coast are scanned under binocular microscope on the biogenic point of view especially of foraminifera which were properly identified by the micropaleontological experts of the Marine Wing Division of Geological Survey of India (Table-1).

Table-1: Micropaleontological studies from the collected beach sands of peninsular India.

Location	Geomorphic zone	Sample No	Sand fraction	Foraminifera	Other biogenic
Visakhapatnam	upper	VS-1	-	-	-
Visakhapatnam	intertidal	VS-2	+35 to +120	<i>Ammonia beccarii</i>	-
Visakhapatnam	lower intertidal	VS-3	+120	-	bryozoan fragments
Visakhapatnam	upper intertidal	VS-4	+45 fraction	<i>Ammonia beccarii</i>	-
Mumbai	intertidal	MB-1	+60 fraction	<i>Ammonia beccarii</i> , <i>Quinqueloculina</i> sp.	bivalve, gastropod
Mumbai	lower intertidal	MB-2	+35, +45, +60 fraction	<i>Ammonia beccarii</i> and <i>Smoutina</i> sp.	gastropod, pteropod
Mumbai	upper intertidal		+35 fraction	<i>Ammonia beccarii</i> and <i>Smoutina</i> sp.	gastropod, pteropod, fishbone, bryozoa
Mumbai	lower intertidal	MB-3	+45 fraction	<i>Ammonia beccarii</i> , <i>Elphidium Crispum</i> , <i>Elphidium advena</i> , <i>Smoutina</i> sp. and <i>Quinqueloculina</i> sp.	gastropod, pteropod, fishbone, bryozoa
Mumbai	lower intertidal		+60 fraction	-	shell fragment of macroinvertebrates, gastropod, pteropod, bryozoa
Mumbai	lower intertidal		+80 fraction	<i>Ammonia beccarii</i> , <i>Quinqueloculina</i> sp.	gastropod, pteropod, fishbone, bryozoa
Mumbai	upper intertidal	MB-3	+35 fraction	<i>Ammonia beccarii</i> , <i>Quinqueloculina</i> sp.	gastropod, pteropod, fishbone, bryozoa
Mumbai	upper intertidal		+45 fraction	<i>Ammonia beccarii</i> , <i>Quinqueloculina</i> sp.	gastropod, pteropod, fishbone, bryozoan fragments
Mumbai	upper intertidal		+60 fraction	<i>Ammonia beccarii</i> , <i>Quinqueloculina</i> sp.	shell fragments, bryozoa
Mumbai	upper intertidal	MB-3	+45 fraction	<i>Ammonia beccarii</i> , <i>Elphidium Crispum</i> , <i>Elphidium advena</i>	shell fragments, bryozoa
Mumbai	upper intertidal		+60 fraction	-	shell fragments, bryozoa
Mumbai	upper intertidal	MB-3	+80 fraction	-	shell fragments, bryozoa

Mumbai		MB-4	+120 fraction	<i>Ammonia beccarii</i>	gastropod
			+35 fraction	-	bryozoa, pteropod,
			+45 fraction	-	gastropod
			+60 fraction	-	macroinvertebrates
			+80 fraction	-	shell fragments and fish bones
Chandrabhaga	lower intertidal	CD-1		<i>Elphidium Crispum</i>	-
			+35 fraction to +60 fraction, +100 fraction	<i>Ammonia beccarii</i>	-
Chandrabhaga	upper intertidal	CD-2	+120 fraction	-	-
Kovalam	upper intertidal	KV-1	+80 fraction	-	gastropods
			+35 fraction to +120 fraction	-	-
Kovalam		KV-2	+35 fraction to +120 fraction	<i>Ammonia beccarii</i>	gastropod, bivalves
Puri	lower intertidal	PR-1	+35 fraction	-	-
			+45 fraction	-	gastropods, bivalves
Puri	upper intertidal	PR-2	+60 fraction	-	-
			+35 fraction	-	-
Chennai		CN-1	+45 fraction	-	-
			+60 fraction	-	gastropods, bivalves
			+35 fraction, +60 fraction, +80 fraction	<i>Ammonia beccarii</i>	gastropods, bivalves
Chennai	lower intertidal	CN-2	+35 fraction to +80 fraction	<i>Ammonia beccarii</i>	-
			+35 fraction to +80 fraction	<i>Ammonia beccarii</i>	small lamellibranches shell
Kasaragod	upper intertidal	KS-1	+35 fraction	<i>Ammonia beccarii</i>	shell fragments of macroinvertebrates
			+45 fraction to +80 fraction	foraminifera rare	shell fragment of macroinvertebrates
Kasaragod	lower intertidal	KS-2	+35 fraction		shell fragments
			+45 fraction to +120 fraction		fine shell fragments
	upper intertidal		+35 fraction		
	lower intertidal		+45 fraction		
			+60 fraction		
	upper intertidal		+80 fraction		
			+120 fraction		
	lower intertidal				

Benthic molluscan communities: Numerous structures preserved in the stratigraphic records are the results of various activities of organisms, although the stratigraphic sequence might be wholly devoid of their actual remains whether in part or full as suggested by the geologists⁶. Life activities imparted by the organisms as structural features in the substratum are recorded as bioturbation structures⁷. These structures are autochthonous and cannot be concentrated by reworking that provides reliable records of benthic communities⁸. Sometimes biogenic activities may be used to interpret the sedimentation pattern, beach morphodynamics. Among the benthic gastropod mollusks, *Polinices turridus* plays an important role by the formation of bioturbation structures which is to be considered as biological tools for the interpretation of the coastal dynamics^{9,10}.

Habitat selection: The coastal zone alongside the north Bay of Bengal is a highly erosive and *Polinices turridus* is available generally at the site of erosion with fine sediments comprising sands and silt. Because of these reasons *Polinices turridus* is likely to be considered as biological indicators for erosion as they prefer habitats in the site of erosion. The erosional phenomena are further evidenced by some very basic erosional structures like mudball, furrow and ridge structures, fragments of wood trunks as obstacle scours found in the intertidal beach environment of the coastal zone¹¹.

***Polinices turridus*:** *Polinices turridus*, commonly known as moon shells of the Family Naticidae; Order Mesogastropoda; Class Gastropoda under the Phylum Mollusca, is a mollusk of burrowing forms moving actively on fine sands or/and sandy silts i.e., soft bottom sediments of the intertidal zone in the coastal environment (Figure-1). *Polinices turridus* feeds mainly on different species of pelecypods, generally the species under the families of veronids, tellinids, and lucinids. Its massive foot helps in ploughing through the fine sands in search of the prey leaving trace or trail marks either for feeding or grazing purposes disturbing the bottom topography¹².

Both mechanical and chemical actions are involved in the entire way of feeding of *Polinices turridus*. During the method of feeding the highly developed foot can be extended and its water tube system helps in spreading to a huge size. The anterior propodium of the foot covers the major portion of the head when folded back after expansion. The foot works like a spade to dig, as a plough to furrow and turn up, sometimes to grasp and force its prey among its various functions^{13,14}.

Mouth contains ventrally a boring gland generally used to make holes in the pelecypod shells along with some accessory organs such as a big ctenidium and a tiny osphradium in the mantle cavity. Corneous jaw plates are present in the protrusible buccal mass¹⁵. During feeding the prey it is entangled with a mucous component and the foot grasps the prey steadily. The radula crushes through the shell and ensures a hole after the boring gland makes softening the bivalve shells. Then *Polinices turridus* penetrates its proboscis through the hole to suck the

unconsolidated form of meat from the bivalve shells¹⁶. Along with the *Polinices* sp., several other molluscan shells under the classes Gastropod and Bivalves are randomly exploited in the coastal tract of West Bengal that disrupts the ecological balance of the coastal environment¹⁷⁻²¹.



Figure-1: Occurrences of *Polinices turridus* in the intertidal beach sands of Bakkhali-Frasergunj, West Bengal.

Mollusks collected and Identified from the Indian coast: Molluscan specimens comprising both gastropods and bivalves were collected from the selected beaches of east and west coasts of peninsular India, and they were properly identified by the eminent experts of Mollusca section of the Zoological Survey of India (Table-2).

Conclusion

The study revealed that the biogenic are mostly reworked in Mumbai and other beaches along the coastline of peninsular India. The macroinvertebrate shells are highly fragmented, polished due to repeated reworking and hydraulic action. The carbonate content of the +35, to +60 fraction around the supratidal beach sands of Mumbai is as high as 90%. The foraminifera and bryozoan fragments represented in the coast samples are very fresh and of Recent to Sub-Recent type. They indicate shallow water deposition which is distributed and redistributed by hydraulic action. In that environment, the gastropod mollusk like *Polinices turridus* is to be considered as biological indicator for the determination of the beach erosion as the gastropod mollusk occurred abundantly only during the erosional phases of sea beaches along the coastal stretches of Odisha and West Bengal respectively.

Table-2: Identified benthic molluscan species from the selected beaches along the coastlines of India.

Location	Class	Species names
Kasaragod beach, Kerala	Gastropoda	<i>Turritella duplicata</i> (Linnaeus)
		<i>Olivancillariagibbosa</i> (Born)
		<i>Turriculajavana</i> (Linnaeus)
		<i>Anadara (Tegillarca) rhombea</i> (Born)
		<i>Pernaviridis</i> (Linnaeus)
	Bivalvia	<i>Mactra (Mactra) cuneata</i> Gmelin
		<i>Mactra (Macrinula) reevesi</i> Gray
		<i>Apolymetis</i> sp.
		<i>Donax (Donax) pulchella</i> Hanley
		<i>Donax (Hecuba) scrotum</i> Linnaeus
Puri beach, Odisha	Bivalvia	<i>Sunetta (Sunetta) scripta</i> (Linnaeus)
		<i>Sunettasolanderii</i> (Gray)
		<i>Meretrix</i> sp.
		<i>Glycymeris</i> sp.
		<i>Cardites antiquata</i> (Linnaeus)
	Gastropoda	<i>Mactra (Mactra) luzonica</i> Deshayes
		<i>Sunetta (Sunetta) scripta</i> (Linnaeus)
		<i>Sunetta (Sunetta) effosa</i> (Hanley)
		<i>Sunettameroe</i> (Linnaeus)
		<i>Timoclea imbricata</i> (Sowerby)
Marina beach, Chennai	Gastropoda	<i>Turritella attenuate</i> Reeve
		<i>Polinices (glossaulax) didyma</i> (Roeding)
		<i>Natica vitellus</i> (Linnaeus)
		<i>Ficus variegata</i> Roeding
		<i>Phalium canaliculatum</i> (Bruguiere)
	Bivalvia	<i>Distorsio reticulata</i> (Roeding)
		<i>Bursa echinata</i> (Link)
		<i>Muricanthus virgineus</i> (Roeding)
		<i>Cantharus tranquebaricus</i> (Gmelin)
		<i>Babylonia spirata</i> (Linnaeus)
Bakkhali-Frasergunj beach, West Bengal	Gastropoda	<i>Terebra commaculata</i> (Gmelin)
		<i>Architectonica laevigata</i> (Lamarck)
		<i>Anadaragranosa</i> (Linnaeus)
		<i>Scapharcadeyrollei</i> Jousseume
		<i>Scapharcainaequivalvis</i> (Bruguiere)
	Bivalvia	<i>Glycymeris taylori</i> (Anton)
		<i>Trachycardium elongatum</i> (Bruguiere)
		<i>Donax scortum</i> (Linnaeus)
		<i>Architectonica perspectiva</i> (Linnaeus)
		<i>Cerithidea (Cerithidea) obtusa</i> Lamarck
Bakkhali-Frasergunj beach, West Bengal	Gastropoda	<i>Naticatigrina</i> (Roeding)
		<i>Polinices turridus</i> (Swainson)
		<i>Gyrineum natator</i> (Roeding)
		<i>Thais lacera</i> (Born)
		<i>Pugilinacochlidium</i> (Linnaeus)
	Bivalvia	<i>Nassarius stolatus</i> (Gmelin)
		<i>Amalda ampla</i> (Gmelin)
		<i>Striarcalactea</i> (Linnaeus)
		<i>Mastraluzonica</i> Deshayes
		<i>Mastraviolacea</i> Gmelin
Bakkhali-Frasergunj beach, West Bengal	Bivalvia	<i>Macomabirmanica</i> Philippi
		<i>Apolymetis edentula</i> Spengler
		<i>Sanguinolaria (Soletellina) acuminata</i> (Deshayes)
		<i>Glauconomesculpta</i> (Sowerby)
		<i>Barnea candida</i> (Linnaeus)

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