

Distribution and Abundance of Intertidal Macrofauna Along the Someshwara Beach

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Abstract In this study, the distribution, abundance and diversity patterns of intertidal fauna from three stations of Someshwara beach along the Mangaluru coast between 12° 47' 748'' N to 12° 48' 165'' N was studied. In all the three stations four phyla of intertidal invertebrates were recorded in which phylum Mollusca was dominated. Total bivalves (14 genera), Gastropods (16 genera), Scaphopods (2 genera), Crustacean (6 genera), Polychaetes (7 genera), Nematodes,

Echinodermata (3 genera) were recorded in the present study. Analysis of variance revealed that organisms did not vary according to station though the variation was seen in different months and season. Simpson's diversity index, Margalef richness index and Pielou's index indicated ecological variations in different seasons with different stations. Shannon's diversity index revealed the moderately diverse status of the intertidal fauna along the Someshwara beach.

Keywords Intertidal organisms, Macrofauna, Abundance, Distribution, Someshwara beach.

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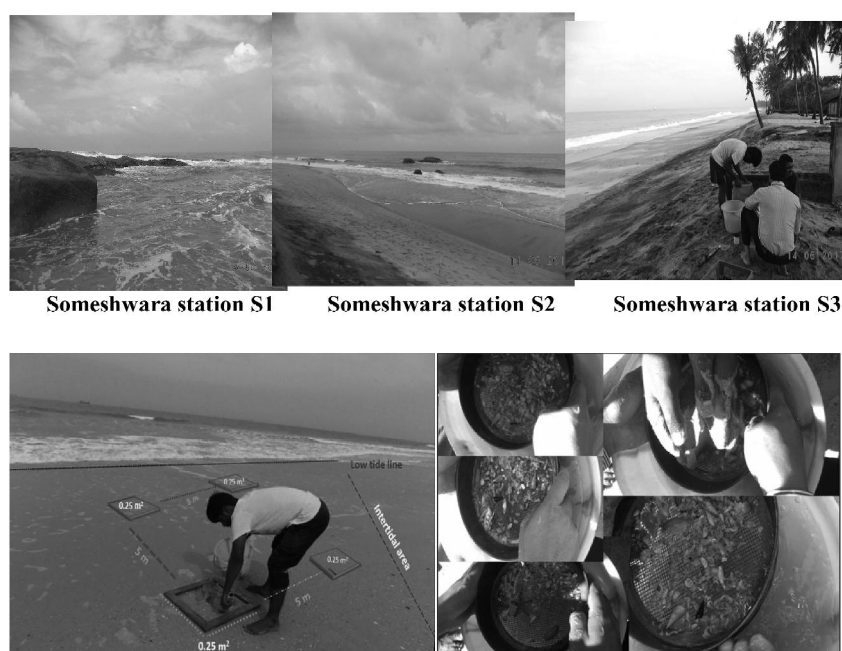
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Introduction

The present investigation was undertaken mainly to know the species abundance and distribution of intertidal organisms in relation to spatiotemporal variations of physico-chemical parameters of water from selected three stations of Someshwara beach and stations were designated as S₁, S₂ and S₃ sampling was carried out from August 2016 to July 2017. Someshwara beach lying in between the Netravati-Gurupura estuarine mouth in the north and Someshwara rock in the south, the beach of the sector 2 is linear and consists of coarse sand (Shruthi and Rajashekhar 2013). The beach face appears very steep throughout the year and the surf zone width is very narrow (5 to 15 m). The width of the beach varies between 20 m and 50 m, and has a prominent high berm.



Sampling design for the collection of intertidal organisms and collection of intertidal organisms and planktonic larvae.

Fig. 1. Sampling design for the collection of intertidal organisms and collection of Intertidal organisms and planktonic larvae.

Materials and Methods

The intertidal water samples were collected using a clean plastic bucket and stored in plastic bottles for analysis of pH, salinity, Nitrite-N, Nitrate-N and Silicate-Si. Samples for dissolved oxygen, ammonia-nitrogen (NH_3 -N) and phosphate-phosphorus (PO_4 -P) analysis were collected in acid washed glass bottles. The sediment samples were collected by using scoop and placed in plastic cover for further analysis in the laboratory (Fig. 1). All the three stations of the Someshwara beach, in each station were selected 4 quadrates with 0.25 m^2 area at an interval of 5 m were sampled every month during low tide. Thus 12 quadrates sampled in every month, this sampling design have covered an area of $3 \text{ m}^2 \text{ month}^{-1}$ over the stretch of Someshwara beach. The sample were sieved through a mesh sieve, above 1 mm mesh size sieve for macro-organisms, less than 1 mm mesh size sieve for micro-organisms and $200 \mu\text{m}$ plankton net for plank-

tonic larvae, retained organisms collected in plastic bottles and preserved in 5% formalin. Then animals were separated, counted, identified up to species/genera level using standard references and expressed in No/m^3 .

Results and Discussion

Air temperature

The air temperature was ranged between 24.0 and 30.8 $^{\circ}\text{C}$ (Fig. 2). The minimum was observed in the month of December (post-monsoon) in Someshwara beach (S_1) while the maximum was observed in the month of April (pre-monsoon) at S_2 and S_3 . Temporally the maximum air temperature was recorded during pre-monsoon and minimum during monsoon season. Lowest temperature recorded during south west monsoon period may be attributed to the monsoon wind and precipitation and soon after monsoon the tempera-

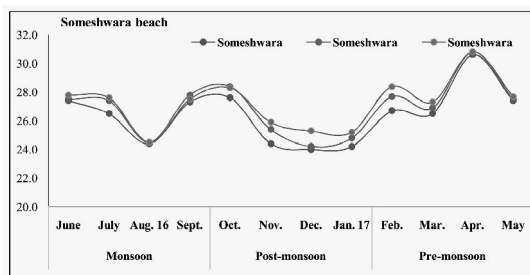


Fig. 2. Monthly variations of air temperature ($^{\circ}\text{C}$) at selected stations during August 2016 to July 2017.

ture increased gradually due to the increase in solar radiation and change in wind condition.

Water temperature

Water temperature was ranged from 23.5 to 30.8 $^{\circ}\text{C}$. The minimum was recorded in the month of September (monsoon) at Someshwara beach stations S_1 and S_2 while maximum was observed in the month of April (pre-monsoon) at station S_2 . Spatially, there were not many variations between the stations of the selected beach. Seasonally the minimum water temperature was observed in monsoon followed by post and pre-monsoon season (Fig. 3).

It is well known that water temperature influences the intertidal organisms directly by effecting on their physiological parameters and indirectly through change in the physico-chemical properties of intertidal water. It influences the chemical processes such as dissolution-precipitation, adsorption-desorption, oxidation-reduction and physiology of biotic com-

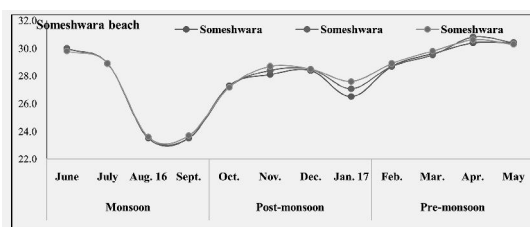


Fig. 3. Monthly variations of water temperature ($^{\circ}\text{C}$) at selected stations during August 2016 to July 2017.

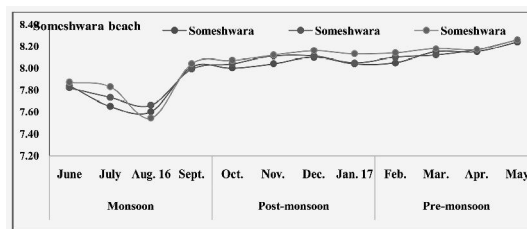


Fig. 4. Monthly variations in pH of water at selected stations during August 2016 to July 2017.

munity in the intertidal habitat. A seasonal increasing trend in air temperature was observed for water temperature during the study period. The minimum water temperature was observed in the month of August (monsoon) at Someshwara beach station (S_1).

pH

The intertidal water pH ranged from 7.54 to 8.26. The minimum pH was observed in the month of August (monsoon) at Someshwara beach S_3 while the maximum was observed in the month of May (pre-monsoon) at Someshwara beach S_2 and S_3 . There were no spatial variations between the stations. During the monsoon season water pH was lower compared to post and pre-monsoon season. The minimum pH 7.40 of intertidal water was recorded in the monsoon season at Someshwara beach station (S_3). However, maximum pH was observed in all stations during pre-monsoon season. The observed pH maxima during pre-monsoon could be attributed to the high rate of evaporation under high temperature conditions. The observed post-monsoon minima can be ascribed to rainfall, resultant freshwater mixing. Similar results were also observed by earlier workers Sushanth and Rajashekhar (2012) observed pH values ranging from 7.9 to 8.5 in coastal waters of Uttara Kannada district. Shruthi (2015) recorded pH 7.8 to 8.6 in Mangaluru coastal waters (Fig. 4).

Salinity

Salinity is a dynamic indicator of the nature of the exchange system. The salinity of water within the coastal and estuarine area tells us how much freshwater has mixed with sea water. Salinity is one of the

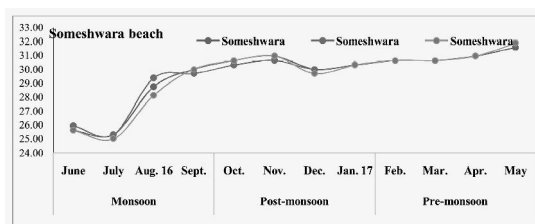


Fig. 5. Monthly variations in salinity (psu) of water at selected stations during August 2016 to July 2017.

key factor in marine environment. Present study the salinity of water varied from 25.00 to 31.88 PSU. The minimum salinity was recorded in the month of July (monsoon) at S_3 while the maximum value was observed in the month of May (pre-monsoon) at S_2 and S_3 . Monsoon season showed low saline condition, while high salinity was recorded in pre-monsoon period and spatially uniform values were recorded in all stations. In the present study, considering the seasonal trend, the maximum salinity (31.88 psu) of water was observed in the month of May 2017 at Someshwara beach (S_2 and S_3), whereas the minimum salinity (25.00 psu) was observed in the month of July 2017 at Someshwara station (S_3). It is well known that salinity is determined by the factors like precipitation, run-off, evaporation and the degree of dilution caused by the mixing of sea and river water (Fig. 5). In the present study also the salinity showed an increasing trend from monsoon to pre-monsoon the most crucial factor responsible for the death of intertidal fauna is salinity which decreased considerably during monsoon (Datta et al. 2010).

Dissolved oxygen (DO)

The dissolved oxygen concentration ranged from 7.52 to 8.15 mg/l. The lower concentration was recorded in the month of June (monsoon) at Someshwara beach S_3 while higher concentration was recorded in the month of September (monsoon) at Someshwara beach S_3 . There was a well oxygenated water condition observed during monsoon followed by post monsoon and pre monsoon season. In the present study the dissolved oxygen concentration fluctuated between 5.71 and 8.15 mg/l irrespective of intertidal wave and tidal activities, with a variation of 2.44 mg/l. The high-

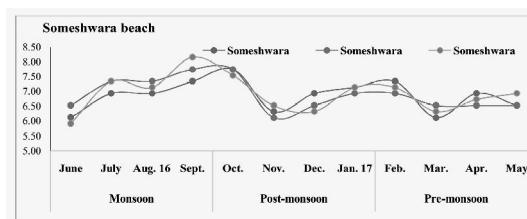


Fig. 6. Monthly variations in dissolved oxygen (mg/l) content of water at selected stations during August 2016 to July 2017.

est concentration was recorded in the month of September and October and lowest in the month of April. The observed high values might be due to the effects of higher wind velocity, increased turbulence coupled with heavy rainfall. However, in intertidal waters the resultant freshwater mixing through run-off also might have resulted in high dissolved oxygen content. The observed low dissolved oxygen concentration could be attributed to high biological activity besides, low solubility of oxygen under high temperature and salinity conditions. The observation of dissolved oxygen showed an inverse trend against temperature and salinity (Fig. 6).

Ammonia-nitrogen

The ammonia content in water was ranged from 7.52 to 13.83 $\mu\text{g-at./l}$. The minimum concentration was reported in the month of November (post-monsoon) at Someshwara beach S_1 while maximum was reported in the month of August (monsoon) at S_3 . Seasonally lower concentration recorded during post monsoon and pre-monsoon season (Fig. 7). In the present investigation, the ammonia was ranged from a mini-

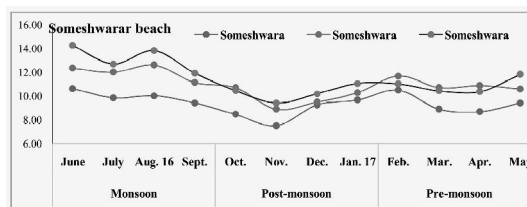


Fig. 7. Monthly variations in ammonia-nitrogen ($\mu\text{g-at./l}$) content of water at selected stations during August 2016 to July 2017.

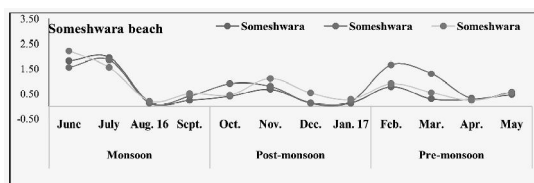


Fig. 8. Monthly variations in nitrite-nitrogen ($\mu\text{g-at./l}$) content of water at selected stations during August 2016 to July 2017.

imum of $7.52 \mu\text{g-at./l}$ in the month of November at Someshwara station S_1 to maximum of $13.83 \mu\text{g-at./l}$ in the month of July at Someshwara beach station S_3 with a variation of $3.791 \mu\text{g-at./l}$. The observed low ammonia-nitrogen values during the study period could be due to the uptake by phytoplankton, which might have influenced the dissociation of total ammonia, thereby resulting in its low level. The observed high values during post-monsoon might be due to influx of nutrient laden terrestrial and river run-off.

Nitrite-nitrogen

Nitrite-nitrogen varied in the range of 0.13 to $2.21 \mu\text{g-at./l}$ with the minimum values in the month of December (post-monsoon) at S_1 and S_2 and maximum in the month of June (monsoon) at Someshwara beach (S_3). Seasonally higher concentration recorded monsoon and pre-monsoon. During the present investigation, the nitrite-nitrogen content was ranged between 0.11 and $4.91 \mu\text{g-at./l}$, with a variation of $4.8 \mu\text{g-at./l}$. The minimum values were observed in the month of January at Someshwara beach station S_1 and maximum are observed in the month of July at Someshwara beach station S_3 . The higher values at Someshwara beach station S_3 which also receive sewage during the post monsoon season, could be due to the oxidation of ammonia, reduction of nitrate and also due to the formation as intermediate compound during the decomposition of autochthonous and allochthonous organic matter. The values obtained in the present study are slightly higher than that of previous works from the same study area (Fig. 8).

Nitrate-nitrogen

Nitrate-nitrogen values ranged between 0.77 and $8.18 \mu\text{g-at./l}$ with the minimum values in the month of De-

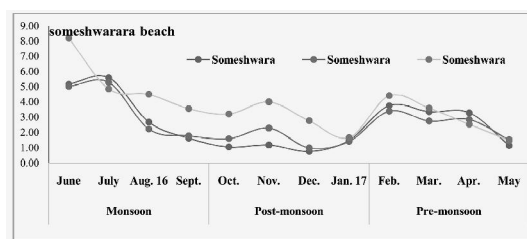


Fig. 9. Monthly variations in nitrate-nitrogen ($\mu\text{g-at./l}$) content of water at selected stations during August 2016 to July 2017.

cember (post-monsoon) at Someshwara beach (S_1) while maximum in the month of June (monsoon) at Someshwara beach (S_3). Seasonally monsoon season recorded higher nitrate-nitrogen concentration than the post and pre-monsoon season. The data collected on the fluctuation of nitrate-nitrogen concentration in Nethravati estuary at selected stations during the study period shown that the concentration ranged between 0.62 and $21.41 \mu\text{g-at./l}$. The minimum value was observed in the month of January at Someshwara station (S_1) and maximum was observed in the month of June at Someshwara station (S_3) (Fig. 9).

Phosphate-phosphorus

The phosphate-phosphorus content was ranged between 0.10 and $2.10 \mu\text{g-at./l}$. The minimum value was observed in the month of February and October (pre-monsoon) at Someshwara beach (S_1) and Someshwara beach (S_3) while maximum was observed in the month of September (post-monsoon) at Someshwara beach (S_3). Seasonally high concentration was recorded during monsoon and post monsoon than pre-monsoon. The minimum concentration of phosphate-phos-

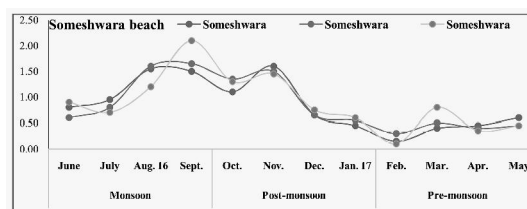


Fig. 10. Monthly variations in phosphate-phosphorus ($\mu\text{g-at./l}$) content of water at selected stations during August 2016 to July 2017.

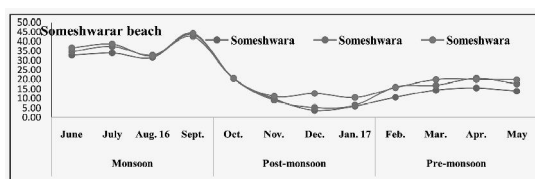


Fig. 11. Monthly variation in silicate-silicon ($\mu\text{g-at./l}$) content of water at selected stations during August 2016 to July 2017.

phorus was observed at Someshwara station (S_3) and Someshwara station (S_3) in the months of February and March, Karl (2000) which could be attributed to increased suspended solids which adsorb the phosphorus (Fig. 10).

Silicate-silicon

The Silicate content had ranged from 3.75 to 46.17 $\mu\text{g-at./l}$. The minimum value was observed in the month of December (post-monsoon) at Someshwara beach (S_1) while maximum was observed in the month of July (monsoon) at Someshwara beach (S_3). Seasonally the silicate-silicon was observed high in monsoon and pre-monsoon than post monsoon (Fig. 11). The present investigation revealed that the higher silicate concentration recorded in the month of June, while relatively lower concentration was recorded from December and September. The silicate content ranged between 3.39 46.46 $\mu\text{g-at./l}$ with a variation of 43.07 $\mu\text{g-at./l}$. The minimum value was observed in the month of December at Someshwara beach station (S_1) and maximum was observed in the month of July at Someshwara beach station (S_3).

Sediment temperature

Sediment temperature was ranged from 26.2 to 33.4 $^{\circ}\text{C}$. The minimum was observed in the month of January (post-monsoon) at Someshwara beach (S_1) while maximum was observed in the month of April (pre-monsoon) at Someshwara beach (S_3). The sediment temperature showed a similar trend with water temperature. Seasonally the minimum sediment temperature was observed in monsoon than post and pre-monsoon season. The sediment temperature values

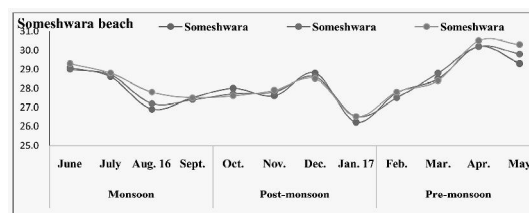


Fig. 12. Monthly variations of sediment temperature ($^{\circ}\text{C}$) at selected stations during August 2016 to July 2017.

indicated a similar trend with water temperature with minor variation in its values. These fluctuations could be due to several factors such as temperature of water that influence air and water temperature, incoming radiation, time of sampling and turbidity conditions of water (Fig. 12).

Sediment total organic carbon

The sediment organic carbon percentage had ranged from 0.01 to 0.19%. The minimum value was observed in the month of December and September at Someshwara (S_1) while maximum was observed in the month of June at Someshwara beach (S_3). Spatially high values recorded in monsoon season (Fig. 13). The data on sediment temperature in the present study indicated a close similarity with the water temperature. The values fluctuated from a minimum of 26.2 C to maximum of 33.4 $^{\circ}\text{C}$ with a variation of 7.2 $^{\circ}\text{C}$. The minimum values of temperature observed at Someshwara beach S_1 during the month of January could be due to the winter season. With the reduction in rainfall and reduced freshwater inputs from the catchment areas, an increasing trend in tempera-

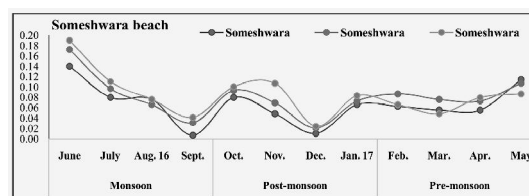


Fig. 13. Monthly variations of organic carbon percentage at selected stations during August 2016 to July 2017.

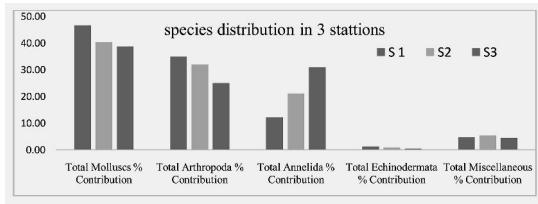


Fig. 14. Species distribution percentage in selected stations of Someshwara beach.

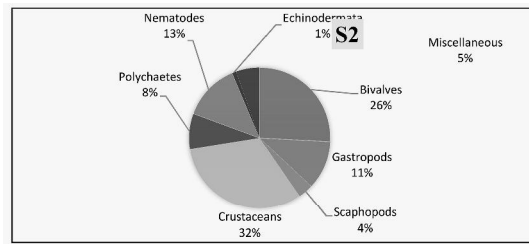


Fig. 16. Species distribution Someshwara beach station S₂.

ture of water and sediment was evident from January onwards. The maximum values were observed in the month of May at Someshwara station S₃. These higher sediment temperature values in pre-monsoon season could be due to the higher penetration of solar radiation has caused for increase in temperature of the water and sediments which are in contact with the water.

Distribution of intertidal organisms

Quantitative analysis

A total of 13 genera (Bivalves), 8 genera (Gastropods), and 2 genera (Scaphopodes) were belonging to the phylum Mollusca. 6 genera (Crustaceans) belongs to Arthropod phylum. 5 genera (Polychaetes and Nematodes) belongs to Annelida phylum and 1 species belongs to phylum Echinodermata have been identified during the study period spatially intertidal faunal density was recorded maximum in station S₁ followed by S₂ and S₃ in Someshwara beach, seasonally higher population recorded in the post-monsoon than monsoon and pre-monsoon season (Figs. 14—17, Table 1).

Station S₁

The abundance (No./m²) of intertidal organisms varied from 39 No./m² in July (monsoon) to 133 No./m² in January (post-monsoon). Intertidal organism community structure comprised of crustaceans 26.74% in June (monsoon) to 53.49% in December (post-monsoon), Bivalves 44.83% in May (pre-monsoon) to 72.29% in August (monsoon), Gastropods 18.75% in July (monsoon) to 39.69% in May (pre-monsoon), Scaphopods 4.26% in March (pre-monsoon) to 15.52% in April (pre-monsoon) were recorded under phylum Mollusca. Polychaetes 25% in July (monsoon) to 54.55% in April (pre-monsoon), Nematodes 45.45% in April (pre-monsoon) to 75% in July (monsoon) were recorded under phylum Annelida. Clypeasteroids 0% in (monsoon) to 2.75% in January (post-monsoon). Miscellaneous (egg cases) 0.78% in December (post-monsoon) to 16.67% in August (monsoon) were recorded. Abundance of intertidal organisms was in the order of crustaceans 35% > bivalves 28% > gastropods 14% > nematodes 7% > scaphopodes 5% > polychaetes 5% > miscellaneous 5% > echinoids 1%.

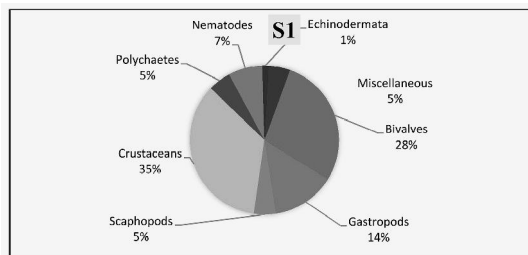


Fig. 15. Species distribution Someshwara beach station S₁.

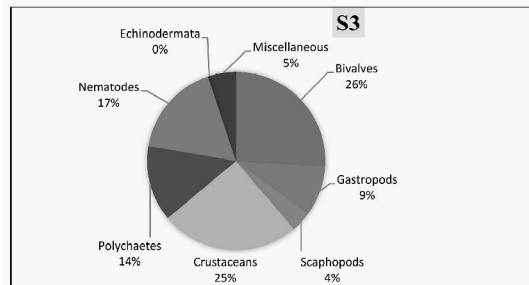


Fig. 17. Species distribution Someshwara beach station S₃.

Table 1. Qualitative analysis of intertidal organisms along the selected stations. (+) present and (-) absent.

Intertidal fauna	Someshwara beach		
	S ₁	S ₂	S ₃
	Molluscs		
Bivalves			
<i>Arca</i> spp.	+	+	+
<i>Anadara granosa</i>	+	+	+
Bivalve spats	+	+	+
<i>Cardium</i> spp.	+	+	+
<i>Crassostrea</i> spp.	+	+	-
<i>Donas faba</i>	-	+	+
<i>Donax scortum</i>	+	+	+
<i>Dosinia</i> spp.	+	+	+
<i>Meritrix casta</i>	+	+	+
<i>Meritrix</i> spp.	+	+	+
<i>Paphia</i> spp.	+	-	+
<i>Paphia malabarica</i>	+	+	-
<i>Pecten</i> spp.	-	-	-
<i>Perna viridis</i>	+	+	+
<i>Tellina</i> spp.	+	+	+
Gastropods			
<i>Bullia</i> spp.	-	-	-
<i>Bursa</i> spp.	-	-	-
<i>Cypraea</i> spp.	-	-	-
<i>Cerithidea</i> spp.	-	+	+
Gastropod spats	+	+	+
<i>Littorina</i> spp.	+	+	-
<i>Nassarius</i> spp.	+	+	-
<i>Oliva</i> spp.	-	+	+
<i>Patella</i> spp.	+	-	-
<i>Surcula</i> spp.	+	-	-
<i>Terebra</i> spp.	-	-	-
<i>Thais</i> spp.	+	-	-
<i>Tibia</i> spp.	-	-	-
<i>Trochus</i> spp.	+	-	-
<i>Turbo</i> spp.	-	-	-
<i>Turritella</i> spp.	+	+	+
<i>Umbonium</i> spp.	+	+	-
Scaphopods			
<i>Dentalium octangulata</i>	+	-	+
<i>Dentalium</i> spp.	+	+	+
	Arthropoda		
Crustaceans			
Amphipods	+	+	+
<i>Balanus</i> spp.	+	+	-
<i>Copepods</i>	+	+	+
<i>Emerita</i> spp.	+	+	+
<i>Ocypode</i> spp.	+	+	+
<i>Eupagurus</i> spp.	-	+	-

Table 1. Continued.

Intertidal fauna	Someshwara beach		
	S ₁	S ₂	S ₃
<i>Lepasanatifera</i>	+	-	-
<i>Mysids</i>	+	+	+
<i>Uca</i> spp.	+	+	+
	Annelida		
Polychaetes			
<i>Echiorus</i> spp.	-	-	-
<i>Glycera</i> spp.	+	+	+
<i>Nephtys</i> spp.	-	-	+
<i>Nereis</i> spp.	+	+	+
<i>Polychaete larvae</i>	+	+	+
<i>Sabellaria</i> spp.	-	+	+
Nematodes	+	+	+
	Echinodermata		
<i>Astropectenindica</i>	-	-	-
<i>Clypeasteroids</i>	+	+	+
<i>Ophiocoma</i> spp.	-	-	-
	Miscellaneous		
Egg cases	+	+	+
Fish larvae	-	-	-
Sand tubes	+	+	+

Station S₂

The abundance (No./m²) of intertidal organisms varied from 48 No./m² August (monsoon) to 86 No./m² January (post-monsoon). Intertidal organism community structure comprised of crustaceans 17.46% in September (monsoon) to 41.43% in November (post-monsoon) were identified under Arthropoda phylum. Bivalves 50.0% in May (pre-monsoon) to 78.26% July (monsoon), Gastropods 13.04% in July (monsoon) to 38.46% in October (post-monsoon), Scaphopods 3.85% in October (post-monsoon) to 14.29% in June (monsoon) were recorded under phylum Mollusca. Polychaetes 20% in August (monsoon) to 69.23% in July (monsoon), Nematodes 30.77% in July (monsoon) to 68.75% in February (pre-monsoon) were recorded under phylum Annelida. Clypeasteroids 0.0% in June, July, August and September (monsoon) to 2.78% in March (pre-monsoon), Miscellaneous (egg cases) 1.39% in March (pre-monsoon) to 25.86% in June (monsoon) were recorded. Abundance of intertidal

organisms was in the order of crustaceans 32% > bivalves 26% > gastropods 11% > nematodes 13% > scapopods 4% > polychaetes 8% > miscellaneous 5% > echinoids 1%.

Station S₃

The abundance (No./m²) of intertidal organisms varied from 34 No./m² in July (monsoon) to 111 No./m² in December (post-monsoon). Intertidal organism community structure comprised of crustaceans 14.71% in July (monsoon) to 32.20% in September (monsoon) were identified under Arthropod phylum. Bivalves 54.55% in September (monsoon) to 76.67% in November (post-monsoon), Gastropods 10.0% in November (post-monsoon) to 34.48% in January (post-monsoon), Scaphopods 0.0% in July (monsoon) to 13.33% in November (post-monsoon) were recorded under phylum Mollusca. Polychaetes 33.33% in December (post-monsoon) to 61.11% in November (post-monsoon). Nematodes 38.89% in November (post-monsoon), to 66.67% in December (post-monsoon) were recorded under phylum Annelida. Clypeasteroids 0.0% in June, July (monsoon) and August (monsoon) to 1.92% in January (post-monsoon), Miscellaneous (egg cases) 0.90% December (post-monsoon) to 29.41% in July (monsoon). Abundance of intertidal organisms was in the order of bivalves 26% > crustaceans 25% > nematodes 17% > polychaetes 14% > gastropods 9% > scaphopods 4% > miscellaneous 5%.

Distribution of intertidal organisms

Molluscs

In the present investigation, the Phylum Mollusca was represented by Class Gastropods, Bivalvia and Scaphopoda. The Molluscs comprising of Bivalvia, Gastropoda and Scaphopoda belong to different families such as Donacidae, Arcidae, Mytilidae, Ostreidae, Umbonidae, Cerithidea, Turritellidae, Trochidae and Olividae. Bivalve population included species such as *Arca* spp., *Anadara granosa*, Bivalve spats, *Cardium* spp., *Crassostrea* spp., *Donax faba* (Beach clam), *Donax scortum*, *Dosinia* spp. *Meritrix casta*, *Meritrix* spp., *Paphia* spp., *Paphia malabarica*, *Pecten* spp., *Perna viridis* (Green mussel) and *Tellina*

spp. The Gastropods population included species such as *Bullia* spp., *Bursa* spp., *Cyrraea* spp., *Cerithidea* spp., Gastropod spats, *Littorina* spp., *Nassarius* spp., *Oliva* spp., *Patella* spp., *Surcula* spp., *Terebra* spp., *Thais* spp., *Tibia* spp., *Trochus* spp., *Turbo* spp., *Turitella* spp. and *Umbonium* spp. The percentage contribution of molluscs to the total intertidal organisms varied from Someshwara beach station S₁ to station S₂ and S₃. The seasonal variation of Molluscs revealed trimodal oscillation with greater abundance in all most throughout the post-monsoon season. In all three stations with lower density during monsoon and moderate density during post-monsoon season. The pre-monsoon peak consisted of Molluscs in Someshwara beach. *Donax faba*, *Dentalium* spp., *Turitella* spp., *Umbonium* spp., *Cerithidea* spp. and spats were highly observed in S₁ and S₂ in post and pre-monsoon season.

Crustaceans

The class Crustacea was represented by individuals of three groups namely Copepods, Decapoda, Ocypods and Mysids. Population was represented species such as *Balanus* spp., Copepods, *Emerita* spp., (mole crab), *Ocypode*, *Lepas anatifera* (goose barnacle), Mysids, *Uca* spp. (fiddle crab), *Emerita* spp., *Uca* spp., and copepods contributed high abundance in crustacean class. *Eupagurus* spp., *Lepas anatifera* and shrimp larvae occurred on occasions. Whereas ocypode crabs occurred more frequently with greater abundance. The abundance was more during pre-monsoon and post-monsoon season at stations of Panambur and Bengre beaches. Copepods and mole crab found to be the bulk of the class Crustacean. It was observed that the *Emerita* spp. and copepods were responsible for bringing down the percentage of population bivalves, polychaetes and gastropods. This relationship is more evident in Someshwara beach station S₃. The percentage composition of crustaceans to the total intertidal organisms varied from season to season. Swetha (2009), Amrutha (2010), could not observe significant contribution of crustaceans in general and Amphipods in particular to the total macrobenthos in the Gangolli, Mangalore coastal waters and Nethravati-Gurupur estuaries respectively.

Table 2. Intertidal organisms Abundance in selected stations during (Aug 2016–Jun 2017).

Months Stations		Monsoon				Post-monsoon				Pre-monsoon			
		Jun	Jul	Aug 16	Sep	Oct	Nov	Dec	Jan 17	Feb	Mar	Apr	May
Someshwara	S ₁	86	39	90	83	94	104	129	133	109	98	109	110
	S ₂	58	59	48	63	84	70	78	86	83	72	76	66
	S ₃	39	34	60	59	51	71	111	62	70	55	57	52

Annelids

Polychaete population was represented species such as *Echiurus* spp., *Glycera* spp., *Nephtys*, *Nereis* spp. (sand worm), Polychaete larvae, *Sabellaria* spp. and Nematodes were also represented in phylum Annelida. The Polychaeta was represented by individuals belonging to families, Nephtyidae, Nereidae, Glyceridae, Spionidae and Sabellaridae. Among these Nephtyidae, Nerridae, Glyceridae and Sabellaridae were most dominant and present throughout the study period. The other forms occurred sporadically with few numbers. The percentage contribution of polychaetes to the intertidal organisms varied from season to season and beach to stations. The seasonal distribution of polychaetes revealed greater abundance during post-monsoon and per-monsoon seasons than that of monsoon season. The spatial distribution indicated increased abundance with increased percent of fine and medium sand. Further higher polychaete population coincided with increased silt and clay percentage in the sediment. The dominance of polychaetes during pre and post-monsoon along the estuaries of west coast of India was observed by Swetha (2009), Amrutha (2010).

Echinoderms

The Echinodermata population was represented specie *Astropecten indica* (star fish), *Opiochoma* spp.,

Clypeasteroids (sand dollar). *Opiochoma* spp., *Astropecten indica* were the sole representatives of the S₁ and S₂. *Clypeasteroids* observed in Someshwara S₁ in the (pre-monsoon) season. Among others Miscellaneous were also reported in present study. The Miscellaneous forms included egg cases, sand tubes and juvenile fishes. The presence of intertidal organisms was less and irregular at Someshwara beach station (S₃) and (S₂) comparatively (S₁). In Someshwara beach S₁ have been observed the highly diversified with good species abundance the reason could be the occurrence rocks and large stones. Finally observed that the number of groups/species, individuals and the diversity index values were significantly moderate condition at all selected stations of Someshwara beach.

Intertidal organisms abundance

The species abundance varied from 34 to 133 No./m². The minimum abundance was observed at Someshwara beach S₃ and S₁ was 34 and 31 July (monsoon) respectively. The maximum abundance was observed as 133 No./m² in January (pre-monsoon) at Someshwara beach station S₁ stations. The minimum species abundance was observed in the monsoon season in all selected station temporally, the intertidal organisms abundance higher during post-monsoon and lowest during monsoon followed by pre-monsoon season (Table 2).

Table 3. Intertidal organisms Richness index in selected stations during (Aug 2016–Jun 2017).

Months Stations		Monsoon				Post-monsoon				Pre-monsoon			
		Jun	Jul	Aug 16	Sep	Oct	Nov	Dec	Jan 17	Feb	Mar	Apr	May
Someshwara	S ₁	5.909	4.754	5.659	6.642	6.349	6.514	7.293	6.916	6.672	7.635	6.87	7.269
	S ₂	5.525	5.004	5.634	5.686	6.465	6.103	6.065	6.039	5.503	5.887	6.024	5.013
	S ₃	4.206	4.612	5.721	5.735	5.099	5.561	6.043	4.685	5.161	6.059	5.508	4.764

Table 4. Intertidal organisms Evenness index in selected stations during (Aug 2016–June 2017).

Months Stations		Monsoon				Post-monsoon			Pre-monsoon				
		Jun	Jul	Aug 16	Sep	Oct	Nov	Dec	Jan 17	Feb	Mar	April	May
Someshwara	S ₁	0.9759	0.9775	0.974	0.977	0.9698	0.9655	0.9588	0.9758	0.9722	0.9768	0.9755	0.9823
	S ₂	0.9719	0.9704	0.987	0.9762	0.9674	0.9741	0.9668	0.9557	0.9683	0.9633	0.9756	0.9688
	S ₃	0.9761	0.9725	0.9807	0.9753	0.9728	0.9818	0.9591	0.9772	0.964	0.9754	0.9777	0.9879

Richness (Margalef's) index

The Index varied from 4.02 Someshwara beach station 3 (S₃) to 7.293 Someshwara station S₁. The richness index was found to be highest 7.293 in the month of December (post-monsoon) and lowest 4.12 in the month of July (monsoon) at Someshwara S₃. Over all richness index observed as station wise Someshwara S₁ (6.804) > Someshwara S₂ (6.752) > Someshwara S₃ (6.088), temporally, the intertidal organisms richness index higher during post-monsoon and lowest during monsoon and followed by pre-monsoon. In the present investigation richness index ranged from 4.202 to 6.804 in Someshwara, stations the minimum Margalef's richness index values were recorded at Someshwara beach station (S₃) and (S₂) generally, in a healthy environment. Margalef richness index is higher at above the 3.5, in the present study the richness index was above the 3.5 values were recorded. Season wise richness index post-monsoon and pre-monsoon were recorded more in all stations. Datta et al. (2010) found that Mumbai waters the distribution of the intertidal fauna was to be uniform along the length of the shores. Similar studies were done by Datta et al. (2010), Palaniswamy et al. (2013) in intertidal coastal areas. Pielou's evenness index reveals the evenness of distribution of various species in the sample. In the present investigation evenness index ranged from 0.947 in Someshwara beach stations. The index varied from 0.9557 to 0.987. At Someshwara beach S₁, the evenness index was found to be highest in the

month of May 0.987 at S₃ station while lowest in the month of January 0.957 at S₂ station (Tables 3–5).

Evenness (Pielou's) index

The index varied from 0.955 to 0.987. At Someshwara beach, the evenness index was found to be highest in the month of May (0.987) at S₃ station while lowest in the month of January (0.957) at S₂ station the higher value was observed in the month of May (0.987) at station S₃ while lowest in the month of February (0.956) at station S₂. Over all evenness (Pielou's) index observed as station wise Someshwara beach S₃ (0.956) > Someshwara beach S₁ (0.953) > Someshwara beach S₂ (0.947). Temporally, the intertidal organisms evenness was higher during monsoon and pre-monsoon lower evenness observed during post-monsoon (Gohil and Kundu 2012).

Diversity (Shannon's) index

The Shannon's index varied from 1.119 to 1.624. The diversity index at Someshwara beach S₃ was found to be minimum in the month of July (1.119) while maximum in the month of March at Someshwara beach S₁ (1.457). Over all Diversity (Shannon's) index observed as station wise Someshwara beach S₁ (1.483) > Someshwara beach S₂ (1.45) > Someshwara beach S₃ (1.413). Temporally, the intertidal organisms diversity was higher during pre-monsoon and lower during monsoon followed by pre-monsoon. In the present

Table 5. Intertidal organisms Diversity index in selected stations during (Aug 2016–Jun 2017).

Months Stations		Monsoon				Post-monsoon			Pre-monsoon				
		Jun	July	Aug 16	Sep	Oct	Nov	Dec	Jan 17	Feb	Mar	Apr	May
Someshwara	S ₁	1.329	1.177	1.308	1.382	1.356	1.366	1.416	1.427	1.392	1.457	1.412	1.451
	S ₂	1.264	1.218	1.284	1.291	1.352	1.326	1.317	1.301	1.28	1.293	1.328	1.216
	S ₃	1.119	1.144	1.297	1.29	1.221	1.298	1.324	1.202	1.233	1.309	1.272	1.216

Table 6. Correlation coefficient (significant at 99% and 95%) between physico-chemical parameters and intertidal faunal abundance of Someshwara beach (S_1 , S_2 and S_3). *Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Parameters	Someshwara beach correlation												
	Air temp	Water temp	Sediment temp	pH	Salinity	Silicate-Si	Phosphate-P	DO	Amonium-N	Nitrite-N	Nitrate-N	Organic carbon	Faunal Abundance
Air temp	1.000												
Water temp.	.998*	1.000											
Sediment temp	0.990	.997*	1.000										
pH	0.963	0.979	0.992	1.000									
Salinity	-0.584	-0.636	-0.693	-0.780	1.000								
Silicate-Si	.999*	1.000*	0.996	0.975	-0.622	1.000							
Phosphate-P	0.906	0.932	0.957	0.986	-0.873	0.925	1.000						
DO	0.972	0.985	0.995	.999*	-0.759	0.982	0.980	1.000					
Ammonium-N	0.991	0.980	0.961	0.918	-0.468	0.983	0.839	0.930	1.000				
Nitrite-N	0.764	0.721	0.666	0.564	0.077	0.733	0.419	0.590	0.845	1.000			
Nitrate-N	0.783	0.821	0.862	0.921	-0.963	0.811	0.973	0.907	0.690	0.197	1.000		
O. carbon	0.933	0.908	0.873	0.803	-0.254	0.915	0.693	0.822	0.974	0.945	0.507	1.000	
Faunal Abundance	-0.992	-0.982	-0.964	-0.922	0.477	-0.985	-0.845	-0.934	-1.000**	-0.839	-0.698	-0.971	1.000

investigation diversity index ranged from 1.413 Someshwara beach stations. The minimum values were recorded as 1.119 in July (monsoon) at Someshwara station S_3 followed by Someshwara station S_2 and Someshwara station S_1 minimum values were recorded as 1.119 in the month of July at Someshwara beach station S_3 . The maximum values were recorded as 1.621 December seasonally recorded diversity indices indicate the less diversity at monsoon season when compared to the pre and post monsoon seasons.

Seasonal variations in species distribution

In present investigation intertidal organisms population varied between season to season and relatively high number of intertidal fauna recorded during the post-monsoon followed by pre-monsoon and monsoon season (Kaiser et al. 2006). High abundance of species observed in post and pre-monsoon may be high percentage of organisms also responsible for higher Margalef richness index throughout the study period at Panambur and Bengre beaches. Shannon's diversity index also indicated highly diverse community in respective beaches Pielou's evenness and Shannon's diversity indices revealed high evenness of the distribution except in the months of heavy

monsoon (June and July) and the present investigation highest intertidal Abundance, distribution and diversity was recorded during post and pre-monsoon in Panambur and Bengre beaches the reason could be due to abounded fine sand and very fine sand substrate which shows the strongest correlation in post and pre-monsoon season with intertidal organisms according to Ganapathi (2012) seasonal variations in the environmental factors and biological properties of organisms (breeding, gonadal maturity influence the occurrence of organisms in the intertidal region (Muruganatham et al. 2012).

Analysis of variance (ANOVA)

Two-way ANOVA was applied to observe the variation in the abundance of intertidal organisms between the stations and between months. As per the result from the anova, research hypothesis indicating that, there is significant difference ($p < 0.05$) in the abundance of intertidal organisms between the stations and between the months. Statistical analysis showed a significant difference ($p < 0.05$) in intertidal organisms community in relation to sediment fractions, due to months and stations in the present investigation (Table 6).

Simple correlation

Simple correlation (Pearson's) was carried out for different physico-chemical parameters of water and sediment fractions to understand their inter-relationships, which finally governs the productivity of the intertidal ecosystem. There was a significant positive correlation between air, water and sediment temperature at all three stations and the statistical relationship indicated that the strong relationship between intertidal organisms and salinity, whereas the organisms abundance negatively correlating with ammonia nitrite.

Conclusion

All the three stations were showed significant difference with seasonality in physico-chemical parameters and faunal composition. Beach profile, topography and grain size distribution are the most important factors in abundance and distribution of intertidal organisms. Diversity indices revealed moderately diverse status of the intertidal organisms along the selected stations of Someshwara beach. The study concludes that though these stations are moderately disturbed due to anthropogenic activities, they still support a rich intertidal biodiversity which needs immediate attention for protection and conservation.

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