

Research Article

MARINE SPONGES AS BIOINDICATOR SPECIES OF ENVIRONMENTAL STRESS AT URAN (NAVI MUMBAI), WEST COAST OF INDIA

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ABSTRACT

In the present study, a survey of marine sponges for biodiversity and distribution was done along three substations; Sheva creek, Peerwadi coast and Dharamtar creek of Uran coast (Raigad), Navi Mumbai, west coast of India. Sponge samples were collected from intertidal regions and shallow coastal waters monthly from June 2013 to May 2015 during spring low tides. A total of 16 species of sponges representing 12 genera, 10 families and 8 orders were identified. Of these, 13 species belongs to class Demospongiae, 2 to Calcarea and 1 to Hexactinellida. Maximum species diversity of sponges is recorded at Peerwadi coast than Sheva creek and Dharamtar creek. Fewer species diversity at Sheva creek and Dharamtar creek is attributed to the close proximity of these sites to human population, non-availability of suitable rocky stretches for settlement and colonization and to maritime activities of Jawaharlal Nehru Port Trust (JNPT). Sponges from Uran coast are under stress due to discharge of domestic wastes and sewage, effluents from industries, oil tanking depots, maritime activities of Jawaharlal Nehru Port Trust (JNPT) and hectic activities of Container Freight Stations (CFS). This study reveals that marine sponges from Uran coast are facing the threat due to industrial pollution and anthropogenic stress.

KEYWORDS: Bioindicator; Sponges; Biodiversity; Anthropogenic stress; Jawaharlal Nehru Port; Uran

INTRODUCTION

The oceans cover about 70% of the earth's surface, and the marine environment includes tremendous biodiversity; all but two of the 28 major animal phyla are represented (Schwartzmann *et al.*, 2001). Marine sponges (Porifera) are the oldest metazoan group and characterized as sessile active filter feeders and (Hausmann *et al.*, 2006). Phylum Porifera is subdivided into three classes' i. e. the Calcarea (calcareous sponges with three-rayed spicules of calcium carbonate), the Demospongiae (skeleton of siliceous spicules) and the Hexactinellida (glass sponges with skeleton of six-rayed siliceous spicules). The Demospongiae contains the vast majority of extant sponges living today and represent 85-90% of the global sponge fauna (Thakur and Muller, 2004).

The knowledge on sponge biodiversity is still largely incomplete and to date, 8517 valid species of sponges are enlisted in the World Porifera Database (Van Soest *et al.*, 2014). A total of 486 species of marine sponges have so far been described from the Indian waters (Thomas, 1998; Venkataraman and Wafer, 2005). Sponges show an amazing variety of shapes, sizes and colours (Thakur and Muller, 2004). Undisturbed natural substrates like coral rubbles, rocks and abandoned shells have always supported for the settlement and growth of sponges (Ramakritinan *et al.*, 2015).

Sponges have an ability to filter four to five times their own volume every minute. The water current supplies food particles and oxygen and removes metabolic waste products (Cristiane *et al.*, 2014; Vinod *et al.*, 2014). Sponges feed by extracting suspended or dissolved food from the surrounding water, using flagellated cells, known as 'choanocytes' (Hausmann *et al.*, 2006).

Easson *et al.* (2015) reported that sponges perform critical functional roles in marine ecology like directly contribute to energy cycling by efficiently clearing dissolved organic carbon, bacteria and pathogens from the water column (De Goeij *et al.*, 2013), incorporating energy sources into the benthic system (Hadas *et al.*, 2006), contribute to primary productivity (photosynthesis) and nutrient cycling in marine environment (Easson *et al.*, 2015), important dietary composition of marine organisms (Barbara *et al.*, 2007, important energy coupling between the benthic and pelagic communities (Duckworth and Wolff, 2007) and binding live corals to the reef frame, regeneration of broken corals and harbouring nitrifying and photosynthesizing microbial symbionts or intervening in erosion processes (Raghunathan *et al.*, 2014).

Marine sponges have a high frequency of bioactive components for their chemical defences against environmental stress factors such as predation, overgrowth by fouling organisms or competition for space

(Perdicaris *et al.*, 2013). They are the richest sources of pharmacologically active compounds found in the marine environment. These bioactive molecules are known as 'secondary metabolites' (Sagar *et al.*, 2010).

Perdicaris *et al.* (2013) documented that marine sponges produce an enormous array of antitumor (Belarbi *et al.*, 2003), antiviral (Sagar *et al.*, 2010), anti-inflammatory (Sipkema *et al.*, 2005), immunosuppressive (Perdicaris *et al.*, 2013), antibiotic (Anand *et al.*, 2006; Jirge and Chaudhari, 2010), antifungal (Dhinakaran *et al.*, 2012; Palpandi *et al.*, 2013), cytotoxic (Mollica *et al.*, 2012), antimalarial (Ravichandran *et al.*, 2007) and other bioactive molecules (anticoagulant, antifouling, antioxidants, hypocholesterolemic, cardiovascular and muscle relaxants) that have the potential for therapeutic use.

Sponges are good bioindicators and are convenient tools for characterizing the state of a marine ecosystem (Berthet *et al.*, 2005). Sponge communities can live same locality and are capable of accumulating metals for a long period; hence they have been chosen as indicators to reveal the environmental crises of a selected area (Vogel, 1977; Rao *et al.*, 2009). Sponges have been recommended as a suitable biomonitor species for metal pollution because of their strong ability to concentrate metals in their tissues (Cebrian *et al.*, 2007; Pan *et al.*, 2011).

Sponges are strongly associated with the abiotic environment, very sensitive to environmental stress and are useful tools for environmental monitoring. Chemical monitoring alone is not enough and that pollution is essentially a biological phenomenon because its impact is on having organisms. Stress induces qualitative and quantitative changes in the structure of communities which can usually be assessed by analyzing diversity and relative abundance (Carballo *et al.*, 1996).

The coastal environment of Uran has been under considerable stress since the onset of industries like Oil and Natural Gas Commission (ONGC), LPG Distillation Plant, Grindwell Norton Ltd., Gas Turbine Power Station (GTPS), Bharat Petroleum Corporation Limited (BPCL) Gas Bottling Plant, Jawaharlal Nehru Port (JNPT, an International Port), DP World, Container Freight Stations (CFS), etc. These activities affect the ecology of sponges from Uran coast, Navi Mumbai (Pawar, 2013; Pawar, 2015).

Although many studies have been undertaken to evaluate the species diversity of sponges in India, no scientific studies have been carried out on the species composition of sponges of Uran, Navi Mumbai; hence, the present study is undertaken. Objective of the study is to evaluate the impact of anthropogenic inputs on species composition of sponges with respect to tidal and seasonal variability.

MATERIALS AND METHODS

Study area

Geographically, Uran (Lat. 18°50'5" to 18°50'20" N and Long. 72°57'5" to 72°57'15" E) with the population of 23,254 is located along the eastern shore of Mumbai harbor opposite to Coloba. Uran is bounded by Mumbai harbor to the northwest, Thane creek to the north, Dharamtar creek and Karanja creek to the south, and the Arabian Sea to the west. Uran is included in the planned metropolis of Navi Mumbai and its port, the Jawaharlal Nehru Port (JNPT) (Figure 1).

The coast of Uran is a tide-dominated and the tides are semidiurnal. The average tide amplitude is 2.28 m. The flood period lasts for about 6-7 h and the ebb period lasts for about 5 h. The average annual precipitation is about 3884 mm of which about 80% is received during July to September. The temperature range is 12-36°C, whereas the relative humidity remains between 61% and 86% and is highest in the month of August.

Sampling strategy

The present study was carried out for a period of two years, i.e., from June 2013 to May 2015. Three study sites namely Sheva Creek, site I (Lat. 18° 50' 20" N and Long. 72° 57' 5" E), Peerwadi coast, site II (Lat. 18° 50' 10" N and Long. 72° 57' 1" E) and Dharamtar Creek, site III (Lat. 18° 48' 3" N and Long. 72° 58' 31" E) separated approximately by 10 km were selected along the coast.

The study sites were surveyed monthly during spring low tides from June 2013 to May 2015 and sponge samples were collected from intertidal regions and shallow coastal waters. Surveys were carried out to record the diversity of sponges and they were removed from the substrate with a chisel and protective gloves. Sponges were collected in clean polythene bags; one sample per bag and microphotographs of the sponges were taken with Cannon EOS1100D digital camera and they were brought to the laboratory.

In the laboratory, morphological characteristics of each specimen including size, shape, colour, texture, total length, and breadth and osculum diameter were recorded (Vinod *et al.*, 2014). The specimens were washed under tap water and then fixed in 10% formaldehyde-seawater solution and then transferred into 70% ethanol.

Preparation of spicules and skeletons was made as per methods recommended by Rutzler (1978) and Evcen and Çinar (2012). Preparations of spicules were made by dissolving sponge fragments in boiling nitric acid, and after rinsing in water and ethanol, spicules were observed under microscope and classification of spicules was made as per work of Hooper and Van Soest (2002) and Evcen and Çinar (2012). Sponges were identified following the standard taxonomic keys of Picton (2007), Venkataraman *et al.* (2012) and Van Soest *et al.*, (2014).

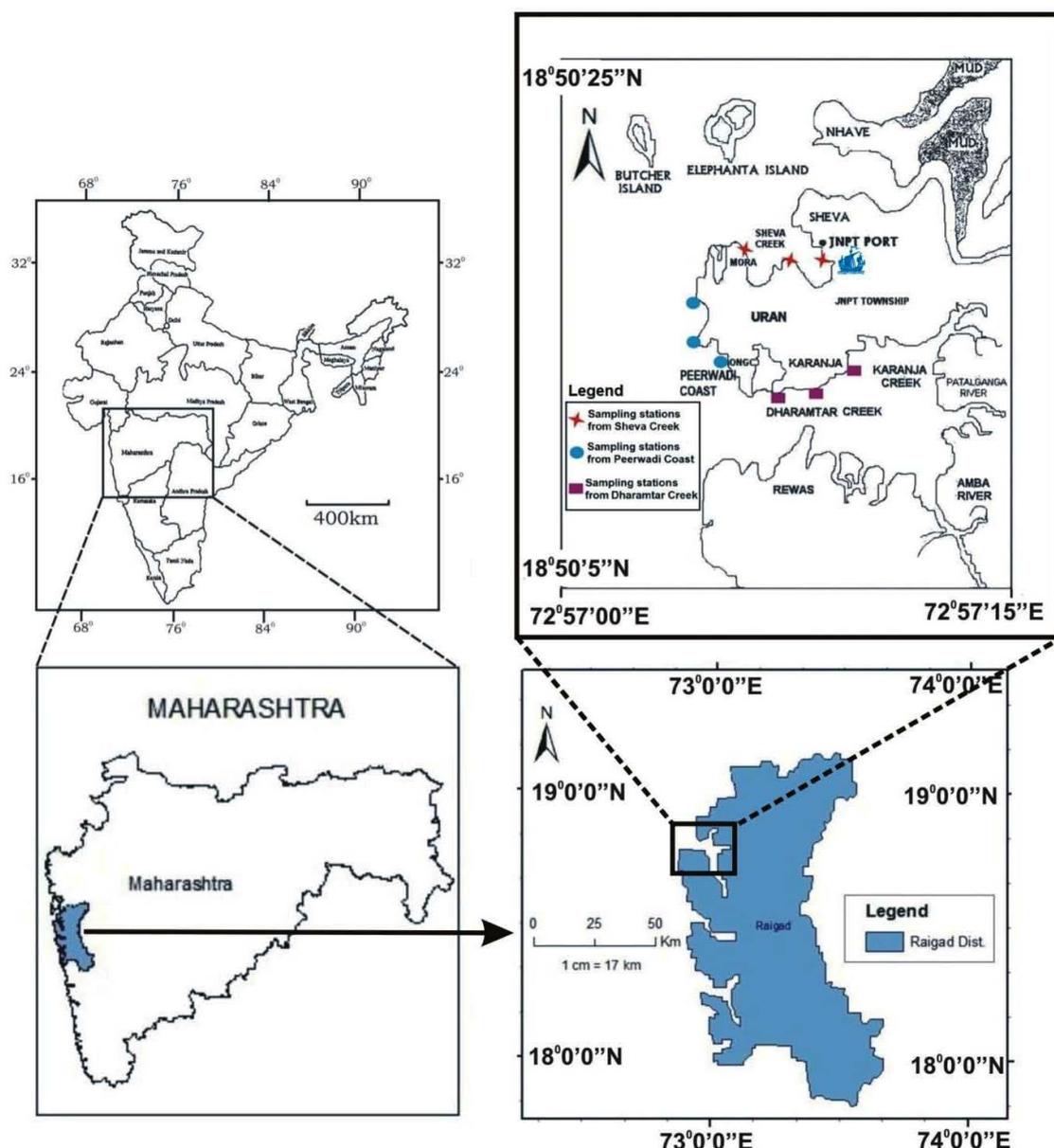


Figure 1: Location map of study area representing sampling stations along Sheva creek, Peerwadi coast and Dharamtar creek of Uran, Navi Mumbai

RESULTS AND DISCUSSION

A total of 16 species of sponges representing 12 genera, 10 families and 8 orders were recorded from Uran coast (Table 1) and (Figure 3). Of the recorded species, 13 species belongs to class Demospongiae, 2 to Calcarea and 1 to Hexactinellida. The percentage distribution (by order) of sponges recorded from Uran coast (Figure 2) showed that the Order Halichondrida had the highest species composition (31.25%), followed by Leucosolenida, Axinellida, Hadromerida, and Poecilosclerida each with 12.5%. The Order Haplosclerida, Homosclerophorida and Hexactinosida had a composition of 6.25% species in each.

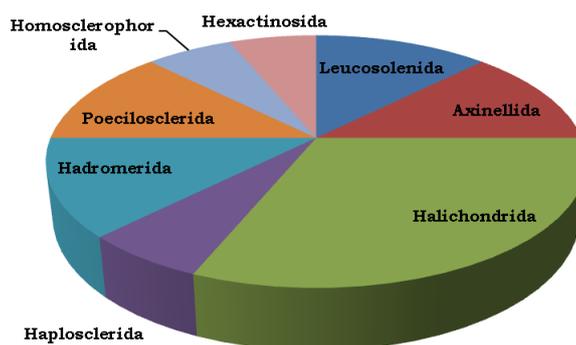
Site wise distribution and species richness of sponges is shown in Table 2. Maximum species diversity of sponges was reported at Peerwadi coast (16 species), followed by

Dharamtar creek (9 species) and Sheva creek (4 species).

The Peerwadi coast is characterized by rocky stretches which would provide suitable substratum and appropriate habitat for easy settlement of the larval forms and better colonization of sponges (Vinod *et al.*, 2014). Abdul Wahab *et al.* (2014) and Ramakritinan *et al.* (2015) have noted that undisturbed natural substrates like coral rubbles, rocks and abandoned shells have always supported for the settlement and growth of sponges. This is also attributed to the water flow; because increased water flow provides greater availability of suspended food (Duckworth and Battershill, 2003). Bell and Barnes (2000) reported that water flow, wave action and current speed acts as limiting factors for growth of sponges and slower growth of sponges in recorded in weak currents. Easson *et al.* (2015) shows that, in Bocas del Toro, Panama, a sponge community in close proximity to human populations consisted of fewer

Table 1: Species of sponges recorded from Uran, Navi Mumbai.

Order	Family	Binomial Name
Class: Calcarea		
Leucosolenida	Leucosoleniidae	<i>Leucosolenia complicata</i> (Montagu, 1818)
Leucosolenida	Leucosoleniidae	<i>Leucosolenia variabilis</i> (Haeckel, 1870)
Class: Demospongiae		
Axinellida	Axinellidae	<i>Axinella damicornis</i> (Esper, 1794)
Axinellida	Axinellidae	<i>Axinella verrucosa</i> (Esper, 1794)
Halichondrida	Halichondriidae	<i>Axinyssa ambrosia</i> (de Laubenfels, 1936)
Halichondrida	Halichondriidae	<i>Halichondria bowerbanki</i> (Burton, 1930)
Halichondrida	Halichondriidae	<i>Halichondria panicea</i> (Pallas, 1766)
Halichondrida	Halichondriidae	<i>Hymeniacidon heliophila</i> (Parker, 1910)
Halichondrida	Halichondriidae	<i>Hymeniacidon perlevis</i> (Montagu, 1814)
Haplosclerida	Haliclonidae	<i>Haliclona permollis</i> (Bowerbank, 1866)
Hadromerida	Hemiasterellidae	<i>Paratimea constellate</i> (Topsent, 1893)
Hadromerida	Suberitidae	<i>Protosuberitis epiphytum</i> (Lamarck, 1815)
Poecilosclerida	Hymedesmiidae	<i>Kirkpatrickia borealis</i> (Koltun, 1970)
Poecilosclerida	Microcionidae	<i>Clathria parthena</i> (de Laubenfels, 1930)
Homosclerophorida	Plakinidae	<i>Plakina monolopha</i> (Schulze, 1880)
Class: Hexactinellida		
Hexactinosida	Aphrocallistidae	<i>Aphrocallistes beatrix</i> (Gray, 1858)

Percentage distribution of sponge species in different orders at Uran, Navi Mumbai**Figure 2:** Percentage distribution of sponge species at Uran, Navi Mumbai**Table 2:** Distribution of sponges from Uran coast, Navi Mumbai.

Sr. No.	Species Name	Sheva creek (Site I)	Peerwadi coast (Site II)	Dharamtar creek (Site III)
1	<i>Leucosolenia complicata</i> (Montagu, 1818)	-	+	+
2	<i>Leucosolenia variabilis</i> (Haeckel, 1870)	+	+	-
3	<i>Axinella damicornis</i> (Esper, 1794)	-	+	+
4	<i>Axinella verrucosa</i> (Esper, 1794)	+	+	+
5	<i>Axinyssa ambrosia</i> (de Laubenfels, 1936)	-	+	+
6	<i>Halichondria bowerbanki</i> (Burton, 1930)	-	+	-
7	<i>Halichondria panicea</i> (Pallas, 1766)	-	+	+
8	<i>Hymeniacidon heliophila</i> (Parker, 1910)	-	+	-
9	<i>Hymeniacidon perlevis</i> (Montagu, 1814)	-	+	-
10	<i>Haliclona permollis</i> (Bowerbank, 1866)	+	+	+
11	<i>Paratimea constellate</i> (Topsent, 1893)	-	+	+
12	<i>Protosuberitis epiphytum</i> (Lamarck, 1815)	-	+	-
13	<i>Kirkpatrickia borealis</i> (Koltun, 1970)	-	+	+
14	<i>Clathria parthena</i> (de Laubenfels, 1930)	-	+	-
15	<i>Plakina monolopha</i> (Schulze, 1880)	+	+	+
16	<i>Aphrocallistes beatrix</i> (Gray, 1858)	-	+	-
	Total number of species	04	16	09



Figure 3: Sponges from coastal waters of Uran, Navi Mumbai

species whereas the community at a site distant from human development included a more diverse assemblage of species.

Sheva creek has extensive mudflats with less rocky substratum. Establishments like Jawaharlal Nehru Port (JNPT), DP WORLD, Naval Armament Depot (NAD), Grindwell Norton Ltd., Indian Oil Tanking (IOT), Container Freight Stations (CFS), Trawler building workshops etc. are located in the stretch of the creek. Also, Gharapuri Island (Elephanta caves, a famous tourist spot) is present on the north side of the creek. The creek receives wastes and effluents from Asia's largest industrialized zone namely Thane Belapur industrialized area along with the Navi Mumbai Urban area (Pawar, 2013). Poor species diversity of sponges at Sheva creek could be attributed to the environmental stress faced by the sponges due to disturbed water quality variables and maritime activities of JNPT, sewage and effluents from port related establishments and non-availability of rocky and coral substratum (Pawar, 2015). Similar results were also reported by Carballo *et al.* (1996) at Algeciras Bay, Goh (2008) in coasts of Singapore, Rao *et al.* (2009) in the coasts of Gulf of Mannar, India and Pan *et al.* (2011) at Eastern Coast of the Red Sea, Saudi Arabia.

Dharamtar creek is the confluence of Karanja creek, Patalganga River and Amba River, opening into southern part of Mumbai harbor. Intertidal region of Dharamtar creek is with rocky and coral substratum towards the Dronagiri Mountain whereas remaining part of the creek is dominated by the marshy areas and mud flats. Towards the Revas side, upper littoral zone is sandy and remaining part of the creek is marshy with mud flats. The rocky substratum of Dharamtar creek supports moderate species diversity of sponges. This is attributed to the waste water received from petrochemical complex and other industries that opens into Dharamtar creek (Pawar and Kulkarni, 2007).

A biomonitor should be able to accumulate a considerable concentration of contaminant in relation to the average contaminant concentration in its ambient environment (Pan *et al.*, 2014). As sponges are sessile and sensitive to environmental stressors (including elevated nutrient concentration), they acts as excellent bioindicator species of environmental stress (Carballo *et al.*, 1996; Rao *et al.*, 2009; Easson *et al.*, 2015).

Percentage species composition of sponges at Uran coast shows maximum number of species from class Demospongiae than Calcarea and Hexactinellida. It could be correlated to the availability of rocky stretches, favorable physical factors, such as water turbidity, salinity, wave exposure, substrate availability, tidal ranges, and biological factors such as competition, larval supply, and predation (Diaz, 2005). Results of the study are in agreement with earlier reports of Putchakarn (2011) along Chanthaburi and Trat Provinces, the eastern coast

of the Gulf of Thailand, Ramkumar *et al.* (2013) in South Andaman, Raghunathan *et al.* (2014) in Andaman and Nicobar Islands and Vinod *et al.* (2014) in Enayam to Kollam, India.

During present study, maximum number of sponge species belonging to class Demospongiae (81.25%) was recorded followed by Calcarea (12.5%) and Hexactinellida (6.25%). Results of the study are in agreement with Thai (2013) from coastal waters of Vietnam where of the 299 sponge species identified, class Demospongiae represents highest number of species (281 species occupying with 94% of the total).

The coastal environment of Uran has been under considerable stress due to onset of JNPT and other industries since 1989. Hectic activities of Container Freight Stations (CFS), urbanization, industrialization, and reclamation on the coast around Uran result in the loss of mangrove biodiversity. Several incidences of coastal pollution occur because of leakage/discharge of transporting materials along with industrial effluents (Pawar, 2013).

Since no earlier reports are available on taxonomy and species diversity of sponges from Uran coast, data presented here can be taken as a baseline data in knowing the status of sponges from Uran coast and effect of industrial development on it and for a better management of marine sponges.

CONCLUSION

This study shows that the Uran coast harbors a diverse group of marine sponges. Species composition of sponges reveals that species belonging to class Demospongiae were dominant over the Calcarea and Hexactinellida. The study also demonstrates that sponge community in close proximity to human populations consists of fewer species whereas the community at a site distant from human development shows more diverse assemblage of species. The variation in abundance of species could result from biological and physical factors such as localized disturbance events, differences in food availability and patterns of water transport affecting larval dispersal. Discharge of sewage, industrial wastes, effluents, maritime activities of Jawaharlal Nehru Port (JNPT), Container Freight Stations (CFS) and anthropogenic stress will affect the species diversity of sponges from Uran coast in near future. Present information on species diversity of sponges would be helpful as a baseline data for further monitoring of anthropogenic inputs on sponges from Uran coast.

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