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Marine sponges as Bioindicator species of Environmental Stress at Uran (Navi Mumbai), west coast of India

[1]Prabhakar R. Pawar and [2]Abdel Rahman Mohammad Said Al-Tawaha

[1]Veer Wajekar Arts, Science and Commerce College, Department of Zoology, Phunde (Uran), Raigad, Navi Mumbai - 400 702, India.
[2]Department of Biological Sciences, Al Hussein Bin Talal University, Ma'an, P.O. Box 20, Jordan.

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Address For Correspondence:
Prabhakar R. Pawar, Veer Wajekar Arts, Science and Commerce College, Department of Zoology, Phunde (Uran), Raigad, Navi Mumbai - 400 702, India.
E-mail: prpawar1962@gmail.com

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ABSTRACT

In the present study, a survey of marine sponges for biodiversity and distribution was done along three substations 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 activities of Jawaharlal Nehru Port (JNP). Sponges from Uran coast are facing threat due to disposal of untreated municipal wastes and sewage, effluents, and reclamation and habitat loss by port activities. This study reveals that marine sponges from Uran coast are facing the threat due to industrial pollution and anthropogenic stress.

KEY WORDS

Bioindicator, Sponges, Biodiversity, Anthropogenic stress, Jawaharlal Nehru Port, Uran,

INTRODUCTION

The marine environment includes tremendous biodiversity and represents 28 major animal phyla [38]. Marine sponges (Porifera) are the oldest metazoan group and characterized as sessile active filter feeders [19]. Phylum Porifera is subdivided into three classes' i. e. the Calcarea (calcarious 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 [41].

Even though, 8517 valid species of sponges are enlisted in the World Porifera Database, information on species composition of sponges is still incomplete [43]. From Indian waters, till today 486 species of marine sponges have been recorded so far [42, 45]. Sponges show an amazing variety of shapes, sizes and colours [41]. Undisturbed natural substrates like coral rubbles, rocks and abandoned shells have always supported for the settlement and growth of sponges [32].

Sponges have an ability to filter water four to five times their own volume every minute. These water current provides food and oxygen to the sponges and also helpful to remove the metabolic waste products [9, 46]. Sponges feed by extracting suspended or dissolved food from the surrounding water, using flagellated cells, known as 'choanocytes' [19].

Easson *et al* [15] 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 [10], incorporating energy sources into the benthic system [18], contribute to primary productivity (photosynthesis) and nutrient cycling in marine environment [15], important dietary composition of marine organisms [3], important energy coupling between the benthic and pelagic communities [13], and harbours nitrifying and photosynthesizing microbial symbionts [31].

Marine sponges have a high frequency of bioactive components for their chemical defences against environmental stress factors [28]. They are the richest sources of pharmacologically active compounds found in the marine environment. These bioactive molecules are known as 'secondary metabolites' [37].

Perdicaris *et al* [28] documented that marine sponges produce an enormous array of antitumor [4], antiviral [37], anti-inflammatory [39], immunosuppressive [28], antibiotic [2, 21], antifungal [11, 23], cytotoxic [22], antimalarial [35] and other bioactive molecules (anticoagulant, antifouling, antioxidants, hypocholesterolemic, cardiovascular and muscle relaxants) that have the potential for therapeutic use.

As sponges are sessile, live in particular ecosystem for longer time and due to their capacity to accumulate metals, they are considered as good bioindicators of health of a particular ecosystem [6, 34, 47]. Sponges have been recommended as a suitable biomonitor species for metal pollution because of their strong ability to concentrate metals in their tissues [8, 24]. Sponges are strongly associated with the abiotic environment, very sensitive to environmental stress and are useful tools for environmental monitoring. Stress induces qualitative and quantitative changes in the structure of communities which can usually be assessed by analyzing diversity and relative abundance [7].

Maritime activities of Jawaharlal Nehru Port (JNP), reclamation, habitat loss and degradation, over exploitation of coastal resources, and unregulated disposal of wastes and effluents have affected the water quality and diversity of macrobenthos at Uran coast, Navi Mumbai [26, 27]. No scientific studies have been carried out on the species composition and distribution of sponges of Uran, Navi Mumbai; hence, the present study is undertaken. Objective of the study is to evaluate the species composition and distribution of sponges from Uran coast.

MATERIALS AND METHODS

Study Area:

Uran (Lat. 18º 50'5" to 18º50'20" N and Long. 72º57'5" to 72º57'15" E) with the population of 28,620, is located along the eastern shore of Mumbai harbor opposite to Coloba. Uran, is bounded by Mumbai harbor to the northwest, the Thane creek to the north, Dharamtar creek and Karanja creek to the south, and the Arabian Sea to the west. Uran and Jawaharlal Nehru Port (JNP) is included in the planned metropolis of Navi Mumbai (Fig. 1).

The coast of Uran is a tide-dominated and the tides are semidiuranal. The average tide amplitude is 2.28 m. The average annual precipitation is about 3884 mm of which about 80% is received during July to September. The temperature range is 12–36ºC, whereas the relative humidity (61% to 86%) is highest in the month of August.

Sampling strategy:

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

In the laboratory, morphological characteristics of each specimen including size, shape, colour, texture, total length, and breadth and osculum diameter were recorded [46]. The specimens were washed under tap water and then fixed in 10% formaldehyde-seawater solution and then transferred into 70% ethanol.

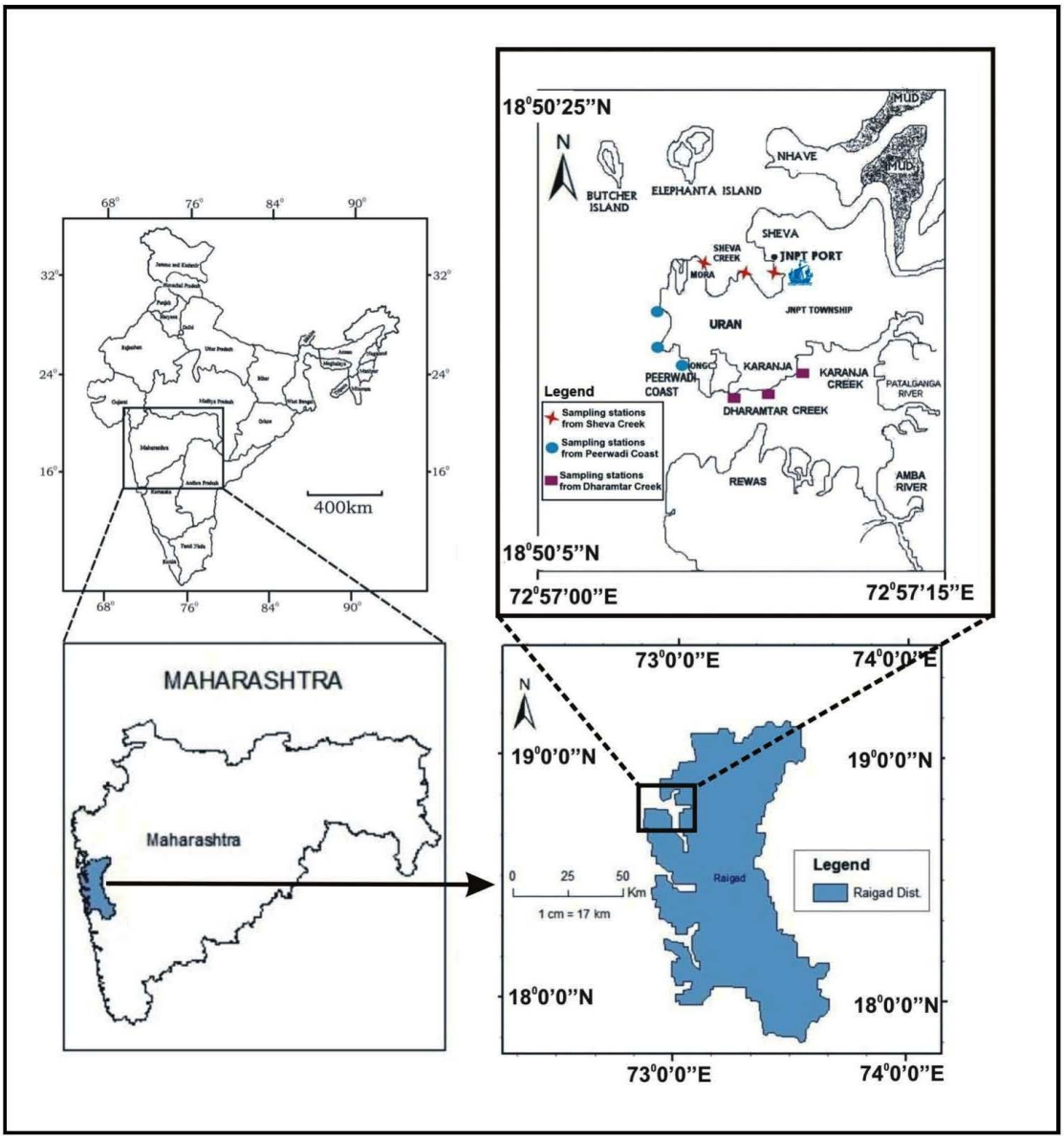

Fig. 1: Location map of study area representing sampling stations along Uran coast, Navi Mumbai

Preparation of spicules and skeletons was made as per methods recommended by Rutzler [36] and Evcen and Çinar [16]. Classification of spicules was made as per work of Hooper and Van Soest [20]. Sponges were identified following the standard taxonomic keys of Picton [29], Venkataraman *et al* [44] and Van Soest *et al* [43].

RESULTS AND DISCUSSION

16 species of sponges representing 12 genera, 10 families and 8 orders were recorded from Uran coast (Table 1) and (Fig. 3). Of the recorded species, 13 species belongs to class Demospongiae, 2 to Calcarea and 1 to Hexactinellida. Order wise percentage distribution of sponges recorded from Uran coast (Fig. 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.

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

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

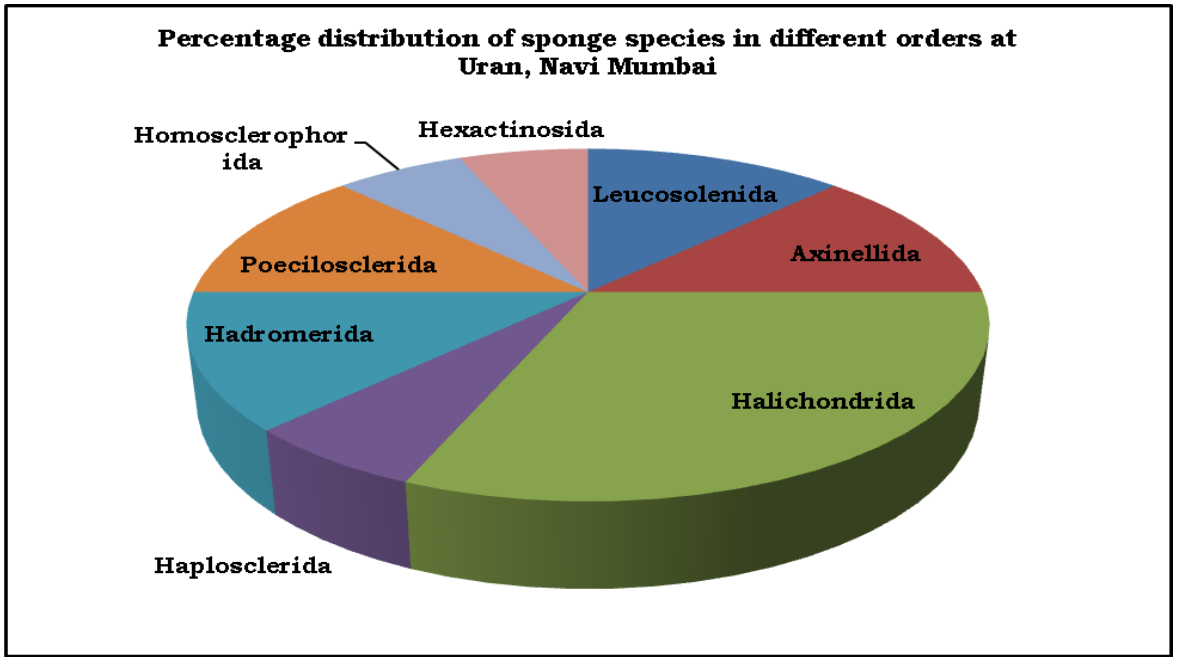

Fig. 2: Percentage distribution of sponge species at Uran, Navi Mumbai

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	*Leucosolenia complicata* (Montagu, 1818)	-	+	+
2	*Leucosolenia variabilis* (Haeckel, 1870)	+	+	-
3	*Axinella damicornis* (Esper, 1794)	-	+	+
4	*Axinella verrucosa* (Esper, 1794)	+	+	+
5	*Axinyssa ambrosia* (de Laubenfels,1936)	-	+	+
6	*Halichondria bowerbanki* (Burton, 1930)	-	+	-
7	*Halichondria panacea* (Pallas, 1766)	-	+	+
8	*Hymeniacidon heliophila* (Parker, 1910)	-	+	-
9	*Hymeniacidon perlevis* (Montagu, 1814)	-	+	-
10	*Haliclona permollis* (Bowerbank,1866)	+	+	+
11	*Paratimea constellate* (Topsent, 1893)	-	+	+
12	*Protosuberitis epiphytum* (Lamarck, 1815)	-	+	-
13	*Kirkaptrickia borealis* (Koltun, 1970)	-	+	+
14	*Clathria parthena* (de Laubenfels,1930)	-	+	-
15	*Plakina monolopha* (Schulze,1880)	+	+	+
16	*Aphrocallistes beatrix* (Gray, 1858)	-	+	-
	Total number of species	04	16	09

Leucosolenia complicata *Leucosolenia variabilis* *Axinella damicornis*

Axinella verrucosa *Axinyssa ambrosia* *Halichondria bowerbanki*

Halichondria panacea *Hymeniacidon heliophila* *Hymeniacidon perleve*

Haliclona permollis *Paratimea constellata* *Kirkpatrickia borealis*

Clathria parthena *Plakina monolopha* *Prosuberites epiphytum* *Aphrocallistes beatrix*

Fig. 3: Sponges from coastal waters of Uran, Navi Mumbai

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 [46]. Abdul Wahab *et al* [1] and Ramakritinan *et al* [32] 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 [14]. Bell and Barnes [5] 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* [15] shows that, in Bocas del Toro, Panama, species diversity of sponges is less at sites present in close proximity to human populations than those present away from human development where more diverse assemblage of species is recorded.

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 [26]. 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 [27]. Similar results were also reported by Carballo *et al* [7] at Algeciras Bay, Goh [17] in coasts of Singapore, Rao *et al* [34] in the coasts of Gulf of Mannar, India and Pan *et al* [24] 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 [25].

As sponges are sessile and sensitive to environmental stressors (including elevated nutrient concentration), they acts as excellent bioindicator species of environmental stress [7, 15, 24, 34].

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 [12]. Results of the study are in agreement with earlier reports of Putchakarn [30] along Chanthaburi and Trat Provinces, the eastern coast of the Gulf of Thailand, Ramkumar *et al* [33] in South Andaman, Raghunathan *et al* [31] in Andaman and Nicobar Islands and Vinod *et al* [46] 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 [40] 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).

At present, coastal ecosystem of Uran is under pressure from anthropogenic activities like port operations by JNP and disposal of un-treated waste and effluents [26]. Data of the present study can be taken as a baseline data of sponges from Uran coast and effect of industrial development on it for 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. Discharge of un-treated wastes and effluents, and maritime activities of Jawaharlal Nehru Port (JNP) will affect the species diversity of sponges from Uran coast in near future.

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