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Present scenario of coral diversity at Saint Martin's Island, Bangladesh

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Abstract
The investigation was gone through to evaluate the present scenario of coral diverseness and water quality criteria of the only coral-bearing island of Bangladesh (Saint Martin's Island) from January 2018 to December 2021 in the eastern Bay of Bengal, which is known as a biologist promised land. The coral protects shorelines from storm surges and land erosion, creates job opportunities for locals and extends recreational activities. It is not only suitable for spawning, breeding, and nursery ground for different marine species but also acts as a reservoir of food and medicinal drugs. Coral specimens were collected at five stations around the Island by applying the best monitoring method as well as the Video Transects technique throughout scuba diving and snorkeling with the conventional underwater video camera. The primary video documentaries were examined and scrutinized at the BORI laboratory. A total of 72 species from 34 genera under 11 families of Scleractinian and 05 species from 4 genera under 2 families of soft corals were identified from the Island. Among Scleractinian corals Porites, Favia, Pavona, Favites, Goniastrea, Platygyra, Goniopora, Hydnophora, and Acanthastrea were the most abundant respectively and among the soft corals Gorgonian Sea fans, small sea fans, Sea whips were dominant primarily. Within the 11 families of hard corals Merulinidae, Faviidae, Mussidae, Agariciidae, Acroporidae, and Siderastrea were the most dominant, respectively. Seasonal change in water quality criteria (Transparency, Salinity, DO, TSS, Conductivity, Water p^H, TDS, Water Temperature, PO_4-P, NO_3-N, NO_2-N & SiO_3-Si, Sediment flux) has great effects on coral diversity. The present investigation unveiled that due to heavy rainfall, a large amount of freshwater discharge from upstream, and a huge amount of sedimentation, global warming, and ocean acidification, about 15% of hard coral bleaching has occurred frequently during monsoon and pre-monsoon period. Generally, most of the bleached coral was naturally regenerated with changing environmental variables during the winter and early pre-monsoon season. Anthropogenic pollution causes coral degradation. It is high time to develop a comprehensive strategy for regular monitoring, conservation, and restoration of corals for sustainable ecosystem management of the vulnerable Island.

Keywords: Coral, bleaching, scleractinian, snorkeling, scuba diving, BORI

1. Introduction
The most diverse and valuable marine ecosystems of the tropical oceans are coral reefs which cover more than 30% of total marine biodiversity [1]. Saint Martin's Island is the only coral-bearing island in Bangladesh that helps to protect coastlines from heavy oceanic waves, storm surges, and beach erosion and is also known as the spawning, reproducing, and nurturing grounds of different kinds of marine vertebrates and invertebrates [2]. Coral reefs provide food and medicines for the livelihoods of billions of people worldwide [3]. It also protects mangrove ecosystems and creates tidal pools rich in marine species [4]. Different kinds of economic activities which are directly linked to the blue economy, such as fishing, tourism, beach amusement, natural coastal protection, scuba diving, snorkeling, restaurant, and reservoir of the ornamental fishery are present at coral reefs [5]. Four species of Scleractinian corals were first recorded by Haider (1992) at Saint Martin's Island tidal pools along with ten more genera e.g. Stylocoeniella, Pocillopora, Stylophora, Porites, Povona, Favia, Favites, Pseudosiderastrea, Goniastrea and Montastrea under six families [6].
In 1997, Tomassic reported 66 corals species in 22 genera under 10 families along the Saint Martin's coastal waters [7]. In 2008, Sultana revealed only 40 corals species on Saint Martin's Island [8]. At a depth of about 0.5 m to 2.0 m in the rock pools, large coral faunal colonies were observed at Saint Martin's Island [9].

According to Rajasuriya, 2004, there are no actual coral reefs in Bangladesh, but the presence of some coral colonies at offshore patches which are highly vulnerable to anthropogenic impacts such as overfishing, coral mining, heavy sedimentation flux, unabating nature of pollution using destructive fishing gears and randomly anchoring boats [10]. Anthropogenic pollution is the main driver for the degradation of the coral colony [10].

According to Edward 2010, about 20% of world coral reefs have shown extreme levels of degradation, and more than 15% are at risk condition [11]. ENSO events, global warming, ocean acidification, increasing SST, eutrophication, loading of coastal nutrients runoff, anthropogenic destructive activities, cyclone, typhoons, and tsunamis can be the main causes of coral degradation [12]. BOBLME (2015) stated that global coral colonies are extremely vulnerable to anthropogenic consequences [13]. According to Carpenter, about 20% of the global coral reefs have been damaged and more than 36% are facing great problems, which considered that one-third of reef-building corals would be extinction [14]. Bostrom stated that in the recent decade hard corals have been suffering an unprecedented loss while need to focus on passive coral habitat protection, regular monitoring, conservation, and restoration [15].

According to Glynn, 1991, mass bleaching of corals was first observed in the late 1970s, which was directly related to an abnormality of SST induced by EL Nino events and global warming [16, 17]. The global and local context indicates that the coral colonies of Saint Martin's Island are in moderately vulnerable conditions and need immediate action for proper regular monitoring, conservation, and restoration for the sustainable ecosystem management system of the Island. The research and documentation of coral colonies and their abundance in historical ecology are very less traveled around the area of Saint Martin's Island. Not many references of previous work could be accumulated for a sound background understanding of the previous state of these colonies.

2. Materials and Methods

2.1 Study Area

Saint Martin's Island, locally known as Narikel Jinjira lying roughly between 20° 34'N - 20° 38.8'N and 92° 18'-92° 20.8'E only 7.5 km^2 sedimentary continental island of Bangladesh, which is situated about 9 km south of Cox's Bazar-Teknaf Peninsula [18]. There were 05 sampling stations selected, namely the coastguard area (Lat:20.631076 Long:92.327723), Golachipa (Lat:20.613195 Long:92.328697), Cheradiwp (Lat:20.588744 Long:92.33557), West coast (Lat:20.620685 Long:92.321350), North Coast (Lat:20.627346 Long:92.313462) of the Island for determination of physicochemical parameters & coral sampling respectively.

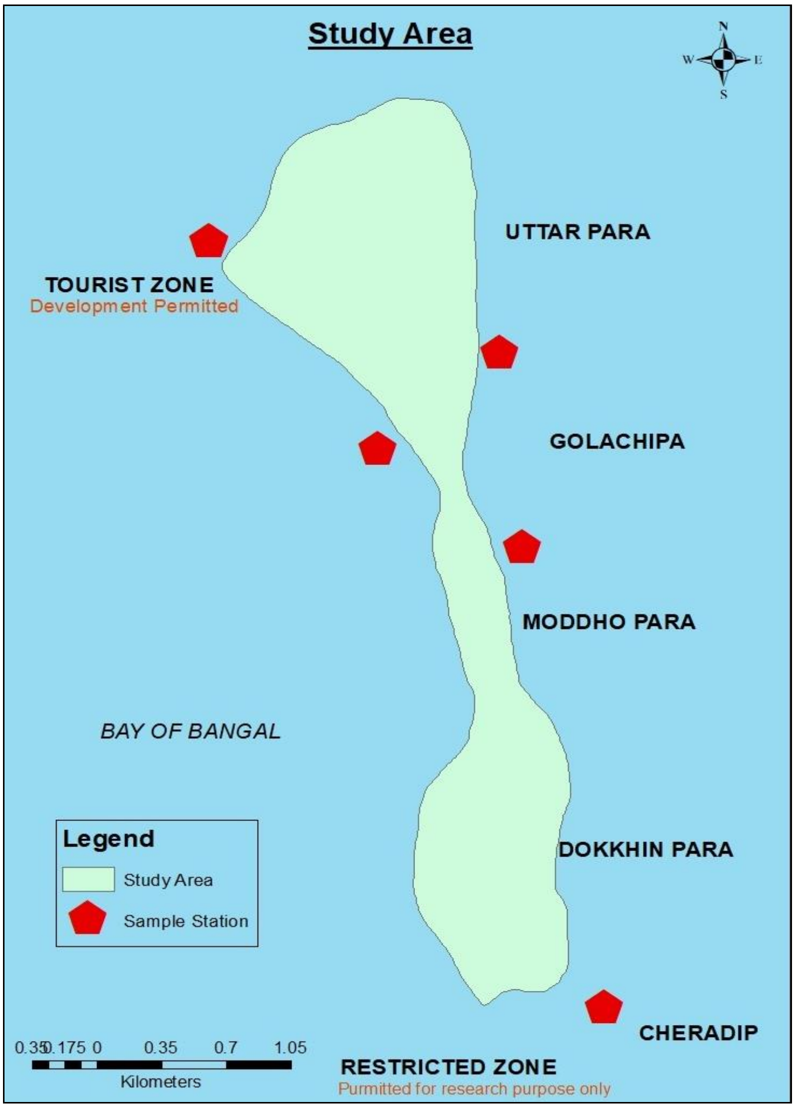


Fig 1: Study Area

2.2 Determination of Environmental Variables

To determine the environmental variables, water samples were collected monthly from the selected stations for afour-year periodr from January 2018 to December 2021. Surface water samples were collected with a sterilized plastic bottle and immediately keep in an icebox and transported to the laboratory for determining the inorganic nutrients. Water Transparency was measured in the *in situ* conditions by using Secchi Disk, Total dissolved solids, salinity, pH, and electrical conductivity were analyzed by using Hanna HI98194 multimeter, and DO was estimated by the modified Winkler's method [19]. The quantity of the dissolved nutrients of Nitrite-N, Nitrate-N, Phosphate-P, and Silicate-Si present in the filter water samples was determined following the standard methods as described by Strickland & Parsons, 1972 [20] through Shimadzoo-1800 Double Beam Spectrophotometer.

2.3 Methodology for Coral Monitoring:

Commonly several surveying techniques are used for coral reef monitoring. Such as-

- Underwater Video Transect (Photo Quadrats) Survey Technique
- Manta Tows Survey Technique
- Timed Swims Survey Technique
- Circular Areas Survey Technique
- Radial Belt Transect Survey Technique
- Belt Transects Survey Technique
- Line Intercept Transect Survey Technique
- Point intercept Transect Survey Technique
- Chain Transects Survey Technique
- Quadrats Survey Technique

Among them, we would like to be implemented the most acceptable and applicable Underwater Video Transect (Photo Quadrats) Survey Technique Method for Saint Martin's Island for Coral Monitoring and capturing the image during our study period. Such techniques have been used for studies of several reefs around the world, among them: the Great Barrier Reef of Australia in 1988, [21], reefs in the Caribbean Sea [22, 23, 24, 25], and in the Philippines [26, 27].

This technique gives us lifelong perceptible evidence of the coral-associated biodiversity, which reduces time consumption in the field. This technique helps to monitor-

- Coverage of coral percentage and other organisms from the study area
- Helps to record the proportion of bleached corals and recovery rates
- To determine the coverage of live and healthy corals
- To identify the dominant types of coral
- To know the migrating/shifting species composition
- To know the absence or presence of bleaching coral
- To identify the abundance and distribution of coral species at different locations of the study area.

According to Leujak and Ormond (2007) for long-term coral monitoring programs, the video transect technique is the most appropriate, which is very efficient and fairly accurate [28].

2.4 Identification Method of Corals

The more complex coral identification was done passionately, mainly with reference to website named Corals of the World with prior knowledge of evolutionary corals found worldwide. Identification of such delicate features video-documented from St. Martin's Island's study locations was also done focusing on their skeletal features, colonial structure as far visible to naked eyes (zooming in and out) from coral pictures shot from videography taking into consideration whether there is any morphological variation they show in general according to their varying microenvironments and even to that of the same colony. Coral identification was done by using competently dissertation [29, 30, 31, 32, 33, 34, 35].

3. Results

In the rainy season due to higher rainfall, high sediment flux, low transparency, and lower water pH were occurring frequently in the coastal waters of Saint Martin's Island, which are a concern for the coral ecosystem. Moreover, the monsoon rain causes major changes in salinity level for 4 months (June-September). The seasonal variation of observed salinity values (‰) were 31.14±4.63 (S1), 31.22±4.63 (S2), 31.30±4.64 (S3), 31.50±4.57 (S4), 31.35±4.60 (S5) respectively (Table-2); coastal water temperature (°C) values was 27.55±1.04 (S1), 27.60±1.05 (S2), 27.64±1.07 (S3), 27.68±1.06 (S4), 27.66±1.03 (S5) respectively (Table-2) and water pH values was 7.99± 0.18 (S1), 8.03± 0.18 (S2), 8.07± 0.18 (S3), 8.09± 0.18 (S4), 7.87± 0.21 (S5) respectively (Table-2); Dissolved Oxygen (mg/l) values were 5.05±0.15 (S1); 45.10±0.20 (S2); 5.18±0.20 (S3); 5.23±0.20 (S4); 5.21±0.20 (S5) respectively (Table-2).

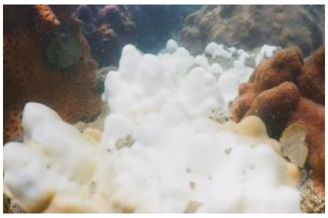
The seasonal variation of observed electric conductivity (mS/cm) values were 48.20± 6.84 (S1); 48.28±6.85 (S2); 48.33±6.86 (S3); 48.37±6.84 (S4); 48.32±6.82 (S5) respectively (Table-3); coastal water TDS (g/l) values were 24.86±2.91 (S1), 24.91±2.92 (S2); 24.95±2.94 (S3); 24.99±2.94 (S4); 24.96±2.94 (S5) respectively (Table-3). The seasonal variation of observed transparency values (ft) was 9.01±3.57 (S1); 9.06±3.59 (S2), 9.10±3.59 (S3); 9.04±3.55 (S4); 9.02±3.55 (S5) respectively (Table-3); observed rainfall (mm) value was 87.58±94.02 (Table-3). The maximum rainfall was recorded in S1 at 220.50 mm during the monsoon season and the minimum was recorded in S5 at 18 mm during the Pre-Monsoon season. As much as about 80% of the total rainfall occurs during the monsoon period.

Nutrients (NO_3-N, NO_2-N, PO_4-P: SiO_4) are the necessary parameters within the coastal waters that influence the growth, reproduction and metabolic activities of biotic components like phytoplankton as well as coral biodiversity. The seasonal variation of observed NO_3-N (mg/l) values were 0.24±0.07 (S1); 0.26±0.07 (S2); 0.27±0.08 (S3); 0.29±0.08 (S4); 0.28±0.08 (S5) respectively (Table-4); NO_2-N (mg/l) values were 0.06±0.01 (S1); 0.06±0.01 (S2); 0.07±0.01 (S3); 0.09±0.01 (S4); 0.07±0.02 (S5) respectively (Table-4); PO_4-P (mg/l) values were 0.07±0.02 (S1); 0.08±0.01 (S2); 0.07±0.01 (S3); 0.08±0.01 (S4); 0.08±0.01 (S5) respectively (Table-4) and SiO_4 (mg/l) values were 0.05±0.01 (S1); 0.07±0.01 (S2); 0.07±0.01 (S3); 0.07±0.01 (S4); 0.06±0.01 (S5) respectively (Table-4).

A total of 72 species from 34 genera under 11 families of Scleractinian corals and 05 species of 4 genera under 2 families of soft corals were identified from the Island. Among Scleractinian corals Porites, Favia, Pavona, Favites, Goniastrea, Platygyra, Goniopora, Hydnophora, and Acanthastrea were the most abundant, respectively and among the soft corals Gorgonian Sea fans, small sea fans, Sea whips were mostly dominant. Within the 11 families of hard corals Merulinidae, Faviidae, Mussidae, Agariciidae, Acroporidae, and Siderastrea were the most dominant, respectively (Table-

1). The present study revealed that coral communities were found to vary from station to station due to the influence of habitats and environmental variables. The highest coral abundance was found in the Chiradip area, with about 45 species, and the lowest on the West coast of Golachipa about 25 species at Saint Martin's Island. Coral showed complete dominance of favia and favites genera with the family of Poritida and Merulinidae. Other frequently occurring corals were *favitidae, Agaricidae* etc. respectively.
Recently, coral bleaching and coral degradation was observed on Saint Martin's Island. There is some reason which is listed here-

- Increased or reduced the ambient temperature
- Acidification
- High UV-Radiation
- Increased sedimentation due to silt runoff
- Bacterial infection
- Abnormal Change in Salinity gradient due to heavy rainfall and freshwater discharges
- Using Herbicides and pesticides
- High tidal exposure
- Illegal or Overfishing
- Destructive fishing Practices
- Randomly Anchoring
- Coastal Development
- Careless Tourism
- Pollution


Porites sp.


Porites sp.


Porites sp.


Porites sp.


Favia sp.

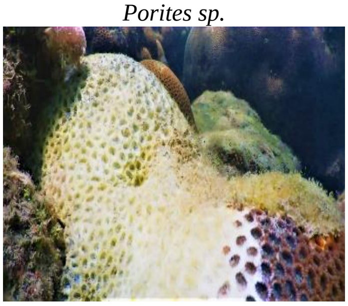

Favia sp.

Fig 2: Bleached Coral of Saint Martin's Island

There are a lot of dead corals found on Saint Martin's Island mainly in the Chiradwip area.


Dead Coral


Dead Coral


Dead Coral


Dead Coral


Dead Coral


Dead Coral

Fig 3: Dead Coral of Saint Martin's Island

4. Discussion

Fluctuations of salinity, water pH has a high influence on the marine environment as well as on coral biodiversity. Salinity distribution variation caused due to dilution and evaporation influences the faunal composition in the intertidal zone [36]. Water temperature reduces due to low solar radiation in the winter season and heavy rainfall during the monsoon season [37]. The high temperatures are recorded in the dry season due to high solar radiation [38]. The present study agrees with earlier reports by Thomasick, 1997 that fluctuate the surface and bottom seawater temperature between 22° and 29°C, transparency by depth from 1.5 m to 8 m, and salinity between 25 to 32 PSU [39].

Higher pH values may cause seawater deprivation and affect high-density phytoplankton and lower pH is influenced by freshwater discharges, dilution of seawater, low temperature, and organic matter decomposition [40, 41, 42]. The present study agrees with the earlier reported by Surana [43]. High conductivity during post-monsoon might be attributed to the low mixing of freshwater input from the Naf River. The low value during the monsoon season was due to rain and the mixing of more freshwater from the Naf River. The conductivity values decreased with an increase in rainfall. In the rainy season, the increased volume of water remarkably diluted the water [44]. The lower values of TDS suggest that the runoff water only contributes to its dilution in the rainy season [45]. Kataria [46] reported that an increase in the value of TDS indicated organic loading by extraneous sources.

Water transparency is a key factor in ocean ecology as the sun is the source of energy for all biological phenomena. Transparency reduction is due to the presence of particles in the water. When light attenuates, it alters or limits the capacity of life of some of the biological communities that live in the sea. The rainfall in Bangladesh varies, depending upon season and location. Rainfall has an important effect on the chemistry and biological activities of organisms in the coastal water.

The distribution of nutrients is principally supported by season, tidal conditions, freshwater influx and land runoff, chemical effluents, and flushing of chemicals employed in the agricultural fields. This study revealed the minimum concentrations of nutrients observed during pre-monsoon and maximum concentrations of nutrients observed during post-monsoon. The low nitrate, nitrite, and phosphate content encountered may be due to the less usage of nitrogen fertilizers and less disposal of wastes around these stations. The present study agrees earlier reported by Hari Muraleedharan [47, 48, 49] on Thondi coastal water. The low value of silicates recorded during the post-monsoonal season could be attributed to the uptake of silicates by phytoplankton for their biological activity [50]. A similar maximum value in Monsoon and minimum in the summer season were additionally recorded by Nair [51] in the Ashtamudi estuary. The present investigation of environmental variables of Saint Martin's Island agrees with earlier reported by Tarikul *et al.* [52, 53]. According to Rani *et al.* (2020), both fisheries and tourism contribute about 32 USD/year to our national economy [54].

Due to environmental stress, some corals are turning white which is known as coral bleaching and our investigation revealed that in a particular season some corals lose their vibrant color and become more porn to developing diseases. Global warming, ocean acidification, rapid fluctuations of environmental variables likewise water salinity, water pH, sedimentation, increasing turbidity of the water, and anthropogenic pollution are directly or indirectly responsible for this phenomenon. As atmospheric temperatures rise, so do seawater temperatures. We have to remove and reduce the greenhouse gas emission rate and pollution that can save the valuable coral diversity of Saint Martin's Island, Bangladesh.

Table 1: Coral abundance and distribution of Saint Martin's Island

SI	Name of the Coral	Name of the Station with coral abundance & distribution				
		S1	S2	S3	S4	S5
	Family: Lobophylliidae					
1	*Acanthastrea brevis* (Milne Edwards & Haime, 1849)	+++	++	++	+	++
2	*Acanthastrea lordhowensis* (Veron and Pichon, 1982)	++	+++	++	++	+++
	Family: Acroporidae					
3	*Acropora sarmentosa* (Brook,1892)	++	++	++	+	+++
4	*Astreopora incrustans* (Bernard, 1896)	+++	++	++	++	++
5	*Montipora millepora* (Crossland, 1952)	+++	++	+++	++	++
	Family: Agariciidae					
6	*Leptoseris caileti* (Duchassaing & Michelotti, 1864)	++	+++	++	+	+++
7	*Pavona chiriquiensis* (Glyn, Mate & Stemann, 2001)	++	++	++	++	+
8	*Pavona clavus* (Dana, 1846)	+++	++	++	+	++
9	*Pavona gigantea* (Verrill, 1869)	++	+	+	++	+
10	*Pavona maldivensis* (Gardiner, 1905)	+	++	++	+	++
11	*Pavona minuta* (Wells, 1954)	+	+	++	+	+
12	*Pavona sp.*	++	++	+	++	+

	Family: Astrocoeniidae					
13	*Stylocoeniella armata* (Ehrenberg, 1834)	++	++	+++	+	++
14	*Stylocoeniella guentheri* (Bassett-Smith, 1890)	++	+	+	++	+
	Family: Dendrophylliidae					
15	*Turbinaria peltata* (Esper, 1794)	++	+++	++	+	++
	Family: Faviidae					
16	*Astrea curta* (Dana, 1846)	+++	++	++	+	++
17	*Cyphastrea japonica* (Yabe and Sugiyama, 1936)	++	+	++	++	+
18	*Favia favus* (Forskal, 1775)	++	++	++	+	++
19	*Favia sp.*	+	++	+	++	+
20	*Favia sp.*	++	++	++	+	++
21	*Favia sp.*	++	++	++	+	++
22	*Favia sp.*	++	++	++	+	++
23	*Favia sp.*	++	++	++	++	++
24	*Favia sp.*	++	+++	++	+	++
25	*Favia matthai* (Vaughan, 1918)	++	++	++	++	++
26	*Favia maxima* (Veron, Pichon & Wijsman-Best, 1977)	++	++	++	+++	++
27	*Favia pallida* (Dana, 1846)	++	++	++	+	++
28	*Favia rosaria* (Veron, 2000)	++	+	++	+	++
29	*Favia rotumana* (Gardiner, 1899)	++	+++	++	++	++
30	*Favia rotundata* (Veron, Pichon & Wijsman-Best, 1977)	++	++	++	+	++
31	*Favia sp.*	++	+++	++	++	++
32	*Favia sp.*	+++	+++	++	+	++
33	*Favia speciosa* (Dana, 1846)	++	++	++	++	++
34	*Favia stelligera* (Dana, 1846)	++	++	++	++	++
35	*Favia veroni* (Moll & Best, 1984)	+++	++	++	+	++
	Family: Merulinidae					
36	*Favites abdita* (Ellis & Solander, 1786)	+++	++	++	+	++
37	*Favites acutecolis* (Ortmann, 1889)	++	+	++	++	+
38	*Favites complanata* (Ehrenberg, 1834)	++	++	++	+	++
39	*Favites flexuosa* (Dana, 1846)	+	++	++	++	++
40	*Favites halicora* (Ehrenberg, 1834)	+++	++	++	+	++
41	*Favites paraflexuosus* (Veron, 2000)	++	+	++	++	+
42	*Favites pentagona* (Esper, 1790)	++	++	++	+	++
43	*Favites russelli* (Wells, 1954)	++	++	++	++	++
44	*Favites sp.*	+++	++	++	+	++
45	*Favites sp.*	++	+	++	++	+
46	*Goniastrea aspera* (Verrill, 1866)	++	++	++	+	++
47	*Goniastrea australensis* (Milne Edwards & Haime, 1857)	++	++	++	+	++
48		+++	++	++	+	++
49	*Goniastrea columella* (Crossland, 1948)	++	+	++	++	+
50	*Goniastrea deformis* (Veron, 1990)	++	++	++	+	++
51	*Goniastrea edwardsi* (Chevalier, 1971)	++	++	++	+	++
52	*Goniastrea palauensis* (Yabe & Sugiyama, 1936)	+++	++	++	+	++
53	*Goniastrea minuta* (Veron, 2000)	++	+	++	++	+
54	*Goniastrea thecata* (Veron, DeVantier & Turak, 2000)	++	++	++	+	++
55	*Leptastrea purpurea* (Dana, 1846)	++	++	++	+	++
56	*Leptastrea pruinosa* (Crossland, 1952)	+++	++	++	+	++
57	*Oulophyllia levis* (Nemenzo, 1959)	++	+	++	++	+
58	*Platygyra contorta* (Veron, 1990)	+	++	++	+	++
59	*Platygyra daedalea* (Ellis & Solander, 1786)	++	++	++	++	++
60	*Platygyra pini* (Chevalier, 1975)	+++	++	++	+	++
61	*Platygyra sinensis* (Milne Edwards & Haime, 1849)	++	+	++	++	+
62	*Platygyra verweyi* (Wijsman-Best, 1976)	++	++	++	+	++
63	*Echinopora pacificus* (Veron, 1990)	++	++	++	+	++
64	*Hydnophora exesa* (Pallas, 1766)	+++	++	++	+	++
65	*Hydnophora microconos* (Lamarck, 1816)	++	+	++	++	+
66	*Hydnophora pilosa* (Veron, 1985)	++	++	++	+	++
67	*Phymastrea colemani* (Veron, 2000)	++	++	++	+	++
	***Family:* Montastraeidae**					
68	*Orbicella franksi* (Gregory, 1895)	++	+	+	++	+
	Family: Mussidae					
69	*Blastomussa merleti* (Wells, 1961)	+++	++	++	+	++
70	*Blastomussa wellsi* (Wijsman-Best, 1973)	++	+	++	++	+
71	*Mussismilia braziliensis* (Verrill, 1868)	++	++	++	+	++
	***Family:* Oulastreidae**					
72	*Oulastrea crispata* (Lamarck, 1816)	+	+	+	+	++
	***Family:* Pectinidae**					

73	*Pectinia paeonia* (Dana, 1846)	++	+	++	+	+
***Family:* Plesiastreidae**						
74	*Plesiastrea versipora* (Lamarck, 1816)	+++	++	++	+	++
***Family:* Pocilloporidae**						
75	*Pocillopora damicornis* (Linnaeus, 1758)	+++	++	++	+	++
76	*Styllopora pistillata* (Esper, 1792)	++	+	++	++	+
***Family:* Poritidae**						
77	*Bernardpora stutchburyi* (Wells, 1955)	+++	++	++	+	++
78	*Goniopora columna* (Dana, 1846)	++	+	++	++	+
79	*Goniopora lobata* (Milne Edwards, 1860)	++	++	++	+	++
80	*Goniopora minor* (Crossland, 1952)	++	++	++	+	++
81	*Goniopora tenuidens* (Quelch, 1886)	+++	++	++	+	++
82	*Porites densa* (Vaughan, 1918))	++	+	++	++	+
83	*Porites desilveri* (Veron, 2000)	++	++	++	+	++
84	*Porites lichen* (Milne Edwards & Haime, 1851)	++	++	++	+	++
85	*Porites sp.*	+++	++	++	+	++
86	*Porites sp.*	++	+	++	++	+
87	*Porites sp.*	++	++	++	+	++
88	*Porites sp.*	++	++	++	+	++
89	*Porites sp.*	+++	++	++	+	++
90	*Porites negrosensis*	++	+	++	++	+
91	*Porites sp.*	++	++	++	+	++
92	*Porites sp.*	++	++	++	+	++
93	*Porites sp.*	+++	++	++	+	++
94	*Porites sp.*	++	+	++	++	+
95	*Porites stephensoni* (Crossland, 1952)	++	++	++	+	++
96	*Porites superfusa (*Gardiner, 1898)	++	++	++	+	++
97	*Porites sp.*	+++	++	++	+	++
98	*Porites sp.*	++	+	++	++	+
99	*Porites sp.*	++	++	++	+	++
101	*Porites sp.*	++	++	+	++	+
***Family:* Siderastreidae**						
102	*Psammocora profundacella* (Gardiner, 1898)	+++	++	++	+	++
103	*Psedosiderastrea formosa* (Pichon, Chuang and Chen, 2012)	++	+	++	++	+
104	*Siderastrea savignyana* (Milne Edwards and Haime, 1849)	++	++	++	+	++
***Family:* Alcyoniidae**						
105	*Cladiella australis* (Macfadyen, 1936)	++	+	+	++	+
106	*Lobophytum mortoni* (Benayahu & Ofwegen, 2009))					
Family: Tubiporidae						
107	*Tubipoora musica (Linnaeus, 1758)*	+	++	++	+	+

N.B: +++ =Indicates Higher Abundance; ++ = Indicates Moderate Abundance; += Indicates Lower Abundance

Table 2: Seasonal variation of Environmental Variables at Saint Martin's Island (2018-2021 FY)

Station	Monsoon	Post monsoon	Pre-monsoon	Avg.	STD	Monsoon	Post monsoon	Pre-monsoon	Avg.	STD	Monsoon	Post monsoon	Pre-monsoon	Avg.	STD	Monsoon	Post monsoon	Pre-monsoon	Avg.	STD
	Salinity (PSU)	Salinity (PSU)	Salinity (PSU)			Temp. (°C)	Temp. (°C)	Temp. (°C)			DO (mg/l)	DO (mg/l)	DO (mg/l)			P^H	P^H	P^H		
1	24.64	33.77	35.02	31.14	4.63	28.45	26.10	28.12	27.55	1.04	4.88	5.05	5.24	5.05	0.15	7.74	8.11	8.13	7.99	0.18
2	24.72	33.82	35.12	31.22	4.63	28.50	26.12	28.18	27.60	1.05	4.86	5.10	5.35	5.10	0.20	7.78	8.15	8.17	8.03	0.18
3	24.78	33.94	35.18	31.30	4.64	28.54	26.14	28.24	27.64	1,07	4.94	5.16	5.44	5.18	0.20	7.82	8.17	8.22	8.07	0.18
4	25.08	34.10	35.34	31.50	4.57	28.58	26.20	28.28	27.68	1.06	4.98	5.24	5.48	5.23	0.20	7.84	8.20	8.24	8.09	0.18
5	24.88	34.04	35.14	31.35	4.60	28.52	26.22	28.26	27.66	1.03	4.96	5.22	5.46	5.21	0.20	7.80	8.21	8.28	8.09	0.21
Avg.	24.82	33.934	35.16	31.30	4.61	28.51	26.15	28.21	27.63	1.05	4.92	5.15	5.39	5.15	0.19	7.79	8.16	8.20	8.05	0.18

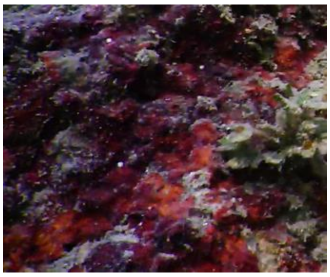
Table 3: Seasonal variation of Environmental Variables at Saint Martin's Island (2018-2021 FY)

Station	Monsoon	Post monsoon	Pre-monsoon	Avg	STD	Monsoon	Post monsoon	Pre-monsoon	avg	STD	Monsoon	Post monsoon	Pre-monsoon	avg	STD	Monsoon	Post monsoon	Pre-monsoon	avg	STD
	TDS (g/l)	TDS (g/l)	TDS (g/l)			Conductivity (mS/cm)	Conductivity (mS/cm)	Conductivity (mS/cm)			Transparency (ft)	Transparency (ft)	Transparency (ft)			Rainfall (mm)	Rainfall (mm)	Rainfall (mm)		
1	20.80	26.31	27.47	24.86	2.91	38.62	51.89	54.10	48.20	6.84	4.73	13.48	8.82	9.01	3.57	220.50	24.25	18	87.58	94.02
2	20.84	26.36	27.54	24.91	2.92	38.68	51.98	54.18	48.28	6.85	4.76	13.54	8.88	9.06	3.59	220.50	24.25	18	87.58	94.02
3	20.86	26.39	27.62	24.95	2.94	38.72	52.04	54.24	48.33	6.86	4.80	13.58	8.94	9.10	3.59	220.50	24.25	18	87.58	94.02
4	20.90	26.41	27.66	24.99	2.94	38.78	52.06	54.28	48.37	6.84	4.78	13.48	8.88	9.04	3.55	220.50	24.25	18	87.58	94.02
5	20.88	26.38	27.64	24.96	2.94	38.76	51.98	54.22	48.32	6.82	4.76	13.44	8.86	9.02	3.55	220.50	24.25	18	87.58	94.02
Avg.	20.85	26.37	27.58	24.93	2.93	38.71	51.99	54.20	48.30	6.84	4.76	13.50	8.87	9.04	3.57	220.5	24.25	18	87.58	94.02

Table 4: Seasonal variation of Environmental Variables at Saint Martin's Island (2018-2021 FY)

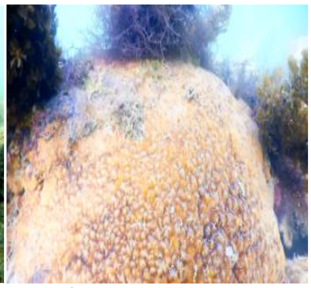
Station	Monsoon	Post monsoon	Pre-monsoon	avg	STD	Monsoon	Post monsoon	Pre-monsoon	avg	STD	Monsoon	Post monsoon	Pre-monsoon	avg	STD	Monsoon	Post monsoon	Pre-monsoon	Avg	STD
	NO_3-N (mg/l)	NO_3-N (mg/l)	NO_3-N (mg/l)			NO_2-N (mg/l)	NO_2-N (mg/l)	NO_2-N (mg/l)			PO_4-P (mg/l)	PO_4-P (mg/l)	PO_4-P (mg/l)			SiO_4 (mg/l)	SiO_4 (mg/l)	SiO_4 (mg/l)		
1	0.22	0.34	0.18	0.24	0.07	0.08	0.07	0.05	0.06	0.01	0.09	0.07	0.05	0.07	0.02	0.06	0.05	0.06	0.05	0.01
2	0.24	0.36	0.19	0.26	0.07	0.09	0.08	0.06	0.07	0.01	0.10	0.08	0.07	0.08	0.01	0.08	0.06	0.07	0.07	0.01
3	0.26	0.38	0.19	0.27	0.08	0.09	0.07	0.07	0.07	0.01	0.09	0.07	0.06	0.07	0.01	0.07	0.07	0.08	0.07	0.01
4	0.28	0.39	0.20	0.29	0.08	0.10	0.09	0.08	0.09	0.01	0.08	0.10	0.07	0.08	0.01	0.06	0.08	0.09	0.07	0.01
5	0.29	0.37	0.18	0.28	0.08	0.09	0.07	0.06	0.07	0.01	0.09	0.09	0.08	0.08	0.01	0.08	0.05	0.07	0.06	0.01
Avg.	0.25	0.36	0.18	0.27	0.07	0.09	0.07	0.06	0.07	0.01	0.09	0.08	0.06	0.07	0.01	0.07	0.06	0.07	0.06	0.01

N.B: Station-1 (Coast Guard Area); Station- 2 (East Coast of Golachipa); Station-3 (East Coast of ChiraDwip); Station-5 (West Coast of Golachipa); Station-6 (North West Coast)

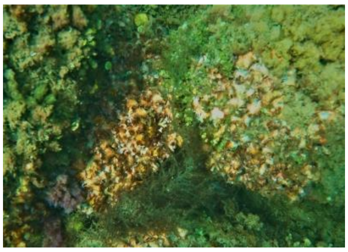

1. Acanthastrea brevis


2. Acanthastrea lordhowensis


3. Acropora sarmentosa


4. Astreopora incrustans


5. Montipora millepora


6. Leptoseris caileti


7. Pavona chiriquiensis


8. Pavona clavus


9. Pavona gigantea


10. Pavona maldivensis


11 Pavona minuta


12. Pavona sp.


13. Stylocoeniella armata


14. Stylocoeniella guentheri


15. Turbinaria peltate


16. Astrea c.f.curta


17. Cyphastrea japonica


18. Favia favus


19. Favia sp.


20. Favia sp.

Fig 4: Image of Coral at Saint Martin's Island


21 Favia sp.


22. Favia sp.


23. Favia sp.


24. Favia sp.


25. Favia matthai


26. Favia maxima


27. Favia pallida


28. Favia rosaria


29. Favia rotumana


30. Favia rotundata


31. Favia sp.


32. Favia sp.


33. Favia speciosa


34. Favia stelligera


35. Favia veroni


36. Favites abdita


37. Favites acutecolis


38. Favites complanate


39. Favites flexuosa


40. Favites halicora

Fig 5: Image of Coral at Saint Martin’s Island


41. Favites paraflexuosus


42. Favites pentagona


43. Favites russelli


44. Favites sp.

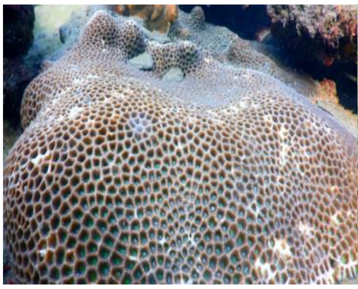

45. Favites sp.


46. Goniastrea aspera


47. Goniastrea australensis


48. Goniastrea columella


49. Goniastrea deformis

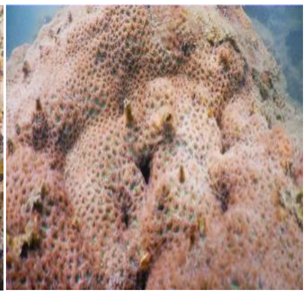

50. Goniastrea edwardsi


51. Goniastrea palauensis


52. Goniastrea minuta


53. Goniastrea thecata


54. Leptastrea purpurea


55. Leptastrea pruinose


56. Oulophyllia levis


57. Platygyra contorta


58. Platygyra daedalea


59. Platygyra pini

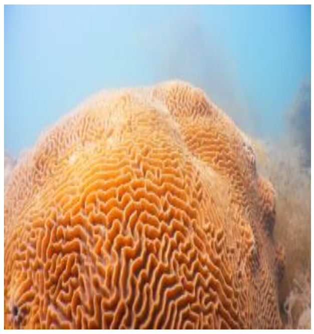

60. Platygyra sinensis

Fig 6: Image of Coral at Saint Martin's Island


61. Platygyra verweyi


62. Echinopora pacificus


63. Hydnophora exesa


64. Hydnophora microconos

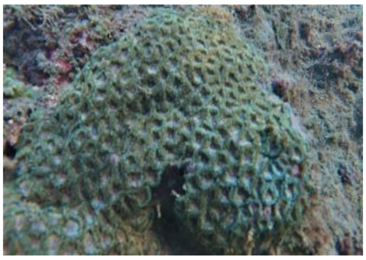

65. Hydnophora Pilosa


66. Orbicella franksi


67. Phymastrea colemani


68. Phymastrea valenciennesi


69. Blastomussa merleti


70. Blastomussa wellsi


71. Mussismilia braziliensis


72. Oulastrea crispata


73. Pectinia paeonia


74. Plesiastrea versipora


75. Pocillopora damicornis


76. Styllopora pistillata


77. Bernardpora stutchburyi


78. Goniopora columna


79. Goniopora lobata


80. Goniopora minor

Fig 7: Image of Coral at Saint Martin's Island


81. Goniopora tenuidens


82. Porites densa


83. Porites desilveri

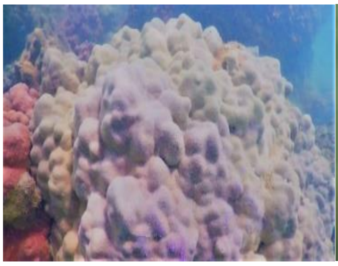

84. Porites lichen


85. Porites sp.

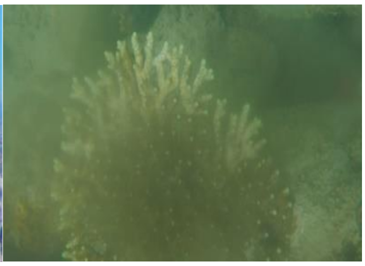

86. Porites sp.


87. Porites sp.


88. Porites sp.



89. Porites sp.



90. Porites negrosensis

91. Porites sp.

92. Porites sp.

93. Porites sp.

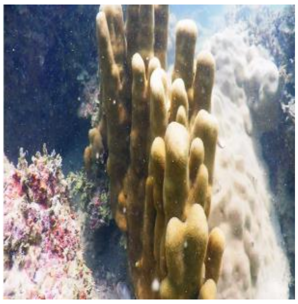
94. Porites sp.

95. Porites stephensoni

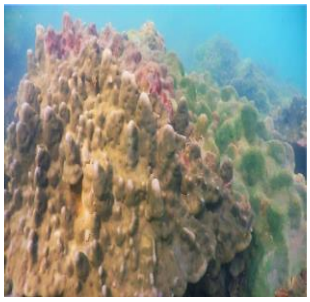
96. Styllopora pistillata

97. Porites sp.

98. Porites sp.



99. Porites sp.



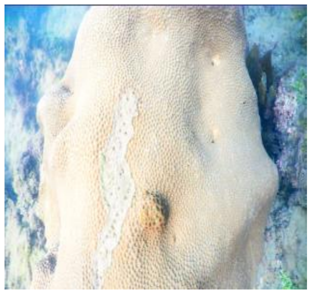
100. Porites sp.

Fig 8: Image of Coral at Saint Martin's Island

101. Porites sp.

102. Psammocora profundacella

103. Psedosiderastrea Formosa



104. Siderastrea savignyana

105. Cladiella australis

106. Lobophytum mortoni

107. Tubipoora musica

108. Paramuricea clavata

Fig-9: Image of Coral at Saint Martin's Island

5. Conclusion

Seasonal change of Physico-chemical parameters has a great influence on the abundance and distribution of coral diversity. The present investigation unveiled that due to heavy rainfall, a large amount of freshwater discharge from upstream, and the huge amount of sedimentation, global warming, and ocean acidification, about 15% of hard coral bleaching has occurred frequently during the monsoon period. Generally, most of the bleached coral was naturally regenerated with changing environmental variables during the winter and early pre-monsoon season. Anthropogenic pollution causes coral degradation. It is high time to develop a comprehensive strategy for regular monitoring, conservation, and restoration of corals for sustainable ecosystem management of the vulnerable Island. On the other hand, due to ocean acidification and global warming, some temperature and pHsensitive coral species face a great problem.

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7. References

1. Ladd MC, Shantz AA, Nedimyer K, Burkepile DE. Density Dependence Drives Habitat Production and Survivorship of Acropora cervicornis Used for Restoration on a Caribbean Coral Reef. Frontiers in Marine Science, 2016.
2. Hossain MM, *et al*. status of the biodiversity of st. martin's island, bay of Bengal, Bangladesh Pakistan Journal of Marine Sciences. 2006;15(2):201-210.
3. Edwards AJ. Reef Rehabilitation Manual. Coral Reef Targeted Research & Capacity Building for Management Program: St Lucia, Australia, 2010.
4. NOAA - Global Perspective. Retrieved from National Centers for Environmental Information (US), 1995. https://www.ncdc.noaa.gov/paleo/outreach/coral/sor/sor_global.html
5. Rajasuriya A. Status report on the condition of reef habitats in Sri Lanka, 2002. In: Coral Reef Degradation in the Indian Ocean: Status report, 2002.
6. Haider SMB. A survey on the coast of the Saint Martin’s Islands, Bangladesh. MSc. Thesis, Institute of Marine Sciences, University of Chittagong, Bangladesh, 1992.
7. Tomascik T. Management Plan for Resources of Narikel Jinjira (St. Martin's Island), 1997.
8. Sultana D, Hossain MM, Ormond R. Coral Associated Fishes & Corals at ST. Martin’s Island, BoB, Bangladesh & Deterioration of its Water Quality Due to Anthropogenic Activity - Need Long Term Study. Presented at SAARC Coral Reef Monitoring Workshop, 21-24 May, 2012, Sri-Lanka, 2008.
9. Hossain MS, Chowdhury SR, Nabi MRU. Resource Mapping of Saint Martin’s Island Using Satellite Image and Ground Observations Journal of Forestry & Environment. 2007;5:23-36.
10. Rajasuriya A, Zahir H, Venkataraman K, Islam Z, Tamelander J. Status of coral reefs in South Asia: Bangladesh, Chagos, India, Maldives, and Sri Lanka. In: Status of Coral Reefs of the World. Wilkinson, C. ed., Australian Institute of Marine Science, Townsville, Queensland, Australia, 2004, 213-233.
11. Edwards AJ. Reef Rehabilitation Manual. Coral Reef Targeted Research & Capacity Building for Management Program: St Lucia, Australia, 2010.
12. Edwards AJ. Reef Rehabilitation Manual. Coral Reef Targeted Research & Capacity Building for Management Program: St Lucia, Australia, 2010.
13. Boblme. Report on Saint Martin’s Island ecosystem boundary, Bangladesh, 2015.
14. Carpenter KE, Abrar M, Aeby G, Aronson RB, Banks S, Bruckner A, *et al*. Vulnerability of the Bay of Bengal to Ocean Acidification 41 O., 2008.
15. Boström-Einarsson L, Babcock RC, Bayraktarov E, Ceccarelli D, Cook N, Ferse SCA, *et al*. Coral restoration - A systematic review of current methods, successes, failures and future directions. PLoS ONE. 2020;15(1):e0226631.
16. Glynn PW. Coral reef bleaching in the 1980s and possible connections with global \warming. Trends in Ecological Evolution. 1991;6(6):175-179.
17. Hoegh-Guldberg O. Climate change, coral bleaching, and the future of the world’s coral reefs. Mar. Freshwater. Res. 1999;50:839-866.
18. Tomascik T. Management Plan for Resources of Narikel Jinjira (St. Martin's Island), 1997.
19. Strickland JD, Parsons TR. A Practical Handbook of Seawater Analysis, Bulletin 167, Ottawa: Fisheries Research Board of Canada, 1972.
20. Strickland JD, Parsons TR. A Practical Handbook of Seawater Analysis, Bulletin 167, Ottawa: Fisheries Research Board of Canada, 1972.
21. Carleton JH, DONE TJ. Quantitative video sampling of coral reef benthos: large-scale application. Coral Reefs. 1995;14:35-46.
22. Aronson RB, Edmunds PJ, Precht WF, Swanson DW, Levitan DR. Large-scale, long-term monitoring of Caribbean coral reefs: simple, quick, inexpensive techniques. Atoll Res. Bull. 1994;421:1-19.
23. Aronson RBE, Swanson DW. Video surveys of coral reefs: uni- and multivariate applications. In: International Coral Reef Symposium, 8, 1996, Panama. Proceedings … Balboa, Panama: Smithsonian Tropical Research Institute. 1997;2:1441-1448.
24. Chaves EA. Sampling design for the study of Yucatan Reefs, Northwestern Caribbean. In: International coral reef symposium, 8, 1996, Panama. Proceedings … Balboa, Panama: Smithsonian Tropical Research Institute, 1997;2:1465-1470.
25. Rogers CS, Miller J. Coral bleaching, hurricane damage and benthic cover on coral reefs in St. John, U. S. Virgin Islands: a comparison of surveys with the chain transect method and videography. Bull. Mar. Sci. 2001;69(2):459-470.
26. Alcala MLR, Vogt H. Approximation of coral reef surface using standardized growth and video counts. In: International coral reef symposium, 8, 1996, Panama. Proceedings Balboa, Panama: Smithsonian Tropical Research Institute. 1997;2:1453-1458.
27. Vogt H, Montebon ARF, Alcala MLR. Underwater video sampling: an effective method for coral reef surveys? In: International Coral Reef Symposium, 8, 1996, Panama. Proceedings … Balboa, Panama: Smithsonian Tropical Research Institute. 1997;2:1447-1452.
28. Leujak W, Ormond RFG. Comparative accuracy and efficiency of six coral community survey methods. J. exp. Mar. Biol. Ecol. 2007;351:168-187.
29. Cairns SD, Hoeksema BW, Van Der Land J. List of Extant Stony Corals. Attol Research Bulletin. 1999;459:13-46.
30. Gosliner TM, Behrens DW, Williams GC. Coral Reef Animals of the Indo-Pacific; Monterey, CA - USA Mather P, Bennett I., 1994; *a Coral Reef Handbook*; Australian Coral Reef Society; Surrey Beatty & Sons Pty

Ltd; Chipping Norton; NSW - AUS.
31. Colin PL, Arneson C. Tropical Pacific Invertebrates; The Coral Reef Press: Beverly Hills, CA - USA, 1995.
32. Veron JEN. Corals of the World; Australian Institute of Marine Science; Townsville, QLD - AUS, 2000.
33. Veron JEN. Corals of Australia and the Indo-Pacific; University of Hawaii Press, Honolulu - USA, 1996.
34. Veron JEN. Corals in Space and Time - The Biogeography and Evolution of the Scleractinia; University of New South Wales Press, Sydney - AUS, 1995.
35. Wood EM. Corals of the World; TFH Publications Inc Ltd.: Neptune City, NJ - USA, 1983.
36. Gibson RN. Recent studies on the biology of intertidal fishes. Oceanogr. Mar. Biol. Annu. Rev 1982;20:363-414.
37. Karuppasamy R, Alokam MR, Elanchezhian C. “Seasonal variations of nutrients in the Uppanar estuary, Cuddalore, Southeast coast of India”, Proc. Intl. sem. Appl. Hydro geo chem., Annamalai University, 1999, 269-274.
38. Das J, Das SN, Sahoo RK. Semidiurnal variation of some Physico-chemical parameters in the Mahanadi estuary, east coast of India. Ind. J Mar. Sci. 1997;26:323-326.
39. Tomascik T. Management Plan for Resources of Narikel Jinjira (St. Martin's Island), 1997.
40. Ganesan M. Ecobiology of seaweed of the Gulf of Mannar with special reference to hydrography and heavy metals”, Ph.D. Thesis Annamalai University, India, 1992, 162.
41. Rajasegar M. Physico-chemical characteristics of the Vellar estuary in relation to shrimp farming. J. Environ. Biol. 2003;24:95-101.
42. Prabu VA, Rajkumar M, Perumal P. Seasonal variations in Physico-chemical characteristics of Pichavaram mangroves, southeast coast of India. Journal of Environmental Biology. 2008;29(6):945-950.
43. Surana R, Gadhia M, Ansari E. Seasonal variations in Physico-chemical characteristics of Tapi Estuary in Hazira Industrial Area. Our Nature-March 2013;10:249-257.
44. Izonfuo WA, Bariweni L. The effect of urban runoff water and human activities on some physicochemical parameters of the Epie creek in the Niger Delta.J. Appl. Sci. & Enviro. Mgt. 2001;5(1):4755.
45. Izonfuo WA, Bariweni L. The effect of urban runoff water and human activities on some physicochemical parameters of the Epie creek in the Niger Delta. J. Appl. Sci. & Enviro. Mgt. 2001;5(1):4755.
46. Kataria HC, Quereshi HA, Iqbal SA, Shandilya AK. Assessment of water quality of Kolar Reservoir in Bhopal (MP). Pollution Research. 1996;15:191-193.
47. Hari Muraleedharan, Abhilash. Physico-chemical Parameters and Planktons Analysis of Sea Water of Thondi of Palk Bay, Tamil Nadu J Bio. sci. Res. 2010;1(1):20-24.
48. Subrahmanyan R. Phytoplankton organisms of the Arabian Sea off the west coast of India. J Indian Bot Soc. 1958;37:435-441.
49. Sampathkumar. “Investigations on Plankton in relation to hydrobiology and heavy metals in the Tranquebar - Nagapattinam Coast," Ph.D., Thesis, Annamalai University, India. 2005;184:1992.
50. Prasanna KS, Sardesai S, Ramaiah N, Bhosle NB, Ramaswamy V, Ramesh R, *et al*. Bay of Bengal process studies (BOBPS) Final Report. Final Report Submitted to the Department of Ocean Development New Delhi, 2007. 142. http://drs.nio.org/drs/handle/2264/535
51. Nair Gopinathan CP, Balachandran VK, Mathew KJ, Regunathan A, Rao DS, Murty AVS. Ecology of mud banks: phytoplankton productivity I Alleppey mudbank”, Bull. Cent. Mar. Fish. Res. Inst. 1984;31:28-34.
52. Tarikul *et al*. Seasonal Variation of Physico-Chemical Characteristics in the South Eastern Coastal Waters of Cox’s Bazar, Bangladesh. International Journal of Science and Research (IJSR) ISSN: 2319-7064. 2019;8(11).
53. Tarikul *et al*. Phytoplankton assemblages in the southeastern coastal area of the Bay of Bengal, Bangladesh with special reference to environmental variables. International Journal of Fisheries and Aquatic Studies 2021;9(6):Part A.
54. Rani S, *et al*. Economic valuation and conservation, restoration & management strategies of Saint Martin’s Island, Bangladesh, 2020.