ANNUAL Report 2019

Bangladesh Oceanographic Research Institute

Ministry of Science and Technology
Government of the People's Republic of Bangladesh

Annual Report
of

Bangladesh Oceanographic Research Institute

July, 2019

Bangladesh Oceanographic Research Institute
Ministry of Science and Technology
Government of the People's Republic of Bangladesh

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BOARD OF EDITORS

Father of the Nation Bangabandhu Sheikh Mujibur Rahman

Bangabandhu established the legal entitlements of Bangladesh maritime areas and marine resources by passing the "Territorial Waters and Maritime Zones Act-1974"

Prime Minister Sheikh Hasina at Inani Sea Beach, Cox's Bazar (6 May, 2017)
(Photo : PID)

"*There is a link between the development of human civilization and ocean. The nearer a society is to the ocean; the better the life is of its members*"

- Sheikh Hasina
(14th HACGAM, 2018)

Arch. Yeafesh Osman
Minister
Ministry of Science and Technology
Government of the People's Republic of Bangladesh

Message

I am glad to know that Bangladesh Oceanographic Research Institute is going to publish 1st Annual Report-2019 containing information on its activities and research works. I felicitate the young scientists for their research.

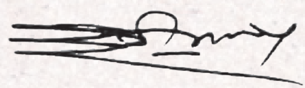
The Father of the Nation Bangabandhu Sheikh Mujibur Rahman, had a great vision to use our ocean resources for developing Bangladesh. His competent daughter, Honorable Prime Minister Sheikh Hasina is putting forward his vision. I am immensely proud to recite-

পিতার মতোই পিতার কন্যা
ধরেছে দেশের হাল
দেশের স্বার্থে সমুদ্র বিজয়
লেখা রবে চিরকাল।

বাংলাদেশের সমুদ্র বিজয়
অর্জন খানা বেশ
দেশের লাগিয়া বাঙালিই পারে
শাবাশ বাংলাদেশ।।

The present Awami League Government, by the leadership of Jononetri Sheikh Hasina, is greatly emphasizing on oceanographic science and technology research. Our huge sea area, exploration of its resources, and tending to Blue Economy based national economy will be the building block of developed Bangladesh.

I hope, this institute will play a vital role in national economic development by its capability and competence on oceanographic research.



(Architect Yeafesh Osman)

Md. Anwar Hossain
Senior Secretary
Ministry of Science and Technology
Government of the People's Republic of Bangladesh

Message

It is a matter of great pleasure for me to know that Bangladesh Oceanographic Research Institute (BORI) is going to publish their Annual Report-2019, which showcases their year-long performances along with the achievement of their research activities.

Bangladesh is now on the Development Boulevard with the efficacious leadership of our Honorable Prime Minister H.E. Sheikh Hasina. Establishment of BORI in 2017 is the result of her visionary determination. She rightly understood that we have to explore, exploit, preserve and utilize marine resources to achieve our development goals.

We achieved a total of 1,18,813 sq. km of sea area by the historic maritime delimitation settlement with our neighboring countries. Within this sea area in the Bay of Bengal, we have a huge amount of living and non-living resources. Our duty is to find out and utilize these resources. The present Government of Bangladesh has taken different measures for utilization of this Blue Economy and subsequent contribution to the development of the country.

Ministry of Science and Technology has been funding BORI since its inception for innovative research ideas, research works and research projects. At present BORI has eight modern laboratories equipped with highly sophisticated instruments for different streams of oceanographic research. BORI will play key role in harnessing marine resources in near future.

I hope, the scientists of BORI will come up with productive and innovative research ideas and will devote themselves for the best uses of oceanographic resources.

Joy Bangla
Joy Bangabandhu

(Md. Anwar Hossain)

Md. Shafiqur Rahman

Director General (Additional Charge)

Bangladesh Oceanographic Research Institute

Message

I am very delighted that Bangladesh Oceanographic Research Institute (BORI) is going to publish the 'Annual Report-2019', focusing on oceanographic researches of the Bay of Bengal, Bangladesh.

At first, I want to recall respectfully The Father of the Nation Bangabandhu Sheikh Mujibur Rahman who opened up the process of getting sovereign sea area for Bangladesh in 1974. After a long period of time and going through different procedures, we got huge sea area which is almost the same area of main land Bangladesh. Now we have sea resources both living and non-living to explore and exploit for future development.

Present government has expedited the process of establishing a research institute on sea and related area. As an outcome, Bangladesh Oceanographic Research Institute (BORI) is established. From 2018, BORI has become functionalized and newly recruited scientists have taken several research projects. In continuation of governments Blue Economy policy, BORI has already taken short-term, mid-term and long-term plans that are expected to be materialized by 2030. Honorable Prime Minister Sheikh Hasina has especial interest on oceanographic resources and its use for future economic development of Bangladesh.

I thank the scientists for their introductory research results and to document these results in the 'Annual Report-2019'. I hope they will extremely devote themselves in oceanographic research for the development of Bangladesh.

(Md. Shafiqur Rahman)

Executive Editorial Remark

The thought of our own 'maritime area and ocean resources' dates back to 1974 when The Father of the Nation Bangabandhu Sheikh Mujibur Rahman enacted "Territorial Waters and Maritime Zones Act-1974". Since then several processes of discussion and debate, we won maritime delimitation cases with Myanmar and India. Finally, for the strong leadership of Honorable Prime Minister Sheikh Hasina, Bangladesh Oceanographic Research Institute (BORI) started its scientific journey with diverse streams of oceanography from January 2018.

BORI conducted its first ever oceanographic research around Saint Martin's island sea area in respect to its all divisional ideas focusing on Chlorophyll-a and Nutrient concentration, Impact of ocean acidification on corals, Sedimentological & Mineralogical Composition of bottom sediments, Taxonomic classification of Seaweed, and Coastal pollution mapping. These researches in our virgin sea area opened up new window of knowledge and information sharing for all sorts of oceanic knowledge hunters. This Annual Report-2019 not only showcases oceanographic research activities but also institutional chronicles in a nut shell.

In this journey or onward, despite different limitations, BORI scientists are confident enough to explore and exploit ocean resources within Bangladesh maritime area. BORI formulated its short-term, mid-term and long-term research targets complying with government strategy on Blue Economy.

I am very glad to work on this Annual Report-2019. I personally thank to all the divisions of BORI for their continuous informative support. This Annual Report-2019 became more enriched for worthful messages from Honorable Minister of Ministry of Science and Technology, Honorable Senior Secretary of Ministry of Science and Technology and Honorable Director General of BORI. My especial gratitude to 'Board of Editors' for their valuable inputs to develop this Annual Report-2019.

Abu Sharif Md. Mahbub-E-Kibria
Executive Editor
Senior Scientific Officer
Environmental Oceanography and Climate
Bangladesh Oceanographic Research Institute
Cox's Bazar-4730

Preface

Bangladesh Oceanographic Research Institute (BORI) is the first and only ocean research organization of Bangladesh under the Ministry of Science and Technology. This newly established institute is on the lookout of modern ocean based economy for Bangladesh through implementing its vision and mission. Besides fundamental and applied oceanographic research BORI also aims to develop expert workforce in this research arena.

The Annual Report-2019 of BORI provides basic and primary information of inception research activity conducted by energetic young scientists on different streams of oceanography such as Physical and space oceanography, Chemical oceanography, Geological oceanography, Biological oceanography, Environmental oceanography and Oceanographic data center. It also showcases activities of different administrative parts including Engineering division, ICT cell, Library cell, and Medical center.

Oceanographic research will play an ever-increasing role in providing scientific information that is useful in almost every aspect of human life and beyond. Oceanographic data is a major concern not only for Bangladesh but also for the world as a valuable assistance for formulation of appropriate policy and strategic plan in boosting up economic development. It is praiseworthy to mention here that Bangladesh has won a huge ocean area to explore and exploit resources for future development.

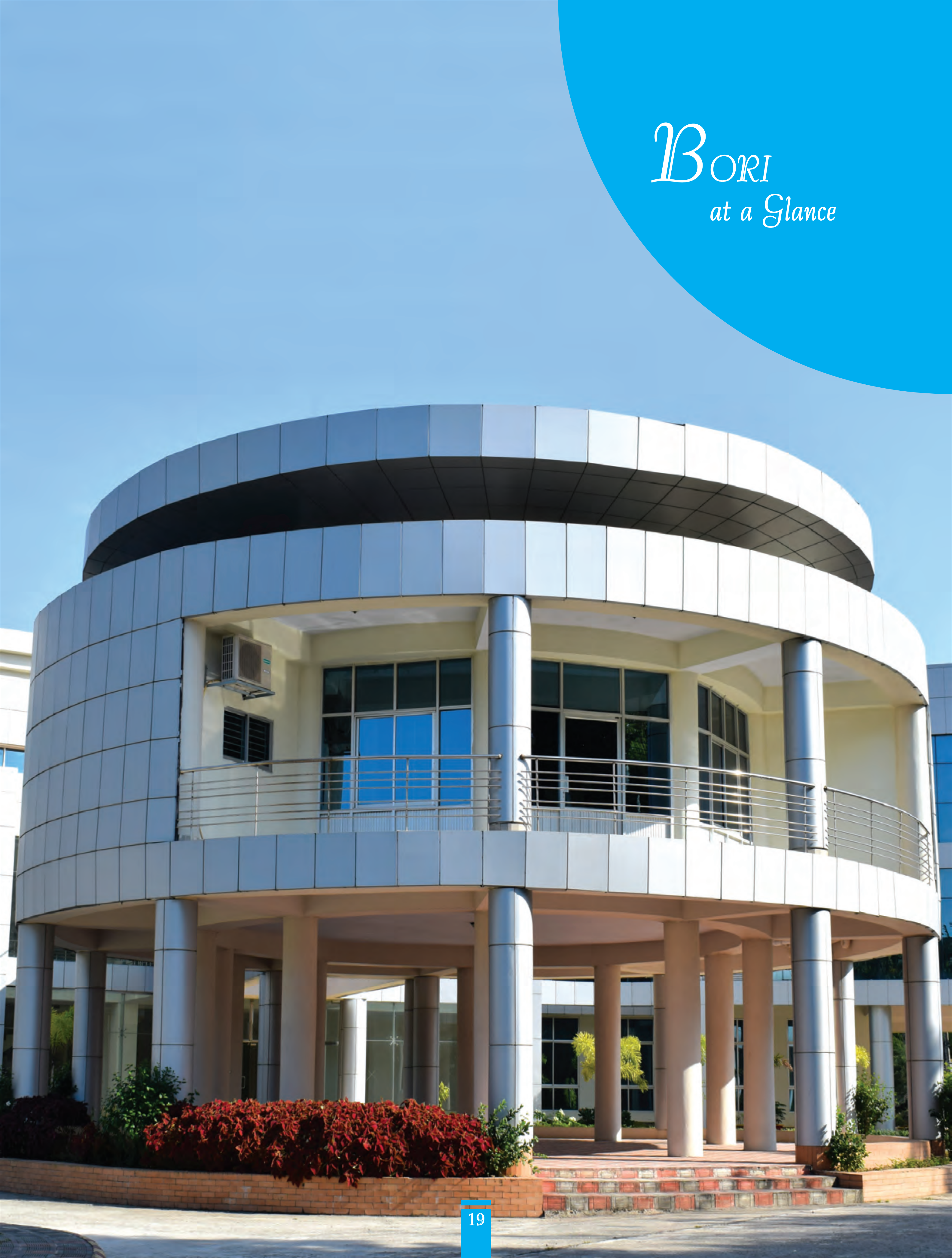
Scientists of BORI have completed 11 research activities led by 06 divisions in the last two financial years 2017-2018 and 2018-2019 respectively funded from the budget of this Institute. Output from these research activities will open up new domain of knowledge and will help scientists, academicians, and other researchers to think about the opportunities lied in our vast ocean area.

Honorable Prime Minister Sheikh Hasina has special interest on ocean and its resources. She is taking various measures to encourage research activities including oceanographic research. BORI has taken short-term, mid-term and long-term plan for the development of Blue Economy through the use of ocean resources.

We are very much grateful to Architect Yeafesh Osman, Honorable Minister, Ministry of Science and Technology for his continuous support. We are also thankful to Mr. Md. Anwar Hossain, Honorable Senior Secretary, Ministry of Science and Technology for looking after us in every situation. We express our appreciation to every officer and personnel who directly or indirectly helped us to develop this Annual Report-2019 successfully.

Content

Bori at a Glance



Chapter 1

Bangladesh Oceanographic Research Institute (BORI)

Background of BORI

Bangladesh Oceanographic Research Institute (BORI) is the first and only national research institution on marine science in Bangladesh, which will be able to play an important role in ensuring the development of Blue Economy. After winning the maritime boundary settlement case with Myanmar on March 14, 2012 andIndia on July 7, 2014, Bangladesh achieved sovereign rights to a total of 1,81,813 square kilometers of sea area, 200 nautical miles of exclusive economic zone, and all types of living and non-living ocean resources. If Bangladesh can ensure the sustainable use of the ocean resources, then the economy of Bangladesh will progress faster. The potential for setting up an international level ocean research institution, development of integrated coastal zone management, mining of mineral resources, and proper utilization of ocean resources including development of tourism and mariculture have increased the interest of the international community towards the Blue Economy in Bangladesh. The prospect of this newly developed sector is unlimited. For this reason, BORI will be able to play an important role in oceanographic research and create skilled manpower. The organization will work to conduct all the activities as a focal point of Bangladesh at national and international levels in the field of oceanography. Besides conducting its own research, BORI will assist in the research work of other local or foreign organizations, colleges and universities as well.

The Father of the Nation Bangabandhu Sheikh Mujibur Rahman initiated the establishment of ocean research institute in 1973 with the aim to enrich the country's economy and reducing poverty through exploring, exploiting and conserving valuable resources of the Bay of Bengal. But after the brutal and tragic killing of Bangabandhu in 1975, that initiative totally stops. In 1996, Honorable Prime Minister Sheikh Hasina constituted a Review Committee for the establishment of National Institute of Ocean Science. After receiving the recommendation of the review committee, the decision of establishing the National Oceanographic Research Institute was acceptedin 2000. In order to ensure proper utilization of marine resources, a project under the Ministry of Science and Technology was adopted in the period from June 2000 to July 2005 for the establishment of National Oceanographic Research Institute (1st Phase). After a long time in 2009, the visible progress of the establishment of National Oceanographic Research Institute (NORI) was achieved through the intensive initiative of Honorable Prime Minister Sheikh Hasina. When presenting the proposal for establishing the institute on 4 acres of land in the ECNEC meeting on 02/07/2009, Honorable Prime Minister extended the amount of land to 40 acres instead of 4 acres. She also ordered to redesign and represent the project including laboratory, residential building, club building, playground, school buildingand marine aquarium with international quality. Acquisition of 40 acresof land in Jungle Goalia Palang Mouza of Khunia Palang Union of Ramu Upazila of Cox's Bazar district was completed in 2010. The establishment project was implemented at a cost of Taka 102.80 crore. Under the heading of "National Oceanographic Research Institute Establishment Project (NORIP) (1st phase) (2nd Revised)" has been constructedwith 13 buildings including 3-storey Institute building with laboratory, 5-storey 3 officer quarters & 2 staff quarters, 1 Director General's Bungalow, 2-storey 1 OfficerDormitory & 1 staff Dormitory, 3-storey 1 Club Building & 1 Rest House, 5-storey 1 security personnel building, and 2-storey 1 school-cum-Medical Centre.Initially BORI has been purchased about 1096 nos. of scientific instruments for oceanographic research. For the implementation of the overall function of the project, 14 officials were working including 1 senior scientific officer, 3 scientific officers, 1 administrative officer and other employees. In addition, under the project, there was 1 platoon Ansar & VDP members for the safety of the Institute and 8 daily-basis manpower to keep the Institute premises neat and clean.

On 5 March 2015, "Bangladesh Oceanographic Research Institute Act, 2015" was passed in the national parliament for the keen endeavor of the present Honorable Minister Architect Yeafesh Osman of the Ministry of Science and Technology. It was a great achievement for oceanographic research. The institute has been established on 08/09/2015 with the powers given in sub-section (1) of 3 of "Bangladesh Oceanographic Research Institute Act, 2015" (Act 07 of 2015). On 19/05/2017, for the appointment of officer and staff the 'employment regulatory of Bangladesh Oceanographic Research Institute, 2017' was issued. A total of 223 posts have been created for the institute. The first meeting of the Board of Governors of BORI was held on 25/05/2017. The organogram of BORI comprises 2 wings. Among them one is research wing (6 research divisions) and the other is administrative wing including engineering sector, medical centre, ICT and library cell. Considering the seer thoughts of Honorable Prime Minister Sheikh Hasina, initiatives have already been taken to establish a Marine Aquarium of international quality in the institute premises for ocean research & tourism.

BORI at a Glance

The Bangladesh Oceanographic Research Institute (BORI) has emerged as an independent organization. It is the first and only national institution in the field of marine science. This institution will be able to play an important role in the exploration and development of country's marine resources and play a leading role in revenue earnings. Multiple research and development programs will be conducted in each of the research departments. Successful implementation of the current action plan will be possible through the development of sustainable technology in the country, achieving poverty alleviation programs and various development targets of the United Nations. Future research activities will be expanded more widely. If this institute effectively handles the management of the sea related research activities, application of research results and management of all the related activities, Bangladesh will emerge as a prosperous and developed country by using marine resources. We have won the sea under the dynamic and visionary leadership of the daughter of Bangabandhu, Prime Minister Sheikh Hasina, and there is no doubt that we will soon emerge as a developed nation using the sea resources. There are two wings of BORI. One is Research wing and another is Admin, Planning & Finance wing.

<table>
<tr><th>Research Wing</th><th>Admin, Planning & Finance Wing</th></tr>
<tr><td>1. Physical and Space Oceanography</td><td>1. Administrative Division</td></tr>
<tr><td>2. Geological Oceanography</td><td>2. Accounts & Finance Division</td></tr>
<tr><td>3. Chemical Oceanography</td><td>3. Engineering Division</td></tr>
<tr><td>4. Biological Oceanography</td><td rowspan="2">4. Information Management Division
• ICT Cell
• Library Cell</td></tr>
<tr><td>5. Environmental Oceanography and Climate</td></tr>
<tr><td>6. Oceanographic Data Center</td><td>5. Medical Center</td></tr>
</table>

Vision of BORI

"To contribute in the economic development of the country by adopting maritime research activities, applying research results, operating, managing and controlling all related activities"

Mission of BORI

- Development of mineral, agriculture, fisheries, environment and industrial sectors through utilization of sea resources and the development of environmentally friendly and sustainable technology and research activities to increase productivity for the benefits of mankind.
- To improve knowledge related to maritime education, research, training and development of knowledge related to the research and use of sea resources and to take action to protect the environment.

- To search all living creatures of the sea and to expedite sustainable production of those resources for economic welfare.
- Identity and research the presence of offshore island, coastal areas and ocean bottom minerals, placer deposits, coal, oil and other minerals including gas.
- Study of hydrography, sedimentation, astrology, meteorology, navigation & communication system and the development of commercial communications.
- Encourage public and private organizations to invest in the trade and trade related to the marine and marine environment and to serve as consulting organizations.
- Providing assistance in respect of the country's maritime strategies and policies and proposals for planning including maritime law.
- Identify various environmental issues (coastal, deep sea circulation, delta formation, water flow, etc.) and environmental natural disaster and climate issues.
- Undertake coordinated approach to improve international relations and linking the oceanography with the local and international organizations.

Potential areas of Marine resources in Bangladesh

According to different research and Ministry of Foreign Affairs-

- Experts are speculating that there is one of the world's largest fuel (oil or gas) reserves in the Bay of Bengal which can control the energy-politics and economy of the day.
- In the Bay of Bengal, Heavy Mineral, such as Ilmenite, Titanium oxide, Rootail, Zircon, Garnet, Magnetite, Monazite, cobalt etc. have been found, which can be a huge source of foreign currency.
- There are about 475 species of fishes in the Exclusive Economic Zone (EEZ) of the Bay of Bengal. Fishing capacity can be increased to the desired level by reviving modem fishing trawlers and training.
- Salt can be exported abroad by using advanced technology in salt cultivation.
- Construction of deep sea ports with modern facilities will increase the activities of feeders of international commercial vessels.
- Marine shellfish and finfish farming can bring foreign currencies. There are already many opportunities of commercially produced PUFA's (Poly Unsaturated Fatty Acids) such as omega-3 and omega-6 antioxidants from different seaweed species.
- Development of existing fish resources can be done through the use of marine biotechnology. Organic technology also can play a role in preventing oil spillage.
- Use of adequate research and advanced technology is necessary to prevent marine and coastal environmental pollution in ship breaking industry.
- Because of the high wind speed in the offshore areas of the sea, renewable energy can be generated by establishing windmills. Electricity can be produced using the wave and tide as well as by applying the Ocean Thermal Energy Conversion (OTEC) technology.
- According to various sources, by the year 2030, 10% of the output the world's cobalt, copper, zinc and Rare Earth Element (REE) will be produced from the sea.
- Construction of marine aquarium, travelling system by cruise ship & by ensuring adequate safety in the coastal area can become one of the main sources of national revenue.

Major achievements of BORI

- The research rules of the Institute were formulated in the "Bangladesh Oceanographic Research Institute Act-2015".
- Total eight different oceanographic laboratories equipped with latest sampler and analytical instruments have been set up.
- Already 103 manpower against 223 post have been recruited including 18 officers and scientists.

- The organization has already started research activities. Researchers conducted sampling and data collection activities in the eastern coastal and nearshore area (from Saint Martin's island to Maheshkhali) of Bangladesh.
- Delegation of China's Third Institute of Oceanography (TIO) recently visited the Institute and discussed about research collaboration and cooperation.
- Possibility of mutual co-operation was discussed in the joint Bangladesh-India science and technology meeting. All the scientists have already taken 15 days training from National Institute of Oceanography (NIO), Goa, India as per cooperation program.
- As a part of manpower development, office management training given to officers and staffs for 67 person-day, technical oceanography and related training given to scientist for 52 person-day.
- A Development Project Proposal (DPP) of "Bangladesh Oceanographic Research Institute 2nd phase" is initiated for development of oceanographic data center, collection of small research vessel and modern oceanography laboratory set up in BORI.
- A Development Project Proposal (DPP) to set up Marine Aquarium of international standard is commenced to develop marine practical experiment of BORI and tourism in Cox's Bazar.
- BORI started to given analytical service in the field of oceanography using the laboratory capacity.
- BORI also arranged internship facilities to different B.Sc level university students and starting supervise and co-supervise the thesis student also.
- BORI has been arranging stall in different science and development fair, short visiting program and study program of different university students.

Institutional Structure

Board of Governors

Director General
Total Personnel: 223

1 X PA/Satlipikar
1 X Driver
1 X Office Sohayak

Director (Admin, Planning & Finance)
Total Personnel: 93

1 X PA/ Satlipikar
1 X Driver
1 X Office Sohayak

Physical & Space Oceanography
(Total Personnel-24)
1 X Chief Scientific Officer
2 X Principal Scientific Officer
4 X Senior Scientific Officer
8 X Scientific Officer
1 X Senior Research Assistant
2 X Research Assistant
1 X Computer Operator
3 X Laboratory Attendant
2 X Office Sohayak

Chemical Oceanography
(Total Personnel-23)
1 X Chief Scientific Officer
2 X Principal Scientific Officer
4 X Senior Scientific Officer
8 X Scientific Officer
1 X Senior Research Assistant
2 X Research Assistant
1 X Computer Operator
2 X Laboratory Attendant
2 X Office Sohayak

Geological Oceanography
(Total Personnel-23)
1 X Chief Scientific Officer
2 X Principal Scientific Officer
4 X Senior Scientific Officer
8 X Scientific Officer
1 X Senior Research Assistant
2 X Research Assistant
1 X Computer Operator
2 X Laboratory Attendant
2 X Office Sohayak

Biological Oceanography
(Total Personnel-27)
1 X Chief Scientific Officer
2 X Principal Scientific Officer
5 X Senior Scientific Officer
10 X Scientific Officer
1 X Senior Research Assistant
2 X Research Assistant
1 X Computer Operator
3 X Laboratory Attendant
2 X Office Sohayak

Environmental Oceanography & Climate
(Total Personnel-18)
1 X Chief Scientific Officer
2 X Principal Scientific Officer
3 X Senior Scientific Officer
6 X Scientific Officer
1 X Senior Research Assistant
2 X Research Assistant
1 X Computer Operator
2 X Office Sohayak

Oceanographic Data Center
(Total Personnel-13)
1 X Senior Scientific Officer
3 X Scientific Officer
1 X GIS Analyst
2 X Data Analyst
1 X Computer Operator
3 X Date Entry/Control Operator
2 X Office Sohayak

Administrative Division
(Total Personnel-49)
1 X Deputy Director (Admin)
1 X Assistant Director (Admin)
1 X Administrative Officer
1 X Store Officer
2 X Computer Operator
1 X Store keeper
1 X Office Assistant cum Computer Typist
3 X Office Sohayak
6 X Cleaner
2 X Mali

a) Security
1 X Security Supervisor
9 X Security Guard

b) Transport
1 X Transport Supervisor
7 X Driver
5 X Boat Man/Diver/Speed Boat Driver
2 X Office Sohayak

c) Dormitory & Rest House
1 X Care Taker
2 X Cook
2 X Assistant Cook

Accounts & Finance Division
(Total Personnel-08)
1 X Accounts Officer
1 X Assistant Accounts Officer
1 X Accountant
1 X Auditor
1 X Computer Operator
1 X Office Assistant cum Computer Typist
2 X Office Sohayak

Medical Center
(Total Personnel-07)
1 X Medical Officer
1 X Nurse
1 X Medical Technician
1 X Office Assistant cum Computer Typist
1 X Medical Attendant
2 X Office Sohayak

Engineering Division
(Total Personnel-15)
3 X Assistant Engineer (Civil, Electrical, Marine)
3 X Sub-assistant Engineer
2 X Work Assistant
3 X Machine Operator
2 X Office Assistant cum Computer Typist
2 X Office Sohayak

Information Management Division
(Total Personnel-10)

ICT Cell
1 X Programmer
1 X Assistant Programmer
2 X Data Analyst
1 X Computer Operator
2 X Office Sohayak

Library Cell
1 X Librarian
1 X Library Attendant
1 X Office Sohayak

Summary of Manpower

SL No	Name of Post	Number
1.	Director General (DG)	1
2.	Director	1
3.	Chief Scientific Officer (CSO)	5
4.	Principal Scientific Officer (PSO)	10
5.	Deputy Director	1
6.	Senior Scientific Officer (SSO)	20
7.	Programmer	1
8.	Scientific Officer (SO)	42
9.	Other Officers Equivalent to Scientific Officer	09
10.	GRADE: 1 to 9	90
11.	GRADE: 10	10
12.	GRADE: 11	10
13.	GRADE: 13	25
14.	GRADE: 14	18
15.	GRADE: 16	5
16.	GRADE: 19	19
17.	GRADE: 20	45
	TOTAL	**223**

Transport and Major office equipments

	Number
1. Transport	
a) Jeep	2
b) Pick up	2
c) Microbus	2
d) Minibus	1
c) Truck	1
f) Motorcycle	5
g) Speed Boat	3
h) Fishing Boat	2
2. Office Equipment	
a) Generator	03
b) Computer & Accessories (with UPS)	115
c) Printer	15
d) Multimedia Projector	5
e) Photocopy Machine	5
f) Scanner	5
g) Fax	3

Physical and Space Oceanography Division

Chapter 2

Physical and Space Oceanography Division

PSOD at a Glance

Physical oceanography focuses on describing and understanding the evolving patterns of ocean circulation and fluid motion, along with the distribution of its properties such as temperature, salinity and the concentration of dissolved chemical elements and gases. Approaches include theory, direct observation, and computer simulation. Research frequently takes place in the context of important multidisciplinary issues including the dynamics and predictability of global climate and the sustainability of human use in coastal and estuarine regions.

Space oceanography deals with the research and development of remote sensing data on the world's oceans, and calibrates instruments, verifies the data, and creates products to meet the needs of users for satellite data and other information on the oceans.

The activity of Physical and Space Oceanography Division (PSOD) started by the mandate of BORI Act, 2015 (article 8) with the starting of BORI. Research activity has been started on 2017-2018 FY with taken a R&D project in the marine area of Saint Martin's Island. The R&D project topic was the spatial and temporal variation of chlorophyll-a and nutrients of the Saint Martin's island near shore area.

In the next FY 201 8-2019, another R&D project has been taken on the nearshore area of Maheshkhali Island. The R&D project deals with the coastal stratification study with physico-chemical parameters. During the field activity of 2018-2019 FY research, a cruise has been operated with the help of Bangladesh Navy R/V Saibal and covered about 900 sq. km.

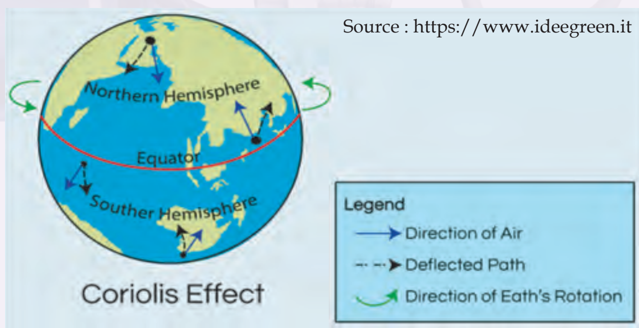
Besides research activity, PSOD is giving oceanography based analytical service and technical support to different government and non-government institutions.

General Features

Physical oceanography is the study of physical conditions and physical processes within the ocean, especially the motions and physical properties of ocean waters. Physical oceanography is one of several sub-domains into which oceanography is divided. Physical oceanography may be subdivided into descriptive and dynamical physical oceanography. Descriptive physical oceanography seeks to research the ocean through observations and complex numerical models, which describe the fluid motions as precisely as possible. (Source-Wikipedia)

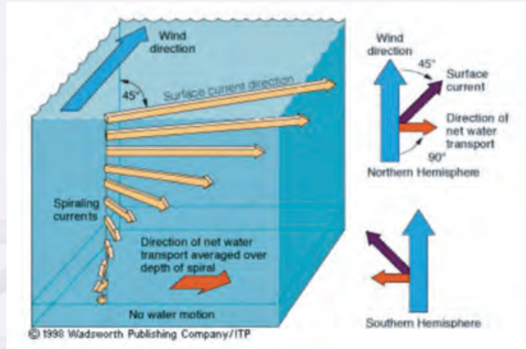
The Coriolis Effect

Because the Earth rotates on its axis, circulating air/water is deflected toward the right in the Northern Hemisphere and toward the left in the Southern Hemisphere. This deflection is called the Coriolis Effect. It is named after the French mathematician Gaspard Gustave de Coriolis (1792-1843) (Ross, 1995).



The Ekman Spiral

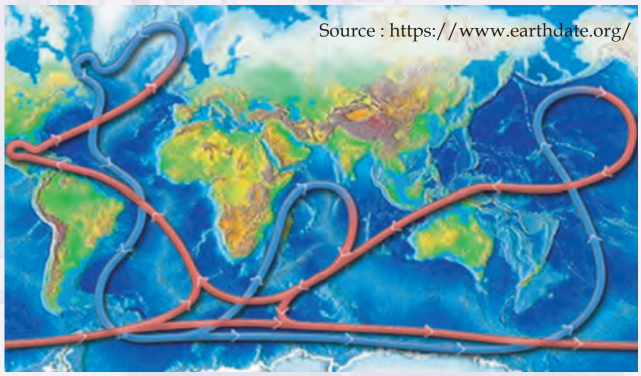
The Ekman spiral, named after Swedish scientist Vagn Walfrid Ekman (1874-1954) who first theorized it in 1902, is a consequence of the Coriolis Effect. When surface water molecules move by the force of the wind, they, in turn, drag deeper layers of water molecules below them. Each layer of water molecules is moved by friction from the shallower layer, and each deeper layer moves more slowly than the layer above it, until the movement ceases at a depth of about 100 meters (330 feet). Like the surface water, however, the deeper water is deflected by the Coriolis Effectto the right in the Northern Hemisphere and to the left in the Southern Hemisphere. As a result, each successively deeper layer of water moves more slowly to the right or left, creating a spiral effect. Because the deeper layers of water move more slowly than the shallower layers, they tend to "twist around" and flow opposite to the surface current.



Thermohaline Circulation /Global Conveyor Belt

Winds drive ocean currents in the upper 100 meters of the ocean's surface. However, ocean currents also flow thousands of meters below the surface. These deep-ocean currents are driven by differences in the water's density, which is controlled by temperature (thermo) and salinity (haline). This process is known as thermohaline circulation.

This figure shows the path of the global conveyer belt. The blue arrows indicate the path of deep, cold, dense water currents. The red arrowsindicate the path of warmer, less dense surface waters. It is estimated that it can take 1,000 years for a "parcel" of water to complete the journey along the global conveyor belt.


Source : https://www.earthdate.org/

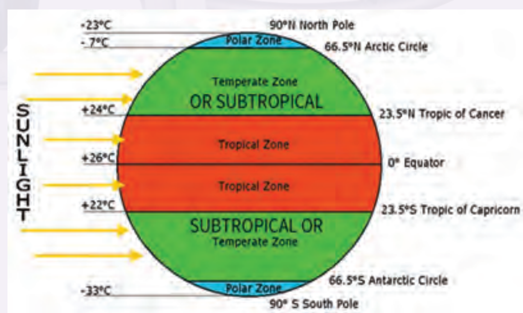
- Cold, salty, dense water sinks at the Earth's northern polar region and heads south along the western Atlantic basin.
- The current is "recharged" as it travels along the coast of Antarctica and picks up more cold, salty, dense water.
- The main current splits into two sections, one traveling northward into the Indian Ocean, while the other heads up into the western Pacific.
- The two branches of the current warm and rise as they travel northward then loop back around southward and westward.
- The now-warmed surface waters continue circulating around the globe. They eventually return to the North Atlantic where the cycle begins again.

Sea water temperature

The temperature of the ocean determines what form the water takes. Most of the ocean is liquid water, but if it gets cold enough, it turns to solid ice, or if it gets hot enough, it can pass into the atmosphere as water vapor.

Water warms up more slowly than air but can hold more heat - water needs 4 times as much energy to raise its temperature by 1ºC as the same mass of air does - so the ocean plays an important part in taking up energy from the Sun and stopping the Earth getting too hot.

The temperature of the ocean, especially the surface, varies from place to place and from season to season. Ocean temperature depends on the amount of solar energy absorbed.



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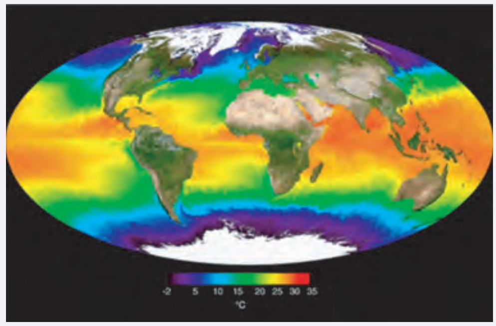
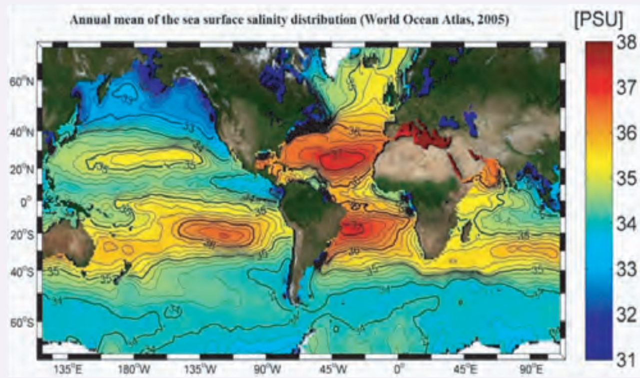
Tropical oceans receive a lot of direct overhead sunlight for much of the year, so the water is warm. Summer is the only time Polar Regions receive sunlight, and even then, it is never directly overhead, so water in these places tends to be cold. The amount of sunlight that hits the temperate regions (between the tropics and the poles) varies between summer and winter. The variation in solar energy absorbed means that the ocean surface can vary in temperature from a warm 30°C in the tropics to a very cold -2°C near the poles.



Salinity Distribution at the Ocean Surface

Although these two key physico-chemical variables of the ocean states are intimately related, the spatial distribution of sea surface salinity in the ocean is significantly different from the sea surface temperature one. Global salinity patterns are linked to rainfall and evaporation. Salinity affects seawater density, which in turn governs ocean circulation and climate. The higher salinity of the Atlantic sustains the oceanic deep overturning circulation. Salinity variations are driven by precipitation, evaporation, runoff and ice freezing and melting.

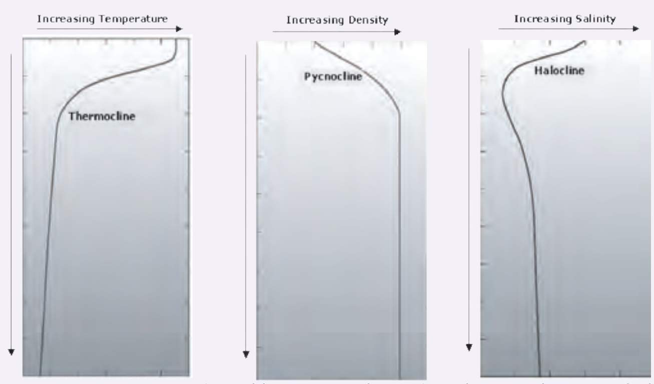


Source : https://www.earthdate.org/

The SSS spatial pattern reflects the climate belts associated with general atmospheric circulation. Comparison of SSS to net sea-air freshwater fluxes reveals remarkably similar patterns (Schmitt et al., 1989; Baumgartner and Reichel, 1975). The great subtropical deserts at the pole ward edges of the atmosphere's Hadley cells are apparent over the ocean as a SSS maximum in the 15° to 30° latitude band. Tropical rain lowers the SSS along the Inter-tropical Convergence Zone. From the mid-latitudes to the Polar Regions, excess precipitation lowers SSS. The marine hydrological cycle varies in longitude, too. Net evaporation leads to a relatively salty Atlantic; net input of freshwater generates low salinity, characteristic of the Pacific Ocean.

Vertical distribution of Temperature, Salinity, and Density

Thermocline is a layer within a body of water or air where the temperature changes rapidly with depth. Because water is not perfectly transparent, almost all sunlight is absorbed in the surface layer, which heats up. Wind and waves circulate the water in the surface layer, distributing heat within it somewhat, and the temperature may be quite uniform for the first few hundred feet. Below this mixed layer, the temperature drops very rapidly-



Source : https://www.meteo.fisica.edu.uy/Materias/oceanografia/

perhaps as much as 20 degrees Celsius with an additional 150 m (500 ft) of depth. This area of rapid transition is the thermocline. Below the thermocline, the temperature continues to drop with depth, but far more gradually. In the Earth's oceans, 90% of the water is below the thermocline. This deep ocean consists of layers of equal density, being poorly mixed.

Pycnocline is a layer where there is a rapid change in water density with depth. In freshwater environments such as lakes this density change is primarily caused by water temperature, while in seawater environments such as oceans the density change may be caused by changes in water temperature and/or salinity.

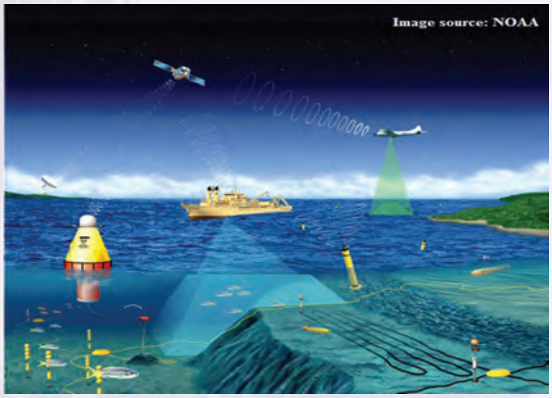
Halocline is a vertical salinity gradient. Because salinity (in concert with temperature) affects the density of seawater, it can play a role in its vertical stratification. Essentially, lower salinity water (= lower density) "floats" on top of higher salinity water (= higher density). The magnitude of the resulting density gradient plays an important role in determining the impact of vertical mixing. A strong salinity gradient will resist mixing, while a weak gradient can be mixed more easily. Typically, ocean vertical structure is dictated by temperature effects on density, but salinity and haloclines play a dominant role in certain regions of the world ocean. The sub-Arctic North Pacific is one such region.

Integrated Ocean Observations

Integrated ocean observation refers to monitoring the ocean in the multidisciplinary systems like ship, satellites, autonomous robot, Argo profiler, and different sensors. Elements of the ocean monitoring system in place today include:

Physical Oceanography Perspectives

- Underwater cabled observatories: long lines of cable on the seabed dotted with nodes of instruments relaying insights into underwater volcanic eruptions and earthquakes that can cause tsunamis.



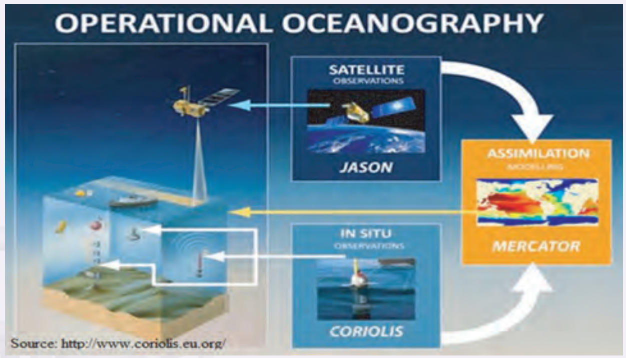
- The recently completed North-East Pacific Time-Series Underwater Networked Experiments cabled observatory system off Canada's west coast will take continuous measurements on the seafloor, equipped with such gadgets as a Doppler ocean current profiler, multi-beam SONAR to reveal masses of life in the water, microbial life samplers, sediment traps, plankton recorders, hydrophones and high resolution video and still cameras.
- A robotic navy of some 3,000 small, drifting "Argo" probes, deployed at a cost of $15 million per year to measure pressure, salinity and temperature at depths down to 2 km and return to the surface every 10 days to transmit readings via satellite. POGO officials say up to 10 times as many floats are needed to produce a high-resolution global picture of shifting marine conditions, incorporating biological and optical measurements;
- Three Equatorial moored buoys, each valued at $5 million, to measure temperature, currents, waves and winds, salinity and carbon dioxide.
- Some 60 globally-distributed reference stations, each valued at $1 million, measuring the oceans' physical, chemical and biogeochemical properties throughout the water column;

Deep Ocean Assessment and Reporting of Tsunamis: DART stations, consisting of a surface buoy and a seafloor bottom pressure recorder that both reports water temperature and detects tsunamis. When a potential tsunami is detected, the buoy reports measurements every 15 seconds for several minutes, followed by 1-minute averages for 4 hours. The US array, completed in 2008, totals 39 stations in the Pacific Ocean, Atlantic Ocean, and Caribbean Sea. Australia, Chile, Indonesia, India and Thailand have also deployed tsunami warning systems.

Satellite and Operational Oceanography

The ocean plays a major role in the earth's climate. It stores, transports and exchanges large amounts of heat, water and gases, and acts as a memory of the climate system. Global ocean observations are critical to understand and forecast the earth's climate and weather as well as for a wide range of ocean services. A system for operational oceanography has been developed in France. Three approaches exist from some years to monitor and forecast the ocean behavior:

· Sea-surface observation using satellite sensors,
· In situ measurements from ships, moored or drifting autonomous systems,
· Assimilation of in-situ and satellite data in an ocean circulation model.



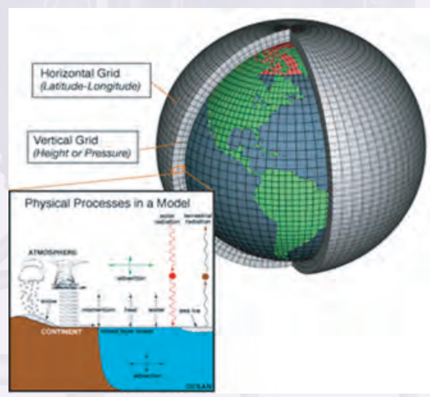
CORIOLIS contributes to the French operational oceanography program for the in-situ observations. The 7 institutes involved in operational oceanography in France (CNES, CNRS, Ifremer, IPEV, IRD, Météo-France, Shom) decided in 2001 to joint their efforts within Coriolis in order to:

· organize & maintain data acquisition in real-time & delayed mode of in-situ measurements necessary for operational oceanography
· set up an operational in-situ data center
· develop and improve the technology necessary for operational oceanography

Its objective is to develop continuous, automatic, and permanent observation networks. The data collected will enable water properties to be mapped, such as temperature, and ocean circulation.

Ocean Modelling and Forecasting

Nowadays, ocean modelling is a very important technique to study the Ocean. It could be also used in the forecasting system for the meteorologists and oceanographers. Satellites can observe some processes almost everywhere every few days, but they observe only some processes and only near or at the surface. Ships, floats and gliders can measure more variables, and deeper into the water, but the measurements are sparse. Hence, numerical models provide the only useful, global view of ocean dynamics and our ability to forecast these. The coherent view of the ocean and predictive capability ocean models are integral for marine environmental monitoring, safety and resources (including fisheries), extreme weather prediction, as well as climate and seasonal forecasting activities. Accurate forecasts of the marine environment are highly dependent on numerical ocean models, which need to incorporate ocean measurements.



General Circulation Model

A general circulation model (GCM) is a type of climate model. It employs a mathematical model of the general circulation of a planetary atmosphere or ocean. It uses the Navier-Stokes equations on a rotating sphere with thermodynamic terms for various energy sources (radiation, latent heat).

Inception Activity of PSOD

Sample Collection from the Study Area (Saint Martin's Island)

Data Processing in the Laboratory at BORI

Investigate the status of Chlorophyll and nutrients around Saint Martin Island

Muhammad Shahinur Rahman
Scientific Officer

Md. Masud-Ul-Alam
Scientific Officer

Rupak Loodh
Scientific Officer

Abstract

The relationship of nutrients and phytoplankton chlorophyll-a (Chl-a) is a basic for understanding eutrophication in a coastal marine ecosystem. This study was conducted to determine the concentration of Chl-a and nutrient distribution during the post monsoon in the coastal water of Saint Martin's Island, Cox's Bazar, Bangladesh. Distribution of Chl-a were described by the spatial map using collected samples of the water. While nutrient distribution was explained using kriging technique and mapped using ArcGIS. Due to the terrestrial influence especially from anthropogenic activities and Naf river discharge, higher Chl-a found in near coastal area and lower towards offshore area. High value of nitrate, ammonia and phosphate in near coastal area during the pre-monsoon indicates influence of terrestrial discharge especially from river outflow and human intervention. Distribution of Chl-a along the Saint Martin's coastal area was influenced by nutrient.

Keyword: Nutrients, Chl-a, St Martin.

Introduction

Life in the Earth is dependent upon the ocean, which is the source of wealth, opportunity and abundance. It is believed that global to regional monitoring of the surface ocean is a fundamental element for sustainable management of the ocean resources (Pitarch et al., 2016). Therefore, it is essential to achieve knowledge of the physical and biological processes of the oceans and their interaction with each other or with the land, ocean and atmosphere. Inaddition, the coupling between physical and biological processes is essential for providing operational ocean forecasts and marine ecosystem management. Moreover, the coupling of biological processes with physical processes improves our understandings of how for instance phytoplankton abundance varies on spatial scales, and how temporal variations are related to geographic location. It is not always possible to collect continuous time series data of Chl-a as well as oceanic parameters data from in-situ observation. The development of satellite remote sensing technology gives us solution which provides great opportunity to determine broadscale measurements of ocean geochemistry with high spatial and temporal resolution of coastal and offshore waters. The standard Chl-a estimation algorithm has developed for open ocean water (case 2) where color of ocean surface depends on chlorophyll concentration (O'Reilly et al., 2000). The standard Chl-a algorithm has overstates the Chl-a concentration. Theregional algorithm is more applicable for better quantification of Chl-a concentration based on in-situ data (Nezlin et al., 2007; Nagamani et al., 2013).

Our main focus on Chl-a and nutrients concentration around the St. Martin Island. The Island experiences normal semidiurnal tides, i.e. two high and two low tides during a period of 24 hours and 52 minutes (Banglapedia, 2008). The mean tidal range at Shahpuri Island (about 9 km north-east of St. Martin's Island) in the Naf estuary is 1.87 m. It is expected that somewhat similar, probably lower, tidal ranges occur at St. Martin's Island. The mean annual temperature of the surface water of the Bay of Bengal is about 28°C. The maximum temperature is observed in May (30°C) and the minimum (25°C) occurs in January-February (Banglapedia, 2008; Vinayachandran and Kurian, 2008).

The surface salinity in the coastal parts of the Bay of Bengal oscillates from 10 to 25 ppt (parts per thousand, ie grams per kilogram of seawater). Coastal seawater is significantly diluted with freshwater throughout the year, although the inflow of river water is greatly reduced during winter. The coastal water salinity of St. Martin's Island, as measured during the dry season (Tomasick, 1997), fluctuates between 26 and 35 ppt. It is expected that the salinity level drops below this level due to increased freshwater discharge from the Naf River during the rainy season (July-October). Water transparency measured in December fluctuated from 0.62 m near St. Martin's Bazar, where the water is heavily affected by human pressure, to 3.9 m at Galachipa (Hossainetal., 2006). This low light penetration is the consequence of many factors. In addition to silt discharged by the Naf, the combined action of wind generated waves, ocean swell and high velocity tidal currents cause re-suspension of bottom sediments (finesand; silts and mud). A Secchi depth 3 of over 7 m is required for optimal growth of reef building corals. Since corals are light sensitive organisms, the turbid coastal waters of St. Martin's Island are a key environmental factor limiting the development of coral reefs. Dissolved oxygen (DO) concentration in the surface waters around St. Martin's Island ranges from 4.56 to 6.24 mg/L in December. The highest value of 6.24 mg/L of DO was found at Badam Bunia, whereas the lowest value was recorded at St. Martin's Bazar (Hossain et al., 2006). These parameters are very important for Chl-a and Nutrients concentration around the St. Martin Island. This study has conducted on in-situ data. And the overall objectives of the studies are to observe the status of Chlorophyll-a and nutrients around the Saint Martin Island as well as the relationship between them. The ultimate aim of this baseline study is to store data for developing regional algorithm and ocean color data for monitoring the ecosystem status.

Study Area

St. Martin's Island locally called 'NarikelJinjira' is located on the southernmost tip of Bangladesh, and the northeast of the Bay of Bengal, about 9 km south of the Cox's Bazar-Teknaf peninsular tip and about 8 km west of the northwest coast of Myanmar at the mouth of the Naf River. There are five distinct physiographic areas within the Island:

The Island lies between latitude 20°34´ and 20°39´N, and longitude 92°18´ and 92°21´E. The area of the Island itself is about 5.9 km^2 and with the rocky platforms extending into the sea the total area of the island is about 12 sq. km. The island is located in the Northeastern part of Bay of Bengal and while being within the tropical belt; its weather is heavily influenced by the subtropical monsoon climate that prevails over Bangladesh.

Source: Saif, Samia. (2010). Environmental profile of St. Martin's Island.

Figure 1: Location map of study area

A recent Bangladesh-Dutch study under Nature Conservation Strategy-2 project has revealed that the island is not actually a coral island but it is the surface of a submarine hill, which is a part of the Teknaf range stretching from Cox's Bazar to Teknaf. St. Martin's Island is a dumbbell shaped sedimentary continental island located on the eastern flank of an anticline, which like Chittagong may be part of the Arakan Yoma Naga folded system (Warrick et. al., 1993). The surface area of the Island is about 8 km2 depending on the tidal level. The Island is almost flat with an average height of 2.5 m above mean sea level (MSL), rising to a maximum of 6.5 m high cliffs along the eastern coast of Dakhin Para (Kabir, 2006).

Methodology

For preparing this report, a review of relevant articles, reports, studies, documents etc. was made, many scientists, representatives from Government and Non-Government organizations and other interested parties provided material for writing this report. Polypropylene bottles pre-cleaned with 1:1 dilute hydrochloric acid and rinsed with Milli-Q water and dried were used for the collection of the samples.

Samples were preserved in ice during the collection till transportation to the laboratory. Samples were immediately filtered using 0.45 µm Millipore membrane filter paper and analyzed for various physicochemical and biological parameters, viz., nutrients such as inorganic phosphate (PO_4^{3-}), nitrite (NO_2-N), nitrate (NO_3- N), Ammonia (NH_3-N), silicate (Si) and Chlorophyll-a (Chla), following the standard methods (Grasshoff et al. 1983; APHA 1995).

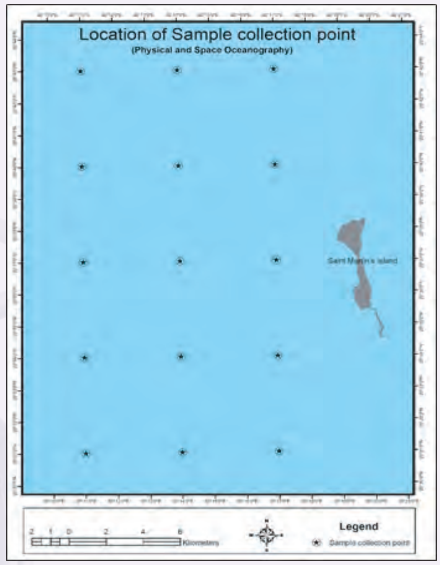


Figure 2: Sample collection sites of this study

Nutrients were measured by the photometric methods (UV- 1800, Shimadzu, Japan). Chlorophyll a was extracted in 90% acetone and measured spectrophotometrically (Spectronic 20 G E N E S Y S , Germany) following Parsons et al. (1984). Kriging technique was applied to estimate and predicts concentration of these parameters at unmeasured locations and mapped using ArcGIS [10]. Kriging is a geostatistical method that applies a semivariogram approach which is widely usedin spatially distributed data.

Results & Discussion

Nitrate and Nitrite

Not much variation was noticed in the nitrate values in the coastal water of Saint Martin's Island, which ranged from 0.17 to 12 µmol/L, whereas nitrite fluctuated between 0.02 and 11µmol/L.

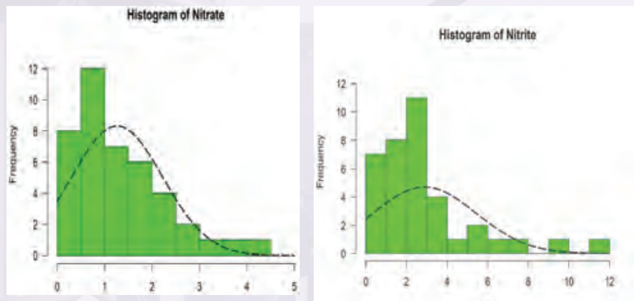


Figure 3: Nitrate (left) and Nitrite (right) concentration in mg/l

A strong positive correlation was observed between nitrite and nitrate ($p \geq 0.05$) during the pre- monsoon season. Strong negative correlation with nitrate and salinity ($p \geq 0.01$) was observed, which might be dueto the less saline condition existing during the pre-monsoon.

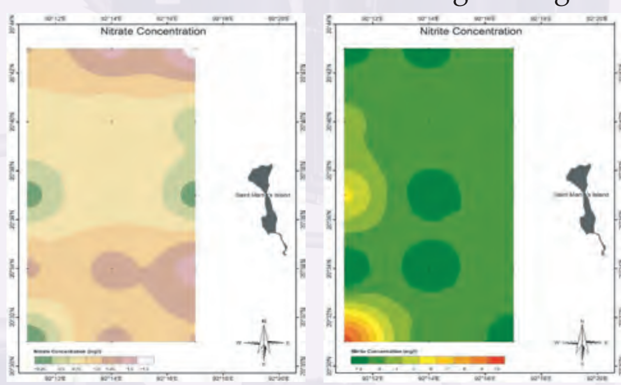


Figure 4: Spatial distribution of Nitrate (left) and Nitrite (right) concentration in mg/l

Nitrite, the intermediate oxidation state between ammonia and nitrate, can appear as a transient species by the oxidation of ammonia or by the reduction of nitrate (Sathpathy et al. 2010). Positive and negative correlation between nitrite and DO during the pre-monsoon ($p \geq 0.05$) was due to the increased runoff resulting in declining of salinity, which led to increase in the DO and nutrient levels.

Ammonia

The possible sources of ammonia input into the waters could be from land runoff, zooplankton excretion, or demineralization of organic matter (Ketchum 1962). Ammonia level was 0.09 to 10.2 µmol/L in all the seasons and did not show significant strong positive correlation ($p \geq 0.01$) with any parameter, except silicate during the pre-monsoon. A positive correlation between ammonia and nitrite ($p \geq 0.05$) observed during the pre-monsoon season might be due to the oxidation of ammonia to nitrite.

Inorganic phosphate

Near shore water generally have relatively low stocks of dissolved inorganic phosphorus and nitrogen (Alongi et al. 1992). Inorganic phosphate value ranged from 0.04 to 0.69 µmol/L. In monsoon season, the runoff transported lots of terrigenous deposits to the coastal waters, the suspended sediments adsorbed to each other and settled at the bottom (Pomeroy et al. 1965).

Phosphate showed negative correlation (p ≥ 0.05) with the DO and pH. Low phosphate levels during the northeast monsoon could be attributed to the wetlands, which trapped the land derived sediments brought in by the runoff in the monsoon season before they entered the ocean by upwelling due to the chemical and biological processes. High concentration of phosphate in the post-monsoon might be because of desorption of phosphate taking place from the sediments with increasing salinity during this period.

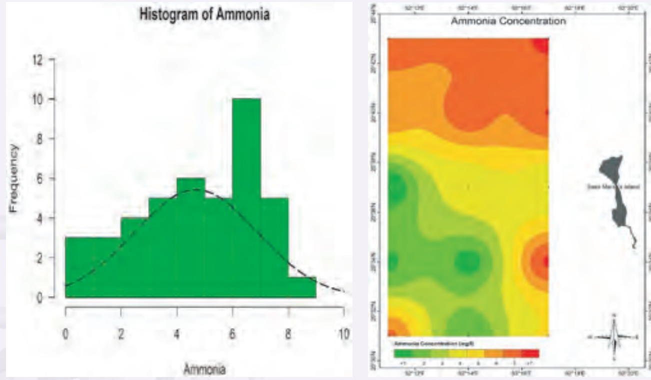


Figure 6: Histogram (left) and spatial distribution (right) of Phosphate concentration in mg/l

Silicate

Silicate concentration varied from 0.77 to 4.68 µmol/L. Higher concentration during the monsoon season could be ascribed to fresh water intrusion into the coastal waters and similar milieu had been reported in different coastal environments (Burton 1970). An abrupt decrease in silicate concentration observed during late post-monsoon season and summer could be due to the phytoplankton uptake, which was indicated by a strong negative correlation (p ≥ 0.01). Strong positive correlation (p ≥ 0.01) with pH noticed during the southwest monsoon could be due to increased pH leading to the reduction in silicate.

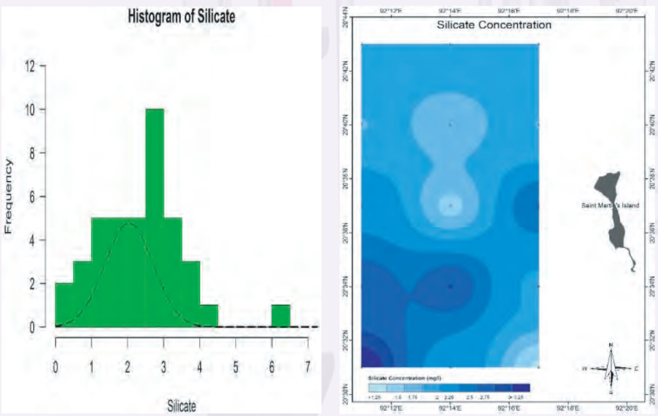


Figure 7: Histogram (left) and spatial distribution (right) of Silicate concentration in mg/l

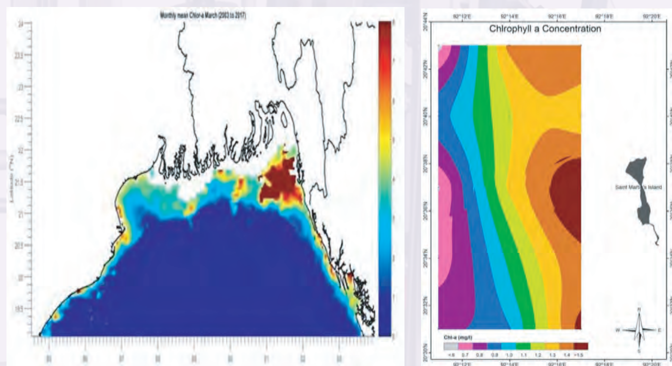


Figure 8: Monthly climatology of Chlorophyll-a concentration (mg/l) in the month of March Sampling period (top) and the Chlorophyll-a concentration (mg/l) of our sampling sites.

Chlorophyll-a

Chlorophyll a is considered as the most reliable in dexofphytoplankton biomass (Tripathyetal. 2005). Fresh water influx and land runoff resulted in low Chl-a concentration (1.54 mg/m^3) during the pre-monsoon with increasing salinity conditions.

Conclusion

The hydrological parameters exhibited distinct variations at the west coast of St. Martin Island. Low concentrations of nutrients during pre-monsoon observed at the stations dominated by the freshwater influx from the land, which trapped land derived sediments brought in by the runoff in the monsoon season before they entered the ocean by upwelling due to chemical and biological processes. Chl-a concentration have a positive relationship with nutrients concentration. Both have a positive value near the coast and concentration are little lower at offshore water from the Island. The results from this study could be used for a better water quality management of St. Martin Island and the coastal zone. The conservation, management and sustainable development of fishery sector at the St. Martin Island would depend on the maintenance of the hydrological characteristics without much alteration.

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Spatio-temporal variation of stratification and surface chlorophyll–a concentration in terms of physical parameters along the Cox's Bazar coast, Bangladesh

Muhammad Shahinur Rahman
Scientific Officer
Rupak Loodh
Scientific Officer

Abstract

This study focus on spatio-temporal variation of stratification and surface chlrophyll-a concentration along the cox's Bazar coast as well as Moheskhali-Sonadia Island adjacent area in winter and pre-monsoon season. In the study we also evaluate the physical parmeters like Sea surface temperature, Sea surface Salinity, Dissolved oxygen, pH, secchi disk depth and nutrients (nitraite, Nitrate, Ammonia, Phosphate and Silicate) in sea water. The area experienced with high chlorophyll a value (range 2.43-14.1 mgl^{-1}) with mean value of 5.78 mgl^{-1}. The highest mean chlorophyll a concentration is found in march (7.65 mgl^{-1}) and lowest mean chlorophyll a concentration is found in January (4.83 mgl^{-1}). This study indicated that this area's Chlrophyll-a controlled by primarily nutrient. This study reveals that there is no significant stratification has seen in the winter and pre-monsoon season in the study area. Partial correlation table indicate that chlorophyll a and Phosphate has positive correlation.

Introduction

Regular monitoring of near shore and open water parameters for marine management in Bay of Bengal waters, Bangladesh is still limited. It is believed that global to regional monitoring of the surface ocean is a fundamental element for sustainable management of the ocean resources (Pitarch et al., 2016). Therefore, it is essential to achieve knowledge of the physical and biological processes of the oceans and their interaction with each other or with the land, ocean and atmosphere. In addition, the coupling between physical and biological processes is essential for providing operational ocean forecasts and marine ecosystem management. Moreover, the coupling of biological processes with physical processes improves our understandings of how for instance phytoplankton abundance varies on spatial scales, and how temporal variations are related to geographic location.

Phytoplankton biomass is an important bio-physical characteristic that is commonly used to appraise the clarity and color of the sea water. The main reason Chl-a being used to indicate the availability of phytoplankton biomass is because it is the most common pigment in most of marine phytoplankton (Li et al., 2002). Very low and high concentrations of the Chl-a can be harmful to marine biota. Thus, measurement of chlorophyll concentration is one of the key indices in the study of the health status of any natural marine ecosystem. Variability of Chl-a concentrations determines the ecological conditions of marine systems such as the changes in the physical and chemical characteristics of the environment.

The Bay of Bengal is famous for its unique and uncommon characteristics in the tropical oceans. It experiences a dominant seasonal reversal in the surface wind field associated with summer (May–September) and winter (November–February) monsoons. BoB receives high precipitation (150 to 200 cm, with standard deviation of 1.5 mm/day) over a year (Fousiya et al., 2016). In short, BoB displays a strong near-surface halocline with very low salinity in the northeastern and higher salinity in the southwest part of the basin (Rao and Sivakumar, 2003). In summer, the freshwater and thermal buoyancy fluxes contribute to high stratification (Prakash et al. 2012; Agarwal et al. 2012).

The eastern coast of Bangladesh is unique for its longest sea beach and great touristic value in the Bay. However, there is very inadequate research on this area especially for the physical oceanographic perspectives. This study will focus on how the Chlorophyll-a concentration varies with the stratification which is mainly the influences of fresh water flux (salinity) and temperature. It also initiates to the first step to collect the high quality datasets for physical parameters like temperature, salinity etc.

Importance of the study

Ocean dynamics results from a complex combination of different processes acting in a wide range of scales. Non-uniform distribution of waters masses, vertical motions have been shown to be key for the modulation of biological activity in the ocean. The main objective of this work will be to identify and understand the key physical processes affecting the distribution of biological components.

The stratification is very important parameter to be estimated for the following reasons-

1. It controls the vertical mixing process
2. Stratified water limits the nutrients which controls the phytoplankton biomass
3. Fresh water causes the water stratification increasing the higher SST that initiates the low pressure system like cyclones

Aim & Objective

- To investigate the spatial & temporal variability of stratification condition along the Cox's Bazar near shore area
- To study the status of Chlorophyll-a along the Cox's Bazar near shore area. Study Area

Study Area

The study area is the extended from the south of Moheshkhali-Sonadia Island to near rejukhal area (figure 1 left). The Conductivity- Temperature- Depth (CTD) and water samples are collected from three tranject line. The 7 stations of Tranject A are located about 1 km away from coastline. Tranject B stations are located about 3 km away from coastlikne. Tranject C stations are located about 5 km away from the coastline which represented in figure 1 (right) with bathymetry contour.

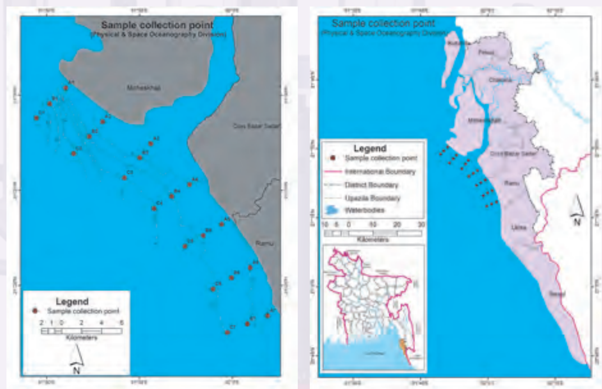


Figure 1: Study area with administrative boundary (left) and Sample collection point location with bathymetry contour (right)

Methodology

Calculation of Stratification

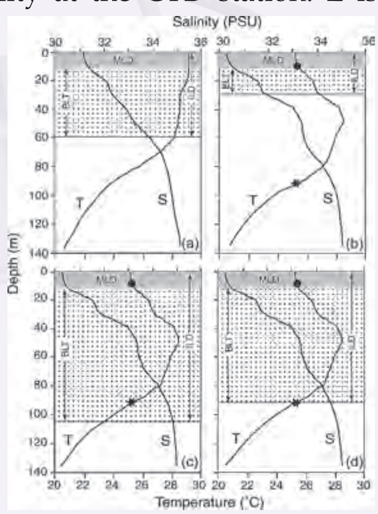
The water stability (E) in terms of the buoyancy frequency estimation is used to calculate the upper layer stratification, subsurface temperature and salinity gradients, and the stability at the CTD station. E is estimated using (Murty et al., 1996)-

$$E = g/p^* [dp/dz - gp^*/c^2]$$

Here, g is the acceleration due to gravity (9.8 ms^{-2}), p is the sea water density (kgm^{-3}), p^* is the mean density in the water column dz, z is the depth (m), and c is the sound velocity (ms^{-1}) in the sea water (Chen and Millero, 1977).

Calculation of Isothermal Layer Depth (ILD)

Different methodologies are exist for selecting ILD in the BOB. Schematics of Mixed Layer Depth (MLD) and Barrier Layer Thickness (BLT) in the BoB in the case of no thermal inversion (Figure 2 (a)) and ILD is calculated as the depth where temperature changes by 1^0 C from surface value, in figure 2 (b) surface lauer inversion layer respectively and ILD is calculated as the depth where the temperature increases by 1^o C from surface value, in



(Source: Thadathil et al., 2002)

Figure 2: Different methods for calculating ILD

figure 2 (c) ILD selected as the depth where temperature drops by 1° C from surface value, in figure 2 (d) ILD selected as the depth where temperature at the base of the inversion layer is equal to the temperature at the top of the inversion layer. BLT is estimated by subtracting MLD from ILD. This criterion has used for this study also.

Water Sample

Samples were preserved in ice during the collection till transportation to the laboratory. Samples were immediately filtered using 0.45 µm Millipore membrane filter paper and analysed for various physicochemical and biological parameters, viz., nutrients such as inorganic phosphate (PO_4^{3-}), nitrite (NO_2-N), nitrate (NO_3-N), Ammonia (NH_3-N), silicate (Si) and Chlorophyll a (CHL-a), following the standard methods (Grasshoff et al. 1983; APHA 1995). Nutrients were measured by the photometric methods (UV-1800, Shimadzu, Japan). Chlorophyll a was extracted in 90% acetone and measured spectrophotometrically following Strickland and Parsons (1984).

Result and Discussion

In order to find the spatial and temporal distribution of chl-a concentration in the study area are represented by monthly surface plot in figure 3(left). From the figure, highest chl-a are always associated with coastline. Highest mean chl-a concentration is found inmarch (7.65 mgl^{-1}) and lowest mean chl-a concentration is found in January (4.83 mgl^{-1}). Secchi disk depth indicate the water transparency. Figure 3 (right) represent the monthly secchi disk depth of the study area. From the figure, the highest mean secchi disk depth is found in January (1.59m) and the lowest is seen in May (0.59m).

Generally, the spatio-temporal variability chl-a, depends on the availability of light, nutrients and oxygen together with physical processes (Vinayachandran, 2010). In the tropics, shallow coastal water is usually well mixed and oxygen rich and phytoplankton growth is not light limited and in that case, phytoplankton growth and abundance are controlled by nutrients (Baliarsingh et al., 2015). However, in case of highly turbid coastal waters, where nutrients are present at moderate to high concentrations, light availability can be a limiting factor for primary production (Vinayachandran et al. 2005). The river discharge is the main source of nutrients in coastal waters (Sarma et al. 2009; Mishra et al. 2009).

In January, the fresh water flux as well as river input bring the terrestrial sediment very low which is the reason for better transparency. On the other hand, In May the riverine input is starting which bring sediment and lowering the transparency. Generally, better transparency is good for biological productivity. In the study area, chl-a concentration is less in January which has better transparency. Riverine input also brings the nutrient and less productivity indicate the nutrient deficiency.

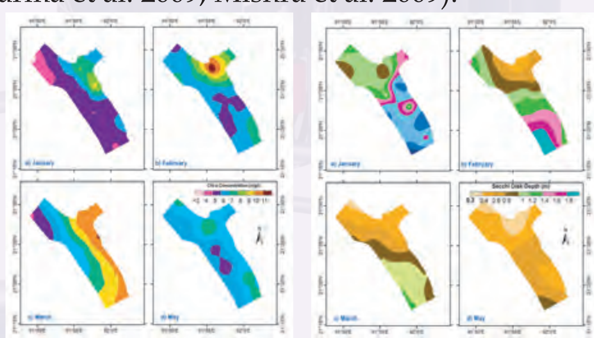


Figure 3: Monthly Chl-a concentration map for a) January, b) February, c) March and d) May (left) and monthly secchi disk depth map respectively (right)

Figure 4 (left) represent the monthly SST distribution for the study period. The highest mean SST value (31.28 ^{0} C) is found in May and lowest mean SST value (23.74 ^{0} C) is seen in January. Low SST is found near coastline as well as water derived from the Moheskhali Channel. SST was increasing with the distance from the channel. Figure 4 (right) represents the monthly SSS distribution of the study area. From the figure, the highest mean SSS value (33.13 psu) had found in February and the lowest mean SSS value (31.01 psu) had seen in May.

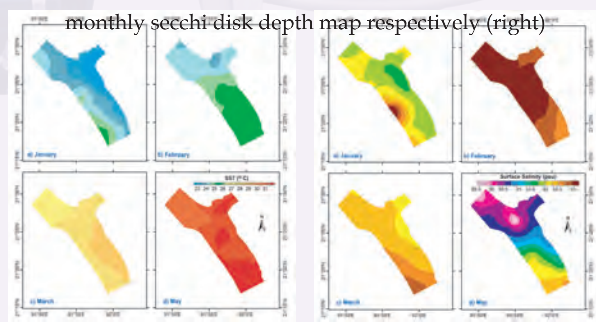


Figure 4: Monthly SST map for a) January, b) February, c) March and, d) May (left) and Monthly surface salinity distribution map respectively (right)

Monthly pH distribution map are shown in the figure 5 (left) and monthly Dissolved oxygen distribution map are seen in figure 5 (right). From the figure, pH value is more than 8 in full study period. The highest mean pH value is found in January (8.29) and the lowest value has found in May (8.13) and the possible reason for changing value is the riverine fresh water input in the study area. The highest DO value have seen in January (4.76mg/l) and the lowest value have seen in February (2.71mg/l).

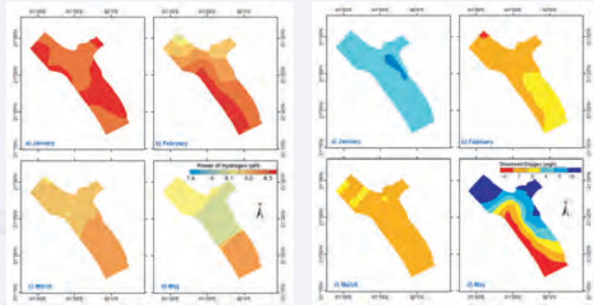


Figure 5: Monthly pH distribution map for a) January, b) February, c) March and d) May (left) and Monthly Dissolved Oxygen concentration distribution map respectively (right)

Figure 6 (left) represents the Phosphate (PO_4) concentration in the study area and the figure 6 (right) have shown the Silicate (SiO_2) concentration in the study area. From the figure, PO_4 value range is less than 0.25 mg/l to 2mg/l. The highest mean PO_4 concentration is seen in March which is the possible reason for highest chlrophyll-a concentration in the study region. On the other hand, figure 6 (left) shows the Silicate (SiO_2) concentration value range is less than 0.5mg/l to 5mg/l and changing value of SiO_2 is related with river input primarily.

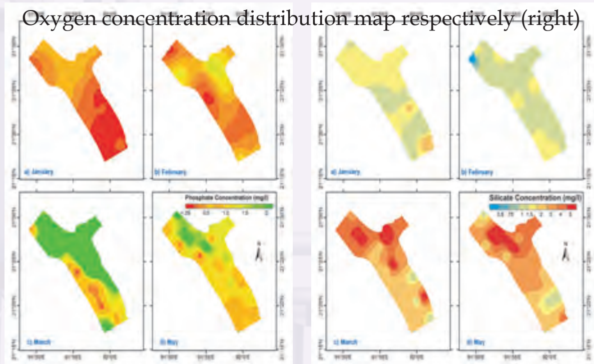


Figure 6: Monthly Phosphate (PO_4) distribution map for a) January, b) February, c) March and d) May (left), and Monthly Silicate (SiO_2) distribution map respectively (right)

Figure 7 have shown the monthly distribution map for nitraite (left), nitrate (middle) & ammonia (right). Frm the figure, the nitraite (NO_2) value range is less than 1 mg/l to 8mg/l, the nitrate (NO_3) value is less than 2 mg/l to 12mg/l & ammonia (NH_4) value range is 0.1 mg/l to higher than 5 mg/l.

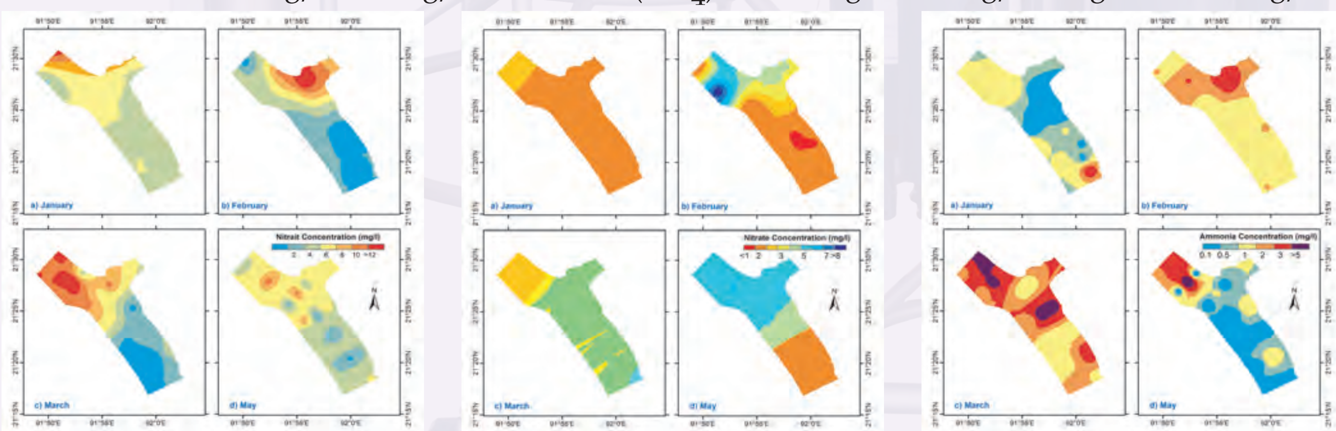


Figure 7: Monthly Nitraite (NO2) distribution map for a) January, b) February, c) March and d) May (left), Monthly Nitrate (NO3) distribution map (middle) and Monthly Ammonia (NH4) distribution map respectively (right)

Figure 8 represents the salinity, temperature and density data of the 2 different water columns. Figure 8 (Left) shows the station C1 which collected in winter season and right one represents the station c4 which has taken in May (after cyclone Fani). Full water column is well mixed if we consider all the criteria for MLD and ILD. So no BLT has developed here. The sample collection has taken in the last of winter season/ starting of pre monsoon when the fresh water influx is very low. So no haline stratification is developed here. From the figure 8 (right), there is no BLD has seen. This Data has collected after cyclone foni.

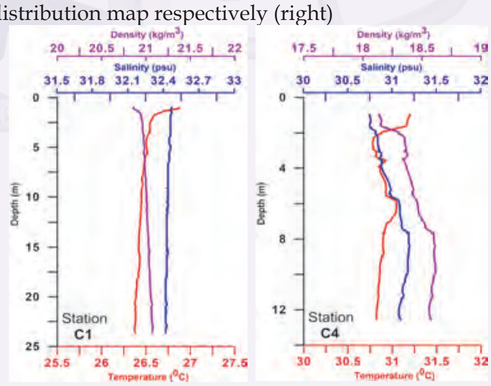


Figure 8: T-S diagram for Station C1 in March (left) and Station C4 in May (right)

Possible reason for no BLD due to Cyclone induced ocean mixing. Another important issue is the study area is shallow (highest depth ~30m). So Tidal effect also affect the vertical mixing.

Pearson partial correlations among the estimated parameters are shown in table 1. From the table, chl-a have positively correlated (0.53) with phosphate. SST and Secchi disk depth have inversely correlated (-0.58). SSS have inversely correlated with DO (-0.53) and SST (-0.57). Phosphate has positive correlation with Ammonia. Silicate has positive correlation with all nutrients.

Table 1: Pearson Correlation matrix among the variables

Variables	*Chl-a*	*Secchi*	*pH*	*DO*	*SST*	*SSS*	*NO_2*	*NO_3*	*NH_4*	*PO_4*	*SiO_2*
Chl-a	1.00										
Secchi	-0.18	1.00									
pH	-0.09	0.28	1.00								
DO	-0.24	0.12	0.39	1.00							
SST	0.07	**-0.58**	-0.24	-0.01	1.00						
SSS	0.10	0.32	0.26	**-0.53**	**-0.57**	1.00					
NO_2	-0.04	-0.27	-0.11	0.21	0.09	-0.28	1.00				
NO_3	0.15	-0.32	**-0.71**	-0.17	0.18	-0.26	0.34	1.00			
NH_4	0.25	-0.35	-0.03	0.00	0.05	0.00	0.45	0.27	1.00		
PO_4	**0.53**	-0.43	-0.22	-0.10	0.26	-0.14	0.31	0.42	**0.50**	1.00	
SiO_2	0.02	-0.43	-0.37	0.05	0.43	-0.36	**0.51**	**0.48**	0.40	**0.56**	1.00

Conclusion

Generally, literature indicates the Bay of Bengal is less productive due to stratification. But in the coastal region, there is no stratification is observed here. From this study, we have collected the physical baseline data. This study should be extended in summer monsoon also because high amount of fresh water are coming in that time in terms of river discharge and precipitation both are favorable for stratification.

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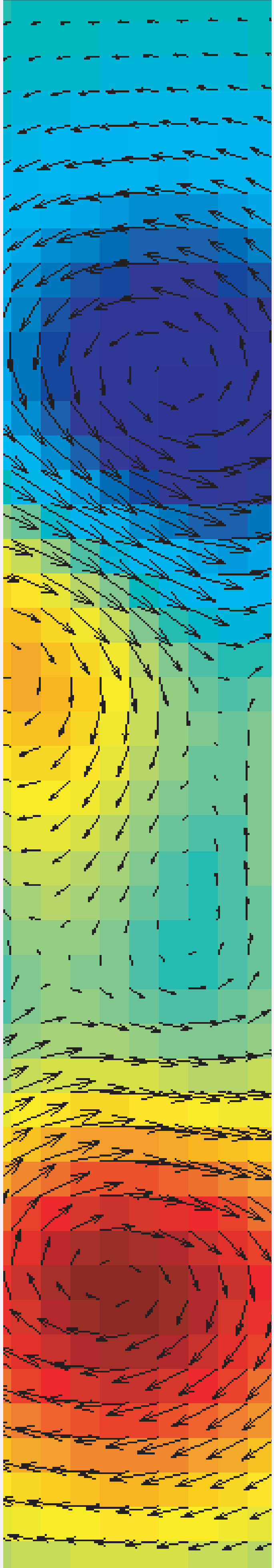
Mr. Muhammad Shahinur Rahman has been working as a scientific officer at Physical and Space Oceanography Division in Bangladesh Oceanographic Research Institute (BORI) since January 2018. He earned B.Sc& MSc degree in Geography and Environment from Jahangirnagar University. He obtained another masters from oceanography department in University of Dhaka. Shahin's main research focus on bio-physical coupling, coastal process studies, satellite oceanography and marine spatial planning. He published 5 (five) scientific articles. He attended several oceanography related training from national and international organization including NIO and INCOIS.



Jang geun Choi (2020)

Mr. Rupak Loodh is 4th child of Sailesh Chandra Loodh and Gita Rani Loodh, was born in Kishoregonj district. He completed his MS degree on Oceanography from University of Dhaka. He completed his internship on Satellite Altimetry from Indo-French Water Cell, Bangalore, India. He participated several oceanographic training in NIO, GOA, ESSO-Incois, Hyderabad, UMT, Malaysia, different national trainings. He was also an assistant researcher on "Hypoxic water in northern Bay of Bengal", a joint collaboration of Nansen Environmental and Remote Sensing Center, Norway and Department of Oceanography, University of Dhaka. In 2018, he joined as a Scientific Officer in Physical and Space Oceanography division at BORI. He has expertise on Ocean modeling, numerical computation, different oceanographic instruments operation, Matlab, R, GIS and other programming. He published 7 (Seven) research articles in different reputed national & international journal. His research interested on Ocean Modelling, Operational Oceanography, Remote sensing etc.

Geological Oceanography Division

Image: @ NAT GEO Maps

Chapter 3

Geological Oceanography Division

General Features

Geology is the study of the Earth. This includes how the Earth was formed, how the Earth has changed since it was formed, the materials that make up the earth, and the processes that act on it. Marine Geology focuses on areas affected by our oceans including the deep ocean floor; the shallower slopes and shelves that surround the continents, and coastal areas like beaches and estuaries. Marine geology is a study of the character and history of that part of the Earth below the sea/ ocean. Philip Kuenen (1958) told that "No Geology without Marine Geology". Most of the sedimentary rocks exposed on land were deposited in marine environments.

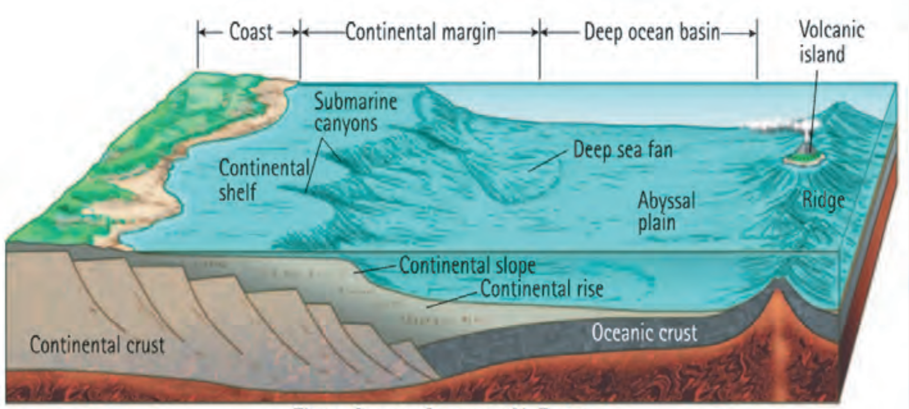


Figure: Common Oceanographic Features

Source: http://data.allenai.org/tqa/the_ocean_floor_L_0019/

Voyage of HMS Challenger (1872-1876) taken as beginning of modern marine geology. Marine geological studies were of extreme importance in providing the critical evidence for sea floor spreading and plate tectonics in the years following World War II.

The deep ocean floor is the last essentially unexplored frontier & detailed mapping in support of both military (submarine) objectives & economic (petroleum & metal mining) objectives drives the research.

The importance of Marine Geology

- Marine geology includes geophysical, geochemical, sedimentological & peleontological investigations of the ocean floor and coastal margins.
- Marine geological studies were of extreme importance in providing the critical evidence for sea floor spreading and plate tectonics.
- Marine geology provides very much information about the topography/ bathymetry, geological processes, and the history of the ocean.

Marine Geological Resources

Oceans cover more than 70 percent of Earth's surface, host a vast variety of geological processes responsible for the formation and concentration of mineral resources, and are the ultimate repository of many materials erodedor dissolved from the land surface.

Hence, oceans contain vast quantities of materials that presently serve as major resources for humans. Today, direct extraction of resources is limited to salt; magnesium; placer gold, tin, titanium, and diamonds; and fresh water.

Marine Geological resources can be stated as two categories:

A. Marine Mineral resources

B. Marine Hydrocarbon resources

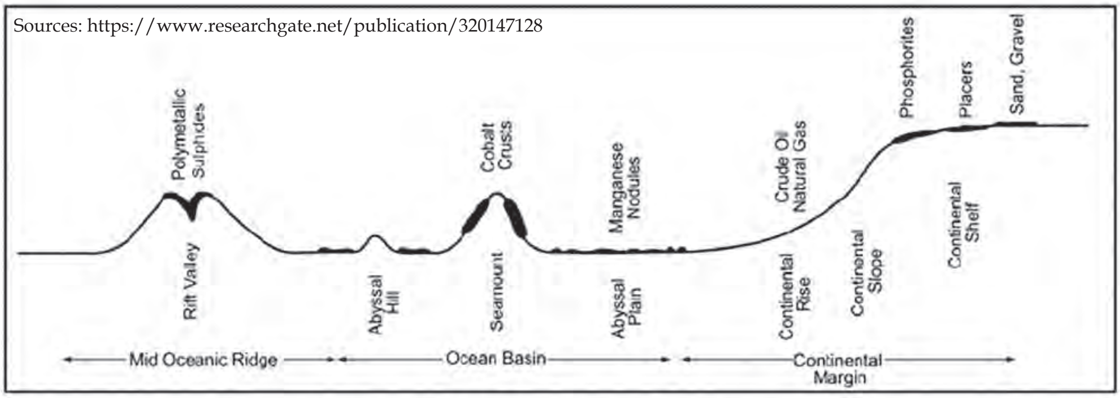
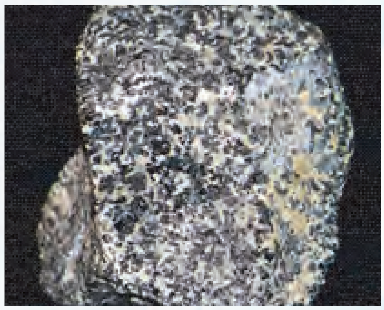


Figure: Distribution of Marine minerals prospecting zone

Figure: Distribution of Marine minerals on Different Seafloor Topographic Features

Some picture of metallic & mineral resources:

PLATINUM NUGGET

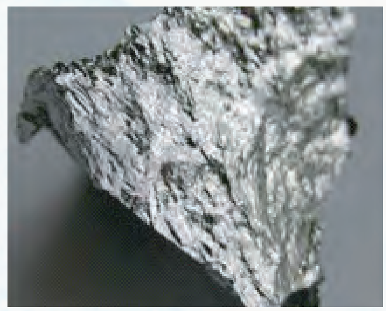


CHROMIUM ORE

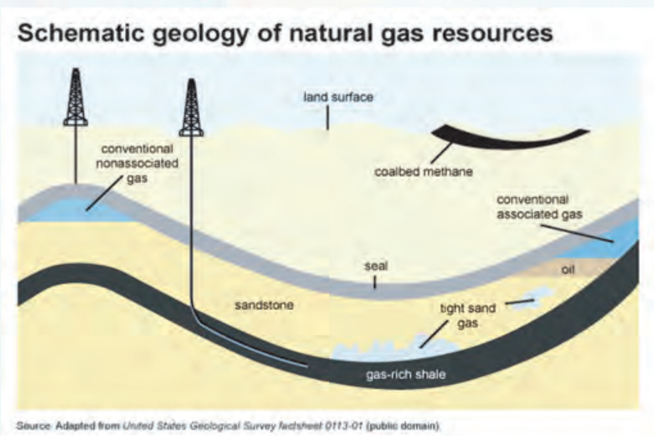
REFINED COBALT

GOLD CRYSTAL

PHOSPHORITE ROCK



MAGANESE



Natural Gas Reservoir

Methane Gas Hydrate

Sources: Difference sources of internet

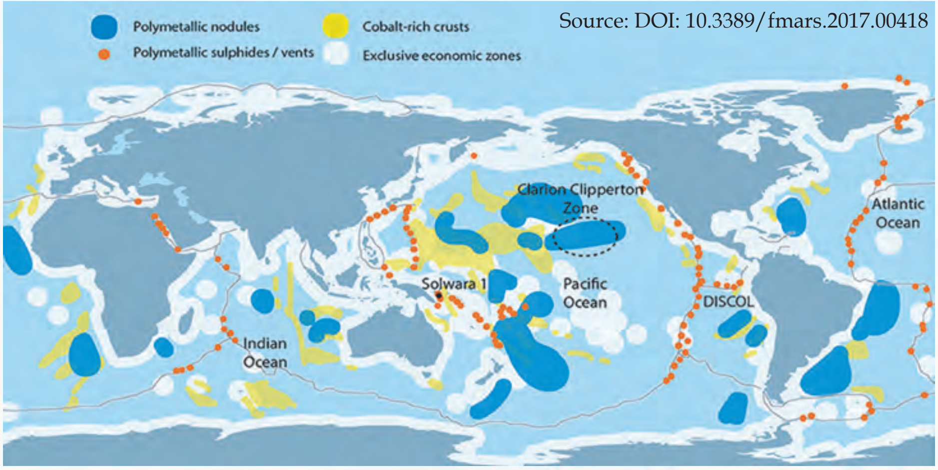


Figure: A world map showing the location of the three main marine mineral deposits

GOD at a Glance

The activity of Geological Oceanography Division (GOD) started by the mandate of BORI Act, 2015 (article 8) with the starting of BORI. Research activity has been started on 2017-2018 FY with taken a R&D project in the marine area of Saint Martin's Island. In the FY 2018-2019, another R&D project has been taken on the marine area of Teknaf to Maheshkhali Island. The R&D project topic was the sedimentological and mineralogical investigations in the selected study area. Sea bottom sediment sample has been collected in the coastal and nearshore area of north-eastern part of Bay of Bengal covered about 3100 sq. km (See the sampling map). During the field activity of 2018-2019 FY research, a cruise has been operated with the help of Bangladesh Navy R/V Saibal and the survey area was about 900 sq. km, distance 50 km seaward from the coastline.

Besides research activity, GOD is giving marine geology based analytical service and technical support to different government and non-government institutions. Some analytical services provided to private institutions and technical support provided to 16 ECB Office, Bangladesh Army, Cox's Bazar on Marine Drive Road project.

Completed research project from 2017-18 to 2018-19

1) Determination of Sedimentary & Mineralogical Composition of the Nearshore Area of Saint Martin Island, Bangladesh.
2) Determination of Sedimentological & Mineralogical Distribution and Sediment Province of the Nearshore Area of Cox's Bazar-Teknaf, Bangladesh


Sea bottom sediment sampling using Van Veen grab sampler by Geological Oceanography Division

Inception Activity of GOD

Sample Collection from the Study Area (Saint Martin's Island)

Data Processing in the Laboratory at BORI

Research Activity of 2017-2018 FY

Determination of Sedimentary & Mineralogical Composition of the Nearshore Area of Saint Martin Island, Bangladesh

Md. Zakaria
Senior Scientific Officer

Summary

This study deals with the determination of Sedimentological& mineralogical composition of the nearshore area of Saint Martin Island. The study area is the nearshore area of the Bay of Bengal where silty sand to clay are mostly dominated. Some of the ground are hard and contain high organic fragment which indicate coral reef exist around it. Mainly suspended sediments are deposited in this marine area. Most of the identified mineral is quartz which is the most resistant mineral. Rutile and Zircon are present in the most sample indicate the presence of heavy mineral.

General discussions

The present research work mainly deals with the sedimentary analysis & qualitative and quantitative analysis of heavy minerals of the nearshore zone of Bay of Bengal at Saint Martin Island. Heavy minerals are particularly useful in studies of sedimentation related to tectonic uplift of orogenic belts, as the evolution and unroofing episodes are reflected in their foreland sediments (Mange and Maurer, 1992). Heavy mineral studies provide useful information about the provenance and the nature of the source rock complexes, particularly about the specific rock types, such as ophiolites and high-pressure rocks (Faupl et al., 1998). Lots of studies on heavy mineral concentration have been carried out at the beach area of Bangladesh coast. But In case of Bangladesh, there have no evidence to study on the nearshore or offshore area of Bay of Bengal. From the different related previous work it can be found that the study area is a heavy mineral concentrate area. So it needs to find out the result for heavy mineral concentration & sediment province analysis of the study area.

Location of the Study Area

The study area comprises Nearshore Area of Bay of Bengal at Saint Martin Island bounded by N 20.5158 to N 20.716667 latitudes and E 92.1880 to E 92.288333 longitudes and covered 240+ sq.km area.

Materials and Methods

Equipment used in the study:

1. Van Veen Grab Sampler
2. Ekman Grab Sampler
3. Sieve Machine
4. Heavy Mineral Separation System (HMS)
5. Petrographic Microscope (Polarizing Microscope)

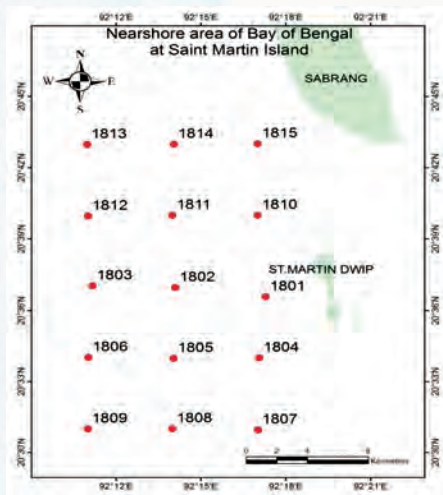


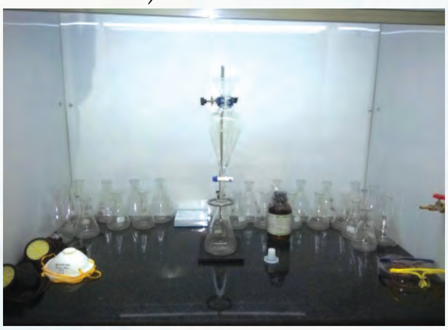
Figure-1: Sampling Location in the coastal and near-shore area of Saint Martin's Island.

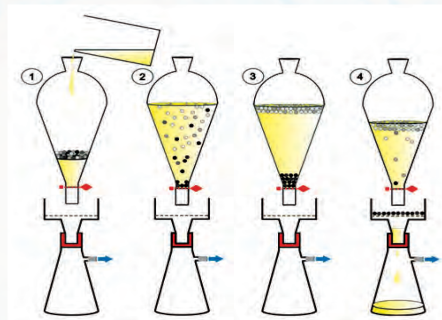
Field Investigation:

- The field investigation and samples collection have been carried out in the Saint Martin areas covering a distance of about 90 km from BORI. For systematic study of the area, GPS as well as traversing and spot location methods were used.
- Samples have been collected along the 5 km seaward from the beach line of the Saint Martin Island. 5 km grid data has been collected where the sampling pattern was 5 km, 10 km & 15 km distance form coast line. During sampling it has been used country boat.
- Sampling along the seaward has been done using Van Veen Grab sampler & Ekman Sampler.

Laboratory Analysis:

- The procedure mentioned in Faupl et al. (1998) for heavy minerals separation has been used to find out heavy mineral concentration in the study area.
- 25 g sand will be taken from each sample for heavy mineral analysis.
- To remove Carbonate minerals acetic acid used (Carbonate mineral dissolves in acetic acid).
- Gravitational heavy liquid separation of the sieve fraction 0.5-0.063 mm was carried out using bromoform as heavy liquid (density 2.89 g/cm3).
- After mounting the grains in Canada balsam, grains have been examined under polarizing microscope. Heavy mineral has been separated from the existing setup of Beach Sand Mineral Extraction Center, Bangladesh Atomic Energy Commission (BAEC), Cox's Bazar.
- After that, Mineral identification with XRD has been examined at Atomic Energy Center Dhaka, BAEC. After peak identification Match 3 software run for each peak to identify mineral (also some element).





Samplic equipments and laboratory equipment used in the study Some finding of the study

Some finding of the study

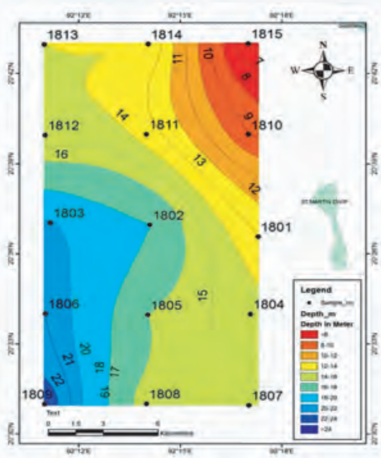


Figure-2:

Bathymetry Contour Map of the study area.

(Depth range is 6 m to 23 m)

Sedimentary Characteristics

Sedimentary Characteristics

Table-1: Sample wise lithological description

Sample No	Lithology	Descriptions
1.	Silty Clay	Clay rich
2.	Silty Clay	Clay rich
3.	Silty Clay	Clay rich
4.	Silty Clay	Clay rich
5.	Silty Clay	Clay rich
6.	Silty Clay	Clay rich
7.	Mud	Clay most
8.	Fine to medium sand (with organic fragment)	Hard Ground (may be reef present around)
9.	Silty Clay	Silt dominate
10.	Silty sand	Hard sand (May be reef present around)
11.	Silty sand	Very fine sand dominate
12.	Silty sand	Silt dominate
13.	Fine Sand	Hard sand (May be reef present around)
14.	Silty sand	Very fine sand dominate
15.	Fine Sand	May be reef present around

X-ray diffraction (XRD) Peak

X-ray powder diffraction (XRD) is a rapid analytical technique primarily used for phase identification of a crystalline material and can provide information on unit cell dimensions. X-ray diffraction is now a common technique for the study of crystal structures and atomic spacing.

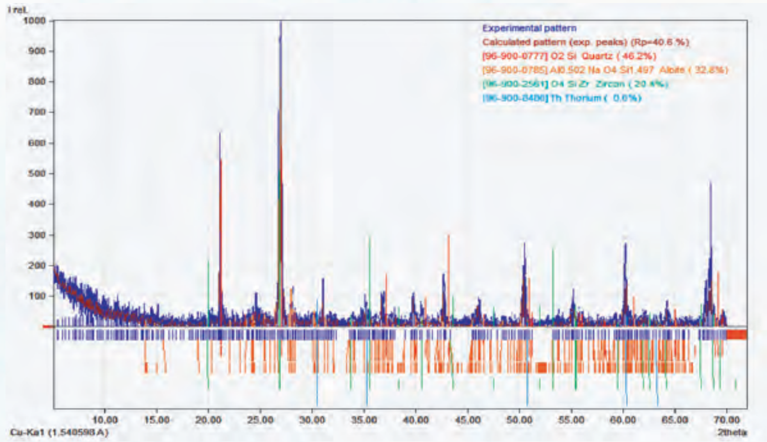


Figure-3: XRD peak of a sample showing the presence of Zircon & Thorium.

Table-2: Sample wise identified mineral and their chemical composition

Sample ID	Identified Mineral	Chemical composition	Sample ID	Identified Mineral Name	Chemical composition
1	Quartz	SiO_2	9	Rutile	TiO_2
2	Quartz	SiO_2		Quartz	SiO_2
	Albite	$NaAlSi_3O_8$		Uranium	U
3	Zircon	$ZrSiO_4$		Platinum	Pt
	Albite	$NaAlSi_3O_8$	10	Quartz	SiO_2
	Quartz	SiO_2		Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$
4	Orthoclase	$KAlSi_3O_8$		Albite	$NaAlSi_3O_8$
	Albite	$NaAlSi_3O_8$		Zircon	$ZrSiO_4$
	Quartz	SiO_2		Ilmenite	$FeTiO_3$
	Magnetite	Fe_3O_4		Hematite	Fe_3O_4
	Pyrite	FeS_2		Platinum	Pt
	Ilmenite	$FeTiO_3$		Thorium	Th
5	Quartz	SiO_2	11	Quartz	SiO_2
	Feldspar	$KAlSi_3O_8$		Zircon	$ZrSiO_4$
	Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$		Pyrite	FeS_2
	Rutile	TiO_2		Magnetite	Fe_3O_4
	Tungsten	W		Uranium-alpha	U
6	Albite	$NaAlSi_3O_8$		Thorium	Th
	Orthoclase	$KAlSi_3O_8$	12	Quartz	SiO_2
	Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$		Periclase	MgO
	Zircon	$ZrSiO_4$		Platinum	Pt
	Tungsten	W		Thorium	Th
	Thorium	Th	13	Quartz	SiO_2
7	Orthoclase	$KAlSi_3O_8$	14	Quartz	SiO2
	Albite	$NaAlSi_3O_8$		Albite	$NaAlSi_3O_8$
	Quartz	SiO_2		Zircon	$ZrSiO_4$
	Zircon	$ZrSiO_4$		Thorium	Th
	Rutile	TiO_2	15	Quartz	SiO_2
	Magnetite	Fe_3O_4		Selenium	Se
	Ilmenite	$FeTiO_3$		Thorium	Th
	Tungsten	W			
8	Zircon	$ZrSiO_4$			
	Quartz	SiO_2			
	Tungsten	W			
	Magnetite	Fe_3O_4			

- The heavy minerals have specific gravity higher than 2.89. Heavy minerals are volumetrically minor population, usually less than 1% by weight, of a terrigenousrock. Based on heavy minerals, an attempt has been carried out to find out their parent rocks in the provenance.

- Sample no 1804, 1807, 1808, 1810, 1811 contain ilmenite and magnetite. The opaques (mainly of ilmenite and magnetite), zircon euhedral, topaz and rutile might have been derived from igneous rocks of acidic and basic compositions of the study area.
- Sample no 1805, 1807 & 1809 contain Rutile. The presence of Rutile is the characteristic of a provenance of metamorphosed argillaceous sediments of high grade schists.
- Most of the samples (1803, 1806, 1807, 1808, 1810, 1811 & 1814) contain Zircon with other mineral. XRD data show that elemental Uranium & Thorium present in the study sample.

Economic Value of some heavy minerals

Titanium Minerals (Such as Rutile)

- About 90% of the world's titanium mineral production is used in the manufacture of white titanium dioxide pigment.
- TiO_2 is the premier pigment, having high refractive index (opacity), whiteness, brightness, thermal stability and chemical inertness. It is used extensively in the paint industry where it has replaced old-fashioned lead carbonate pigments, and as a pigment in plastics, paper, and latex rubber. Because of non-toxic it is used in cosmetics and pharmaceuticals.
- About 6% is used to manufacture titanium metal, a light, strong, corrosion-resistant metal used in aircraft, spacecraft and medical prostheses. Minor TiO_2 uses include welding rod coatings, sand blasting and water filtration.

Zircon

- Zircon sands are used in range of industrial applications and in a variety of markets ranging from foundry molding sands to zirconium-metal manufacture.
- The ground flour of zircon is commonly used in refractory paint for coating the outer surface of moulds. In steel production, zircon sands are used in order to produce ladle brick, coatings, mortars and as ladle-nozzle fill.
- Zircon sands can be fused to make refractory bricks and blocks that are widely used in line kilns, glass melting furnaces and in hearths for containing molten metals due to its resistance to melt in high temperatures (zircon completely melts at 276^0 C).
- Zircon sand is used to produce zirconia and alumina-zirconia abrasive materials and to clean turbines in electrical generating plants.
- Zircon is also used in TV. Face plate glass and Zirconium metal is used as fuel cladding and structural material in nuclear reactors.

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Research Activity of 2018-2019 FY

Determination of Sedimentological & Mineralogical Distribution and Sediment Province of the Nearshore Area of Cox's Bazar-Teknaf, Bangladesh

Md. Zakaria
Senior Scientific Officer

Summary

This study deals with the determination of Sedimentological characteristics & mineralogical composition of the coastal and nearshore area of Teknaf to Maheshkhali Island. The study area is the nearshore area of the Bay of Bengal where Medium to fine grained sand are mostly dominated. Some of the ground sediment sampling missing in some places with Van Veen grab sampler because of compact ground indicates lacking of loose sediment and deposition in this location. In the channel area of Naf River and Maheshkhali Channel contain high organic remnant. Most of the identified mineral is quartz which is the most resistant mineral. Aluminium and Iron are the next abundant element presents in the sediment. Heavy mineral concentration is high as 10% to 20% in some place which indicate rich zone of economic heavy mineral present in the most sample indicate the presence of heavy mineral.

Study Area

The study area lies in the coastal to nearshore marine area of Saint Martin Island to Maheshkhali Island. The area is about 3100 km^2 and it is bounded by N 21°30′ to N 21°40′ latitudes and E 91°25′ to E 91°40′ longitudes. The study area is covered by coastal & nearshore sea water.

Figure-1: Sampling Location in the coastal and nearshore area of Cox's Bazar

Methods used for the study

The field investigation and sample collections will be carried out in the coastal and nearshore marine area from Teknaf to Maheshkhali Island covering a distance of about 15-20 km toward sea. For systematic study of the area, GPS as well as traversing and spot location methods were used. Sampling along the seaward will be done was done with the help of sediment Van Veen grab sampler, Niskin water sampler and secchi disk. The field investigation will be carried out in above mentioned locations of Bangladesh considering potential site for a heavy mineral concentration.

Field investigation is divided into three phases

In first phase, detailed literature review will be done to know about the study area. Extensive field work will be carried out. Information regarding surface & subsurface geology, meteorology, hydrogeology and demography will be collected to co-relate with the field survey data. Survey data will be stored for analysis in Laboratory. In second phase, field raw data will be accumulated and analyzed for heavy mineral separation & analysis, Mineral identification, Elemental Analysis. In last phase, research outcome has been presented through seminar. Following the procedure mentioned in Faupl et al. (1998), heavy minerals were separated from both loose sand samples. 25g will be taken from each sample for heavy mineral analysis. Carbonate minerals were dissolved in acetic acid. Gravitational heavy liquid separation of the sieve fraction 0.5-0.063 mm was carried out using bromoform as heavy liquid (density 2.89g/cm^3). After mounting the grains in Canada balsam, the grains will be examined under the polarizing microscope. More than 450 translucent grains of each sample will be counted with the ribbon count method. Several minerals, such as biotite, chlorite and glauconite were excluded from qualitative examinations. After that, Mineral identification with XRF has been examined from IMMM, Joypurhat. The separated heavy mineral, identified all mineral composition plotted separately.

Some finding of the study

There are 55 samples collected from the nearshore area of around Teknaf to Maheshkhali Island. This is the first ever try to collect sea bottom sediment sample in this area. The Northern Bay of Bengal continental margin of eastern Bangladesh is covered by fine to medium sand in the nearshore area. On the northern zone, sediment is mainly mixtures of sand, silt, and clay. Adjacent to the sandy beach around Cox's Bazar, medium to coarse sand is prevalent. Medium and Coarse sand occur mainly in the mouth of Maheshkhali Channel, RejuKhal and Naf River where fluvial deposited them. The southern limit of sedimentation is marked by fine sand and silty sand that stretches from elephant point, southeastward across Teknaf and Saint Martin's Island and along the seaward part of Teknaf where grab sampler cannot perform because of compactness of surface sediment.

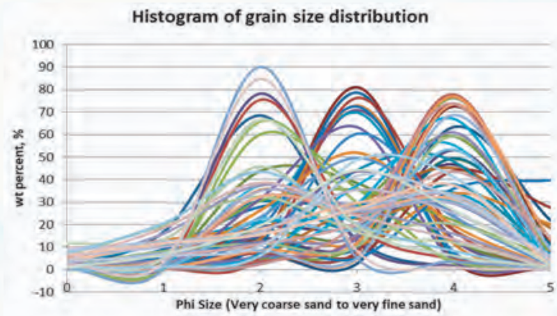

Figure-2: Histogram presentation of grain size distribution of sea bottom sediment.

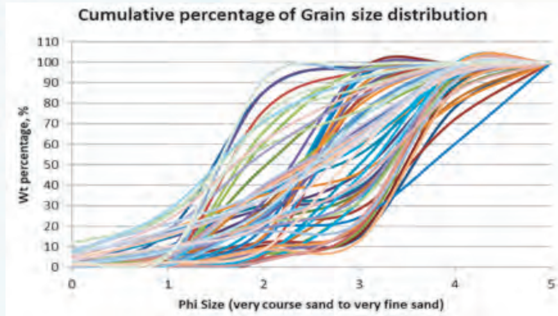

Figure-3: Cumulative percentage of grain size distribution of sea bottom sediment.

According to the above Figure-2, the study area is mostly covered by medium to fine size sediment deposit. Some coral reef ground has been found in the study area which comprises coarse to medium size sand deposit.

Water Transparency measurement

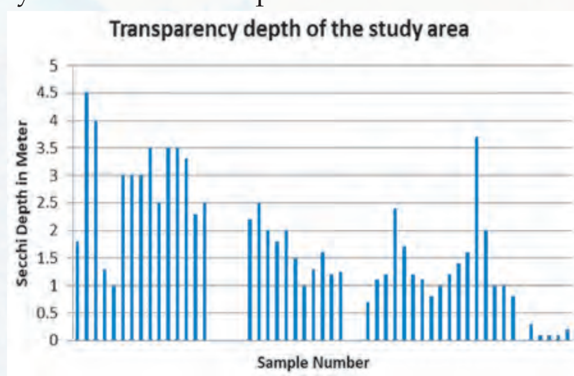

Figure-4: Transparency or turbidity of the study area measured by secchi disk

Secchi depth is a measure of water transparency, where transparency increases with increasing secchi depth. The secchi depth is the depth of water beyond which a high-contrast pattern on a submerged disk is no longer visible. Turbidity is a result of sediment load and biomass in a given environment, so while it is generally true that clearer lakes are cleaner; this is not always the case. However, due to decreased light penetration a highly turbid lake may be relatively unproductive with respect to phytoplankton, since they need light to live. So, when interpreting Secchi disk results, one must consider other aspects such as possible sediment or pollution sources, nutrient loading, etc. In the study area, the transparency is high (higher than 2 meter to 4.5 meter) in most places especially in the deeper area where turbidity is low. In the place near to the coast or channel shows low transparent and high turbidity.

Heavy Mineral Concentration

Most of the area has covered by less than 2.00% of heavy mineral concentration but there have some zone with very high concentration of heavy mineral (more than 10.00 % to 20.00 %). Table shows the heavy mineral concentration percentage in the nearshore and coastal area around Cox's Bazar. Presence of 10-20 percent concentration of heavy mineral represents very much economically viable concentration for Bangladesh and world perspective.

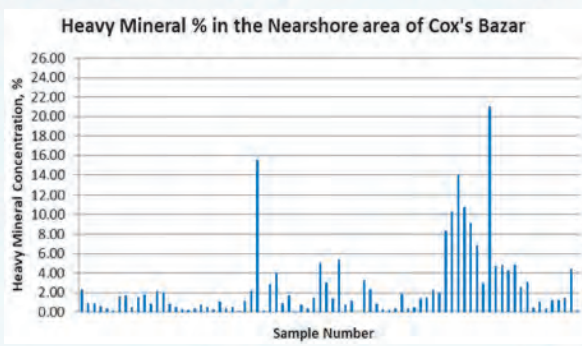

Figure-5: Weight percentage of Heavy Mineral of the study area

X-ray Fluorescence (XRF) Analysis

Elemental oxides percentage has been determined by X-ray Fluorescence (XRF) spectroscopy analysis with the help of Institute of Mining, Mineralogy and Metallurgy (IMMM), Joypurhat. 51 samples has been examined to determined elemental oxides weight percentage of sea bottom sediment samples collected. Some of the samples contains Thorium (ThO_2) a radioactive element, indicates the presence of radioactive minerals in the study area.

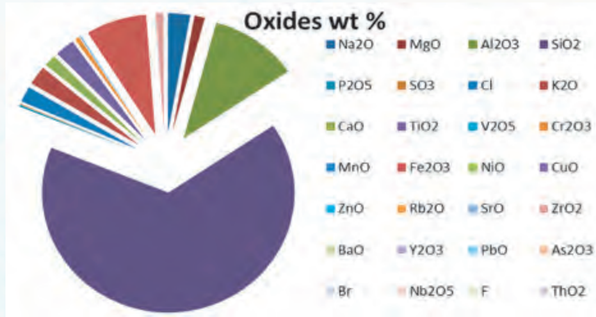

Figure-6: Weight percentage of elemental oxides of different mineral of the study area.

Quartz is a mineral composed of silicon and oxygen atoms in a continuous framework of SiO_4 silicon oxygen tetrahedral, with each oxygen being shared between two tetrahedra, giving an overall chemical formula of SiO_2. Quartz is the second most abundant mineral in Earth's continental crust, behind feldspar. Quartz is a defining constituent of granite and other felsic igneous rocks. It is very common in sedimentary rocks such as sandstone and shale. It is a common constituent of schist, gneiss, quartzite and other metamorphic rocks. Quartz has the lowest potential for weathering in the Goldich dissolution series & consequently it is very common as a residual mineral in stream sediments and residual soils. In the study sample, quartz is most abundant mineral. XRF shows that the oxides wt% of silicon (SiO_2) is more than 60% and in some samples it is near or above 80%.

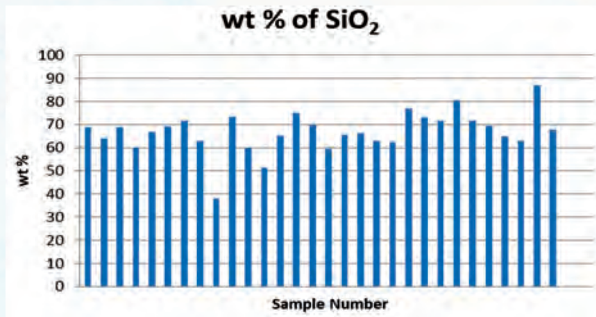

Figure-7: Weight percentage of SiO_2 of the study area

Aluminium is the second abundant element found in the samples. XRF shows that the oxides weight percentage of aluminium (Al_2O_3) is more than 8% to 16%. Third abundant element is iron where weight percent of iron oxide (Fe_2O_3) is 6% to 10%.

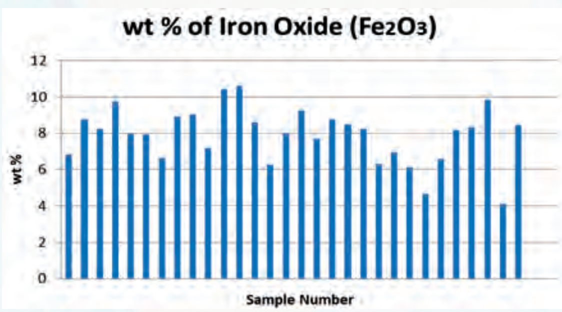

Figure-8: Weight percentage of Fe_2O_3 of the study area.

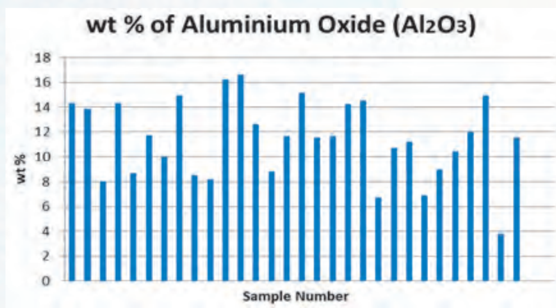

Figure-9: Weight percentage of Al_2O_3 of the study area.

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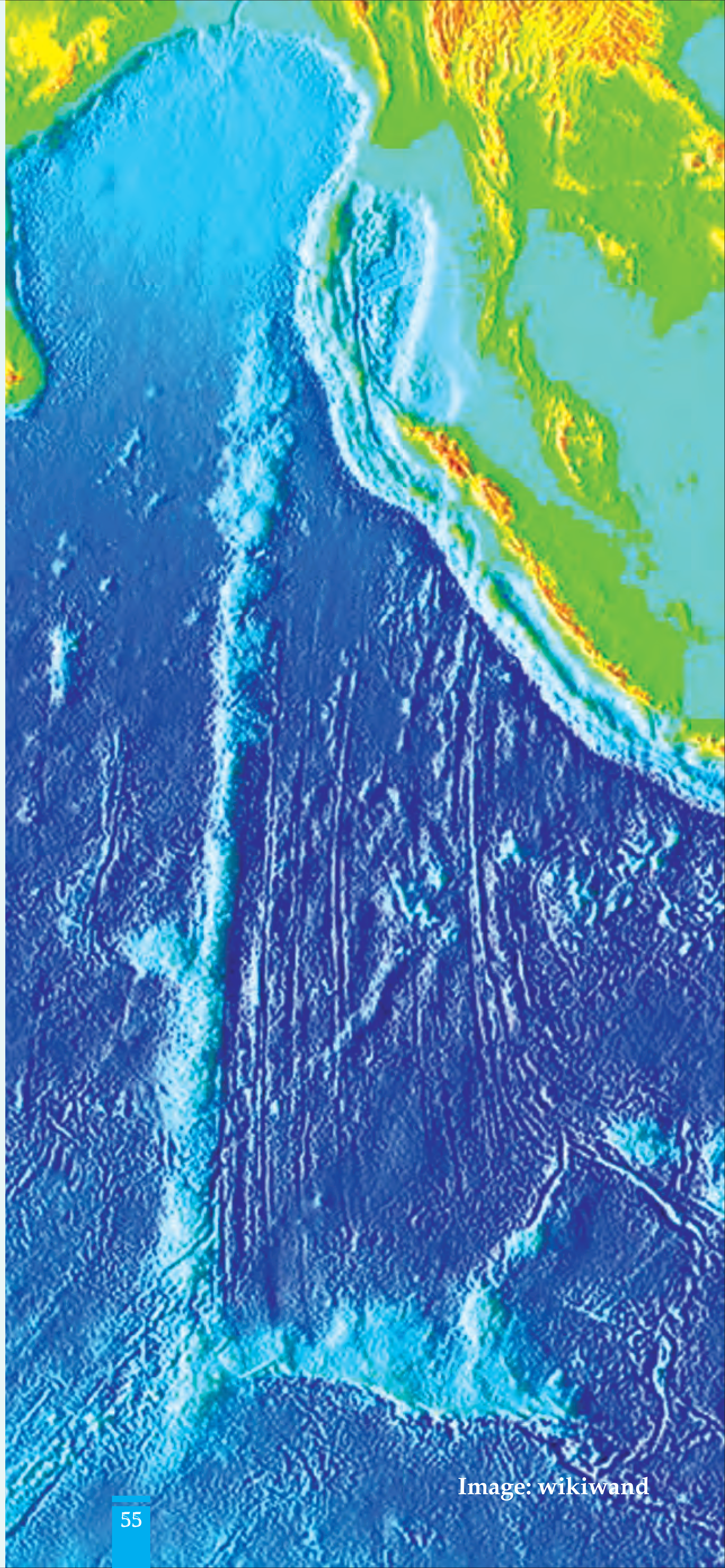
Mr. Md. Zakaria is 3^{rd} child of Md. Abul Hosain & Samsun Nahar, born in Brahmanbaria district. He earned B.Sc & MS degree in Geological Sciences from Jahangirnagar University. After completion of study, he join as a GIS Analyst in BRRI, then joined at NORI 1st phase project as a Scientific Officer on 1st July, 2014, where he keeps valuable inputs in oceanography equipment collection and policy development for BORI establishment and in his tenure NORI project completed successfully and established BORI as a national institute. After project completion, he transferred to BORI revenue post. In 2018, he joined as a Senior Scientific Officer in the Geological Oceanography Division of BORI. He carried out oceanography related training from NOAMI, NIO-CSIR, India, Marine Spatial Planning (MSP) Training, China etc and visited different country to make collaboration on oceanography field. Now he is coordinating the research activity as well as developing project for BORI 2^{nd} phase & Marine Aquarium including other significant activity of BORI. He published 7 (seven) scientific articles in renowned national & international journals. He is interested on paleoceanography, sedimentology, mineralogy, RS & GIS etc in the field of geological oceanography. He is working as pioneering geological oceanographer in BORI and keeping his dynamic effort for the development of oceanography field in Bangladesh.



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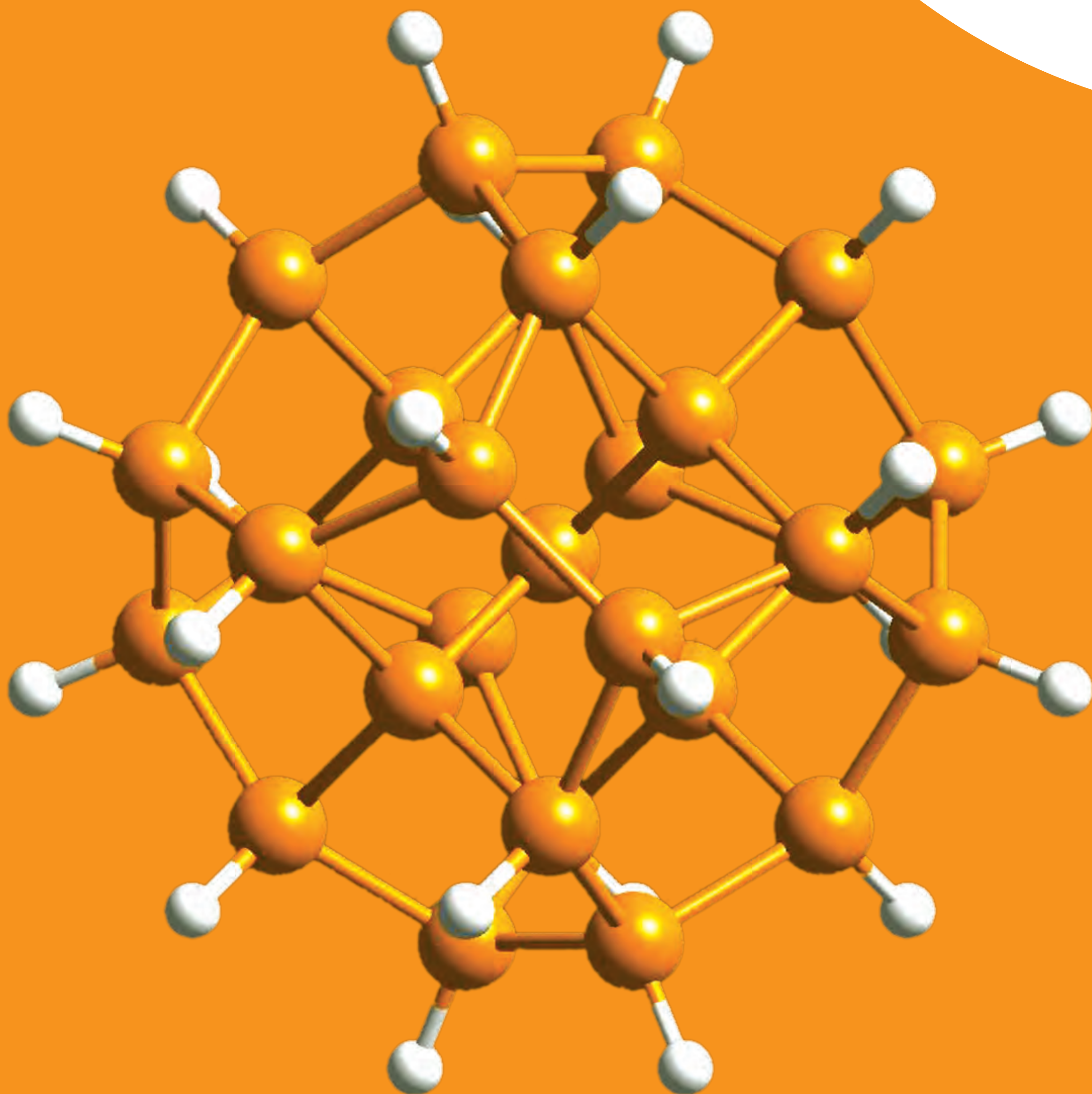
Chemical Oceanography Division



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Chapter 4

Chemical Oceanography Division

General Features

Chemical Oceanography

Chemical Oceanography is fundamentally interdisciplinary. Chemical Oceanographers examine the chemical composition of the oceans.They examine the acidity or otherwise and attempt to understand how the ecology, biology and other elements of an ocean might change based on the shifting chemical profile.The chemistry of the ocean is closely tied to ocean circulation, climate, the plants and animals that live in the ocean, and the exchange of material with the atmosphere, cryosphere, continents, and mantle.

Business of chemical Oceanographer

They are essentially oceanographers, but rather than studying the ecology, biological life and geology of the oceans as a broad subject, they examine the chemical composition of this particular environment. The chemistry of our oceans is important. Many plant and animal species have evolved to thrive in certain acidities and cannot thrive when the seawater is too acidic or not acidic enough. When an ocean's chemical composition becomes too unbalanced, it can have a profound effect on the ecology.

One of the most important roles they may be working on now is the monitoring of ocean acidification. Oceans are a net carbon sink, but acidification is increasing and this has had measurable effects on the acid levels in the ocean - corals have been bleached as a result of increased carbon emissions and are under serious threat. As the ice caps melt, ocean acidification could be diluted in some areas. Chemical Oceanographers may work with environmental engineers to attempt to redress these problems and restore balance.

We approach our research from two directions: field measurements and laboratory studies. The research is interdisciplinary and involves investigating interactions between chemical, biological and physical processes in the oceans. We study the distributions, behavior and chemical speciation of trace metals, nutrients and carbon in the water column. We are also interested in the environmental chemistry of contaminants and nanoparticles in marine systems. We investigate how anthropogenic drivers change the chemistry of the ocean and thus impact on biological processes.

It's not just coral and it's not just about climate change. They will look at the problems caused by industrial chemicals and pollution, and advice on policy. They may also work as government advisors, providing evidence for court cases where civil action is brought against a business.

Areas of Research

Carbon Cycle

Many of ours are researching how carbon is distributed and exchanged between the oceans, atmosphere, biosphere and geosphere. Atmospheric carbon dioxide levels influence Earth’s surface temperature and are an integral part of the carbon cycle. All living things and the fossil fuels can evolve, are comprised of carbon. The ocean contains a large reservoir of carbon many times the size of the atmospheric reservoir that can substantially alter atmospheric CO_2 levels.

Geochemistry of Rivers and Estuaries

The ultimate source of the chemical constituents of the sea is primarily from rivers that deliver their dissolved and particulate input through estuaries. This is the location of the most intimate contact of the ocean with humans.

Marine Biogeochemistry

Chemical oceanography investigates the chemical composition of sea water. Chemical oceanographers study the interactions between organic and inorganic substances and the biological, physical and geological conditions of the ocean. They want to understand how marine chemistry is influenced by physical processes and exchanges with the atmosphere, biosphere and geosphere.

Processes, which introduce chemical species into the ocean and those which remove or transform the substances, are important targets of marine chemical research. We preferentially investigate the cycling of those elements which are important for biological processes (eg. carbon, nitrogen, phosphorus, iron). The ocean contains each chemical element of our planet either in its pure form or in any kind of chemical compounds either dissolved or particulate.

The origin and fate of gases, affecting the atmosphere are a very special element of research therefore. Greenhouse gases, contributing to atmospheric warming, trace gases forming aerosols and those destroying ozone belong to this category. As chemistry controls and reflects the environment of the ocean-earth-atmosphere system, chemical oceanography has links to all the other disciplines of the GEOMAR.

Marine Sediment Geochemistry

Chemical reactions in the ocean change dramatically and are facilitated by a unique set of microbes when the oxygen concentration is exhausted. The most widespread example of this is in ocean sediments which become the most important sink for nitrate after organic matter digenesis depletes oxygen. Other examples are the oxygen minimum zones of the ocean and anoxic basins like the Black Sea.

Paleoclimatology

Several of our scientist research Earth's climate and how it has varied in the recent and more distant past. Understanding the natural variability of the climate system is essential for determining when the current climate is outside its normal range. Since thermometers, rain gauges, weather balloons, oceanographic research vessels, and satellites have only been used extensively for less than a century the only way to reconstruct climate is from ocean and lake sediment cores, tree rings, coral and the like. Most of these techniques involve chemical analyses of one type or another, a specialty of our department. Accurate reconstructions of the "pre-instrumental" climate are necessary in order to test the complex mathematical models used to predict future climate changes.

Hydrothermal Systems & Chemistry

Chemical reactions at mid-ocean ridge spreading centers that bisect all ocean basins involve unique reactions that greatly influence ocean chemical mass balance and provide a host for unique biological systems.

Inception Activity of COD

Sample Collection from the Study Area (Saint Martin Island)

Data Processing in the Laboratory at BORI

Adaptive responses to ocean warming and acidification of different marine invertebrates inhabit in the South east coastal area of Cox's Bazar, Bangladesh

Md. Tarikul Islam
Scientific Officer

Abstract

Ocean acidification, a complex phenomenon that lowers seawater pH, is the net outcome of several contributions. A study pertaining to the seasonal variation in physico-chemical properties and its impacts on marine invertebrates inhabit at the south east coastal waters of Cox's Bazar, Bangladesh for a period of January 2018 to June 2018. It shown that the coastal water was significantly influenced by the freshwater discharged from Naf River and other sources from upstream to the coastal area. Total five sampling stations namely saint Martin Island (S1), Naf River (S2), Teknaf (S3), Inani (S4) and Rezukhal estuary (S5) were considered for taking the desirable parameters reading. The physic-chemical parameters like Dissolved oxygen, Salinity, Temperature, Conductivity, Total dissolved solids, Transparency were determined by using Hanna HI98194, Refract meter, YSI Pro30 multimeter, Hach HQ11d, Winklers Titration method, Secchi disk respectively. There were implementing two types of experiment 1) Insitu experiment and 2) Exsitu experiment to assess the adaptive responses of different marine invertebrates inhabit on ocean acidification and their potential detrimental effects to marine environment as well as ecosystem processes and services. The foreseen danger to marine invertebrates by acidification is in fact expected to be amplified by several concurrent and interacting phenomena. In addition, a robust ocean acidification monitoring program over time will provide necessary information to scientists and resource managers on the status and trends in ocean parameters related to OA, and thus aid decisions in light of ocean change.

Key words: Ocean Acidification, Invertebrates, Adaptability, Parameter, Ecosystem

Introduction

The partial pressure of CO_2 in the ocean has increased rapidly over the past century, driving ocean acidification and raising concern for the stability of marine ecosystem. Ocean acidification is responsible for changes in the oceanic carbonate system, with effects on partial pressure of CO_2 (pCO_2), DIC, pH, alkalinity, and calcium carbonate saturation state (Feely et al., 2010; Beaufort et al., 2011). A 30%decline or damage of coral reef ecosystems has been estimated worldwide, and it is predicted that as much as 60% of the world's coral reefs might be lost by 2030 (Hughes et al., 2003).

The sources of elevated atmospheric CO_2 first of all include anthropogenic activities such as fossil fuels combustion, i.e., coal, petroleum, and natural gas (Le Quéré et al., 2009), enhanced land-use practices (Le Quéré et al., 2009), as well as deforestation (van derWerf et al., 2009; Lapola et al., 2014). The extent and effects of ocean acidification can be exacerbated by several complex processes, some of which act as stimulating factors, such as local environmental impacts including terrestrial or riverine runoff (Sunda and Cai, 2012; Bauer et al., 2013), modified land use practices (Lapola et al., 2014), and atmospheric acid rain (Baker et al., 2007). Considering the possible devastating consequences on the marine ecosystems, their organisms and the related ecosystem services (Cooley et al., 2009; Doney et al., 2009, 2012; Cai, 2011), it is important to ascertain all the possible causes of ocean acidification and their interlinks.

It has been suggested that ocean acidification will occur, as a consequence of atmospheric CO_2 sequestration into the ocean threatening the biodiversity & survival of marine organisms and ecosystems that may be unable to adapt to the current rate of CO_2 absorption by the oceans which exceeds that of any other time on the planet (Caldeiraand Wickett, 2003; Guinotte and Fabry, 2008; Turley et al., 2006).

Ocean Acidification poses significant problems to marine organisms that form calcium carbonate shells, skeletons, or internal structures (e.g., otoliths and statoliths) (Anderssonet al., 2008; Cohen and Holcomb, 2009).Although calcification is a central focus of OA research, there is growing evidence from CO_2 perturbation experiments that OA may alter other processes, notably aspects of reproduction and development (Kurihara, 2008), acid-base regulation (Portner, 2008), photosynthesis (Anthony et al., 2008, Crawley et al., 2010, Iglesias- Rodriguez et al., 2008), respiration (Rosa and Seibel, 2008), aspects of behavior (Mundayet al., 2009), and tolerances of other stressors (Hoegh-Guldberget al., 2007, Hutchins et al., 2009, Portneret al.,2005).The surface of our oceans will experience a decrease in pH from a level of 8.1–8.2 by 0.3–0.5 units and 0.7–0.77 units by the years 2100 (pH 7.6–7.9) and 2300 (pH 7.33–7.5) respectively (Raven et al., 2005; Royal Society, 2005; Pörtner and Farrell, 2008). Such decreases in pH may most affect the sensitive and vulnerable early developmental stages of marine organisms because these life histories have specific environmental needs (Thorson, 1950; Kurihara, 2008; Dupont&Thorndyke, 2009).

Studies on the effects of ocean acidification have only been conducted on a few crustacean species (Ries, et al., 2009; Pane & Barry, 2007; Walther et al., 2009; Kuriharaet al., 2004; Spicer et al., 2007). However, some of these studies show their vulnerability to elevated seawater CO_2 as adults and juveniles while another shows that the ability to tolerate a range of temperatures is reduced (Walther et al., 2009). Ocean acidification may therefore affect such organism's physiology, reducing their ability to produce calcium carbonate structures (Feely, 2009; Wicks & Roberts, 2012). Compared to the other parts of world, the south eastern coastal area of Cox's Bazar, Bangladesh is comparatively less studied from this perspective. This study would be the baseline data & also useful for the further research & sustainable ecosystem based health management.

Objective of the Project

The specific objectives of the project was

- To set up infrastructure for conducting research of ocean acidification impacts on marine invertebrates
- To know the adaptive capability of marine invertebrates species due to ocean acidification
- To study the effect of temperature and pH on the growth & survival of selected marine invertebrate species.
- To determine the physico-chemical parameters such as SST, pH, SSS, Dissolved Oxygen, Total Dissolved Solids, Electric conductivity, Surface water Transparency of the study area

Materials and Method

Study Area

An adjacent river estuary along the south eastern coast of Cox's-bazar and only existing coral island of Bangladesh was the study site for conducting this research. Five sampling sites were selected for this study namely Saint Martin Island (S1), Nafriver(S2), Teknaf (S3), Inani (S4), Rezukhal (S5) repectively.

Experiments

There were two experiments for this research. One is in-situ experiment and another is ex-situ experiments. For in-situ experiment, water samples were collected and measured from the selected sampling station by using different scientific equipment. Surface water samples were collected monthly in preconditioned (pre-washed in 10% nitric acid) 500 ml polyethylene bottles. At the same time two invertebrate species representing from the phylum molluska and arthropods were collected from their natural habitat and transferred to the laboratory with proper precautionary measures. Once collected, the invertebrate species were acclimatized in flowing seawater in the container/rearing tank system at ambient temperatures and pH for at least 24 hour.

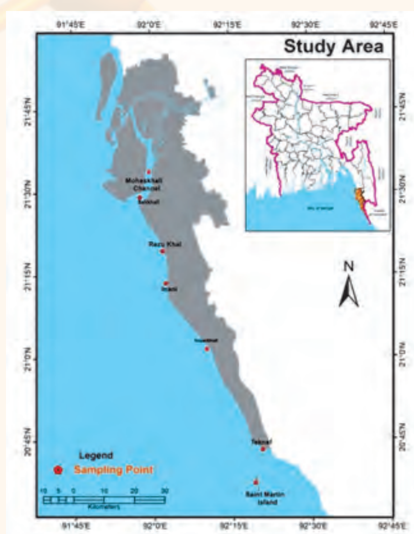

Figure-1: Study area showing sampling stations

For in-situ experiment water quality parameters such as salinity, temperature, pH, dissolved oxygen (DO), total dissolved solids (TDS), conductivity were measured using YSI Portable water quality meter.

The effects of altered temperature and pH on the growth and survival of selected invertebrate species were assessed by rearing them in the culture tank & aquarium under controlled environment. The experiments were conducted in a purpose-built flow-through seawater system with UV sterilized and filtered water delivered independently into each individual rearing container using irrigation dripper valves. The experimental pH was regulated by injection of pure CO_2 into the seawater as it passed through reservoirs in the system using an automatic CO_2 injection system, mixed using a vortex mixer and continuously bubbled with air to aid mixing and to maintain dissolved oxygen. The pH in sections of system were regulated according to water chemistry conditions in the rearing containers with pH controllers. This water was fed into subsequent reservoirs where it was warmed to the required temperatures, using aquarium heaters.

Temperature was automatically regulated using temperature sensors in the rearing containers and a temperature controller connected to the heaters. Water from each sub-header tank was continually circulated using pumps to maintain even temperatures within each treatment. Temperature, pH and salinity of water of rearing containers were measured daily in all treatments. The measured temperature and pH were contrasted among treatments by analysis of variance (ANOVA) with nominal pH or temperature treatment as fixed factors and day as a random factor.

The test species were reared in the container for the assessment of their growth and survival at different temperature and pH level. At least three replicate experiments were conducted in order to test the effects of increased temperature & lowered pH and their interaction on the survival and growth of different experimental species. One control treatment was set in each experiment where the temperature and pH will maintain at the condition that prevails in the natural environment. Three more experiment was conducted treated with different level of temperature and pH on different life stages of the experimental marine invertebrates. Marine invertebrate species at different age group were collected from the field in different month of the year and placed individually into the containers supplied with seawater in the experimental flow through seawater system. Experimental species of each container were examined daily, provided with fresh food if needed, and their containers were cleaned of faces and detritus.

Histological effects on Invertebrates

Histological changes in experimental species were checked over time by microscope to observe the influence of changed condition.

Data analysis

After 15 and 30 days, the number of surviving species in each container was recorded. Size of individuals of each species was observed by taking photographs. Size was measured from a digital image using the length of the curved line drawn from anterior region to posterior region of the experimental species. Survival at days 15 and 30 were contrasted among treatments by analysis of variance (ANOVA) with the number surviving per species as the dependent variable, and pH and temperature as fixed, factorial independent variables. The size and growth rate of surviving species were contrasted among treatments using ANOVA with temperature and pH as fixed factors and different invertebrate species as a random factor nested within each combination of pH and temperature.

Result and Discussion

For conducting this type of research work there was need to install/construct some infrastructures which are given at table-1 and it was installed successfully at Bangladesh Oceanography Research Institute Campus under the department of Chemical Oceanography.

Table-1: Materials for infrastructure construct

SI	Name of the Item	Description	Quantity	Remarks
1	Cartidge Filter	24 Ton capacity per hour	1	Installed & operating Scuccessfully
2	UV Filter	24 Ton capacity per hour	1	Installed & operating Scuccessfully
3	Aquarium	Dimension (L×W×H): 4'×2'×2' with 8mm temper glass	10	Installed & operating Scuccessfully
4	Sea water reservoir Tank	Dimension (L×W×H): 12'×12'×10'	1	Installed & operating Scuccessfully
5	Sea water overhead tank	Dimension (L×W×H): 10'×10'×8'	1	Installed & operating Scuccessfully
6	Small culture tank	Dimension (L×W×H): 10'×3'×4'	4	Installed & operating Scuccessfully
7	Plankton culture tank	Dimension (L×W×H): 10'×3'×4'	2	Installed & operating Scuccessfully
8	Large culture tank	Dimension (L×W×H): 12'×5'×4'	4	Installed & operating Scuccessfully
9	Ring Blower	1" Ring Blower	1	Installed & operating Scuccessfully
10	Other accessories	Air hose pipe, Airstone, light, Water pump	As required	Installed & operating Scuccessfully

In-situ Experiment

At the Saint Martin Island max. temperature was in June, pH , Salinity in May, DO in January and Transparency in February respectively. On the other hand, Min. temperature was in January, pH, Salinity, DO and Transparency in June respectively (Table-2).

Table-2: Monthly physico-chemical parameters result of Saint Martin Island

Station-1: Saint Martin Island							
Month	Water Temperature(°c)	Salinity (ppt)	Conductivity (mS/cm)	pH	TDS (g/L)	Transparency (m)	DO(mg/l)
Jan.	21.3	30.5	43.66	8.18	28.85	4.71	5.44
Feb.	23.5	31.45	44.85	8.21	29.52	4.82	5.34
March	25.68	32.44	45.43	8.23	30.22	3.84	5.22
April	28.8	33.08	49.54	8.28	31.32	3.65	5.12
May	29.35	34.6	51.94	8.3	31.65	3.44	4.98
June	30.25	30.35	44.55	8.13	28.78	2.42	4.94
Averag.	26.48	32.07	46.66	8.22	30.06	3.81	5.17
Max.	30.25	34.6	51.94	8.3	31.65	4.82	5.44
Min.	21.3	30.35	43.66	8.13	28.78	2.42	4.94
SD	3.58	1.63	3.30	0.06	1.23	0.89	0.20

At Naf river max. temperature, pH was in June, Salinity in May, DO in January and Transparency in April respectively. On the other hand, Min. temperature was in January, pH in June, Salinity in January, DO and Transparency in June respectively (Table-3).

Table-3: Monthly physico-chemical parameters result of Naf River

Station-2: Naf River							
Month	Water Temperature(°c)	Salinity(ppt)	Conductivity (mS/cm)	pH	TDS (g/L)	Transparency (m)	DO(mg/l)
Jan.	21.22	27.7	43.66	8.08	27.64	1.02	4.98
Feb.	23.23	28.45	44.65	8.02	27.88	1.04	4.65
March	25.12	28.54	44.68	8.06	26.95	0.98	4.66
April	28.32	30.12	46.65	8.13	28.44	1.11	4.45
May	28.98	31.44	46.75	8.12	28.56	0.98	4.42
June	29.88	30.88	49.45	8.00	28.84	0.88	4.32
Averag.	26.13	29.42	45.97	8.068	28.05	1.00	4.58
Max.	29.88	31.44	49.45	8.13	28.84	1.11	4.98
Min.	21.22	27.7	43.66	8	26.95	0.88	4.32
SD	3.48	1.41	2.09	0.052	0.70	0.077	0.24

At Teknaf max. temperature, DO, Transparency was in April, pH in January, Salinity in May respectively. On the other hand, Min.temperature was in January, pH in April, Salinity in January, DO and Transparency in June respectively (Table-4).

Table-4: Monthly physico-chemical parameters result of Teknaf

Station-3: Teknaf							
Month	Water Temperature(°c)	Salinity(ppt)	Conductivity (mS/cm)	pH	TDS (g/L)	Transparency (m)	DO(mg/l)
Jan.	22.08	30.04	45.74	8.13	27.64	1.32	4.64
Feb.	23.66	30.12	45.84	8.02	27.88	1.12	4.56
March	25.88	30.9	45.94	8.06	26.95	1.44	4.86
April	29.94	31.22	46.56	8	28.44	1.46	4.94
May	29.12	31.94	46.88	8.12	28.56	1.32	4.54
June	29.04	30.28	45.46	8.08	28.84	0.98	4.48
Averag.	26.62	30.75	46.07	8.07	28.05	1.27	4.67
Max.	29.94	31.94	46.88	8.13	28.84	1.46	4.94
Min.	22.08	30.04	45.46	8	26.95	0.98	4.48
SD	3.26	0.75	0.54	0.05	0.70	0.19	0.19

At Inani max. temperature, Transparency was in May, pH in February, Salinity in May, DO in January respectively. On the other hand, Min. temperature was in January, pH in June, Salinity in January, DO and Transparency in June respectively (Table-5).

Table-5: Monthly physico-chemical parameters result of Inani

Station-4: Inani							
Month	Water Temperature(°c)	Salanity(ppt)	Conductivity (mS/cm)	pH	TDS (g/L)	Transparency (m)	DO(mg/l)
Jan.	22.1	30.12	45.82	8.1	27.72	1.12	4.94
Feb.	23.7	30.18	45.94	8.20	27.94	1.15	4.68
March	25.76	30.98	45.98	8.18	27.05	1.34	4.56
April	29.12	31.44	46.68	8.12	28.64	1.26	4.84
May	29.98	32.02	46.96	8.09	28.68	1.42	4.34
June	29.84	30.24	45.68	8.02	28.75	0.88	4.24
Averag.	26.75	30.83	46.18	8.118	28.13	1.195	4.6
Max.	29.98	32.02	46.96	8.2	28.75	1.42	4.94
Min.	22.1	30.12	45.68	8.02	27.05	0.88	4.24
SD	3.39	0.79	0.52	0.065	0.68	0.19	0.28

At Rezukhal estuary max. temperature, Salinity was in May, pH in February, DO in January and Transparency in March respectively. On the other hand, Min. temperature was in January, pH, Salinity, DO and Transparency in June respectively (Table-6).

Table-6: Monthly physico-chemical parameters result of Rezukhal estuary

Station-5: Rezukhal							
Month	Water Temperature(°c)	Salanity(ppt)	Conductivity (mS/cm)	pH	TDS (g/L)	Transparency (m)	DO(mg/l)
Jan.	24.32	28.32	44.76	8.08	27.62	1.14	5.22
Feb.	25.25	28.56	44.02	8.14	26.94	1.18	5.12
March	25.84	28.84	45.2	8.02	27.05	1.24	4.98
April	29.64	29.45	45.54	7.98	28.24	1.2	4.84
May	30.12	30.56	45.68	7.94	28.18	1.22	4.54
June	29.56	27.26	44.24	7.88	26.65	0.84	4.22
Averag.	27.46	28.83	44.91	8.007	27.45	1.14	4.82
Max.	30.12	30.56	45.68	8.14	28.24	1.24	5.22
Min.	24.32	27.26	44.02	7.88	26.65	0.84	4.22
SD	2.59	1.11	0.68	0.094	0.67	0.15	0.38

Ex-situ experimental Result

There were two selected species (Green Mussel & Mud Crab) from two individual phylum (Mollusca &Arthopoda) taken for conducting this research. Here I try to measure the physico-chemical parameters and the total biomass with different environmental condition. There were taken three Tank. Tank-A for represents normal environment, Tank-B represents control unit-1 and Tank-C represents control unit-2.

Table-7: Physico-chemical parameters of the normal environment at Tank A (Normal unit)

SI	Name of the parameter	Unit	parameter reading at initial month	Parameter reading after 1 month later	Parameter reading after 2 month later	Water Exchange
1	Salinity	ppt	30	29	29.54	Monthly 70%
2	Temperature	°c	27	27.22	27.45	
3	PH		8.2	8.24	8.18	
4	Transparency	m	3	2.92	2.88	
5	DO	mg/l	8.2	7.98	7.84	

Table-8: Total biomass of the sample with normal environment (Tank-A)

SI	Name of the sample	Quantity	Size/wet weight at Initial month	Size/wet weight at 1 month later	Size/wet weight at 2 month later	Weight Gain (Final-Inital)	Mortality Rate	Morphological change	Behavior change	Remarks
1	Green Mussel	20 nos.	150 gm	165gm	178gm	28gm	20%	Normal	Normal	Good
2	Scylla serrata	20 nos.	80gm	95gm	110gm	30 gm	30%	Normal	Normal	Good

Table-9: Physico-chemical parameters of the control environment at Tank B (control unit-1)

SI	Name of the parameter	Unit	parameter reading initial month	Parameter reading 1 month later	Parameter reading 2 month later	Water Exchange
1	Salinity	ppt	27	25.54	25.2	Monthly 70%
2	Temperature	°c	25	25.24	25.44	
3	PH		8.02	8.08	8.04	
4	Transparency	m	2.84	2.62	2.52	
5	DO	mg/l	7.98	7.52	6.84	

Table-10: Total biomass of the sample with control environment (Tank-B)

SI	Name of the sample	Quantity	Size/wet weight at Initial month	Size/wet weight at 1 month later	Size/wet weight at 2 month later	Weight Gain (Final-Inital)	Mortality Rate	Morphological change	Behavior change	Remarks
1	Green Mussel	20 nos.	150 gm	160gm	171gm	21gm	24%	Partial Normal	Partial Normal	Not good
2	Scylla serrata	20 nos.	80gm	90gm	105gm	25 gm	35%	Partial Normal	Partial Normal	Not good

Table-11: Physico-chemical parameters of the control environment at Tank C (control unit-2)

SI	Name of the parameter	Unit	parameter reading initial month	Parameter reading 1 month later	Parameter reading 2 month later	Water Exchange
1	Salinity	ppt	25	23.24	22.26	Monthly 70%
2	Temperature	°c	23	22	22.21	
3	PH		7.88	7.72	7.74	
4	Transparency	m	2.54	2.42	2.3	
5	DO	mg/l	6.88	6.42	6.22	

Table-12: Total biomass of the sample with control environment (Tank-C)

SI	Name of the sample	Quantity	Size/wet weight at Initial month	Size/wet weight at 1 month later	Size/wet weight at 2 month later	Weight Gain (Final-Inital)	Mortality Rate	Morphological change	Behavior change	Remarks
1	Green Mussel	20 nos.	150 gm	157gm	166gm	16gm	32%	Abnormal	Abnormal	Not good
2	Scylla serrata	20 nos.	80gm	86gm	100gm	20 gm	38%	Abnormal	Abnormal	Not good

Finally we can say that good water quality would be enhances the biomass of selected species and they show the great adaptive response with the change of water parameter.


Observing Salinity at the sampling station


Sieving benthos with sieve net


Measuring Soil PH


Deploying Green Mussel at Rezukhal


Mussel collection at Moheshkhali


During sampling at Rezukhal


Mussel culture at Rezukhal


Sea water culture unit at BORI


Live feed culture unit at BORI


During crab health observing at BORI culture unit

During fish heath observation at BORI culture unit

Chemical analysis at COD lab-1

Sample analysis at COD lab-1

Chemical Oceanography lab-1

Chemical Oceanography lab-2

Marine Specimen preserving

Conclusion

The uptake of anthropogenic changes the seawater chemistry and will significantly impact biological systems in the up- CO_2 by the ocean per oceans. The carbonate ion concentration will also decrease by almost 50% relative to preindustrial levels. Such changes will significantly lower the ocean's buffering capacity and, therefore, reduce its ability to accept more CO_2 from the atmosphere. Laboratory studies revealed that the carbonate chemistry of seawater has a significant effect on the calcification rates of individual species especially on marine invertebrates. This research would be first ever research on ocean acidification in terms of Bangladesh. Furthermore studies will be needed to evaluate the actual acidification status and its impacts in coastal areas of Bangladesh.

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A study on seasonal variation in physico-chemical properties and its impacts on coral associated biodiversity at the south eastern coastal waters of Cox's Bazar, Bangladesh

Md. Tarikul Islam
Scientific Officer

Abstract

The present investigation carried out to assess the seasonal variation in physico-chemical properties and its impacts on coral associated biodiversity at the coastal waters of Saint Martin Island, Bangladesh for a period of July 2018 to June 2019. It shown that the coastal water was significantly influenced by the freshwater discharged from Naf River and through heavy precipitation during the monsoon period. Total nine sampling stations namely Saint Martin Island (S1), ShahporirDwip (S2), Teknaf (S3), Inani (S4), Rezukhal (S5), Himsori (S6), Bakkhali (S7), Moheshkhali (S8) & Sonadia (S9) were considered for taking the desirable parameters reading. The parameters like Dissolved oxygen, Salinity, Temperature, Conductivity, Total dissolved solids, Transparency were determined by using Hanna HI98194, Refract meter, YSI Pro30 multimeter, Hach HQ11d, Winklers Titration method, Secchi disk respectively. Salinity and water pH showed very strong changes between 14 psu to 34 psu and 7.78 to 8.28 due to heavy precipitation and freshwater discharges into the stations from the Naf River. Water pH, Total dissolved solids and Electrical conductivity displayed strong correlation with salinity changes. The physico-chemical parameters such as temperature, Salinity, pH, TDS, Water Transparency and EC were increased during Pre-Monsoon season and decreased during monsoon season. In contrast, only temperature was decreased during winter & monsoon season. The physico-chemical properties have exposed reasonable seasonal and spatial variations. Saint Martin is the only coral Island of Bangladesh and generally we referred it as a biological paradise. Due to the change of physico-chemical properties seasonally, its strongly influenced on the coral associated biodiversity. This study revealed that coral bleaching has been occurred frequently during the monsoon and post monsoon period. About 15% boulder coral were partly bleached. But it is a hope that most of the bleached coral were regenerate easily with the change of physico-chemical properties during the winter and pre-monsoon season. Physico-chemical properties have strong influence on Saint Martin seaweed vegetation. During the study period the author shown that from May to December about 95% seaweed was totally absence and January to April were heavily vegetated. On the other hand due to ocean acidification and surface water warming some of the invertebrate species were migrated from the coastal area to another place and some inhabitants face great problem.

Keywords: Physico-chemical parameters, Coastal waters, Seasonal variation, spatial variation, Cox's Bazar

Introduction

The chemistry of water reveals much about the metabolism of the ecosystem and explains the general hydro biological interrelationship (Meena et al., 2017). The coastal ecosystem is the vibrant host for fauna and flora and it is the most important resource to provide a good platform for the coastal life (Adebola et al., 2019). The physico-chemical parameters of coastal water and the dependence of all life process of these factors make it desirable to take water as an environment. (Soundarapandian et al., 2009).

Coastal marine environments are reported to have greater biodiversity than open ocean regions and majority of world's most productive marine ecosystems are found within coastal environments and owe their productivity, diversity and wealth of life to their terrestrial adjacency (Bierman et al., 2009). The open ocean is a lot of stable compare to the close to shore waters wherever the interaction with terrestrial and makes the variations in hydro graphic properties. The water quality depends on each natural processes, like precipitation, erosion, weathering of crustal materials and evolution processes like urbanization, industrialization, mining and agricultural activities (Meena et al., 2017). The interactive physical, chemical, and biological processes operation in the coastal ecosystems sustain higher resulting in richness in diversity (Zhou et al. 2007).

The salinity stratification has a strong stabilizing effect on the upper ocean, maintaining a shallow mixed layer (Mignot et al., 2007) and often resulting in the formation of a barrier layer, i.e. a salinity-stratified layer between the bottom of the mixed layer and top of the thermocline (Lukas and Lindstrom, 1991). Barrier layers usually appear during summer in the eastern Bay of Bengal and mature during winter both in amplitude and spatial extent, covering the entire northern Bay of Bengal (Rao and Sivakumar, 2003). In a recent study using an ocean general circulation model, Behara and Vinayachandran (2016) found that freshwater fluxes induced a ~0.5°C warming in the northwestern Bay of Bengal during summer, and 0.5 to 1.5°C cooling in the eastern Bay of Bengal during both summer and winter. Climate models and theoretical arguments indeed support an intensification of the hydrological cycle as the troposphere warms in response to increasing greenhouse gases concentrations (e.g. Held and Soden, 2006). The observational records already detect an intensification of salinity contrasts as a result, i.e. increasing salinities in regions dominated by evaporation, and decreasing salinities in high rainfall regions, including in the Bay of Bengal (e.g. Durack and Wijfels, 2010).

The pH level reduction rate may be around 0.08 per year which is very shocking news for the biodiversity of the Bay of Bengal. Feely et al. 2009 have shown a map on the global ocean acidification scenario of 2095 that the pH level of sea water in Bay of Bengal will be less than 8.0 in 2050 and bellow 7.8 in 2095. They also reported that the current pH of North Indian Ocean where Bay of Bengal is situated is 8.068 ± 0.03. Over the past 200 years, atmospheric CO_2 has increased from 280 ppm to a global average of nearly 390 ppm due to burning of fossil fuels, cement production and landuse changes (Hilmi et al. 2012).

The Bay of Bengal is a reservoir of lot of marine species specially shells, coral reefs and many sea fish and mammals. The effect of ocean acidification on marine ecosystems and organisms that inhabit them has only recently been recognized and is of serious concern to scientists and policy makers involved in climate change, biodiversity and the marine environment.

The Physico-chemical parameters, which is useful to evaluate the health of the coastal system, the present study was conducted to study the Physico-chemical properties of water in some place of south eastern coastal area of Cox's Bazar, Bangladesh during July 2018 to June 2019.

Materials and Methods

Study area

Cox's Bazar is a city, fishing port, tourism center and district headquarter in south-eastern Bangladesh. The beach in Cox's Bazar is sandy and has a gentle slope and it is the longest natural sea beach in the world running 120 kilometers (Panday, V.C., ed. 2004). A lot of rivers and channels flow to the south eastern part of the Bay of Bengal and these rivers carry fresh water to the open sea. The mixing of fresh water with sea water reduces the pH and Salinity.

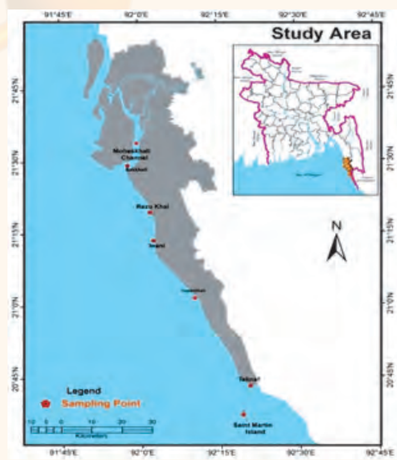


Figure 1: Study area

The study area consists of nine different locations (S1) Saint Martin Island (Lat. 20º63′33″ N and Lon. 92º32′54″ E), (S2) ShahporirDwip (Lat. 20º76′89″ N and Lon. 92º34′25″ E), (S3) Teknaf (Lat. 20º91′10 N and Lon. 92º20′′16″ E), (S4) Inani (Lat. 21º13′68″ N and Lon. 92º04′15″ E), (S5) Rezukhal (Lat. 21º30′52″ N and Lon. 92º04′05″ E), (S6) Himchori (Lat. 21º33′15″ N and Lon. 92º00′67″ E), (S7) Bakkhali (Lat. 21º45′70″ N and Lon. 91º93′29″ E), (S8) Moheshkhali (Lat. 21º58′13″ N and Lon. 91º98′79″ E), and (S9) Sonadia Island (Lat. 21º47′79″ N and Lon. 91º88′67″ E), respectively. The study area is shown in the Figure 1.

The main intention of study is to estimate the baseline characteristics for the sea water and to analyze the chemical and physical characteristics of sea water of the southeastern coast of Cox's Bazar.

Estimation of Water Analysis

Water samples were collected monthly from the nine stations for a period of one year during July 2018 to June 2019. Samples were collected every month with a sterilized plastic bottle and immediately kept in an ice box and transported to the laboratory for determining the physical and chemical parameters. Water temperature was measured by using digital multi-stem thermometer of 0.1^{o} C accuracy. Salinity was measured by using a hand held refractometer (Atago hand refractometer, Japan). Total dissolved solids, pH and electrical conductivity were analyzed by using Hanna HI98194 multimeter and YSI portbablemultimeter.

Statistical Analysis

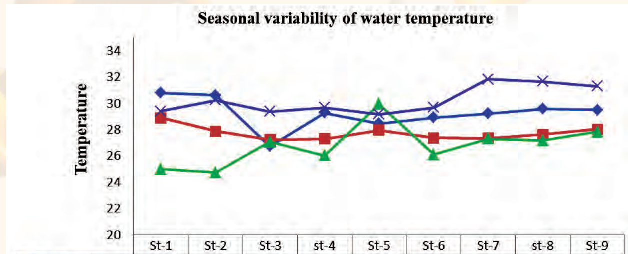
For the data analysis Microsoft Excel 2010 and SPSS 16.0 has been used.

Result and Discussion

Physico-chemical parameters were measured one of the most significant characteristics that have the ability to impact marine ecosystem and shown wider progressive and spatial variations. All physico-chemical parameters have presented with certain periodic patterns that are typical to the tropical marine ecosystem.

Status of Sea Surface Temperature (SST)

The temperature is important for its effects on the chemistry and biological activities of organisms in water. The seasonal variation of the coastal water temperature values ranged from 25-30±1.72 (S1), 24-30±1.72 (S2), 26-29±1.72 (S3), 26-29±1.72 (S4), 27-29±1.72 (S5), 26-29±1.72 (S6), 27-31±1.72 (S7), 27-31±1.72 (S8), 27-31±1.72 (S9) (Figure-2). The maximum temperature (31.8°C±1.72°C) was recorded in Bakkhali (S7) during pre-monsoon and minimum (24.7°C±1.72°C) was recorded in ShahporirDwip (S2) during winter season. Generally, surface water temperature is influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling and mix up with ebb and flow from adjoining neritic waters. Less solar radiations with misty sky and moderate rainfall during the Monsoon season may greatly reduce the water temperature (Karuppasamy et al., 1999). Higher temperature values recorded in the dry season may be because of heat raising temperature of surface water. Low temperature in post monsoon season was due to winter (Das et al., 1997).



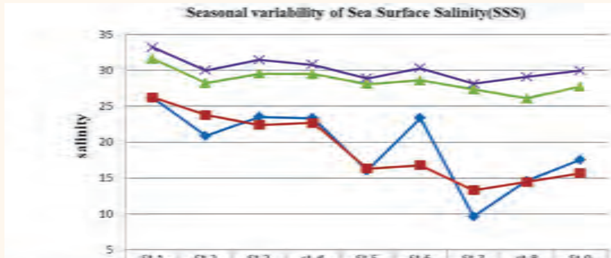
	St-1	St-2	St-3	st-4	St-5	St-6	St-7	st-8	St-9
Monsoon	30.8	30.6	26.74	29.26	28.46	28.92	29.23	29.57	29.5
Post monsoon	28.9	27.87	27.25	27.3	27.96	27.38	27.35	27.62	28.02
Winter	25	24.73	27.07	26.03	29.94	26.1	27.3	27.16	27.83
Pre monsoon	29.4	30.23	29.37	29.67	29.17	29.67	31.83	31.66	31.3

Figure-2: Variability of Water Temperature

Status of Sea Surface Salinity (SSS)

Salinity acts as a vital factor among environmental parameters in distribution of living organisms to the earnest coastal water. Fluctuations in salinity affect fauna of the coastal areas and determine the succession of species and it has a high influence on the marine environment of the Bay of Bengal. The seasonal variation of observed salinity values (‰) are ranged from 26-33±6.19 (S1), 20-30±6.19 (S2), 22-31±6.19 (S3), 22-30±6.19 (S4), 16-30±6.19 (S5), 16-30±6.19 (S6), 9-28±6.19 (S7), 14-29±6.19 (S8), 15-29±6.19 (S9) (Figure-3). The maximum salinity was recorded in Saint Martin Island 33.21±6.19 ‰ (S1) during Pre-monsoon season and the minimum was recorded in Bakkhali 9.6±6.19‰ (S7) during Monsoon season. The ascertained higher values might be attributed to the low quantity of rainfall, higher rate of evaporation and additionally as a result of neritic water dominance (Balasubramanian and Kannan, 2005). Observations just like to present study were reported earlier by Palpandi (2011) in Vellar estuary.

The variability of salinity indicates the upright mixing of the water column due to the nature of the sea-tide seasonally. Salinity demonstrates the negative liaison with phytoplankton biota, whereas Dissolved Oxygen (DO) indicates the symmetry between respiration and photosynthesis and exposed a positive liaison (Barik, et al, 2017). Salinity acts as a limiting factor in the distribution of living organisms, and its variation caused by dilution and evaporation is most likely to influence the fauna in the intertidal zone (Gibson, 1982).



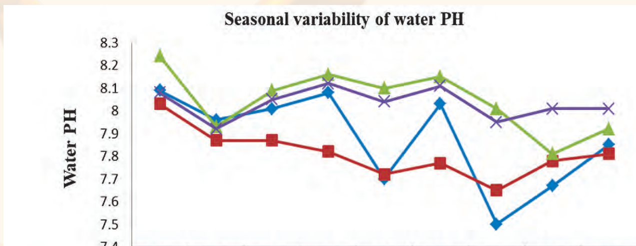
	St-1	St-2	St-3	st-4	St-5	St-6	St-7	st-8	St-9
Monsoon	26.15	20.86	23.5	23.37	16.03	23.34	9.6	14.6	17.54
Post monsoon	26.23	23.8	22.39	22.67	16.3	16.8	13.3	14.43	15.69
Winter	31.63	28.23	29.53	29.5	28.1	28.6	27.34	26.1	27.76
Pre monsoon	33.21	30	31.46	30.8	28.9	30.33	28.16	29.1	29.97

Figure-3: Variability of Sea Surface Salinity

Status of Water $_{P}$H

The pH value depends upon the salinity and temperature of the water and the climatic conditions of that area. The chemical & biological condition of water also places a role in the control of pH concentrations. The seasonal variation of observed PH values were ranged from 8.03-8.24± 0.16(S1), 7.87-7.96± 0.16 (S2), 7.78-8.09± 0.16 (S3), 7.82-8.16± 0.16 (S4), 7.70-8.10± 0.16 (S5), 7.77-8.15± 0.16 (S6), 7.50-7.01± 0.16 (S7), 7.67-8.01± 0.16 (S8), 7.81-8.01± 0.16 (S9) (Figure-4).

The maximum PH was recorded in Saint Martin Island 8.24±0.16 (S1) during Pre-monsoon season and the minimum was recorded in Bakkhali 7.5±0.16 (S7) during Monsoon season. The low pH observed during the month of June to September may be due to the influence of fresh water, dilution of seawater, low temperature and organic matter decomposition as suggested by Ganesan (1992). Generally, fluctuations in pH values during different seasons of the year is attributed to factors like removal of CO_2 by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, low primary productivity, reduction of salinity and temperature and decomposition of organic materials as stated by Rajasegar, 2003. High pH values observed may cause sea water deprivation and high density phytoplankton effect (Prabu, et al., 2008).



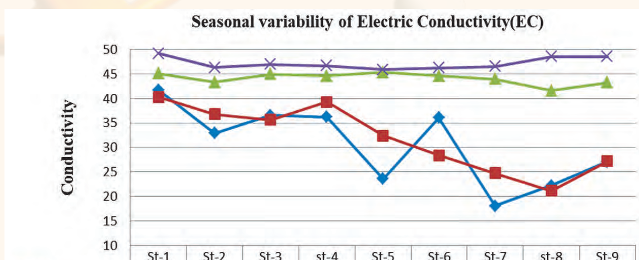
	St-1	St-2	St-3	st-4	St-5	St-6	St-7	st-8	St-9
Monsoon	8.09	7.96	8.01	8.08	7.7	8.03	7.5	7.67	7.85
Post monsoon	8.03	7.87	7.87	7.82	7.72	7.77	7.65	7.78	7.81
Winter	8.24	7.93	8.09	8.16	8.1	8.15	8.01	7.81	7.92
Pre monsoon	8.08	7.92	8.05	8.12	8.04	8.11	7.95	8.01	8.01

Figure-4: Variability of Water pH

Status of Electric Conductivity

Conductivity is a measure of water's capability to pass electrical flow. It shows seasonal variation with respect to different study sites. It chiefly depends on the amount of dissolved solids in water. The conductivity of water is affected by the suspended impurities and also depends up on the amount of ions in the water.

The seasonal variation of observed electric conductivity (mS/cm) values were ranged from 40-49± 8.89 mS/cm (S1), 32-46± 8.89 mS/cm (S2), 35-46± 8.89 mS/cm (S3), 36-46± 8.89 mS/cm (S4), 23-45± 8.89 mS/cm (S5), 28-46± 8.89 mS/cm (S6), 18-46± 8.89 mS/cm (S7), 21-48± 8.89 mS/cm (S8), 27-48± 8.89 mS/cm (S9) (Figure-5). The maximum EC was recorded in Saint Martin Island 49.22± 8.89 mS/cm (S1) during Pre-monsoon season and the minimum was recorded in Bakkhali 18.09± 8.89 mS/cm (S7) during Monsoon season. The present study agrees with earlier reported by (Surana, R et al., 2013). High conductivity during post monsoon might be attributed to low mixing of fresh water input from river (Izonfuo and Bariweni, 2001).



	St-1	St-2	St-3	st-4	St-5	St-6	St-7	st-8	St-9
Monsoon	41.72	32.93	36.54	36.24	23.6	36.08	18.09	22.24	27.12
Post monsoon	40.31	36.8	35.64	39.3	32.45	28.42	24.76	21.17	27.2
Winter	45.1	43.31	44.93	44.59	45.34	44.57	43.98	41.6	43.27
Pre monsoon	49.22	46.3	46.96	46.7	45.87	46.29	46.52	48.56	48.55

Figure-5: Variability of Electrical Conductivity

Status of Total Dissolved Solids (TDS)

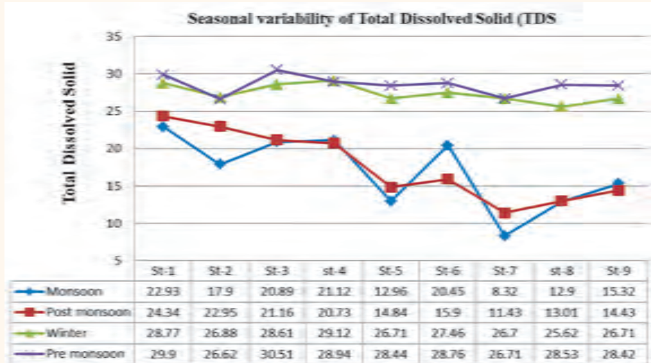


Figure-6: Variability of TDS

Total dissolved solids (TDS) include all of the disassociated electrolytes that make up salinity concentrations, as well as other compounds such as dissolved organic matter. The amount of total dissolved solids in sea water was increased by the influence of activities on the land. The investigated coastal water TDS (g/l) values ranged from 22-29±6.28g/l (S1), 17-26±6.28g/l (S2), 20-30±6.28g/l (S3), 20-29±6.28g/l (S4), 12-28±6.28g/l (S5), 15-28±6.28g/l (S6), 8-26±6.28g/l (S7), 12-28±6.28g/l (S8), 14-28±6.28g/l(S9) (Figure-6). The maximum TDS (30.5±6.28g/l) was recorded in Teknaf (S3) during pre-monsoon and minimum (8.32±6.28g/l) recorded in Bakkhali (S7) during monsoon season.

TDS can be influenced by changes in pH. Changes in the pH will cause some of the solutes to precipitate or will affect the solubility of the suspended matter. TDS value was higher during pre-monsoon and lower during monsoon. The mean values for the total dissolved solids (TDS) were higher in dry season than in the rainy season. The lower values of this parameter suggest that the runoff water only contributes to its dilution in the rainy season (Izonfuo and Bariweni, 2001). Water with a high total dissolved solids indicated more ionic concentration, which is of inferior palatability and can induce an unfavorable physicochemical reaction in the consumers. Kataria et al., (1996) reported that increase in value of TDS indicated pollution by extraneous sources.

Impacts of seasonal variation of physic-chemical properties on coral associated biodiversity

Corals occupy less than 1% of the world's ocean bed, but provide habitats to more than one quarter of the marine life globally. There are at least 68 species of corals and about 100 species of seaweed around Saint Martin Island, making its marine area a unique biodiversity hot spot in Bangladesh. The study revealed that about 15% boulder coral were partly bleached. But it is a hope that most of the bleached coral were regenerate easily with the change of physico-chemical properties during the winter and pre-monsoon season. Physico-chemical properties have strong influence on Saint Martin seaweed vegetation. Field study shows, from May to December about 95% seaweed is totally absent and January to April is heavily vegetated. On the other hand due to ocean acidification and surface water warming some of the invertebrate species migrate from coastal area to other places.

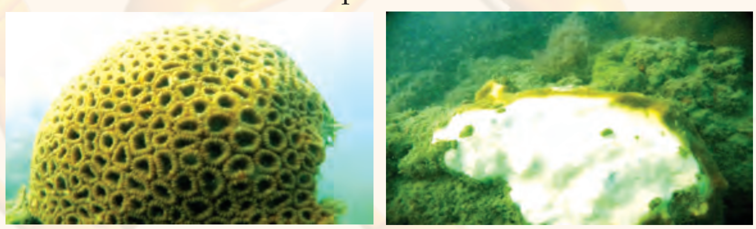


Figure 6&7: Healthy (6) & Bleached (7) Coral of Saint Martin's Island, Bangladesh respectively.

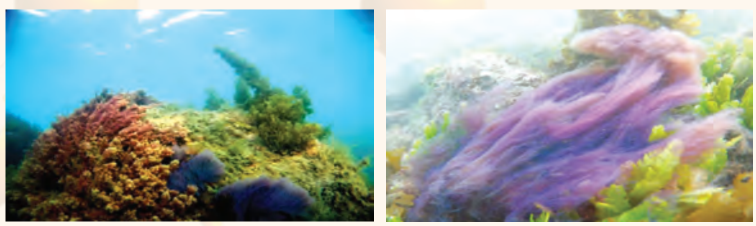


Figure 8 & 9: Seaweed vegetation of Saint Martin's Island Bangladesh

Conclusion

The study aims to know the physico-chemical characteristics in the water quality based on season and anthropogenic inputs. The seasonal fluctuation in physico-chemical parameter the seasonal tidal amplitude and fresh water influx leading to the continual exchange of organic, inorganic, plant and animal matters in the coastal water. However, the nine stations the water quality parameters such as temperature, pH, TDS and EC were increased during Pre Monsoon season. The precipitation received during the Monsoon long and short rainy periods, were found have appreciable impact on coastal water characteristics at this location. Distributions of nutrient levels were also altered by the seasonal variation.

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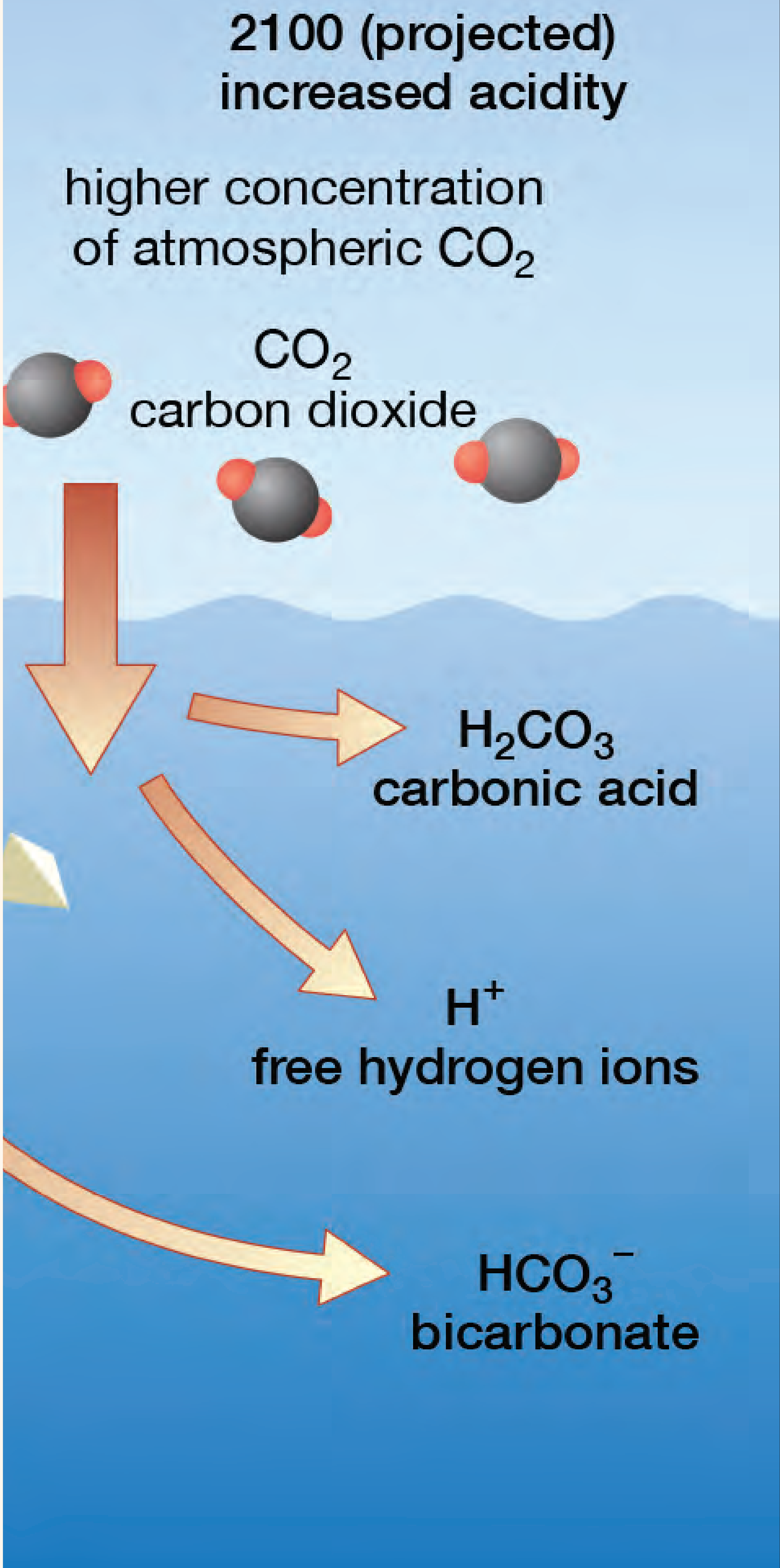
Mr. Tarikul Islam has been served as a Scientific Officer in National Oceanographic Research Institute establishment project (NORIP) from July 2014 to December 2017. Now he has been working as a Scientific Officer at Bangladesh Oceanographic Research Institute (BORI) since January 2018. Mr. Islam received his B.Sc& M.S in Marine Science under the Institute of Marine Sciences & Fisheries from University of Chittagong. Mr. Islam has a strong interest in Marine Chemical Ecology, Ocean Acidification, Mariculture, Nutrient Dynamics & Planktology.



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Biological Oceanography Division

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Chapter 5

Biological Oceanography Division

BOD at a Glance

Biological Oceanography is the study of life in the oceans- the distribution, abundance, adaptation and production of marine species along with inter and intra relationship (processes) that govern species' spread, development and coping to the environment. Biological oceanography mainly focuses on marine organisms their morphology, life cycle, diversity, nutritional sources, motility, and metabolism, productivity and role in global carbon cycle, etc.

The Biological Oceanography Division (BOD) is implementing the mandate of BORI Act 2015. This division is engaged in exploring biological resources of the Bay of Bengal as a part of baseline study through Research and Development (R&D) projects. The division is working to find potential commercial seaweeds around the Saint Martin’s Island, evaluating occurrence, distribution and diversity of phytoplankton & zooplankton in the Bay of Bengal.

- Seaweed Study: The Seaweed Research Team (SRT) of BOD is studying taxonomic variability and distribution of seaweeds around St. Martin’s Island.
- Plankton Diversity Study: A total of 220 phytoplankton taxa from nine divisions, 109 taxa of zooplankton from 24 major groups and 53 Ichthyoplankton are identified from BOD.
- Supervise MSc thesis: So far 3 students completed their MSc thesis research under the supervision and laboratory support of BOD.
- Dr. Fridtjof Nansen Research cruise survey: Scientist from BOD participated in Dr. Fridtjof Nansen Research cruise across the whole BoB survey and contributed in the CTD and Plankton Laboratory.
- Collaboration with Research Institute and Universities: BOD is doing collaborative research on Seaweed Biochemical composition study with BCSIR, seaweed genetic diversity study with NIB, seaweed Bar code study with Department of Fisheries-BSMRAU, seaweed study and mari-culture with BFRI, and seaweed Study with Institute of Marine Sciences and Fisheries- University of Chittagong.

General Features

Primary Productivity: Primary productivity is the rate at which atmospheric or aqueous carbon dioxide is converted by autotrophs (primary producers) to organic material. Primary production via photosynthesis is a key process within the ecosystem, as the producers form the base of the entire food web, both on land and in the oceans. The oceans play a significant role in global carbon budgets via photosynthesis. Approximately half of all global net annual photosynthesis occurs in the oceans, with ~10-15% of production occurring on the continental shelves alone (Müller-Karger et al. 2005).

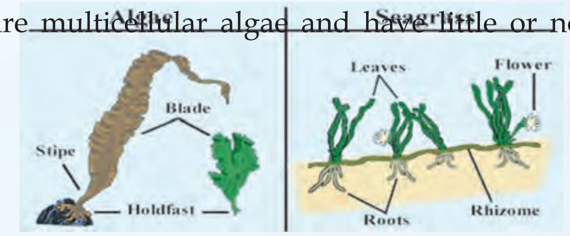
Phytoplankton: Derived from the Greek words phyto (plant) and plankton (made to wander or drift), phytoplanktons are microscopic organisms that live in watery environments, both salty & fresh. Like land plants, phytoplankton have chlorophyll to capture sunlight, & they use photosynthesis to turn it into chemical energy. They consume CO_2 & release oxygen.

Zooplankton: The word zooplankton is derived from the Greek zoon meaning "animal", and plankton meaning "wanderer" or "drifter". Individual zooplanktons are usually microscopic, but some (such as jellyfish) are larger and visible to the naked eye.

Seaweed: Seaweed or macro algae refer to several species of macroscopic and multi-cellular marine algae.

Seagrass: Seagrasses are flowering plants which grow in marine environments, despite their name, seagrass are actually not ‘grasses’ at all, as they do flower.

Difference between Seagrass and Seaweed: Seagrass can easily be confused with marine macroalgae or seaweed but there are many important differences between the two. While seagrasses are considered vascular plants and has roots, stems and leaves, seaweed are multicellular algae and have little or no vascular tissues. The two differ in reproduction, structure, and how they transport nutrients and dissolved gases. The table and diagram below illustrate some of these distinctions.



Source: http://www.sms.si.edu/irlspec/ComparAlgae_Seagr.htm.

Table 1: Difference between Seagrass and Seaweed

--	Seagrass	Macroalgae (Seaweed)
Reproduction	• Have separate sexes • Produce flowers, fruits, and seeds	• Produce spores
Structure	• Evolved from terrestrial plants and have tissues that are specialized for certain tasks • Possess roots, leaves, and underground stems called rhizomes that hold plants in place	• Relatively simple and unspecialized • Holdfast anchors plant to a hard surface; does not possess roots
Transport/ Classification	• Use roots and rhizomes to extract nutrients from the sediment; use leaves for extracting nutrients from the water • Are categorized as vascular, with a network of xylem and phloem that transport nutrients and dissolved gases throughout the plant	• Use diffusion to extract nutrients from the water • Not plants or animals, but protists

Maximum Sustainable Yield: The sustainable yield of natural capital is the ecological yield that can be extracted without reducing the base of capital itself, i.e. the surplus required to maintain ecosystem services at the same or increasing level over time. This yield usually varies over time with the needs of the ecosystem to maintain itself, e.g. a forest that has recently suffered blight or flooding or fire will require more of its own ecological yield to sustain and re-establish a mature forest. While doing so, the sustainable yield may be much less. In fisheries, the basic natural capital, or virgin population, must decrease with extraction. At the same time productivity increases. Hence, sustainable yield would be within the range in which the natural capital together with its production is able to provide satisfactory yield. It may be very difficult to quantify sustainable yield, because dynamic ecological conditions and other factors not related to harvesting induce changes and fluctuations in both the natural capital and its productivity.

Blue Economy and Biological Resources: Bangladesh has vast coastal and marine resources along its south edge. Due to the geographical position and climatic condition, the coastal area of the country is known as one of the highly productive areas of the world. Bangladesh is rich not only in terms of its vast water areas but also in terms of the biological diversity. One of the unique features of the coastal areas is the influence of the mangrove forests, which support a high number of fishes and other commercially important aquatic organisms. Bangladesh formed by a delta plain at the confluence of the several trans-boundary mighty rivers, in usually characterized by its typical geographical settings, the Himalayan range in the North and the Bay of Bengal in the South. These two unique features historically shaped formation of major habitats and human habitation, social-economic structures, development priorities and, often, the basis of relationship and diplomacy with the neighbors and other south Asian countries. Country's 710 km long coast line extending from the tip of St. Martin's Island in the southeast to the west coast of Satkhira and 121,110 km^2 sea area are characterized with uniquely differentiated ecosystems having significant ecological and economic importance and potential. There will be a human flow to the southern part of Bangladesh due to blue economic zone development. It will create employment opportunities and other income-generating activities, develop other social services, security services as well as the overall standard of life for the local people at coastal areas. Sector wise emphases are given below:

Fishery: A large number of commercially important fishes have long been exploited which are of high export values. Shrimp Mariculture has become a highly traded export-oriented industry now-a-days. In spite of having bright prospects, marine Mariculture on a commercial basis as well as marine stock enhancement and sea ranching are yet to be developed. The marine fisheries sector has been suffering from chronic disintegration and mismanagement that have led to many consequences. Most of the commercially important fish stocks are either over-exploited or under threat. Marine pollution has reached a level that could create an unmanageable situation in the near future; coastal shrimp farming has generated considerable debates due to its adverse environmental and socio-economic impacts.

Fishing activities will continue to represent a large part of economic and food output for many developing countries. As demand for fish continues to grow, Bangladesh needs to explore options to keep benefiting from this activity while ensuring sustainable management of stocks too.

Coastal aquaculture and Mariculture: Coastal aquaculture and Mariculture offers huge potential for the provision of food and livelihoods, though greater efficiency in provision of feed to coastal aquaculture and maricultureneed to be realized, including reduced fish protein and oil and increased plant protein content, if the industry is to be sustainable. Mariculture under the Blue Economy will incorporate the value of the natural capital in its development, respecting ecological parameters throughout the cycle of production, creating sustainable, decent employment and offering high value commodities for export. Coastal aquaculture and Mariculture is the fastest growing global food sector now providing 47% of the fish for human consumption. As the demand for fish continues to grow and the availability of wild-capture fish decreases, there will be a greater role for mariculture to augment the wild capture supply and ensure that wild stocks for Bangladesh.

Food Security: One billion people in developing countries like Bangladesh depend on seafood for their primary source of protein. Besides this all around the globe, a lot of people like seafood. Oceans can be the biggest sources for food for all the developing countries and may help to meet the challenges of food security issue too.

Biotechnology and Medical Technology: The global market for marine biotechnology products and processes is currently estimated at US $ 2.8 billion and projected to grow to around US$ 4.6 billion by 2017. Marine bio-tech has the potential to address a suite of global challenges such as sustainable food supplies, human health, energy security and environmental remediation. Marine bacteria are a rich source of potential drugs it is also known as probiotic. In 2011 there were over 36 marine derived drugs in clinical development, including 15 for the treatment of cancer. One area where marine bio-tech may make a critical contribution is the development of new antibiotics. The potential scope is enormous; by 2006 more than 14,000 novel chemicals had been identified by marine bio-prospecting and 300 patents registered on marine natural products. On the energy front algal bio-fuels offer promising prospects. The European science Foundation postulates a production volume of 20-80 thousand liters of oil per hectare per year can be achieved from micro algal culture, with even the lower part of this range being considerably higher than terrestrial bio-fuel crops.

Blue Economic Zone of Bangladesh: World Bank (2014) reported that middle-income economies are those with a Gross National Income (GNI) per capita of more than US$ 1045 but less than US$ 12,746. Bangladesh was found in lower-middle-income country category in the year 2014, as it achieved US$ 1080.00 which was only US$ 958 in the year 2013. Bangladesh Bureau of Statistics (BBS) published that the per capita income in Bangladesh rose from $ 1190 to $ 1314 on May 14, 2015.

Gimenez, et al. (2014) stated that the vision 2021 plan and the associated perspective plan 2010-2021, adopted by the Government of Bangladesh lay out a series of development targets for 2021. Among the core targets identified to monitor the progress toward the vision 2021 objectives is that of attaining a poverty headcount of 14 percent by 2021. The rate of poverty headcount was about 28.5 percent by 2015, which significantly ahead of scheduled at Millennium Development Goal (MDG). Attaining the vision 2021 poverty target of 14 percent by 2021, however, is less certain as it requires a GDP growth of at least 8 percent, or more than 2 percentage points higher than that observed in recent years.

According to the Bangladesh Bureau of Statistics (2016) records, GDP in Bangladesh was 7.11% in FY: 2015-2016 at Bangladesh and estimated to be increased at 7.20 in 2017 (BBS, 2016). So, the trend is positive, and if Bangladesh cannot utilize all the possible scopes as exporting sectors, marine resources, it may not be possible to become a Middle Income Country within the expected year by 2021.

Bangladesh has an aim to graduate from the Least Development Country (LDC) status to that of a middle income country by 2021 as per the United Nations' classification. In this context, it is very important to assess the capacity of the country's social infrastructure in achieving the desired level of economic growth rate and subsequently the targeted per capita income level.

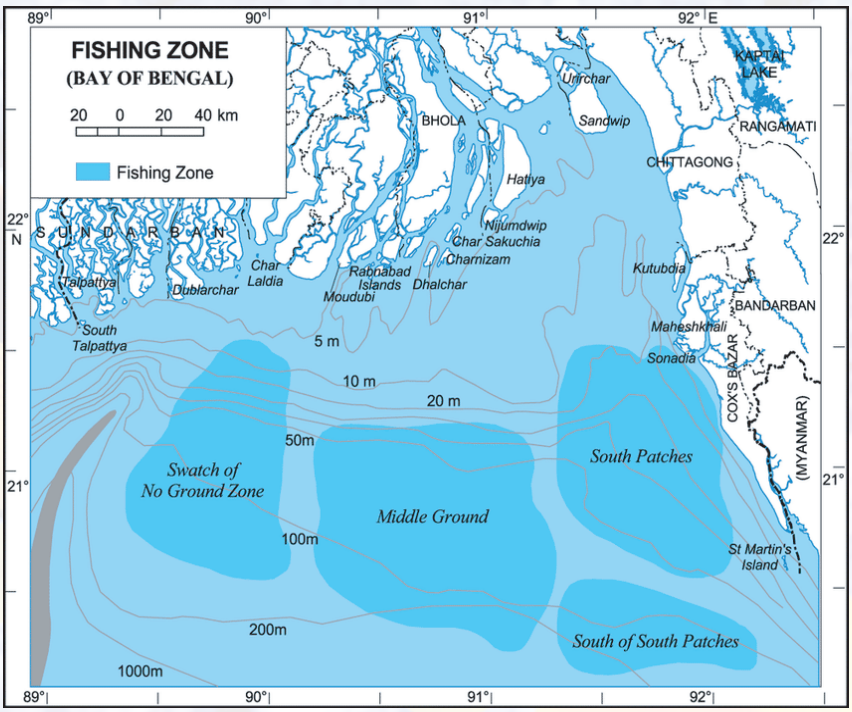
Bangladesh can develop port facility, capacity as well as increase in numbers too. Having more ports & developing the existing ports will be lower operating costs, even from the higher sized of vessels too. Including tourism all the scopes can help to attend the goals accordingly.

Marine Fishing ground in Bangladesh

1. South Patch - Located at 91.30^{0} E to 92.10^{0}E and 20.55^{0} N to 21.52^{0}N, having a total area of 3,662 sq km. Depth ranging from 10m to 100m. Bottom sediment is sandy or slightly muddy sand. Nearest distance of the ground from Chittagong and Cox's Bazar is 40 km and 10 km respectively. Salinity in surface water ranges from 26 ppt to 32ppt and 30 ppt to 35 ppt in bottom water. Water temperature varies between 20^{0}C and 28^{0}C.

2. South of South Patch - Located at 91.30^{0} E to 92.20^{0} E and 20.15^{0} N 20.50^{0}N, having an area of 2,538 sq km. The nearest boundary of this area is 5 km from Teknaf. Depth ranges from 10m to 100m. Within this ground 75% of the area is more than 40m deep. Bottom is sandy or muddy sand. Surface salinity ranges from 18ppt to 34ppt and bottom water salinity from 28ppt to 38ppt. Water temperature ranges between 22^{0}C and 30^{0}C.

3. Middle Ground - Located at 90.20^{0} E to 91.30^{0} E and 20.25^{0} N to 21.20^{0} N, having a total area of about 4,600 sq km. The nearest distance from Cox's Bazar is about 65 km. The depth of 70% of the total area is more than 40m. Bottom sediment is soft mud or muddy sand. Surface salinity ranges from 22 ppt to 34 ppt and bottom salinity 28 ppt to 35 ppt. Water temperature is between 26^{0}C and 28^{0}C.



Source : Iqbal et al., 2011

4. Swatch of No Ground - Located at 89.35^{0}E to 90.10^{0} E and 20.55^{0} N to 21.55^{0} N, about 30 km away from Dublarchar and 40 km from Sunarchar. Total area is about 3,800 sq km, of which 70% is more than 40m deep. Overall depth of the area ranges from 10m to 100m. Bottom sediment consists of muddy sand. Surface salinity is 28ppt to 34ppt, while the bottom salinity is 30 ppt to 35 ppt. Water temperature falls within 24^{0}C to 30^{0}C.

Inception Activity of BOD

Sample Collection from the Study Area (Saint Martin Island)

Data Processing in the Laboratory at BORI

Preliminary taxonomic checklist of marine algae (seaweed) around St. Martin's Island Bangladesh- A baseline survey

Abu Sayeed Muhammad Sharif
Senior Scientific Officer

Abstract

The present study was conducted around the St. Martin's Island to prepare a taxonomic checklist of seaweed. The study was executed into three phases, viz: phase 1: 25 February to 2nd March; phase 2: 28 March to 1st April; and phase 3: 9 April to 12 April. From the findings of the present study, it is revealed that a total of 72 species were found at 10 sites around St. Martin's Island. 41 species were identified among the 72 species and reported as a checklist. Among 41 identified species, 16 species belong to Phaeophyceae, 13 species belong to Rhodophyta and 12 species belong to Chlorophyta. The occurrence of seaweed in the study area varied due to spatial and temporal impacts. Rhodophyta was the dominant group in the south (Site 1 and site 2), southeast (Site 3 and site 4), north (site 6 and site 7) and northwest (site 8) sites. The taxonomic checklist provides preliminary information on the species that is important to conserve these species in that specific area.

Keywords: Taxonomic checklist, Seaweeds, Species, Spatio-temporal, St. Martin's Island

Introduction

Seaweed is commonly known as marine algae that have no true roots, stems or leaves (Apayd n et al. 2009). They are widely distributed in the ocean and seas attached to substrates such as sand, mud, rocks, shells, coral inter alia, shells and other plant bodies (like mangroves) (Cadar et al. 2016; Apayd n et al. 2009). In Bangladesh, the natural abundance of commercially important seaweeds is reported from the St. Martin's Island and some south-eastern rocky area near Inani shore. St. Martin's's Island have got rocky substratum and are the suitable natural growth of seaweeds. About 177 species of seaweeds have been recorded in the coastal and estuarine areas of Bangladesh (Islam 1976; Islam and Aziz, 1987).

Seaweeds play a vital role in the nutrient dynamics of coastal systems and reflect variations in water quality (Wilson, 2002). Several possible uses of seaweeds have been identified and these have been divided into 10 categories (1) agriculture, horticulture and agronomy, (2) uses in animal aquaculture, (3) aesthetics, (4) cosmetics, (5) environmental health, monitoring and remediation, (6) food, (7) health, thalassic and wellness, (8) industry, (9) pharmaceutical and pharmacology and (10) science, technology and biomedicine (Apayd n et al. 2009). Several species are extensively used as food (humans and livestock), for the extraction of agar and carrageenan, in traditional medicine or as biofertilizer (Huynh and Nguyen H. Dinh, 1998; Dang et al. 2007). In Asia, seaweed is consumed as vegetable one of the most important sources of calcium, useful for expectant mothers, adolescents and elderly all exposed to a risk of calcium deficiency (Burtin, 2003). Knowledge of the marine seaweed diversity of St. Martin's Island is not enough.

Many phycologists worldwide have developed a checklist of seaweed flora (Tsiamis et al. 2014; Nguyen Van et al. 2013; Le, 2004; Le and Dai Nguyen, 2006; Pham, 1999). A study on the taxonomy of seaweed is needed to identify and to record the diversity of marine algae on St. Martin's Island, Bangladesh. Some attempts have been made to produce a checklist of St. Martin's Island seaweeds. But these attempts are out of date. The present study is the checklist intended to develop a catalog of marine algae of the St. Martin's Island, Bangladesh.

Objectives of the study

The present study was performed to meet the following objectives

1. Morphometric taxonomical identification of seaweed available in the study area

2. Find out seaweeds diversity and their distribution in the study area
3. Providing a systematic checklist of seaweed as a baseline information for further ecological study

Materials and methods

Study area

The present study was conducted at 10 sites around St. Martin's Island (Figure 1). It is a small island (area only 8 km^2) in the northeastern part of the Bay of Bengal. The coastline and near the shore of the island is sandy with bolder rocks. This habitat and ecosystem are suitable for marine seaweed. Considering the availability and habitat this island was selected for the study.

Table 1: Coordinate table showing sampling sites.

Sampling site	Coordinate		Depth (m)
Site 1	20° 34′ 45″ N	92° 20′ 40″ E	6-7
Site 2	20° 34′ 35″ N	92° 20′ 20″ E	1-2
Site 3	20° 35′ 15″ N	92° 20′ 35″ E	4-5
Site 4	20° 35′ 45″ N	92° 20′ 30″ E	5-7
Site 5	20° 37′ 30″ N	92° 20′ 10″ E	3-5
Site 6	20° 38′ 50″ N	92° 19′ 10″ E	8-10
Site 7	20° 38 ′35 ″ N	92° 18′ 30″ E	10-12
Site 8	20° 37′ 30″ N	92° 18′ 50″ E	3-4
Site 9	20° 36′ 50″ N	92° 18′ 50″ E	5-6
Site 10	20° 34′ 40″ N	92° 19′ 20″ E	7-8

The samples were collected from nearshore under water and the intertidal zone where they are available. The samples were collected by professional divers from underwater (depth approx. 0-12 m). In the nearshore, a total of 10 sites were sampled during the study (Table 1). The surveys were conducted into three phases, phase 1: 25 February to 2nd March; phase 2:28 March to 1st April; and phase 3: 9 April to 12 April. For unfavorable weather in mid-April, only two cruises were carried out for sampling.

Sample collection

Seaweeds sampling surveys were conducted at 10 sites adjacent to shore around the island and about 2 km of intertidal zones from the north and north-west region of the Island. Seaweeds remain attached on the rock, bolder and or coral. The samples were collected carefully to ensure holdfast remain with the samples. Samples were collected systematically by diving, snorkeling, and nearshore (intertidal zone) direct observation. During the sampling period, underwater photographs were also taken as of reference.

Sample preservation

The collected samples were isolated and initially transferred in zipped lock with in-situ seawater and put in the box on board.Then the samples were taken to the room (temporary lab at the hotel) to take photographs. Immediate after photographic session samples were preserved in 8-10% formalin. Then the samples were labeled and put in the vial (plastic bottle). The vial containing samples were then transferred to the BORI laboratory for further study. In the laboratory, samples were photographed carefully with scale and stored in formalin again for future identification.

Species identification

The checklist was based on an exhaustive bibliographical search. Both local reports and scientific publications were screened for species records, and the species were recorded in a database. Seaweed species were identified and recorded in the following groups Rhodophyta, Chlorophyta, and Phaeophyceae. All taxon names were revised to employ currently accepted species names following Algaebase (Guiry and Guiry, 2012), Islam (1976), Islam and Aziz (1982), Zafar (2005), Sarker (1992) etc. References to the original publications are indicated in square brackets, and taxonomic synonyms and their references are included within round brackets. Some few samples are yet under taxonomic identification.

Results and discussion

In the present study, a total of 72 specimens were recorded at 10 sites around St. Martin's Island of which 41 species were identified. Among 41 species, 16 species belong to Phaeophyceae (Table 2), 13 species belong to Rhodophyta (Table 3) and 12 species belong to Chlorophyta (Table 4). It was observed that the composition and distribution of seaweeds varied in spatial and temporal basis around the Island. In the south (Site 1 and site 2), southeast (Site 3 and site 4), north (site 6 and site 7) and northwest (site 8) sites were dominated by Rhodophyta. These sites are characterized by huge species diversity. Site 5 and site 9 observed to be more disturbed and only a few specimens occurred. Whereas site 10 was less diverse but abundance was high.

Table 2: The distribution of Phaeophyceae species around the St. Martin's Island.

Sl No.	Name of the species	Sampling sites										
		St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	St 10	Coast line
1	*Sargassumarnadianum*	√	√	√	√	√	√	√	√	-	-	-
2	*Sargassumoligocystum*	√	√	√	√	√	√	√	√	√	√	-
3	*Sargassumfilipendula*	√	-	√	√	-	-	√	√	-	-	-
4	*Sargassumilicifolium*	√	√	√	√	√	√	√	√	-	-	-
5	*Pudinafraseri*	-	√	-	-	-	√	√	-	-	-	√
6	*Padinaantillarum*	-	√	√	√	√			√		-	√
7	*Padinaantillarum*	√	-	-	-	-	-	-	-	-	-	√
8	*Padinagymnospora*	√	√	√	√	√	-	-	√	-	-	√
9	*Padinaboryana*	-	√	-	-	-	-	-	√	-	-	√
10	*Spatoglossumasperum*	-	-	√	√	-	-	-	√	√	-	-
11	*Hydroclathrusclathratus*	-	√	√	√	-	-	-	-	-	-	√*
12	*Colpomeniasinuosa*	-	-	√	√	-	-	-	-	-	-	*
13	*Rosenvingeaintricata*	-	-	√	√	-	-	-	-	-	-	*
14	*Spatoglossumsp*	√	√	√	√	-	√	√	√	-	-	*
15	*Padinafraseri*	-	√	-	-	-	-	-	-	-	-	√
16	*Dictyotamenstrualis*	-	-	√	-	-	√	√	-	-	-	-

Legend: " √ "= available, "*"= drifted from other area and "-" = not recorded

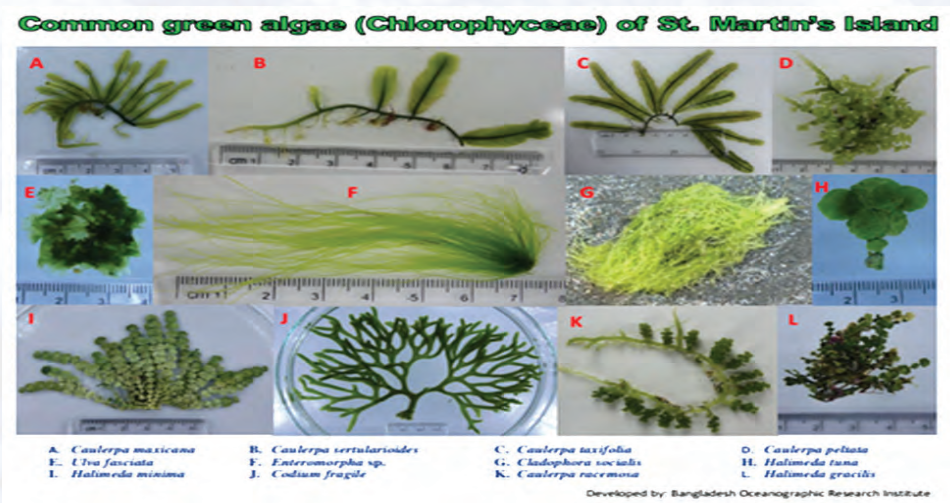
Table 3: The distribution of Rhodophyta species around the St. Martin's Island.

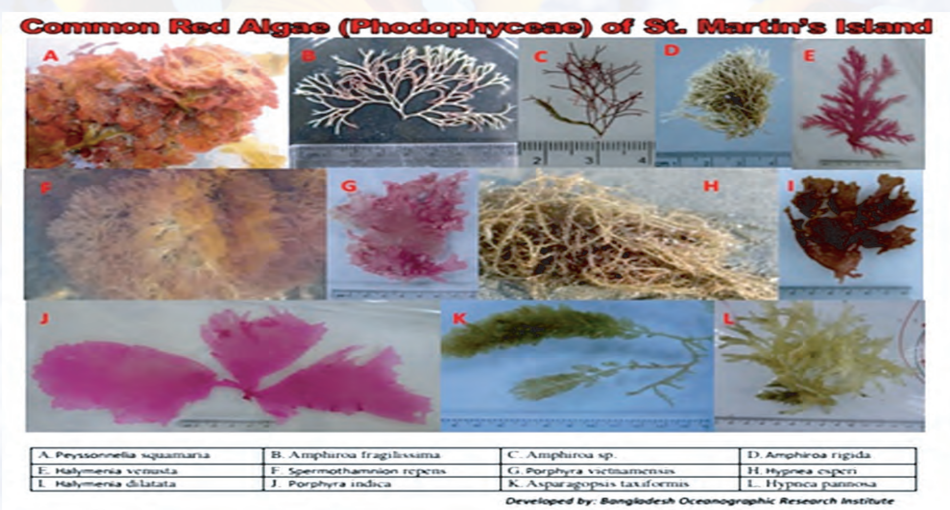
Sl No.	Name of the species	Sampling sites										
		St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	St 10	Coast line
1	*Asparagopsistaxiformis*	-	√	√	√	-	-	-	√	-	-	-
2	*Amphiroaliagora*	-	√	-	-	-	-	-	√	-	-	-
3	*Peyssonneliasquamaria*	-	-	√	√	-	-	-	√		-	-
4	*Halymeniavenusta*	-	-	√	√	-	√	√	-	-	-	-
5	*Porphyravietnamensis*	-	-	√	√	-	√	√	-	-	-	-
6	*Amphiroarigida*		√	√	√	-	-	-	-	-	-	-
7	*Porphyraindica*	-	-	√	√	-	-	-	-	-	-	-
8	*Amphiroafragilissima*	-	-	-	-	-	-	√	-	-	-	
9	*Hypneapannosa*	-	-	-	-	-	-	√	-	-	-	*
10	*Halymeniadilatata*	-	-	√	√	-	-	√	√	-	-	-
11	*Eucheumacottonii*	√	√	√	√	√	√	√	√	√	√	*
12	*Hypneaesperi*	√	-	√	√	-	√	√	√	-	√	-
13	*Spermothamnionrepens*	-	√	√	√	-	-	-	√	-	-	√

Table 4: The distribution of Chlorophyta species around the St. Martin's Island.

Sl No.	Name of the species	Sampling sites										
		St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	St 10	Coast line
1	*Codium fragile*	-	-	-	-	-		√	-	-	-	-
2	*Caulerparacemosa*	√	√	√	√	√	√	√	√	√	√	√
3	*Caulerpapeltata*	-	-	-	-	-	-	-	√	-	-	-
4	*Halimeda tuna*	√	√	√	√	-	√	√	√	-	-	√
5	*Halimeda minima*	-	√	√	√	-	√	√	√	-	-	√
6	*Halimedagracilis*	-	√	-	-	-	√	√	√	-	-	-
7	*Caulerpamaxicana*	-	√	√	√	√	√	√	√	-	-	√
8	*Caulerpataxifolia (other one)*	-	√	√	√	-	√	√	√	-	-	√
9	*Caulerpasertularioides (S.G.Gmelin) M.Howe*	-	√	√	√	-	√	√	√	-	-	√
10	*Enteromorpha*sp.	-	-	-	-	-	-	-	-	-	-	√
11	*Ulvafasciata*	-	√	-	-	-	-	-	-	-	-	√
12	*Cladophorasocialis*	-	-	-	-	-	-	-	-	-	-	√*

It was bserved that Phaeophyceae and Chlorophyta formed colony whereas Rhodophyta was found scattered. Again Chlorophyta mostly occurred at shallow region whereas Phaeophyceae were found at shallow and middle zone and Rhodophyta at the deeper area. Sargassum, Padina, and Dictyota were dominating species of Phaeophyceae group. Hypnea, Porphyra, and Halymenia were dominating species belong to the Rhodophyta group while Caulerpa and Halimeda were dominating species of Chlorophyta group. The photographs of common seaweeds of green, red and brown algae are figured bellow.





Conclusion

St. Martin's Island is a very dynamic in its ecosystem that has a great diversity in case of seaweed species. Though the species occurrence varied with respect to sites and seasons, a great variety of seaweed was recorded in the present study. A systematic checklist was prepared on the basis of recorded seaweeds species. This checklist can be used as baseline information for researchers, academician, and policymakers. This species checklist is very important for the further ecological study that is required for the conservation of the biodiversity. Biodiversity plays important role in the economy since it is regarded as a potential renewable energy.

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Study on seaweed Biochemical composition with references to physico-chemical parameters of water, bottom sediment and continuation of taxonomic identification of seaweeds around St. Martin Island, Bangladesh

Abu Sayeed Muhammad Sharif
Senior Scientific Officer

Abstract

The present study was conducted around the St. Martin's Island to prepare a taxonomic checklist of seaweed. From the findings of the present study, the depth of sampling sites ranged from 1.2-10.0 m. Transparency of water fluctuated between 1.5 - 12.5 m. Surface water temperature, salinity, pH, DO, Conductivity and FNU ranged for 22.6-32.1^{o}C, 25.16-33.89‰, 6.67-8.6, 3.90-6.91 mg/L, 41064-52435 µS/cm, 2.4-18.4 respectively whereas bottom water temperature, salinity, pH, DO, Conductivity and FNU varied for 21-31.2^{o}C, 28.09-35.81‰, 6.3-8.8, 4.22-6.73 mg/L, 47605-54642 µS/cm, 2.3-41.1 respectively. The concentration of nutrients in surface water recorded 0.0-19.93 mg/l for PO_4-P, 0.0-2.5 mg/l for NO_3-N, 0.0-5.43 mg/l for NO_2-N, 0.0-10.0 mg/l for SiO_3 and 0.96-12.55 mg/l for NH_3 while the concentration of nutrients in bottom water were recorded in the range of 0.03-20.74 mg/l for PO_4-P, 0.0-2.1 mg/l for NO_3-N, 0.0-7.0 mg/l for NO_2-N, 0.0-3.0 mg/l for SiO_3 and 1.32-12.8 mg/l for NH_3. Sediment temperature and pH varied from 20.0-32.0^{0} C and 5.3-7.9. Gravel, shell, sand and silt+clay ranged for 0.0-12.62%, 0.0-86.22%, 9.25-99.33% and 0.03-23.0% in the study area. The concentrations of heavy metals in water found below the detection limit at all stations during all month. sediment varied from BDL-8.6 mg/kg for Pb; BDL-940 mg/kg for Mn; BDL-22.31 mg/kg for Cr; BDL-49.2 mg/kg for Zn; BDL-42.6 mg/kg for Ni; BDL-316.0 mg/kg for Cu. A total of 84 seaweed species were recorded at 10 sites around the St. Martin's Island. Among 84 species, 19 species belong to Chlorophyta, 44 species belong to Rhodophyta and 21 species belong to Phaeophyceae.

Keywords: Seaweeds, Physico-chemical parameters, Taxonomic identification, St. Martin's Island.

Introduction

Marine seaweed is being used as a source of renewable energy (nutraceutical, biofuel and biofertilizer) (Pise and Sabale, 2010). Seaweeds are rich in proteins, carbohydrates, vitamins, and minerals required for human nutrition (Pise and Sabale, 2010). Seaweed supplies biochemical composition, nutrients, and calories for the human diet (Holdt and Kraan, 2011; K?l?nç et al. 2013; Nunes et al. 2017). The concentration of various carbohydrates in seaweed is higher in seaweed than land plants (Arasaki and Arasaki, 1983). Possible uses of seaweeds have been identified and these have been divided into 10 categories (1) agriculture, horticulture and agronomy, (2) uses in animal aquaculture, (3) aesthetics, (4) cosmetics, (5) environmental health, monitoring and remediation, (6) food, (7) health, thalassic and wellness, (8) industry, (9) pharmaceutical and pharmacology and (10) science, technology and biomedicine (Apayd?n et al. 2009). Several species are extensively used as food (humans and livestock), for the extraction of agar and carrageenan, in traditional medicine or as bio-fertilizer (Huynh and Dinh, 1998; Dang et al. 2007). In Asia, seaweed is consumed as vegetable one of the most important sources of calcium, useful for expectant mothers, adolescents and elderly all exposed to a risk of calcium deficiency (Burtin, 2003). Seaweed is commonly known as marine algae that have no true roots, stems or leaves (Apayd?n et al. 2009). They are widely distributed in the ocean and seas attached to substrates such as sand, mud, rocks, shells, coral inter alia, shells and other plant bodies (like mangroves) (Cadar et al. 2016; Apayd?n et al. 2009). In Bangladesh, the natural abundance of commercially important seaweeds is reported from the St. Martin's Island and some south-eastern rocky area near the Inani shore. St. Martin's Island has got rocky substratum and is the suitable natural growth of seaweeds. About 177 species of seaweeds have been recorded in the coastal and estuarine areas of Bangladesh (Islam 1976; Islam and Aziz, 1987).

Water quality plays an important role in the ecosystem. Different physico-chemical parameters like pH, DO, salinity, temperature has an immense effect on the total marine ecosystem (Dang et al. 2007). Along with physico-chemical parameters, nutrients also exert great influence on the growth of different organisms in the ecosystem.

Heavy metals found in water and sediment create pollution of the aquatic environment regarded as a worldwide concern. Atmospheric deposition or geologic weathering and industrial waste discharge pose heavy metals in marine water and sediments. Since these metals have toxic effect and they can biomagnify in aquatic ecosystems (Rainbow, 2007; Wang and Rainbow, 2008), that's why heavy metals pollution attracted more public concerns (Christophoridis et al. 2009; Larrose et al. 2010; Feng et al. 2011; Sundaray et al. 2011; Varol, 2011; Gao and Chen, 2012; Yang et al. 2012).

Many phycologists worldwide have developed a checklist of seaweed flora (Tsiamis et al. 2014; Nguyen Van et al. 2013; Le, 2004; Le and Dai Nguyen, 2006; Pham, 1999). A study on the taxonomy of seaweed is needed to identify and to record the diversity of marine algae on St. Martin's Island, Bangladesh. Some attempts have been made to produce a checklist of St. Martin's Island seaweeds. But these attempts are out of date and knowledge of the marine seaweed diversity of St. Martin's Island is not enough. The present study is the checklist intended to develop a catalog of marine algae of the St. Martin's Island, Bangladesh. Besides, water quality parameters and nutrients were also analyzed.

Objectives of the Study

1. Analyze physico-chemical parameters of seawater and bottom sediment of sampling sites
2. Collect and store seaweed samples for morphometric taxonomic identification
3. Define the occurrence and distribution of seaweed

Materials and Methods

Study Area

The present study was conducted at 10 sites around the St. Martin's Island (Figure 1). It is a small island (area only 8 km2) in the northeastern part of the Bay of Bengal. The coastline and near the shore of the island is sandy with bolder rocks. This habitat and ecosystem are suitable for marine seaweed. Considering availability & habitat of this island was selected for the study.

The samples were collected from nearshore underwater and the intertidal zone where they are available. The samples were collected by professional scuba divers from underwater (depth approx. 0-12 m). In the nearshore, a total of 10 sites were sampled during the study (Table 1). The surveys were conducted into three phases, phase 1: 25 February to 2nd March; phase 2: 28 March to 1st April; and phase 3: 9 April to 12 April. Since the weather was unfavorable to conduct the sampling in mid-April, that's why only two cruises were carried out.

Table 1: Coordinate table showing sampling sites.

Sampling site	Coordinate around		Depth (m)
Site 1	20° 34' 45" N	92° 20' 40" E	1.5-3
Site 2	20° 34' 35" N	92° 20' 20" E	2.5-4.5
Site 3	20° 35' 15" N	92° 20' 35" E	2-4
Site 4	20° 35' 45" N	92° 20' 30" E	2-5.5
Site 5	20° 37' 30" N	92° 20' 10" E	3-3.5
Site 6	20° 38' 50" N	92° 19' 10" E	3.5-10
Site 7	20° 38 '35 " N	92° 18' 30" E	6-12.5
Site 8	20° 37' 30" N	92° 18' 50" E	2.8-4
Site 9	20° 36' 50" N	92° 18' 50" E	3-6.5
Site 10	20° 34' 40" N	92° 19' 20" E	2.5-4

Figure 1: Map showing the sampling sites

Sample Collection

Seaweeds sampling surveys were conducted at 10 sites adjacent to shore around the island and about 2 km of intertidal zones from the north and north-west region of the Island. Seaweeds remain attached on the rock, bolder and or coral. Sampling was followed by transect methods. A hundred meters transect was sampled from each sampling site. The samples were collected carefully to ensure holdfast remain with the samples. Samples were collected systematically by diving, snorkeling, and nearshore (intertidal zone) direct observation. During the sampling period, underwater photographs were also taken as of reference. Water and sediment samples were also collected from every station to study the physicochemical parameters, heavy metals and soil texture analysis.

Sample Preservation

The collected seaweed samples were isolated and initially transferred in zipped lock with in-situ seawater and put in the box on board. Then the samples were taken to the room (temporary lab at the hotel) to take photographs. Immediate after the photographic session samples were preserved in 8-10% formalin. Then the samples (seaweed, water, and sediment) were labeled and put in the vial (plastic bottle). The vial containing samples were then transferred to the Bangladesh Oceanographic Research Institute (BORI) laboratory for further study. In the laboratory, samples were photographed carefully with scale and stored in formalin again for future identification.

Analysis of Water and Sediment

Physico-chemical Parameters (Water and Sediment): Water parameters like Temperature, pH, Conductivity, Formazin Nephelometric Unit (FNU) were analyzed using Multiparameter (YSI Pro DSS, Made in USA) (Figure 2). Sediment temperature was determined using Thermometer and soil pH was detected using Soil pH Tester (Takemura electric ltd., Japan) (Figure 3).

Figure 2: Multiparameter (YSI Pro DSS, Made in USA)

Figure 3: Soil pH Tester (Takemura electric works ltd., Japan)

Nutrient Analysis (Water): Nutrients were assessed using a colorimeter (Nutrient Auto Analyzer, HACH, DR 900) (Figure-4). Phosphate-phosphorus (PO_4-P) was analyzed following the Ascorbic Acid Method which is accepted by USEPA (Rand et al. 1976). Nitrate-nitrogen (NO_3-N) was analyzed following Cadmium Reduction Method (Nichela et al. 2014). Nitrite-nitrogen (NO_2-N) was analyzed by Ferrous Sulfate Method (Stone et al. 2013; Varner et al. 1953). Ammonia (NH_3-N) was analyzed following Nessler Method which is accepted by USEPA (Mohammad et al. 2004; Varner et al. 1953). Silica (SiO_3) was analyzed following the Silicomolybdate method (Parsons, 2013).

Figure 4: Colorimeter (HACH, DR 900)

Heavy Metal Determination (Water and Sediment): The heavy metal contents were determined by AAS using standard analytical procedures (Bhuyan et al. 2019). Sample collection is an important stage for metal analysis. Samples were generally carefully handled to avoid contamination. Glassware was properly cleaned, and the reagents were of analytical grade. Distilled water was used throughout the study. Reagents blank determinations were used to correct the instrument readings (Bhuyan et al. 2019). The techniques for sample preparation, standard preparation and analysis for metal analyses have been briefly described below.

Sediment Sample Preparation: This procedure was also used for the destruction of organic matter. The precaution was to be taken to avoid losses by volatilization of elements. The samples were weighed accurately a suitable quantity (10 to 20 g) in a tared silica dish. After that, the samples were dried at 120°C in a laboratory oven (Bhuyan et al. 2019). These dishes were then placed in the muffle furnace at ambient temperature and slowly raised the temperature to 450°C at a rate of no more than 50°C/h. The samples were ignited in a Muffle furnace at 450°C for at least 8 hrs. After the samples cool, then the dishes were removed from the furnace. Then the sediment samples were digested in the desired amount of 50% nitric acid on a hot plate. Then the samples were filtrated into a 100 ml volumetric flask using Whatman No. 44 filter paper and washed the residue. Each sample solution was made to the mark with distilled water (Bhuyan et al. 2019).

Water Sample Preparation: 100 ml water of each water sample was taken in a beaker. Then the samples were digested with adding 5ml conc. HNO_3 on a hot plate. Then the samples were filtrated into a 100 ml volumetric flask using Whatman No. 44 filter paper & revolumed with distilled water (Bhuyan et al. 2019).

Standard Preparation: Every metal standard solution was prepared for calibration of the instrument for each element is determined on the same day as the analyses were performed due to possible deterioration of standard with time (Bhuyan et al. 2019). All samples were prepared from chemicals of analytical grade with distilled water. 1gm of metal Cadmium, Copper, Lead, Nickel were dissolved in HNO_3 solution; 1 g of Cobalt, Iron, Manganese, Zinc, Aluminum were dissolved in HCl solution; 2.8289 g $K_2Cr_2O_7$ (=1g Chromium) was dissolved in water and made up to 1 liter in volumetric flask with distilled water, thus stock solution of 1000 mg/l of Cd, Cu, Pb, Ni, Co, Fe, Mn, Zn, Al and Cr were prepared (Cantle, 1982). Then 100 ml of 0.1, 0.25, 0.5, 0.75, 1.0 and 2.0 mg/l of working standards of each metal except iron were prepared from these stock using micropipettes in 5ml of 2N nitric acid. 100 ml of 2.0, 2.5, 5.0, 10.0 & 20.0 mg/l of working standards of iron metal were prepared from the iron stock solution. Reagent blank was prepared in same manner of sample preparation without a sample to avoid reagents contamination (Bhuyan et al. 2019).

Analysis of Sample

The atomic absorption instrument was set up and flame condition and absorbance were optimized for the analyte. Then blanks (deionized water), standards, sample blank and samples were aspirated into the flame in AAS (Model- iCE 3300, Thermo Scientific, Designed in UK, Made by China). The calibration curves obtained for concentration vs. absorbance. Data were statistically analyzed using fitting of straight line by the least square method. A blank reading was also taken and necessary corrections were made during the calculation of the concentration of various elements (Bhuyan et al. 2019).

Sediment Texture Analysis: Sediment texture was analyzed following the method stated by Boggs (2009), Folk (1954), Folk and Ward (1957) and Friedman (1979).

Seaweed Species Identification: The checklist was based on an exhaustive bibliographical search. Both local reports and scientific publications were screened for species records, and the species were recorded in a database. Seaweed species were identified and recorded in the following groups Rhodophyta, Chlorophyta, and Phaeophyceae. All taxon names were revised to employ currently accepted species names following Algaebase (Guiry and Guiry, 2012), Islam (1976), Islam and Aziz (1982), Zafar (2005), Sarker (1992), etc. References to the original publications are indicated in square brackets, and taxonomic synonyms and their references are included within round brackets. Some few samples are yet under taxonomic identification.

Results and Discussion

The depth of sampling sites varied from 1.2-10.0 m. Transparency fluctuated between 0.5-10.5 m. The highest Secchi depth was found during January at station 10 while the lowest was recorded during April at station 2, 3, 9 and 10. Surface water temperature, salinity, pH, DO, Conductivity and FNU ranged for 22.6-32.1 C, 25.16-33.89‰, 6.67-8.6, 3.90-6.91 mg/L, 41064-52435 µS/cm, 2.4-18.4 respectively (Figure 5).

The highest value (32.1^0 C) of temperature was recorded during April at station 9 whereas the lowest value (22.6^0 C) was found during January at station 9. The maximum value (33.89‰) of salinity was documented during February at station 5 while the minimum value (25.16‰) was reported during March at station 1 (Figure 6). The greatest amount (8.6) of pH was found during April at station 6 and the lowest value (6.67) was recorded during February and March at station 3 and 8 respectively. The supreme value (6.91) of DO was reported during January at station 9 and the least amount (3.90) was recorded during April at station 2. FNU is the detector of turbidity. The maximum concentration (18.4) was recorded during April at station 9 whereas the lowest value (2.4) during January at station 1 (Figure 6).

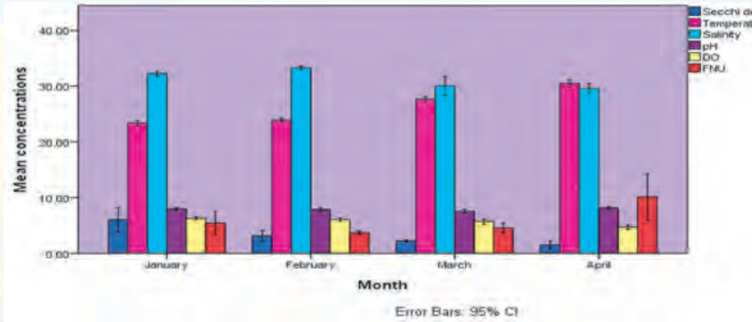


Figure 5: Surface water quality parameters status in different months in the St. Martin's Island

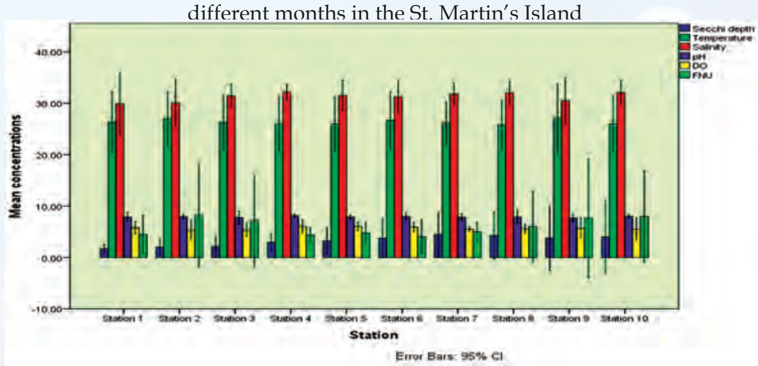


Figure 6: Surface water quality parameters status in different stations in the St. Martin's Island

The concentration of nutrients in surface water recorded 0.0-19.93 mg/l for PO_4-P, 0.0-2.5 mg/l for NO_3-N, 0.0-5.43 mg/l for NO_2-N, 0.0-10.0 mg/l for SiO_3 and 0.96-12.55 mg/l for NH_3 (Figure 7).

The concentration of PO_4-P varied from 0.0-19.93 mg/l. The maximum amount (19.93 mg/l) was found during February at station 10. The lowest value (0.0 mg/l) was recorded during January and February at stations 3 and 7 respectively (Figure 8). The amount of NO_3-N ranged for 0.0-2.5 mg/l in the study area. 2.5 mg/l NO_3-N was reported during January at station 5 and the least amount (0.0 mg/l) was found during March and April at station 4 and 8. 5.43 mg/l of NO_2-N was recorded as the maximum value during January at station 4 while the lowest value (0.0 mg/l) was found during January at most of the stations (Figure 8). During January, SiO_3 concentration was found 0.0 mg/l at most of the station whereas the highest amount 10.0 mg/l was reported during February at station 9. The maximum value (12.55 mg/l) of NH_3 was documented during February at station 10 and the minimum amount (0.96 mg/l) was recorded during March at station 4 (Figure 8).

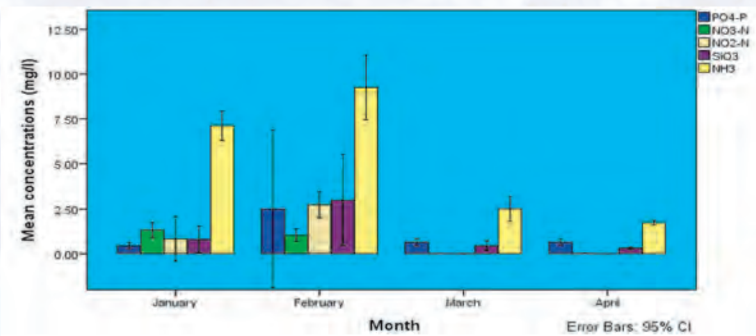


Figure 7: Surface water nutrients concentrations (mg/l) in different months in the St. Martin's Island

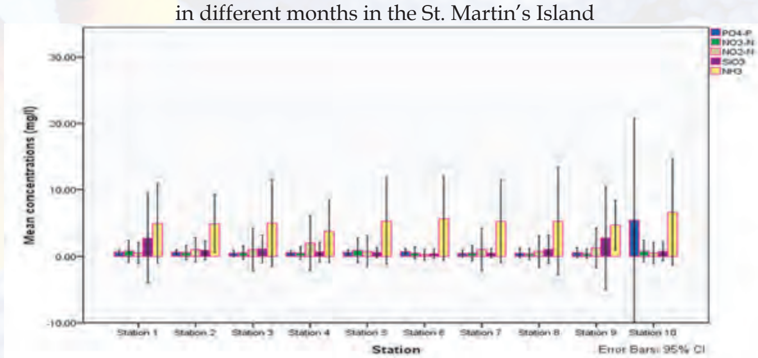


Figure 8: Surface water nutrients concentrations (mg/l) in different stations in the St. Martin's Island

Bottom water temperature, salinity, pH, DO, Conductivity and FNU varied for 21-31.2 C, 28.09-35.81‰, 6.3-8.8, 4.22-6.73 mg/L, 47605-54642 μS/cm, 2.3-41.1 respectively (Figure 9).

The maximum value (31.2^0 C) of temperature was recorded during April at station 1 and 9 whereas the lowest value (21.0^0 C) was found during February at station 7 (Figure 10). The maximum value (35.81‰) of salinity was documented during February at station 7 while the minimum value (28.09‰) was reported during April at station 6. The greatest amount (8.8) of pH was found during January at station 7 and the lowest value (6.3) was recorded during March at station 10 (Figure 10). The supreme value (6.73) of DO was reported during January at station 4 and the least amount (4.22) was recorded during April at station 9. FNU is the detector of turbidity. The maximum concentration (41.1) was recorded during April at station 2 whereas the lowest value (2.3) during January at station 6 (Figure 10).

The concentration of nutrients were found in the range of 0.03-20.74 mg/l for PO_4-P, 0.0-2.1 mg/l for NO_3-N, 0.0-7.0 mg/l for NO_2-N, 0.0-3.0 mg/l for SiO_3 and 1.32-12.8 mg/l for NH_3 (Figure 11).

The value of PO_4-P varied from 0.03-20.74 mg/l. The maximum amount (20.74 mg/l) was found during January at station 7. The lowest value (0.03 mg/l) was recorded during April at station 8. The amount of NO_3-N ranged for 0.0-2.1mg/l in the study area (Figure 12). 2.1 mg/l NO_3-N was reported during February at stations 4 and 9 respectively. The least amount (0.0 mg/l) was found during March at station 8 and 10. 7.0 mg/l of NO_2-N was recorded as the maximum value during February at station 5 while the lowest value (0.0 mg/l) was found during January at station 2, 6 and 10 (Figure 12). During January and February, SiO_3 concentration was found 3.0 mg/l at stations 2 and 7 respectively. Whereas the lowest amount 0.0 mg/l was reported during January and February at most of the station. The maximum value (12.8 mg/l) of NH_3 was documented during February at station 1 & the minimum amount (1.32 mg/l) was recorded during March and Aril at station 8 & station 1 respectively (Figure 12)

Bottom sediment temperature fluctuated from 20.0-32.0 C and pH varied from 5.3-7.9 in the study area. The percentage of gravel, shell, sand and silt+clay ranged for 0.0-12.62%, 0.0-86.22%, 9.25-99.33% and 0.03-23.0% in the study area

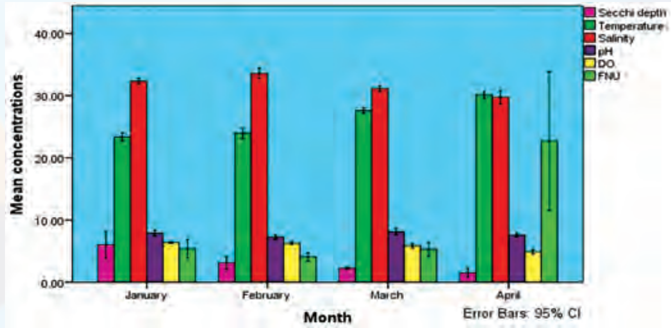


Figure 9: Bottom water quality parameters status in different months in the St. Martin's Island

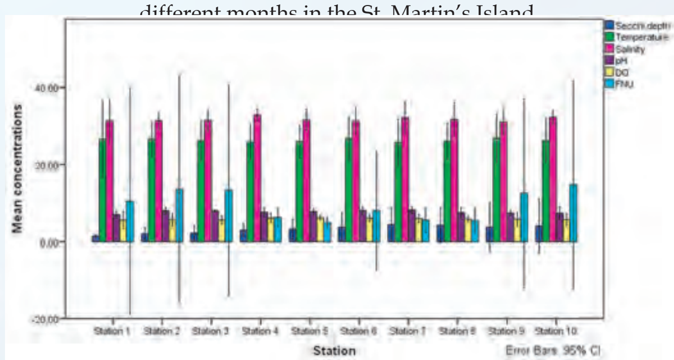


Figure 10: Bottom water quality parameters status in different stations in the St. Martin's Island

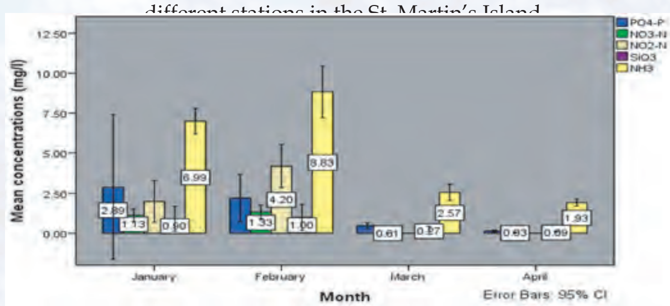


Figure 11: Bottom water nutrients concentrations (mg/l) in different months in the St. Martin's Island

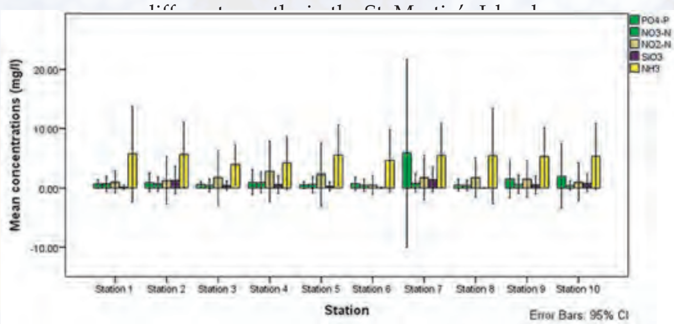


Figure 12: Bottom water nutrients concentrations (mg/l) in different stations in the St. Martin's Island

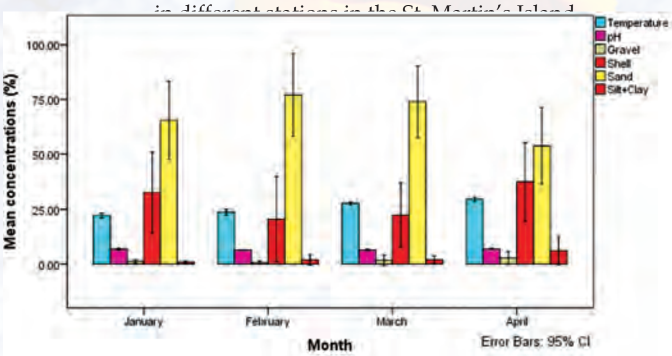


Figure 13: Sediment grain size concentrations (%) in different months in the St. Martin's Island

Sediment temperature was recorded between 20.0-32.0^{0} C in the study area. The maximum temperature (32.0^{0} C) was documented during April at station 6 while the minimum (20.0^{0} C) was recorded during February at station 7 (Figure 14). The highest pH (7.9) was found during January at station 5 and the lowest (5.3) was reported during March at station 1. The greatest percentage of gravel (12.62%) was recorded during April at station 9 and the minimum value (0.0) was during many months at a different station. Shell concentration (86.22%) was recorded as the highest value during January at station 8 (Figure 14). While 0.0% was recorded as the minimum value during March at station 7. The sand was found in the highest concentration in the sample than other parameters. Up to 99.33% sand was found in the sample during February at station 8. The lowest value 9.25% was reported during April at station 9. The greatest percentage (23.0%) silt+clay was documented from station 3 during April and the lowest percentage (0.03%) was reported during January at station 8 (Figure 14).

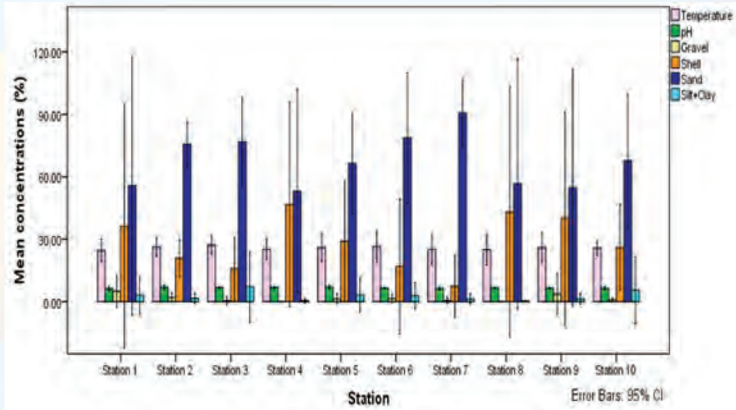


Figure 14: Sediment grain size concentrations (%) in different stations in the St. Martin's Island

The concentrations of heavy metals in sediment varied from BDL-8.6 mg/kg for Pb; BDL-940 mg/kg for Mn; BDL-22.31 mg/kg for Cr; BDL-49.2 mg/kg for Zn; BDL-42.6 mg/kg for Ni; BDL-316.0 mg/kg for Cu. The value of Cd was found below the detection limit during all months at all stations (Figure 15).

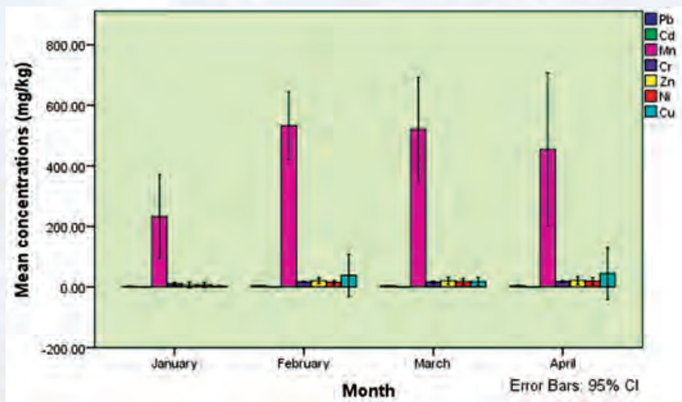


Figure 15: Heavy metals concentrations (mg/kg) in different months in the St. Martin's Island

Pb concentration was recorded between BDL-8.6 mg/kg. The maximum value 8.6 mg/kg of Pb was recorded from station 8 during February. The lowest value found below the detection limit during January at most of the stations (Figure 16). 940 mg/kg Mn was found during April at station 8 while the lowest amount was recorded from station 2, 8 and 9 during January. The maximum concentration (22.31 mg/kg) of Cr was found during April at station 9 whereas the minimum concentration was recorded from station 2, 8 and 9 during January. The supreme amount (49.2 mg/kg) of Zn was reported from station 10 during March and the least was found below the detection limit during January at station 2, 7, 8, and 9 respectively (Figure 16). The greatest value (42.6 mg/kg) of Ni was recorded from station 10 during March and the minimum value was documented below the detection limit during January at station 2, 7, 8, 9 and 10 respectively. The highest value (316 mg/kg) of Cu was found station 1 during February and the lowest value was recorded below the detection limit during January at station 2, 3, 4, 5, 8 and 9 respectively (Figure 16).

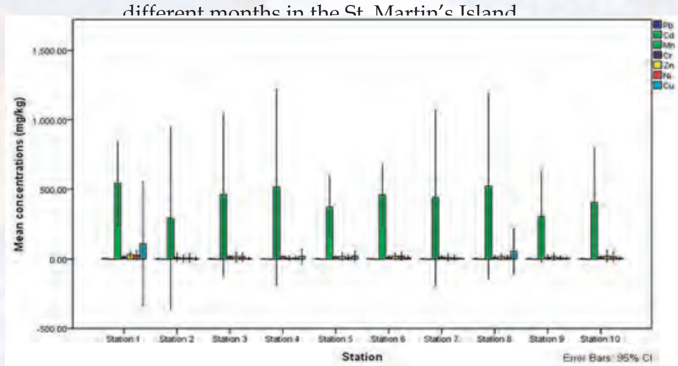


Figure 16: Heavy metals concentrations (mg/kg) in different stations in the St. Martin's Island

In the present study, a total of 84 seaweed species were recorded at 10 sites around the St. Martin's Island. Among 84 species, 19 species belong to Chlorophyta, 44 species belong to Rhodophyta and 21 species belong to Phaeophyceae (Table 2).

Table 2: Identified species of Rhodophyta, Chlorophyta and Phaeophyta in the St. Martin's Island.

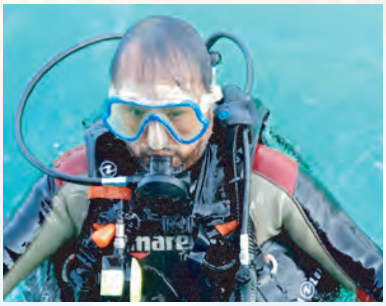
Red Algae (Rhodophyta)		Green Algae (Chlorophyta)	Brown Algae (Phaeophyta)
Acanthophora spicifera	*Halymenia pseudofloresii*	*Avrainvillea erecta*	*Colpomenia sinuosa*
Actinotrichia fragilis	*Halymenia venusta*	*Avrainvillea sp.*	*Dictyopteris woodwardia*
Amphiroa fragilissima	*Hypnea cornuta*	*Caulerpa fergusonii*	*Dictyota cervicornis*
Amphiroa franciscana	*Hypnea musciformis*	*Caulerpa peltata*	*Dictyota ciliolata*
Amphiroa rigida	*Hypnea valentiae*	*Caulerpa mexicana*	*Dictyota dichotoma*
Asparagopsis armata	*Liagora ceranoides*	*Caulerpa racemosa*	*Dictyota dichotoma*
Asparagopsis taxiformis	*Liagora viscida*	*Caulerpa sedoides*	*Dictyota friabilis*
Asteromenia anastomosans	*Lomentaria clavellosa*	*Caulerpa sertularioides*	*Dictyota menstrualis*
Chondracanthus intermedius	*Lomentaria hakodatensis*	*Caulerpa taxifolia*	*Hydroclathrus clathratus*
Chondrophycus ceylanicus	*Nemalion elminthoides*	*Codium fragile*	*Lobophora variegata*
Cryptonemia sp.	*Neurymenia fraxinifolia*	*Codium intricatum*	*Rosenvingea intricata*
Cryptonemia undulata	*Peyssonnelia capensis*	*Halimeda cuneata*	*Rosenvingea sanctae-crucis*
Gayliella flaccida	*Peyssonnelia novae*	*Halimeda discoidea*	*Sargassum carpophyllum*
Gayliella mazoyerae	*Peyssonnelia rubra*	*Halimeda gracilis*	*Sargassum ilicifolium*
Gibsmithia dotyi	*Peyssonnelia squamaria*	*Halimeda opuntia*	*Sargassum oligocystum*
Halurus equisetifolius	*Plocamium cartilagineum*	*Halimeda opuntia*	*Sargassum piluliferum*
Halymenia dilatata	*Rhodymenia pseudopalmata*	*Halimeda tuna*	*Sargassum sp.*
Halymenia duchassaingii	*Scinaia carnosa*	*Ulva flexuosa*	*Sargassum vulgare*
Halymenia durvillei	*Scinaia furcellat*	*Ulva rigida*	*Spatoglossum asperum*
Halymenia floresii	*Sebdenia flabellata*		*Spatoglossum howellii*
Halymenia maculata	*Spermothamnion repens*		*Spatoglossum variabile*
Halymenia microcarpa	*Vanvoorstia coccinea*		

Conclusion

The St. Martin's Island is very dynamic with great diversity in the case of seaweed species. From the findings of the present study, it can be concluded that the water of the St. Martin's Island is in good condition. Since the water quality parameters are in safe limit and the heavy metals found below the detection limit though a small amount of metal found in sediment. The total ecosystem of the Island is favorable for seaweed growth. Seaweed has a great impact on the marine ecosystem.

Activities of Seaweed Research Team (SRT)



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Mr. Abu Sayeed Muhammad Sharif currently working as senior scientific officer and head of Biological Oceanography Division at Bangladesh Oceanographic Research Institute (BORI). He is the son of Dr. AQM Shamsul Alam and Sajjadun Nessa, borne in a small island “Hatiya” under Noakhali District. Hehas a cheerful academic background and placed1^{st} class 1^{st} both BSc and MSc in Marine Sciences from Institute of Marine Science, University of Chittagong. He is a recipient of NST fellowship research grant during 2000-2001. Further, he achieved Commonwealth Scholarshipfor his MS in Aquatic Resource Development (ARD) from University of Stirling, UK. So far he published 21 scientific research articles in several national and international reputed journals. His academic book on “Seaweeds of Saint Martin’s Island, Bangladesh” is going to be published very soon. Before joining the BORI he worked in different national and international research institutions as well as development Projects like IUCN under 4^{th} fisheries, APN, CNRS, RDRS, UNDP, USAID, etc. He actively contributed in the establishment of BORI working as Senior Scientific Officer in the NORI 1^{st} phase project from 2014 to 2017. He was on boardRV Dr. Fridtjof Nansen (Norwegian oceanographic research vessel) as scientist for the Bay of BengalExpeditionduring 2017. He has strong command in marine sciences precisely on planktology, phycology, marine ecology and biology from field to laboratory analysis. He started to explore the seaweeds and corals around the St. Martin’s Island. Recently he is working on its industrial product development as a part of socio economic development and blue economy addressing SDG17. He is passionate to Oceanographic exploration. His research interests include biological modeling, marine biotechnology, mariculture and IMTA, bioremediation, development of medicinal agents, probiotics, etc.

Image: @ Nick Hobgood

Environmental Oceanography and Climate Division

Image: @ flickr.com

Chapter 6

Environmental Oceanography and Climate Division

EOCD at a Glance

Marine Environment covers not only the ocean, but estuaries (e.g., bays), which are coastal areas where the sea water is diluted with freshwater coming from rivers and streams, or sometimes groundwater.

-Judith S. Weis

Environmental Oceanography and Climate Division (EOCD) is concerned in marine, coastal and estuary environments as these environments have been suffering diverse modes of degradation, including pollution with xenobiotic compounds, accelerated input of dissolved plant nutrients, discharge of untreated industrial effluents and physical modifications ranging from unplanned coastal constructions and developments.

The EOCD is engaged in investigating and monitoring the marine pollutions of the Bay of Bengal as a part of baseline study through Research and Development (R&D) projects. The Research activity of EOCD has been started in 2017-2018 FY with a R&D project: Determination of marine pollution by coastal water quality monitoring & mapping marine litter loads around the Coastal Area of Saint Martin Island. In the FY 2018-2019, another R&D project has been taken on Determination of marine pollution by assessing seasonal seawater quality & identifying the status of micro-plastic in coastal area of Saint Martin's island.

EOCD got funding for 1research projects under the "Special Allocation for Science and Technology" from Ministry of Science and Technology (MoST) which was implemented in 2018-2019 FY.

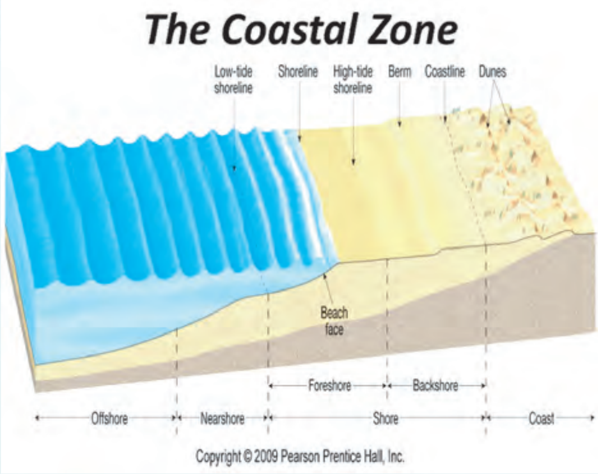
EOCD provides services as analysis of water quality parameters (Water Temperature, Salinity, Conductivity, pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Biological Dissolved Oxygen (BOD) and Chemical Dissolved Oxygen (COD)) and Local Meteorological parameters (Air Temperature, Wind Speed, Wind Direction and Relative Humidity).

General Features

Marine Environment

The oceans, seas, bays, estuaries, and other major water bodies, including their surface interface and interaction, with the atmosphere and with the land seaward of the mean high water mark is refer to as Marine Environment. (Source- Dictionary of Military and Associated Terms, US Department of Defense 2005) The marine environment supplies many kinds of habitats that support marine life. Marine life depends in some way on the saltwater that is in the sea (the term marine comes from the Latin mare, meaning sea or ocean). A habitat is an ecological or environmental area inhabited by one or more living species. *(Source- Wikipedia)*

Coastal Zone



A coastal zone is the interface between the land and water. These zones are important because a majority of the world's population inhabit such zones. Coastal zones are continually changing because of the dynamic interaction between the oceans and the land. Waves and winds along the coast are both eroding rock and depositing sediment on a continuous basis, and rates of erosion and deposition vary considerably from day to day along such zones. The energy reaching the coast can become high during storms, and such high energies make coastal zones areas of high vulnerability to natural hazards. Thus, an understanding of the interactions of the oceans and the land is essential in understanding the hazards associated with coastal zones. *(Source- Prof. Stephen A. Nelson, Tulane University, USA)*

Natural Disaster

Natural disasters are disasters that are out of human control and are usually caused by the weather. Disasters that include but are not limited to; storms, tsunamis, typhoons, flooding, tides, waterspouts, nor'easters, and storm surge. Coastal Hazards are physical phenomena that expose a coastal area to risk of property damage, loss of life and environmental degradation. Rapid-onset hazards last over periods of minutes to several days and examples include major cyclones accompanied by high winds, waves and surges or tsunamis created by submarine earthquakes and landslides. Slow-onset hazards develop incrementally over longer time periods and examples include erosion and gradual inundation. *(Source- Schwartz, M. (2005) Encyclopaedia of Coastal Science, Springer)*. Besides the above-mentioned hazards, other significant disasters in Bangladesh are arsenic contamination, salinity intrusion, drought, water logging and landslides. The southwestern coastal belt of Bangladesh is suffering from salinity intrusion and water logging for ages.

Coastal Zone Management

Coastal zone management involves managing coastal areas to balance environmental, economic, human health, and human activities. The concept of coastal zone management is a relatively new one, emerging less than four decades ago from the need to tackle an array of interconnected problems associated with population growth and development along coasts. *(Source- National Ocean Service, NOAA)*. Integrated coastal zone management (ICZM) or Integrated coastal management (ICM) is a process for the management of the coast using an integrated approach, regarding all aspects of the coastal zone, including geographical and political boundaries, in an attempt to achieve sustainability. This concept was born in 1992 during the Earth Summit of Rio de Janeiro. The specific regarding ICZM is set out in the proceedings of the summit within Agenda 21, Chapter 17. *(Source- Wikipedia)*

Marine Pollution

Marine pollution occurs when harmful effects result from the entry into the ocean of chemicals, particles, industrial, agricultural, and residential waste, noise, or the spread of invasive organisms. Eighty percent (80%) of marine pollution comes from land. Air pollution is also a contributing factor by carrying off pesticides or dirt into the ocean. Land and air pollution have proven to be harmful to marine life and its habitats. The pollution often comes from nonpoint sources such as agricultural runoff, wind-blown debris, and dust. Nutrient pollution, a form of water pollution, refers to contamination by excessive inputs of nutrients. *(Source- Wikipedia)*

Estuarine Pollution

The estuaries of the world receive a large proportion of the waste discharged by mankind into aquatic environments. Within the sea, almost all pollution is concentrated into estuaries and nearshore coastal zones. Pollution by definition is 'The introduction into the estuarine environment of a diverse range of materials, derived from human activities, in such quantities that the environment is made less suitable for existing life forms'. *(Source- The Estuarine Ecosystem:pp 133-176)*. Poor water quality affects most estuarine organisms, including commercially important fish and shellfish. The pollutants that have the greatest impact on the health of estuaries include toxic substances like chemicals and heavy metals, nutrient pollution (or eutrophication), and pathogens such as bacteria or viruses. *(Source-https://oceanservice.noaa.gov/education/)*

Harmful Algal Bloom (HAB)

Harmful Algal Bloom (HAB) are organisms that can severely lower oxygen levels in natural waters, killing marine life. Some HABs are associated with algae-produced toxins. (Source- Harmful Algae. 2008 Dec; 8(1): 3–13) Blooms can last from a few days to many months. After the bloom dies, the microbes which decompose the dead algae use up even more of the oxygen, which can create fish die-offs. When these zones of depleted oxygen cover a large area for an extended period of time, they are referred to as dead zones, where neither fish nor plants are able to survive.

HABs are induced by an overabundance of nutrients in the water. The two most common nutrients are fixed nitrogen (nitrates, ammonia, and urea) and phosphate. (Source-Harmful Algal Blooms-Center for Disease Control) These nutrients are emitted by agriculture, other industries, excessive fertilizer use in urban/suburban areas and associated urban runoff. Higher water temperature and low circulation are contributing factors. HABs can cause significant harm to animals, the environment and economies. They have been increasing in size and frequency worldwide, a fact that many experts attribute to global climate change. The U.S. National Oceanic and Atmospheric Administration (NOAA) predicts more harmful blooms in the Pacific Ocean. *(Source-Harvey, Chelsea (2016-09-29))*

Red Tide


Red tide in a harbor, Japan (Wikipedia)

Red tide is a common name for algae blooms, which are large concentrations of aquatic microorganisms (protozoans or unicellular algae such as dinoflagellates and diatoms). The upwelling of nutrients from the sea floor, often following massive storms, provides for the algae and triggers bloom events. Harmful algal blooms can occur worldwide, and natural cycles can vary regionally. The growth and persistence of an algal bloom depends on wind direction and strength, temperature, nutrients, and salinity. Red tide species can be found in oceans, bays, and estuaries, but they cannot thrive in freshwater environments. *(Source: Harmful Algae 14 (2012): 156–178)*

Sea Water Quality

Marine water quality refers to the presence or absence of any number of pollutants in ocean waters. Some of the more important pollutants include oil, sedimentation, sewage, nutrients, heavy metals, and thermal pollution. Water quality monitoring relies on taking a suite of measurements of ocean water. These include temperature, salinity, density, light transmission, the concentration of dissolved oxygen, and the concentration of chlorophyll (an indicator of the amount of phytoplankton in the water). Water samples are analyzed in the laboratory for the presence and concentration of various forms of bacteria, chlorophyll, phaeopigment (an indicator of the amount of dead phytoplankton in the water), nitrate, nitrite, ammonium, orthophosphate, and silicate. *(Source-Encyclopedia.com)*

Plastic Pollution in Marine Environment


Plastic Pollution in Saint Martin's Island

Plastic pollution is the accumulation of plastic objects (e.g.: plastic bottles and much more) in the Earth's environment that adversely affects marine life, wildlife, wildlife habitat and humans. (Source-Plastic pollution:Encyclopædia Britannica) Plastics that act as pollutants are categorized into micro-, meso-, or macro debris, based on size. (Source-Hammer et al (2012). Plastics in the marine environment: pp. 1–44) Plastics are inexpensive and durable, and as a result levels of plastic production by humans are high. Moreover, the chemical structure of most plastics renders them resistant to many natural processes of degradation and as a result they are slow to degrade. Together, these two factors have led to a high prominence of plastic pollution in the environment. *(Source- Wikipedia)*

- Over 300 million tons of plastic are produced every year for use in a wide variety of applications.
- At least 8 million tons of plastic end up in our oceans every year, and make up 80% of all marine debris from surface waters to deep-sea sediments.
- Marine species ingest or are entangled by plastic debris, which causes severe injuries and deaths.
- Plastic pollution threatens food safety and quality, human health, coastal tourism, and contributes to climate change.
- There is an urgent need to explore the use of existing legally binding international agreements to address marine plastic pollution.
- Recycling and reuse of plastic products, and support for research and innovation to develop new products to replace single-use plastics are also necessary to prevent and reduce plastic pollution.

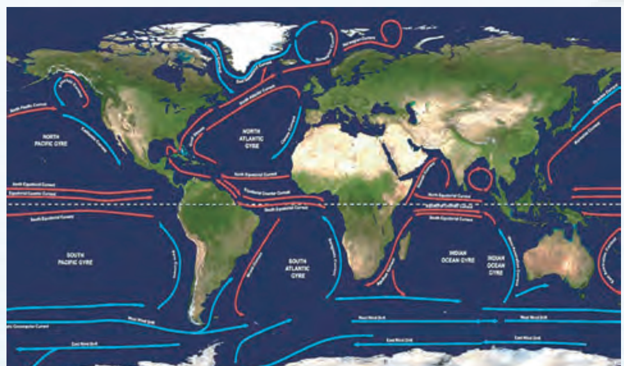
(Source- https://www.iucn.org/resources/issues-briefs/marine-plastics)

Micro-Plastic in Marine Environment

Micro-plastics are small, barely visible pieces of plastic that enter and pollute the environment. (Source- Environmental Science and Pollution Research) Microplastics are not a specific kind of plastic, but rather any type of plastic fragment that is less than five millimeters in length according to the U.S. National Oceanic and Atmospheric Administration (NOAA). They enter natural ecosystems from a variety of sources, including, but not limited to, cosmetics, clothing, and industrial processes. *(Source-NOAA Technical Memorandum)*

Microplastics exhibit a global distribution and have been detected in all levels of the marine environment. The most visible and disturbing impact of microplastics are their ingestion and consequent suffocation of hundreds of marine species. Microplastics can contribute considerably to the transport of non-indigenous marine species to a new area thereby threatening the marine biodiversity and the food web. *(Source- Journal of Pollution Effects & Control)*

Ocean Gyre and Pollution



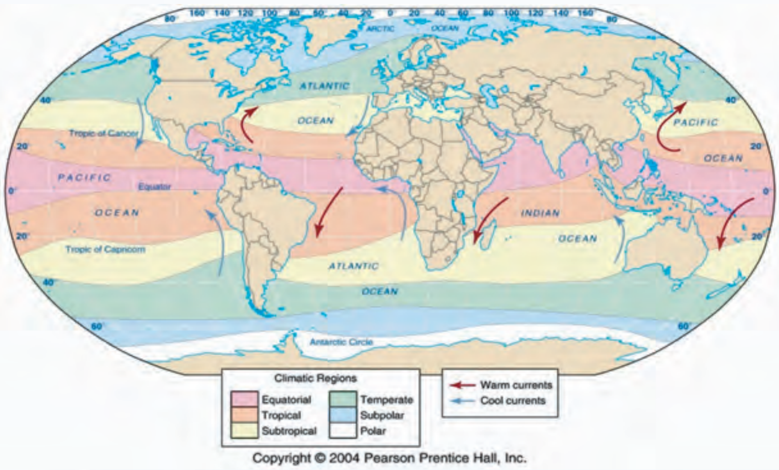
A gyre is a large system of rotating ocean currents. Wind, tides, and differences in temperature and salinity drive ocean currents. The ocean churns up different types of currents, such as eddies, whirlpools, or deep ocean currents. Larger, sustained currents—the Gulf Stream, for example—go by proper names. Taken together, these larger and more permanent currents make up the systems of currents known as gyres. There are five major gyres: the North and South Pacific Subtropical Gyres, the North and South Atlantic Subtropical Gyres, and the Indian Ocean Subtropical Gyre. In some instances, the term "gyre" is used to refer to the collections of plastic waste and other debris found in higher concentrations in certain parts of the ocean. While this use of "gyre" is increasingly common, the term traditionally refers simply to large, rotating ocean currents. *(Source- National Ocean Service, NOAA)*

Marine Oil Spill

An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially the marine ecosystem, due to human activity, and is a form of pollution. The term is usually given to marine oil spills, where oil is released into the ocean or coastal waters, but spills may also occur on land. Oil spills may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil. Oil spills penetrate into the structure of the plumage of birds and the fur of mammals, reducing its insulating ability, and making them more vulnerable to temperature fluctuations and much less buoyant in the water. Cleanup and recovery from an oil spill is difficult and depends upon many factors, including the type of oil spilled, the temperature of the water (affecting evaporation and biodegradation), and the types of shorelines and beaches involved. Spills may take weeks, months or even years to clean up. *(Source- NOAA)*

Global Ocean Climate

An oceanic climate, also known as a marine or maritime climate, is the Köppen classification of climate typical of west coasts in higher middle latitudes of continents, and generally features mild summers (relative to their latitude) and mild winters, with a relatively narrow annual temperature range and few extremes of temperature, with the exception for transitional areas to continental, subarctic and highland climates. Oceanic climates are defined as having a monthly mean temperature below 22^0 C (72^0 F) in the warmest month, and above 0^0 C (32^0 F) (or -3^0 C (27^0 F)) in the coldest month.(Source- Wikipedia)



We can divide the ocean into six climate zones: *(Source- Indiana University)*

Equatorial: Along the equatorial Inter-tropical Convergence Zone is an area of persistent cloudiness, year-round high precipitation, light winds and warm ocean water. The characteristics of this area are a result of the convergence of the north and south trade winds and the uplifting of warm moist air.

Trades (Tropical): These zones are found in the areas of the trade winds and are characterized by dry conditions, persistent winds and high evaporation rates.

Sub-tropical: Along the divergence (separating) between the Hadley and Ferrel atmospheric circulation cells is an area of light winds, clear skies and low rainfall. Subtropical climates zones are found generally between 25 and 35 degrees latitude- coastal areas within this climate zone are frequented by tourists because of the almost guarantee of warm, sunny conditions.

Temperate: Located in the areas of the westerly winds, temperate zones are characterized by high rainfall and strong storms called extratropical cyclones. The storms are most severe in the winter along the boundary of the Polar and Ferrel cells.

Sub-polar: Located north of 60 degrees latitude in each hemisphere, subpolar zones are characterized by low rainfall and cold temperatures. Sea ice forms in these areas during winter months, creating high salinity water beneath the ice (remember, salts do not get incorporated into ice). In summer months, ice melts creating a low salinity layer at the surface.

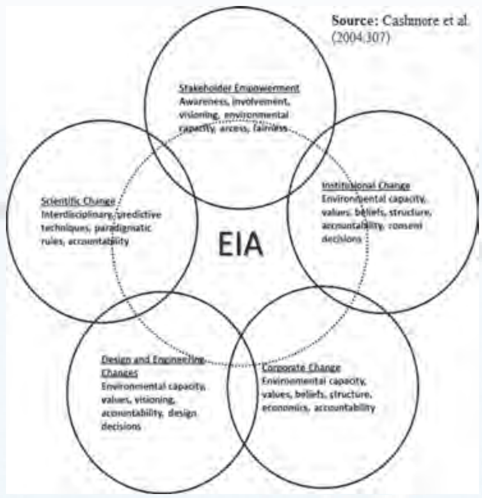
Polar: Located near the polar regions of each hemisphere, the polar zone is characterized by low rainfall and light winds. Most of this zone is covered by ice all year and water temperatures below ice cover are near freezing.

Monster of the Ocean (Cyclone, hurricane or typhoon)

Cyclones are formed exclusively in the inter-tropical zone between 5° and 20° latitude on either side of the equator. They are called typhoons in the northwest Pacific Ocean, hurricanes in the North Atlantic and northeast Pacific oceans, and cyclones in the Indian and southwest Pacific oceans. Tropical storms and cyclones are identified by first names, alternating between male and female, in alphabetical order. These lists, prepared in advance by the World Meteorological Organization, are recycled every five years, except for the names of the most destructive storms, which are retired.

The internal structure of a cyclone: A cyclone is composed of rain bands formed by convection of warm, humid air over the ocean. These convective cells are organized in spirals turning counter-clockwise (in the Northern Hemisphere), which are attracted to the eye of the cyclone, a zone of very low pressure (30 km in diameter). Because of centrifugal force, the winds do not penetrate to the eye but reach maximum speed (more than 250 km/h) in the eye wall, where they whirl in a circular motion as they rise. When they reach the top of the cloud, the air is pushed clockwise (in the Northern Hemisphere) toward the periphery of the cyclone, where it forms cirrus clouds. A cyclone can reach radius of 500 km and a depth between 10 and 15 km. Prevailing winds (such as the trade winds) propel cyclones at an average speed of 25 km/h. *(Source-http://www.ikonet.com/en/visualdictionary/static/us/cyclones)*

Environmental Impact Assessment (EIA)

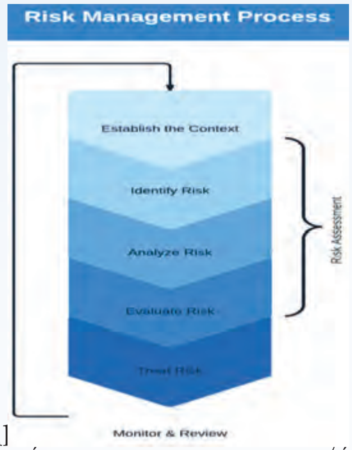


Environmental assessment (EA) is the assessment of the environmental consequences (positive and negative) of a plan, policy, program, or actual projects prior to the decision to move forward with the proposed action. In this context, the term "environmental impact assessment" (EIA) is usually used when applied to actual projects by individuals or companies and the term "strategic environmental assessment" (SEA) applies to policies, plans and programmes most often proposed by organs of state. *(Source-Environmental Impact Assessment: A Guide to Best Professional Practices)*

EIA has been practiced in Bangladesh since the late 1980s but it is through the enactment of theEnvironment Conservation Act, 1995 and the Environment Conservation Rules, 1997 EIA gained formalstatus in the country. Although a rigorous administrative procedure of submission and approval ofnecessary environmental documents are in place, evidence suggests that EIA has not yet evolved satisfactorily in Bangladesh. In this paper, an established set of evaluation criteria has been applied toevaluate the departure from ideality of the Bangladesh EIA system. The nature of the shortcomings of the EIA system in practice is discussed. Despite the many shortcomings, the basic structure of theBangladesh EIA system can be considered to be sound. It is important for the country to improve on these limitations with an aim to building a robust EIA system for sustainable development. *(Source-https://conferences.iaia.org)*

Oil Spill Risk Assessment (OSRA)

Oil spill risk assessment, in terms of establishing, analyzing and evaluating the risk, is a keyelement in a risk management process. The outputs of the OSRA link directly to oil spill responseplanning, which is integral to risk reduction. The OSRA will often be part of an overall riskassessment process for safety, environment and assets. ISO 31000:2009 concerns risk managementand emphasizes the importance of establishing the context prior to starting or executing any ofthe elements included in the risk assessment process, and the importance of updating thecontext throughout the process. It also emphasizes the importance of communication, consultation, monitoring and review throughout the entire process. *(Source- IPIECA)*



Coastal Zone Policy

Bangladesh's coastal zone covers 19 southern districts with a land area of 47,201 square kilometres. The coastal zone is inhibited by 35.08 million people. The coast of Bangladesh is known as a zone of vulnerabilities as well as opportunities. It is exposed to natural disasters like tropical storm, storm surge and downpour. The mixture of natural and artificial hazards, such as earthqual various forms of pollution, wearing away, high arsenic content in land water, water sorting, risks from weather change, etc, have adversely affected life and livelihoods in the coastal zone and slowed down the speed of community progress in those areas. To reduce coastal vulnerabilities, improve the livelihood of the coastal people, ensure the optimum use of coastal resources and to create an enabling institutional environment; the Ministry of Water Resources formulated the Coastal Zone Policy, which was approved by the cabinet on January 17, 2005 and was also published in the official Gazette in March 2005. The Coastal Zone Policy has been developed for all concerned ministries, agencies, private sector, local government institutions, NGOs, and the civil society to put their efforts together for the development of the coastal zone of Bangladesh. The Coastal Zone Policy initiates a process that commits the ministries, departments and agencies to toning and organizing their activities in the coastal zone and elaborates the basis for a firm co-ordination mechanism. But so far not much has been done for the development of the coastal zone. *(Source- https://www.thedailystar.net)*

Inception Research Activity of EOCD

Sample Collection from the Study Area (Saint Martin Island)

Data Processing in the Laboratory at BORI

Assessment of Physico-chemical Status of Coastal Seawater of the Saint Martin's Island, Bangladesh

Mir Kashem
Scientific Officer

Sultan Al Nahian
Scientific Officer

Abu Sharif Md. Mahbub-E-Kibria
Senior Scientific Officer

Abstract

Saint Martin's island is a beautiful tourist attractive place and a unique coral island in Bangladesh. Marine biodiversity of this island is very rich for its favorable environment but its marine environment is facing threats day by day due to natural calamities, various types of pollution, and other anthropogenic activities. So it is very important to know the present physico-chemical status of seawater around the island as a baseline scenario. At first, coastal water samples were collected from 24 sites. Niskin water sampler is used to collect samples from 26 February to 02 March, 2018. Six physico-chemical parameters like temperature, salinity, conductivity, dissolved oxygen (DO), pH and total dissolved solids (TDS) were measured directly at in-situ position. The ranges for the physico-chemical parameters of coastal seawater were 25 to 30°C for temperature, 30.8 to 33.4 ppt for salinity, 48966 to 55235 µS/cm for conductivity, 5.08 to 6.87 mg/L for DO, 8.05 to 8.38 for pH and 29575 to 31980 mg/L for TDS. The highest and lowest salinity was found in the southern and northern part of the Saint Martin's Island respectively. The highest DO is found on three sides especially the northern side but the lowest DO was found in the eastern side.

Keywords: Temperature, Salinity, Conductivity, Dissolved Oxygen, Coastal water & Saint Martin's Island.

Introduction

Saint Martin's island is one of the unique coral islands and popular tourist destinations in Bangladesh due to its and favorable environmental condition. It is also recognized as therichest biodiversity hotspot in terms of marine biotic resources in Bangladesh. St. Martin's Island is only 8 km^2 dumb-bell shaped sedimentary Continental Island located in the northeast part of the Bay of Bengal and about 9 km far from the Cox's Bazar-Teknaf peninsula tip, and the southernmost part of Bangladesh. Contrary, it is about 8 km west of the northwest coast of Myanmar at the mouth of the Naf River. There is a small connected island that is separated at high tide, called Chera Island. The area of the island itself is about 5.9 km^2 whereas with the rocky platforms extending into the sea the total area of the island is about 12 km^2. It was connected to the mainland of the Teknaf peninsula as-recently-as 6,000-7,000 years ago.

It is also treated as an ideal site for fishing zone that provides a variety of marine fish species. Mr. Hossain stated that about 1650 Metric Tons (MT) of marine fishes are being caught in every year. There are about 234 species of fish, 66 species coral (36 are found living), 187 species crab 14 species of algae have been recorded from this island.The major macro-invertebrate communities of this island comprises with about 61 species of mollusks, 9 species of echinoderms, 4 species of Zoanthids and 4 species of Bryozoans.

The ecosystem of Saint Martin's island is blessed of nature with vast resources but these resources are facing threats day by day due to natural calamities, various types of pollution, and other anthropogenic activities. Over exploitation of renewable marine and coastal resources (e.g. rocky reef fisheries, coral and shell for marine ecosystem of the island. Destructive fishing practices, mainly the use of rock-weighted gill nets over the inshore boulder reefs are one of the prime aggravates. The environmental quality and ecological value of this island is regularly degrading by the increasing of human intervention and natural disasters in every year. There are several authorities are tried to concern about the sustainability of waste management, drainage system and water quality problems for the island. It may definitely append to increase of solid wastes by rising of visitors or tourists into the Saint Martin's island that is also future threat for the coral habitat. The physical action of wastes throwing by tourists either on the beach or in the water might not be an apparent threat. The Marin park islands would have coped with the waste problem from the local inhabitants of the islands as well as with the increased amount of wastes from hotels, lodges, and resorts. At present, solid wastes disposal system remains absent.

Water quality plays an important role for the production of fisheries. Although monitoring water quality does not measure the environmental health on an ecosystem, it is argued that the water quality of an aquatic ecosystem can provide a rapid assessment of the environmental quality before it is manifested in living organisms. The objective of the research was to assess the physico-chemical Status of Seawater around the Saint Martin's Island. The study has been conducted with the following objectives:

- To determine the physico-chemical properties (temperature, salinity, pH, conductivity, dissolved oxygen and total dissolved solids) of coastal water of the Saint Martin's Island
- To investigate the present status of physico-chemical properties of North and South, East and West of coastal water of the Saint Martin's Island

Study Area

The Saint Martin's Island, locally called 'NarikelJinjira' is located in the northeast of the Bay of Bengal (Figure.1). The island is an administrative union of TeknafUpazila under Cox's Bazar district in Bangladesh. Saint Martin's Island is situated between 20°34´ to 20°39´ N latitude and 92°18´ to 92°2´ E longitude (Figure 1). To the east the Myanmar boundary (Arakan coastal plain) lies only 4.5 km away, while to the west and southwest it faces the Bay of Bengal.

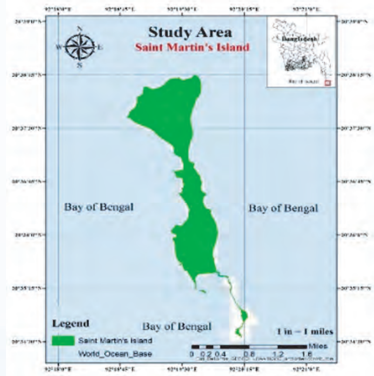


Figure 1: Geographic location map of St. Martin Island, Bangladesh

Materialsand Methods

Seawater samples are collected by two systematic ways. The coastal seawater samples are collected from 24 sites of the around of Saint Martin's Island by niskin water sampler (Figure 2c) from 26 February 2018 to 02 March 2018. These sampling sites included intertidal areas and inshore. The Site positions, sampling dates, sampling time, weather and tide conditions are given in Table 1. The sampling locations included areas with different environmental backgrounds for examples fish aquaculture, restaurants, resorts, jetty, and recreational sea beach areas.

Marine aquatic ecosystem needs careful protection to maintain the water quality and its The physico-chemical properties of the surface water (0-0.5m) seawater samples are collected by niskin water sampler and analyzed directly in the field at each sampling sites are temperature, salinity, pH, conductivity, Total Dissolved Solids (TDS) and resistivity by using an YSI water quality multi-probe and DO was analyzed by in-situ DO meter (Fig. 2a & 2b). When doing the measurements, the probe was submerged fully into the water at least around 30 cm from the coastal water surface and collecting seawater samples. From each sampling sites, 500 ml of water are collected by PVC water sample bottles. Before sampling, the bottles were cleaned and washed with detergent solution and rinsed 3 to 4 times with the water to be sampled. Hydrochloric acid is used as preservative in these sample bottles and containing samples are sealed immediately to avoid exposure to air and placed into the safe place. A total of two replicates are taken for each parameter at every sampling site. The sample bottles are screwed carefully and marked with the respective identification number. Surface water (0-0.5m) seawater samples are collected for analysis of total dissolved solids (TDS).

Data Processing and Analysis

The relevant data are processed and analyzed through manually and for computer based analysis MS Excel of Office 2013 version is used. For graphical and data displaying, Arc GIS is used.

Table 1: Coastal water sampling information with descriptions of sampling sites

Site No.	Site Position (From Saint Martin's Island)	Date	Time/ Weather	Geographic Coordinate System (GCS)		Tide
				Latitude (°) N	Longitude (°) E	
1	North	26 Feb 2018	05.10 p.m. Clear & Mild Sunny	20.63719	92.32824	High Tide
2	North	26 Feb 2018	05.25 p.m. Clear & Mild Sunny	20.63628	92.32594	High Tide
3	North	26 Feb 2018	05.34 p.m. Clear & Mild Sunny	20.63608	92.32317	High Tide
4	North	26 Feb 2018	05.42 p.m. Mild Sunny	20.63456	92.32076	High Tide
5	North	26 Feb 2018	05.51 p.m. Mild Sunny	20.63452	92.31798	High Tide
6	North	26 Feb 2018	06.02 p.m. Twilight	20.63265	92.31683	High Tide
7	North	26 Feb 2018	06.17 p.m. Twilight	20.62886	92.31459	High Tide
8	West	27 Feb 2018	12.05 p.m. Clear and Sunny	20.6265	92.31441	Low Tide
9	West	27 Feb 2018	12.22 p.m. Windy and Sunny	20.6248	92.3178	Low Tide
10	West	27 Feb 2018	12. 35 p.m. Windy and Sunny	20.62095	92.32193	Low Tide
11	West	27 Feb 2018	12.48 p.m. Windy and Sunny	20.61606	92.325	Low Tide
12	West	27 Feb 2018	01.02 p.m. Sunny	20.60618	92.32612	Low Tide
13	South	27 Feb 2018	01.15 a.m. Clear and Sunny	20.59225	92.32519	Low Tide
14	South	27 Feb 2018	01.28 a.m. Clear and Sunny	20.59033	92.32936	Low Tide
15	South	27 Feb 2018	01.39 a.m. Clear and Sunny	20.59259	92.33192	Low Tide
16	East	27 Feb 2018	01.52 a.m. Clear and Sunny	20.60022	92.33219	Low Tide
17	East	27 Feb 2018	02.05 p.m. Clear and Sunny	20.6065	92.32914	Low Tide
18	East	01 Mar 2018	02.03 p.m.; Sunny	20.61518	92.32771	Low Tide
19	East	01 Mar 2018	02.18 p.m.; Sunny	20.61853	92.32639	Low Tide
20	East	01 Mar 2018	02.30 p.m.; Sunny	20.62312	92.32736	Low Tide
21	East	01 Mar 2018	02.42 p.m.; Sunny	20.62743	92.32709	Slag Tide
22	East	01 Mar 2018	02.55 p.m.; Sunny	20.62955	92.32748	Slag Tide
23	East	02 Mar 2018	05.56 p.m. Twilight	20.63268	92.32849	High Tide
24	East	02 Mar 2018	06.08p.m. Twilight	20.63528	92.32873	High Tide

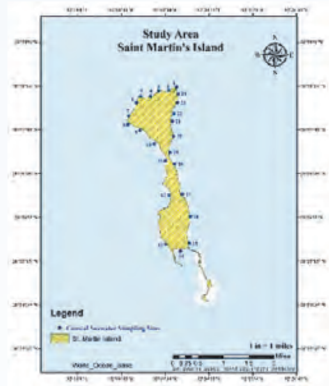


Figure 2: Sample collecting sites in Saint Martin's Island.

Resultsand Discussion

The water quality parameters at the 24 sampling sites of coastal water of the Saint Martin's Island are summarized in Table 2.

Coastal Seawater Temperature: Coastal seawater temperatures ranged from 25 to 30°C.The study showed that the lowest temperature of coastal seawater was at the St-23 (25.7°C) near the Jetty Ghat and highest temperature of coastal seawater was at the St-11 (29.5°C) near the Gola-Chipa of the Saint Martin's Island.The average temperature was 27.53° C (Table 2).

Table 2: Overall values of physico-chemical parameters of the intertidal waters (Inshore) collected from the Saint Martin's Island (N= 24)

N=24	Minimum	Maximum	Mean	Standard Error
Temperature (°C)	25.7	29.5	27.53	0.216
Salinity (ppt)	30.8	33.4	32.76	0.133
Conductivity (µS/cm)	48966	55235	52477.63	307.73
pH	8.05	8.38	8.19	0.018
DO (mg/L)	5.08	6.87	5.89	0.051
TDS (mg/L)	29575	31980	31083.96	143.1232

Salinity (ppt): Salinity is an ecological factor of considerable importance, influencing the types of organisms that live in a body of water. Coastal seawater salinity ranged from 30.8 to 33.4 ppt. The study showed that the lowest salinity of coastal seawater was at the St-2 (30.8ppt) and highest salinity of coastal seawater was at the St-14 (33.4 ppt). The average salinity was 32.76 ppt (Table 2).

Conductivity (µS/cm): The conductivity of water depends on the concentration of ions and its nutrient statues. Conductivity of coastal seawater ranged from 48966 to 55235 µS/cm. The study revealed that the lowest conductivity of coastal seawater was at the St-02 (48966 µS/cm) and highest conductivity of coastal seawater was at the St-11 (55235 µS/cm). The average conductivity was 52477.63 µS/cm (Table 2).

pH: pH value is very important for plankton growth through the marine ecosystems. The pH values which measure how acidic/basic water is, ranged from pH 7.9-8.4 for all sampling sites. pH of Coastal seawater ranged from 8.05 to 8.38. The study showed that the lowest pH of coastal seawater was at the St-10 (8.05) and highest pH of coastal seawater was at the St-18 (8.38). The average pH was 8.19 (Table 2).

Dissolved Oxygen (mg/l): The dissolved Oxygen (DO) refers to the amount of oxygen dissolved in the water and it is particularly important in limnology (aquatic ecology) [12]. In the present study DO of Coastal seawater ranged from 5.084 to 6.87 mg/l. The study showed that the lowest DO of coastal seawater was at the St-19 (5.084 mg/l) and highest DO of coastal seawater was at the St-02 (6.87 mg/l). The average DO was 5.89 mg/l (Table 2).

Total Dissolved Solids (mg/L): TDS of coastal seawater ranged from 29575 to 31980 mg/L. The study revealed that the lowest TDS of coastal seawater was at the St-02 (29575 mg/L) and highest TDS of coastal seawater was at the St-11 (31980 mg/L). The average TDS was 31083.96 mg/L(Table 3). Mainly primary sources for TDS in receiving waters are agricultural runoff, leaching of soil contaminant and point source water pollution discharged from industrial or sewage treatment plants.

Comparison of average physico-chemical properties: The present status of physico-chemical properties of surface water of the North and South, East and West of the coast (inshore) of the Saint Martin's Island are given in the Table 3.

Table 3: Comparison of average physico-chemical properties at different sides of the Saint Martin's Island

SLNo	Parameter	North	South	East	West	Average
1	Temperature (°C)	26.95	27.6	27.62	28.14	27.58
2	Salinity (ppt)	32.58	33.36	32.76	32.65	32.84
3	Conductivity (µS/cm)	51345.57	53412.67	52719.56	53066	52635.95
4	pH	8.14	8.21	8.20	8.17	8.18
5	DO (mg/L)	5.98	5.96	5.83	5.87	5.92
6	TDS (mg/L)	31262.14	31515	31039.56	30666	31119.26

The average temperature of coastal seawater were 26.95, 27.6, 27.62 and 28.14 °C at the north, south, east and west sides of the Saint Martin's Island respectively. The average temperature of coastal seawater was 27.58 °C at 28 February and 01 & 02 March 2018. The highest and lowest temperature was found at the west and north sides of Saint Martin's Island respectively (Figure: 4a). The average salinity was 32.58, 33.36, 32.76 and 32.65 ppt at the north, south, east and west sides of the Saint Martin's Island respectively. The average salinity of coastal seawater was 32.84 ppt. The highest and lowest salinity were found at the south and north sides of Saint Martin's Island respectively (Figure: 4b). The average conductivity is similar pattern to the salinity of the coastal seawater. The average conductivity of coastal seawater was 52477.63. The maximum and minimum conductivity were found at the south and north sides of Saint Martin's Island respectively (Figure: 4c).

On the other hands, the average pH were 8.14, 8.21, 8.20 and 8.17 at the north, south, east and west sides of the Saint Martin's Island respectively. The average pH of coastal seawater was 8.18. The highest and lowest pH was found at the north and south sides of Saint Martin's Island respectively (Figure: 4d). The average DO were 5.98, 5.96, 5.83 and 5.87 mg/L at the north, south, east and west sides of the Saint Martin's Island respectively. The average DO of coastal seawater was 5.92 at 28 February and 01 & 02 March 2018. The highest and lowest DO was found at the north & south and east sides of Saint Martin's Island respectively (Figure: 4e). The average TDS of the coastal seawater were 31262.2, 31515, 31039.56 and

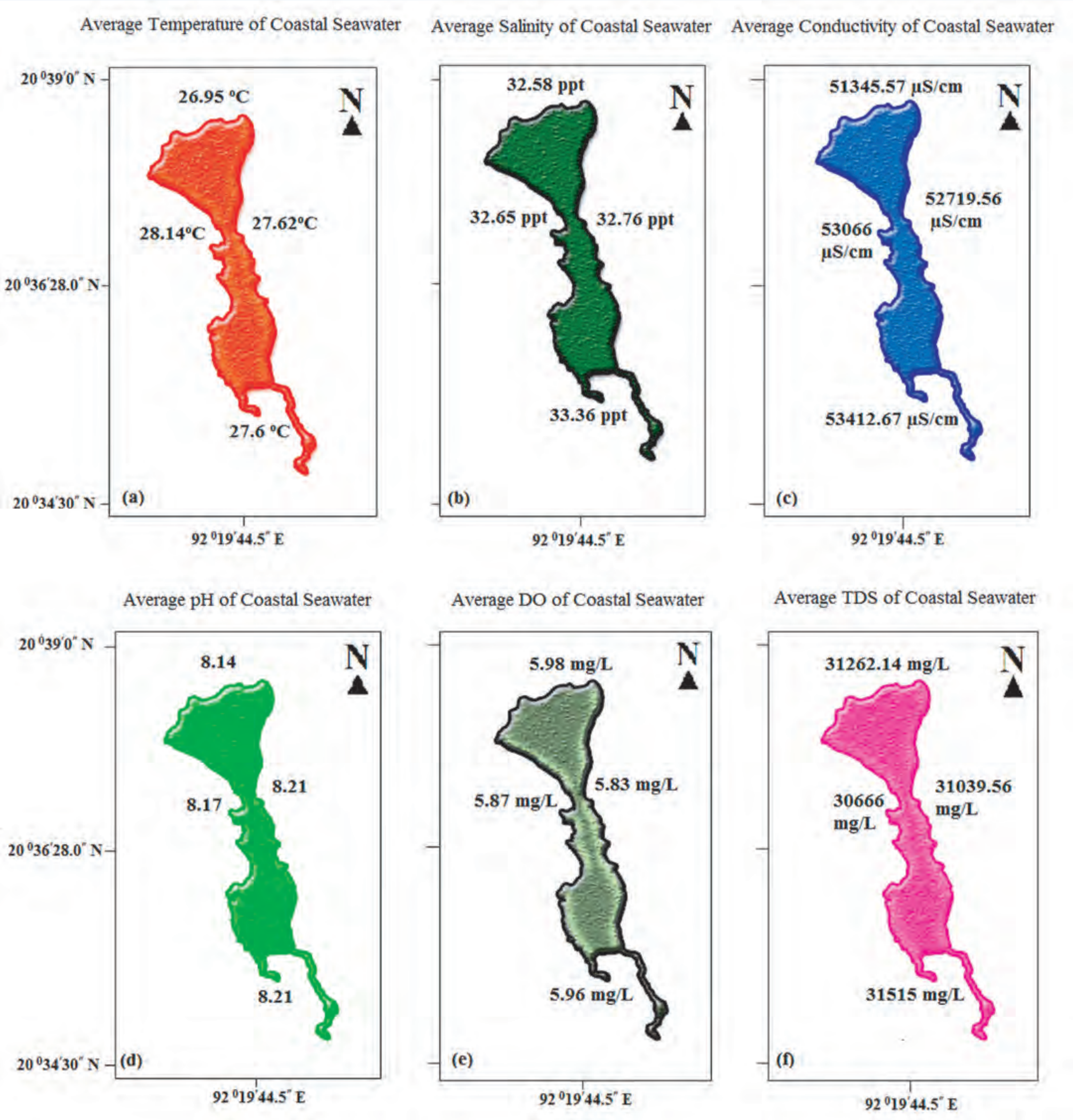


Figure 4: Average coastal seawater temperature (a), salinity (b), conductivity (c), pH (d), DO (e) and TDS (f) of the north, south, east and west sides of the of Saint Martin's Island.

30666 mg/L at the north, south, east and west sides of the Saint Martin's Island respectively. The average TDS of coastal seawater was 31083.96 mg/L. The maximum and minimum TDS were found at the south and west sides of Saint Martin's Island respectively (Figure: 4f).

Conclusion

Water quality is truly linked to the surrounding environment and land use. Seawater quality around the Saint Martin's Island is affected by community uses such as agriculture, settlements, unplanned infrastructure especially hotel, tourism, recreation drainage systems and sewerage line etc. In the present study, we try to assess the seawater quality around the Saint Martin's Island. The findings are-

- the ranges for the physico-chemical parameters of coastal seawater were 25 to 30°C for temperature, 30.8 to 33.4 ppt for salinity, 5.08 to 6.87 mg/L for DO, 8.05 to 8.38 for pH, 29575 to 31980 mg/L for TDS, 48966 to 55235 µS/cm for Conductivity and 18.08Ω to 20.43 -cm for resistivity.
- The higher temperature is found at the west and south of the Saint Martin's Island which connect to the open ocean.
- The highest and lowest salinity is found at the south and north of the Saint Martin's Island respectively.
- The average DO of coastal seawater of the Island was 5.92. The highest DO is found in three sides' especially northern side of the Island.

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Mapping marine litters and find the Clean Coast Index (CCI) of Saint Martin's island coastline

Sultan Al Nahian
Scientific Officer

Mir Kashem
Scientific Officer

Abu Sharif Md. Mahbub-E-Kibria
Senior Scientific Officer

Abstract

This study examines marine litters in the using geographic information systems (GIS) & GPS, Clean Coast Index (Alkalay et al., 2007) and OSPAR guideline to develop (1) a detailed map of intensity and distribution of marine litter (2) results of baseline clean coast index (CCI) (3) a complete outline for a spatial database of shoreline litter of Saint Martin's island. A total of 72 sampling units (100-150 m transects approx.), covering 12 kilometers of coastline in Saint Martin's Island were surveyed by 12-15 volunteers. In total, over 840 volunteer hours were spent detecting and recording around 50,000 pieces of litter. As per clean coast index rate Saint Martin's Island can be measured as "Moderate" (>5.2 plastic pieces/m^2).

Introduction

Marine litter (also known as marine debris) is a growing environmental problem worldwide (NOAA, 2014). According to National Academy of Sciences, USA marine litter is defined as ''solid materials of human origin that are discarded at sea or reach the sea through waterways or domestic and industrial outfall''. Basically There are two sources of marine litter: sea-borne and land based such as industrial wastes and litter originating from human activity on the beach (UNEP, 2005). According to the US Department of Commerce and the US Navy, approximately 80% of litter is washed off the land, blown by winds, or intentionally dumped from shore (The Ocean Conservancy, 2005). Saint Martin's Island coast (only coral island of Bangladesh) is characterized by a rich diversity of natural, environmental, ethnic and economic resources and is among the country's most valuable assets. The quality of Saint Martin's Island coast has deteriorated significantly over the last decade as a result of heavy tourist activity, heavy marine vehicle transportation and over population. Basically, high litter density, of more than 10 items/m of beach would deter over 50% of tourist and local beachgoers. Litter which reaches the sea, borne by wind or waves, also discarded from marine vehicle causes damage to the local marine biota, and underwater coral ecosystems. Some of the litter, especially plastic, is returned to some beaches, as a result of storms, as the energy of the waves draws plastic bags out of the seabed. Challenges in studying marine litter include having a baseline understanding of litter composition, concentrations, and sources necessary for addressing environmental and aesthetic impacts of this crisis.

Materials and methods

Study area

The Saint Martin's Island, locally called 'NarikelJinjira' (figure 1) is located in the northeast of the Bay of Bengal. Saint Martin's Island is situated between 20°34´ to 20°39´ N latitude and 92°18´ to 92°2´ E longitude. There are more than 8000 people on this coral island of 12 sq. km. area. In tourist season (end of Oct.-Feb.) on average 3.5-4 thousand people visit this island every day, which is beyond the holding capacity of this small marine island. During tourist season tens of big ship and

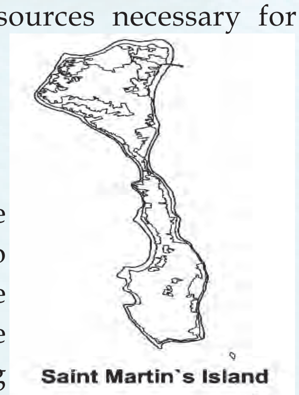

Figure 1: Study area Saint Martin's Island

commuter boat services, used for passage of tourist, to the island. Bilge water from marine vehicle, tons of plastic and other non- degradable debris were discharged in the coastal water of the island. The Saint Martin's island coast stretches about 12 km and it is not homogeneous. It varies from long sandy beaches, surrounded by sand dunes to narrow rocky shores with beach rocks & pebbled covered by seashells.

Time and tools

Field data collection occurred February 2018 over 2 weeks in the winter. Tools used consisted of a GPS handheld unit (Garmin e-trex 10), a 100-m engineer tape, four red surveying flags, and approximately 20 kg size transparent trash bags for collection of litter from the survey sites. Collecting complete and detailed data on a study sample site ranged about 1-2 h, depending on intensity of debris.

Sampling transects

The guideline is mainly based on the outline described in the OSPAR guideline for monitoring marine litter on the beaches in the OSPAR maritime area (OSPAR 2010). Depending on the shores transects in each sampling unit covered approximately 100 m of coastline and width covers recent high tide line (along the strandline) to backline of the beach (e.g. up to the edge of the sand dunes, sea wall or promenade, vegetation line). For narrow and interrupt shoreline 150 m (approx.) transect was taken. Four red surviving flag was marked in between recent high tide line and the back of the beach with in 100m transect. GPS reading was also taken for each red flag position. Litters range from 2.5 cm to 50 cm (approx.) litter (mostly plastic substance) considered as a sample. Each piece of litter on the measured area of beach was counted and recorded on standardized data sheets, categorizing the items according to material type (such as plastics, metal, sanitary, etc.) and, in most cases, exact identity (e.g. bottle, bottle cap, crisp packet, straw, cotton bud stick, plastic buoy etc.). Each transect was surveys twice by 10 to 12 local volunteer.

Results and Discussion

Distribution of debris

The collection of 72 sampling unit around the island of all locations revealed multiple items of debris per data point throughout the entire study. The highest number of items found in the north and southern tip of the island. East and west part of the island found moderately clean. Approximately 50 thousand pieces of debris was counted during the survey where more than 35 thousand counted plastic materials. Plastics was dominated across all study sites comprising between 70% and 90% (approx.) of all debris items recorded, consistent with literature reports that plastics commonly make up between 60 and 80% of overall marine debris recorded (Gregory and Ryan 1997; Derraik 2002).

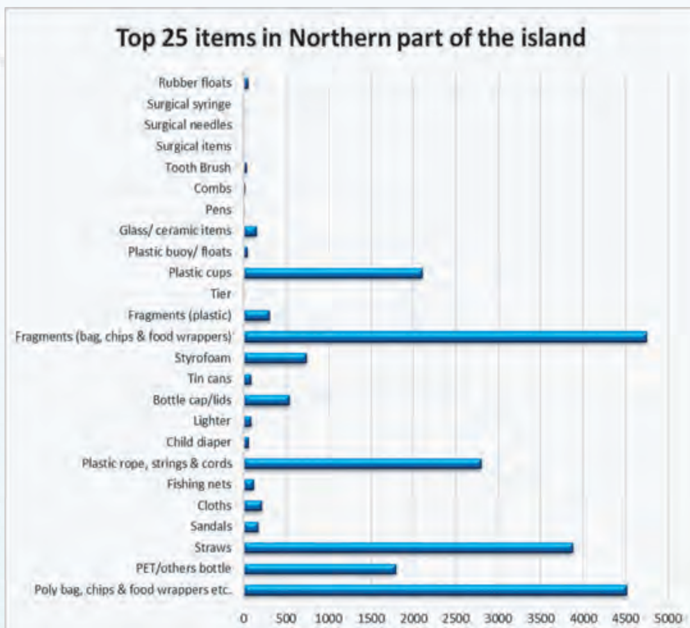

Figure 2: Items observed in northern part of the island.

The most common 25 items found during the survey is illustrated in figure 2 and 3. Litter distribution of the island is little different in northern and southern part of the island.

Poly bags, chips and food wrappers, PET or drinks bottle, straws, plastic cups and fragments was commonly found items because of high tourist activity, local market and hotels and local household waste were main litter source of southern part of the island, on the other hand aged plastic and polythene fragments, plastic and rubber floats, Styrofoam's, fishing items was dominated in southern part of saint martin's island. Sea borne litters, fishing activity and few local debris were main sources of the northern part of the island.

Clean Coast Index (CCI)

According to Alkalay et al. the calculation of the CCI is presented in the following Equation:

Clean Coast Index (CCI) = (Total litter on sampling unit/total area of sampling unit) x K

Where CCI is the number of litter items per m^2, the total area of the sampling unit is generated by multiplying the sampling unit's length with the width and K is a constant that equals to 20 (Alkalay R., 2000).

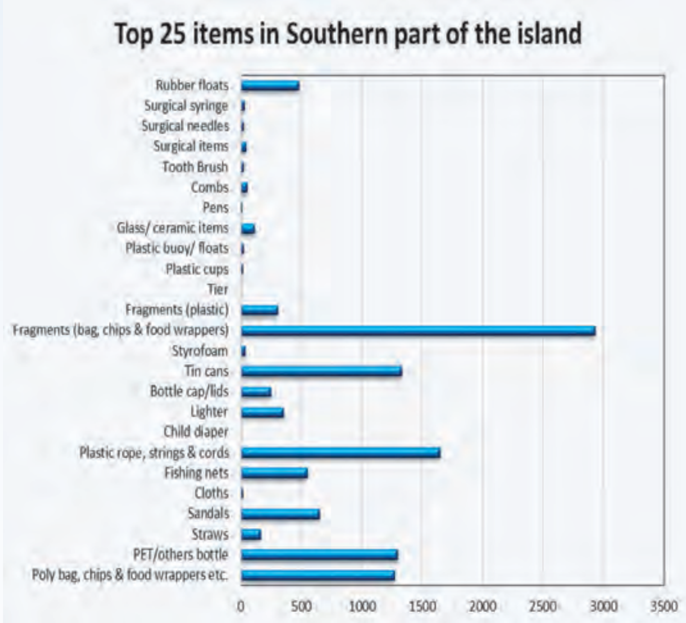

Figure 3: Items observed in southern part of the island.

In order to make the picture clearer for the public, results for appearance of litter on the coasts were graded as follows:

0-2: very clean-no litter is seen,
2-5: clean-no litter is seen over a large area
5-10: moderate-a few pieces of litter can be detected
10-20: dirty-a lot of debris on the shore
20 +: extremely dirty-most of the beach is covered with plastic debris.

Coast Index	Very clean	Clean	Moderate	Dirty	Extremely dirty
Numeric Index	0-2	2-5	5-10	10-20	20 +

Usually marine litter is affected by the waves, tidal and wind effect its distribution is not constant. After storms, litter is usually found at the highest watermark or strandline also reaching the edge of the beach. During the tourist season, distribution of litter is affected mainly by tourist and local activity (Alkalay et al., 2007). Figure 4 illustrated the Results of baseline clean coast index (CCI) of Saint Martin's Island. According to clean coast index (CCI) 31% and 41% of the beach was very clean and clean respectively which is eastern and some western portion (pebbled coasts covered by seashells) of the island where tourist activity is very limited. 12% and 13% of the beach found moderate and dirty respectively which is northwestern (gently sloped sandy beaches) and south part (narrow rocky shores with beach rocks) of the island. North part (sandy beach with dunes) of the island found extremely dirty (3% CCI) where tourist activity, local bazar, fish market, jetty and others activity is very prominent.

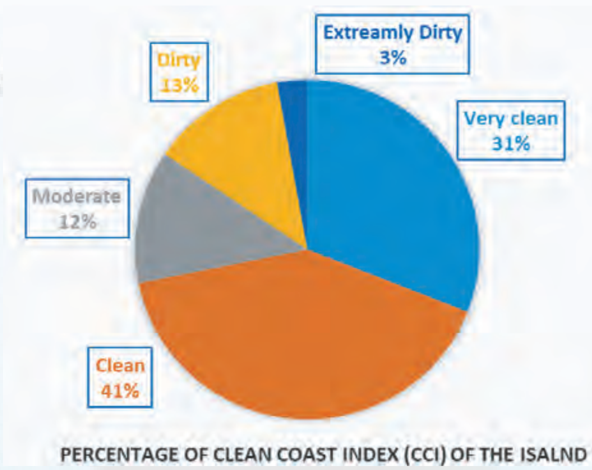

Figure 4: Results of baseline clean coast index (CCI) of Saint Martin's Island

GIS mapping of marine litter intensity and distribution

Both degradable and non-degradable litters were existing in the Saint Martin's Island beach. Degradable litters generally came from household, restaurants, fish market and also from local market. Non-degradable litters were classified in to 25 categories mostly plastics materials like ploy bags, food wraps, pet bottle, straws, cups are commonly found. Plastics and coconut shells were common in beach due to beach activities. Marine litter's intensity and distribution showed in figure 5. Litters intensity found highest north and south west corner of the island. At northern part where Jetty, fish market, local bazar, plenty of resort and restaurant are situated which dispose tons of waste in the open coast. South west coast of the island were polluted by sea borne litters where rocky shore and a small mangrove trapped the debris. East and west coast of the island appearances very low litter intensity, local beachgoers and environmental process is the main sources of litters.

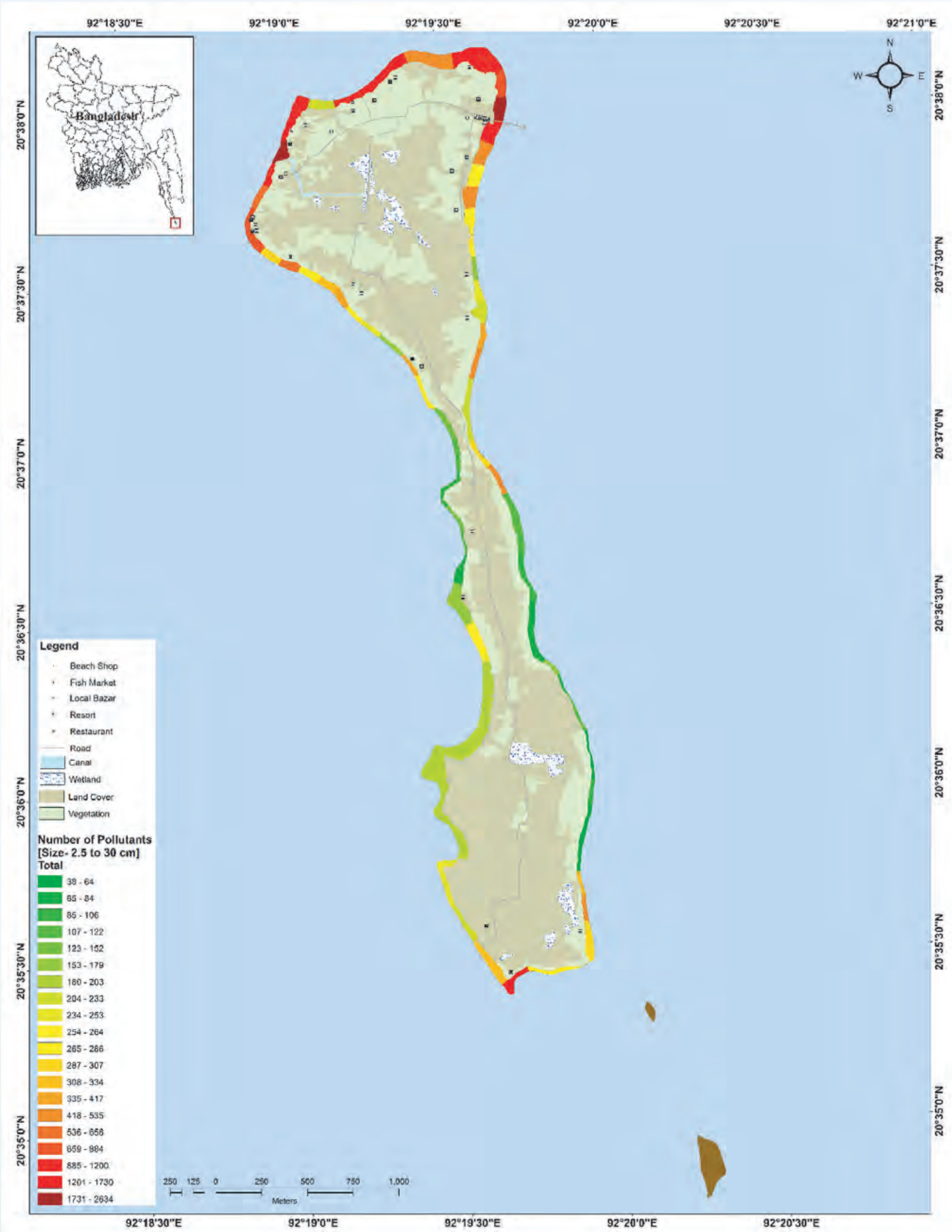

Figure 5: Intensity of marine litter along the coast of Saint Martin's island.

Extremely Polluted Point (EPP) considers as a point or area where all kinds of solid wastes (degradable and non-degradable) dumped in an open place adjacent to the beach. Around 10 location or point has been identified along the coastline of the Saint Martin's island. Five EPPs were found in the Northeast part of the island where every kind of anthropogenic activity is very high. Local bazar, fish market, restaurants,

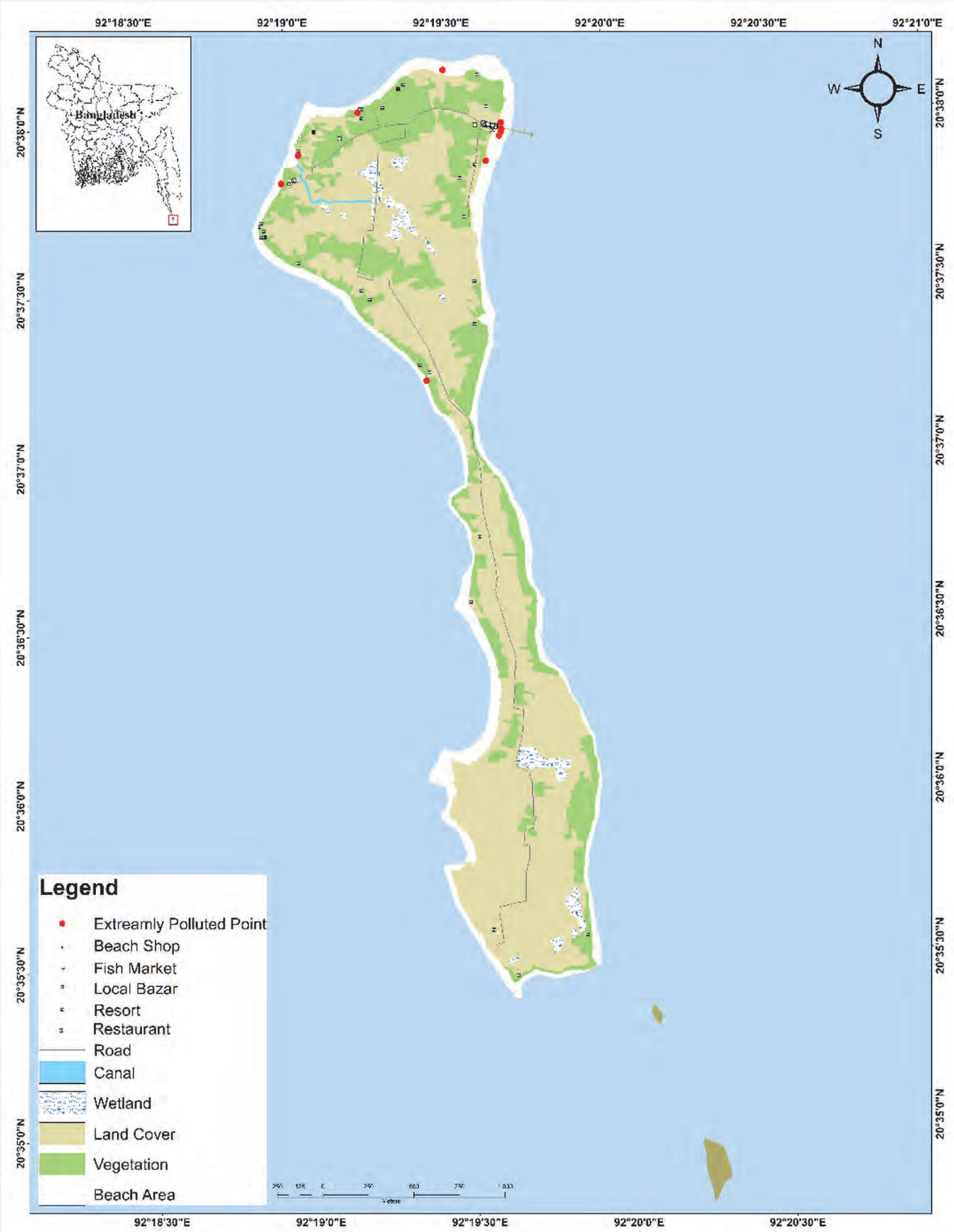

Figure 6: Position of Extremely Polluted Point (EPP)

resorts, hotels and domiciles waste were dumped regularly in the same location as a results it became as a dumping zone. Another four EPPs are scattered along the North to Northwest part of the island, where tourist activity is moderately high, source of wastes were local house, resorts and beach shops and one EPP has been identified in the Western part where the main source was resorts and coconut shop.

Conclusion

The intentions of this work were to gain a baseline understanding of marine debris or litters in Saint Martin's island and to deliver a preliminary outline for future actions to address such issues in the country as well as add to global studies of marine debris in demonstrating the utility of GIS-based research. According to clean coast index (CCI) average numeric index is 5.2 which represent moderate CCI index. 31% found very clean and only 3% of the coastline carriage extremely dirty coast index (CCI). Using the data collected in this study as a starting point offers a scientific basis for the country regarding marine debris issues and can encourage local community, students and researchers involvement through beach surveys and cleanup program. Marine litters or debris is a human caused problem, but it can be better managed if we know the locations of problem hotspots and if we learn ways to successfully promote proactive litter programs.

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Seasonal Variation of Seawater Quality around the Saint Martin's Island, Bangladesh

Mir Kashem
Scientific Officer

Sultan Al Nahian
Scientific Officer

Abu Sharif Md. Mahbub-E-Kibria
Senior Scientific Officer

Abstract

Saint Martin's island is a beautiful tourist attractive place and a unique coral island in Bangladesh. Seawater quality is truly linked to the surrounding environment and land use. Seawater quality around the Saint Martin's Island is affected by community uses such as agriculture, settlements, unplanned infrastructure especially hotel, tourism, recreation drainage systems and sewerage line etc. Physico-chemical parameters were determined the coastal waters and offshore water around the Saint Martin's Island. All the physico-chemical parameters such as sea surface temperature, salinity, pH and dissolved oxygen were studied for a period of 3 months (07 to 10 January 2019 – 08 to 10 March 2015). The coastal and offshore seawater around the Saint Martin's Island where sea surface temperature varied from 22.6 to 29.6 °C and 22.7 to 25.90 °C, salinity varied from 31.12 to 33.8 and 31.05 to 33.9 ppt, hydrogen ion concentration ranged between 7.9 to 8.29 and 7.95 to 8.24, variation in dissolved oxygen content were from 6.16 to 7.94 and 5.17 to 6.5 mg l^{1} and also varied independently.

Keywords: Sea Surface Temperature, Salinity, pH, Dissolved Oxygen and Saint Martin's Island.

Introduction

Saint Martin's island is one of the unique coral islands and popular tourist destinations in Bangladesh due to it's and favorable environmental condition (Muhibbullah and Sarwar I, 2017).It is also recognized as therichest biodiversity hotspot in terms of marine biotic resources in Bangladesh (Upal, 2015). St. Martin's Island is only 8 km^2 dumb-bell shaped sedimentary Continental Island located in the northeast part of the Bay of Bengal and about 9 km far from the Cox's Bazar-Teknaf peninsula tip, and the southernmost part of Bangladesh (Afrin, 2013). Contrary, it is about 8 km west of the northwest coast of Myanmar at the mouth of the Naf River. There is a small connected island that is separated at high tide, called Chera Island. The area of the island itself is about 5.9 km^2 whereas with the rocky platforms extending into the sea the total area of the island is about 12 km^2. It was connected to the mainland of the Teknaf peninsula as-recently-as 6,000 -7,000 years ago (Warricket al., 1993; Chowdhury, 2012).

Destructive fishing practices, mainly the use of rock-weighted gill nets over the inshore boulder reefs are one of the prime aggravates (Hossain and Islam, 2006). The environmental quality and ecological value of this island is regularly degrading by the increasing of human intervention and natural disasters in every year. There are several authorities are tried to concern about the sustainability of waste management, drainage system and water quality problems for the island (Rahman, 2009). It may definitely append to increase of solid wastes by rising of visitors or tourists into the Saint Martin's island that is also future threat for the coral habitat. The physical action of wastes throwing by tourists either on the beach or in the water might not be an apparent threat (UNDP, 2010).

Sometimes oil pollution is created by the passenger engine boats, ships; fishermen's boats are contributing for deterioration of water quality of the island. The cumulative effects of the oil residues could also effect on the health of the marine resources. Snorkeling and scuba diving are the most popular activities that tourists are tried to enjoy during their visit to the marine park of the island also. These types of activities, which are identified to pose with significant threat to the living corals in shallow water. Thus, inexperienced snorkelers and scuba divers are tending to either crush or stand on the reefs. The coral breakage could be the result of diving activity as well as anchoring of boats by the irresponsible boat operators or illegal fishermen. Sometimes, the ill-motivated visitors were tried to engage on illegal activities, such as; stealing live corals and other marine lives from the island to sell them for souvenirs all the year round. Though tourists are also prohibited from fishing within the marine parks limit but some bodies are associated with this illegal activity with the help of local administrative authority (Upal, 2015).

Marine aquatic ecosystem needs careful protection to maintain the water quality and its standard. Water quality plays an important role for the production of fisheries (Riedel GF et. al, 2000). Although monitoring water quality does not measure the environmental health on an ecosystem, it is argued that the water quality of an aquatic ecosystem can provide a rapid assessment of the environmental quality before it is manifested in living organisms (Connell 1981). Every living organism has a range of tolerance for all abiotic factors (water quality) in their surrounding habitats. Any parameter which is out of the tolerance range could be considered as being detrimental to living organisms. Thus, this would affect the distribution and abundance of organisms. Some physio-chemical properties such temperature, salinity, dissolved oxygen (DO), total dissolved solids (TDS), turbidity, pH and conductivity can potentially affect the fate of any contaminant in the water, control their speciation and thus their distribution within the dissolved or particulate fractions. These parameters can be used to indicate the pollution level of the water body (Kamal et al. 2007).

Objectives of this research

- To determine the physico-chemical properties (temperature, salinity, pH, dissolved oxygen and Biological Oxygen Demand) of surrounding seawater of the Saint Martin's Island
- To compare the physico-chemical properties between sea surface water (0-1m) and 5m deep near bottom water within 5 km of the Saint Martin's Island
- To assess the pollution status based on the analyses of data of physico-chemical properties

Study Area

The Saint Martin's Island, locally called 'NarikelJinjira' is located in the northeast of the Bay of Bengal(Figure.1). The island is an administrative union of TeknafUpazila under Cox's Bazar district in Bangladesh.Saint Martin's Island is situated between 20°34´ to 20°39´ N latitude and 92°18´ to 92°2´ E longitude (Figure 1). To the east the Myanmar boundary (Arakan coastal plain) lies only 4.5 km away, while to the west and southwest it faces the Bay of Bengal. The Saint Martin's island has divided into 7 local administrative units (locally called Para) namely Uttar Para, Puschim Para, Purba Para, Maddam Para, Kona Para, Gala Para, Daskin Para and Pug Kata Bonia. The island has a wide variety of land-cover types, such as sandy shore, rocky shore, mangrove forest and agricultural land producing rice, water melon, ground nut, maize, seasonal vegetable as well as coconut, betel leaf and nut.

Figure 1: Geographic location map of St. Martin Island, Bangladesh

Materials and Methods

Seawater samples are collected by two systematic ways. Firstly, coastal seawater samples are collected from 9 sites of the around of Saint Martin's Island and Secondly, sea surface water and 5 m in depth seawater samples are collected from 8 sites within 5 km of the Saint Martin's Island (Figure 3) by niskin water sampler (Figure 2) from 07 to 10 January 2019, 07 to 10 February 2019, and 7 to 10 March 2019. These sampling sites included intertidal areas, inshore and offshore. The Site positions, sampling dates, sampling time, weather and tide conditions. The sampling locations included areas with different environmental backgrounds for examples fish aquaculture, restaurants, resorts, jetty, and recreational sea beach areas.

The physico-chemical properties of the surface water (0-0.5m) and 5m deep seawater samples are collected by niskin water sampler and analyzed directly in the field at each sampling sites are temperature, salinity and pH, by using an YSI water quality multi-probe, digital Refractometer, pH meter (Figure 2) and DO was analyzed by in-situ DO meter (Figure 2). When doing the measurements, the probe was submerged fully into the water at least around 30 cm from the coastal water surface and collecting seawater samples. From each sampling sites, 500 ml of water are collected by PVC water sample bottles. Before sampling, the bottles were cleaned and washed with detergent solution and rinsed 3 to 4 times with the water to be sampled. Hydrochloric acid is used as preservative in these sample bottles and containing samples are sealed immediately to avoid exposure to air and placed into the safe place. A total of two replicates are taken for each parameter at every sampling site. The sample bottles are screwed carefully and marked with the respective identification number. Surface water (0-0.5m) and 5m deep seawater samples are collected for further lab analysis.

Figure 2: (a) Multi-water analyzer (YSI Professional Series-626909-4, Made in USA); (b) In-Situ DO meter (SmarTROLL RDO CA30, Made in USA); (c) Seawater Refractometer (HANNA: HI 96822); (d) Niskin Water Sampler (Hydrobius, Made in Germany); (e) pH Meter (HANNA: HI 8424) and (f) Secchi Disc

Data Processing and Analysis

The relevant data are processed and analyzed through manually and for computer based analysis MS Excel of Office 2013 version is used. For graphical and data displaying, Arc GIS, R programing, Matlab, Surfer and Grapher are used.

Figure 3: Map showing the water samples collecting sites in Saint Martin's Island.

Resultsand Discussion

The seawater quality parameters at the 9 sampling sites of coastal water (inshore) and 8 sampling sites of offshore of the Saint Martin's Island.

Seasonal (08 & 09 January to March 2019) Variation of physico-chemical parameters of the seawater around the Saint Martin's Island

Physico-chemical parameters are considered as one of the most important features that are capable of influencing the marine environment and have showed wide variation monthly. All the physico-chemical parameters showed clear seasonal patterns, which are very typical to the tropical marine environment.

Seasonal (08 & 09 January to March 2019) Variation of physico-chemical parameters of the coastal water of the Saint Martin's Island

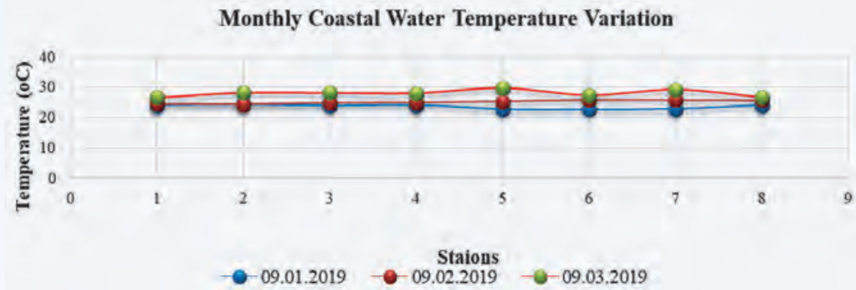

Figure 4: Monthly variation of SST of coastal water around the Saint Martin's Island

Coastal Water Temperature

Sea surface temperature recorded at nine different stations ranged from 22.6 to 29.6 °C. The minimum SST was observed during January 2019 at station St-1 and the maximum was registered during March 2019 at station St-5 (Fig 4). From the observation of the coastal water temperature data, the trend of SST was increased in every month respectively due to might be intensity of solar radiation and evaporation. The trend of SST of the March 2019 is higher than the trend of SST of January 2019 (Figure-4).

Coastal Water Salinity

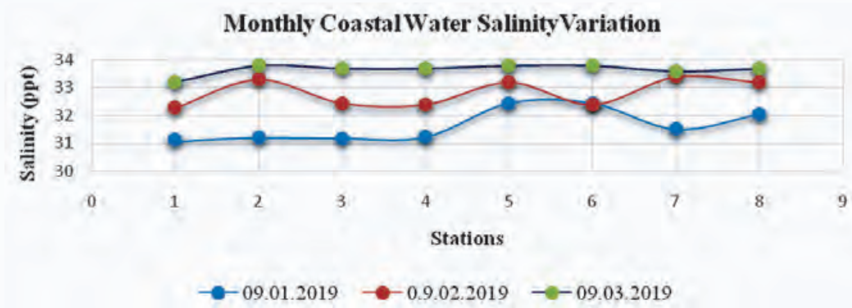

Figure 5: Monthly variation of SSS of coastal water around the Saint Martin's Island

Sea surface salinity recorded at nine different stations ranged from 31.12 to 33.8 ppt. The minimum SSS was observed during January 2019 at station St-1 and the maximum was registered during March 2019 at station St-2, 5 & 6 respectively (Fig 5). From the observation of the coastal water salinity data, the trend of SSS was increased in every month due to might be intensity of solar radiation and higher rate of evaporation. The trend of SSS of the March 2019 is higher than the trend of SST of January 2019 (Fig 5).

Hydrogen concentration (pH) of Coastal Water

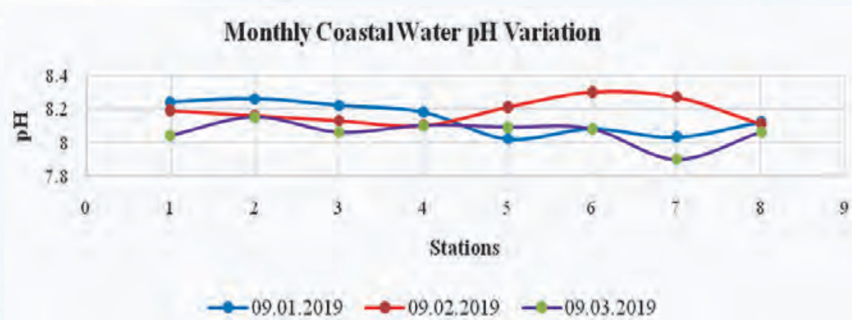

Figure 6: Monthly variation of pH of coastal water around the Saint Martin's Island

Hydrogen concentration (pH) recorded at nine different stations ranged from 7.9 to 8.29. The minimum pH was observed during March 2019 at station St-7 and the maximum was registered during February 2019 at station St-6 (Fig 6). From the observation of the coastal water pH data, the trend of pH shows the abnormal trend in every sampling month due to factors like removal of CO_2 by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, reduction of salinity and temperature and decomposition of organic matter (Upadhyay, 1998; Rajasegar, 2003; & Paramasivam & Kannan, 2005).

Dissolved Oxygen (DO) of Coastal Water

The level of dissolved oxygen (DO) was recorded at nine different stations ranged from 6.16 to 7.94 mg/L. The minimum DO was observed during March 2019 at station St-4 and the maximum was registered during February 2019 at station St-7 (Fig 7).

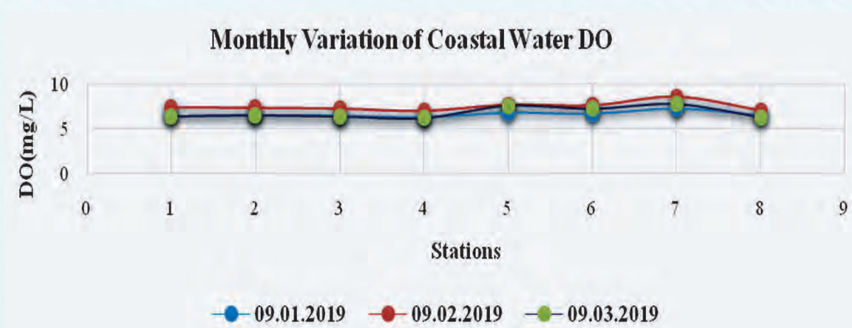

Figure 7: Monthly variation of DO of coastal water around the Saint Martin's Island

From the observation of the coastal water salinity data, the trend of DO was increased in February due to presence of surface strong wind in this period. The correlation between SST and DO is negative. Where SST is high, DO is low. The trend of DO of the March 2019 is lower than of February 2019 (Figure 7).

Seasonal (08 & 09 January to March 2019) Variation of physico-chemical parameters of the offshore seawater (Within 5 km from the Island) of the Saint Martin's Island

Upper Ocean is so dynamics with its physico-chemical parameters. This short time series data may allow us to understand the effects of short time variations in the physico-chemical conditions in the coastal waters and offshore seawaters. Hence, the present study investigated the seasonal change in physico-chemical parameters in the coast of Saint Martin's Island with respect to the prevailing hydrographical environment through planned systematic new data collections.

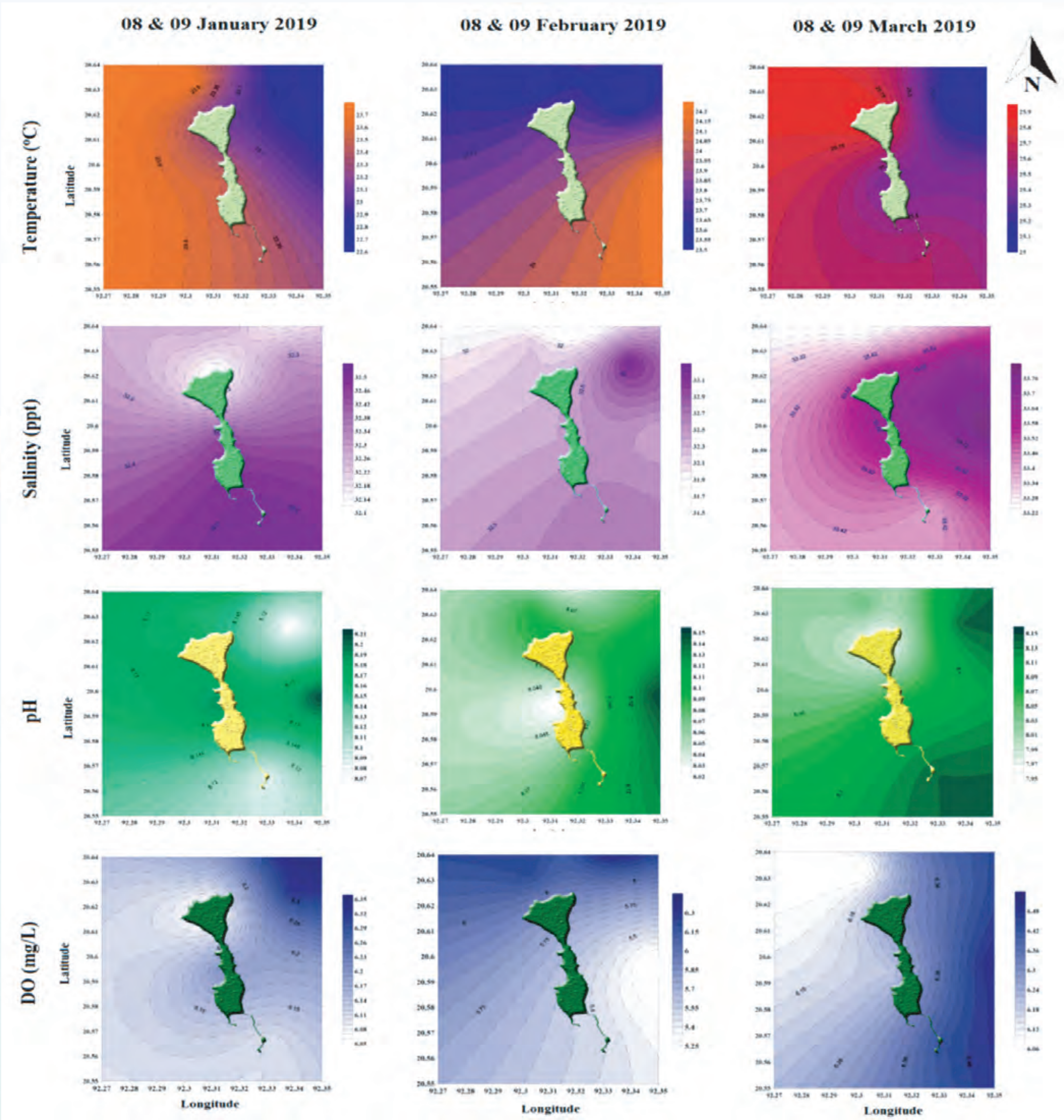

Figure 8: Seasonal variation of physico-chemical parameters (SST, SSS, pH & DO) of the offshore seawater around the Saint Martin's Island.

Generally, surface water temperature has been influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling and mix-up with ebb and flow from adjoining neritic waters (Eppley 1972). The minimum SST (22.7 °C) was observed during January 2019 at station St-1 and the maximum SST (25.9 °C) was registered during March 2019 at station St-4. The warm SST was found in west-southern side of the Saint Martin's Island during 08 & 09 January and March 2019 except 08 & 09 February 2019. The weather of February (08 & 09) 2019 was abnormal, sky was cloudy and strong north-east wind was present in this time and the fresh water influx of Naf river was may active in the northern side of the Island. As a result cool SST was found in the northern side of the Island. Salinity did not fluctuate much between the seasons registering the maximum (33.8‰) during 09 March 2019 at station St-7, coinciding with the low amount of rainfall and higher rate of evaporation (Govindasamy et al. 2000) prevailing in the region during this season and the seasons registering the minimum salinity (31.05‰) during 09 February 2019 at station St-2. The salinity of northern side was lower than the southern side of the Island due to the presence of fresh water influx of the Naf River. From the observation, the eastern side of the Island where salinity was maximum during the March 2019 than the other sides of the Island due to low amount of rainfall and higher rate of evaporation (Govindasamy et al. 2000). The minimum pH (7.95) was observed during March 2019 at station St-4 and the maximum SST (8.21) was registered during January 2019 at station St-7. Comparatively, the higher pH was found in the eastern side than the western side of the Island. The pH values might be due to the influence of seawater inundation and the high density of phytoplankton (Das et al. 1997; Subramanian and Mahadevan 1999). The DO level varied between 5.17 mg/l (February 2019) and 6.7 mg/l (February 2019) at the stations St-7 and St-1 respectively. In 08 & 09 February 2019, the increased DO (6.7 mg/l) level can be attributed to comparatively less SST and salinity recorded in this station and another cause's strong north-east wind was present in this time. From the observation, cool SST and less salinity that is mixed fresh water contain much DO and warm SST and high salinity water contain less DO.

Conclusion

Seawater quality around the Saint Martin's Island is affected by community uses such as agriculture, settlements, unplanned infrastructure especially hotel, tourism, recreation drainage systems and sewerage line etc. Protecting aquatic ecosystems is in many ways as important as maintaining water quality. In the present study, we try to assess the seasonal seawater quality around the Saint Martin's Island. The finding of the research is:

- The ranges for the physico-chemical parameters of coastal seawater in 08 & 09 January, February and March 2019 were 22.6 to 24.7°C, 24.3 to 25.86°C and 26.5 to 29.6°C for temperature, 31.12 to 32.45, 32.3 to 33.4 and 33.2 to 33.8 ppt for salinity, 8.02 to 8.29, 8.1 to 8.29 and 7.9 to 8.28 for pH and 6.25 to 7.4, 6.77 to 7.94 and 6.16 to 7.71 mg/L for DO respectively.
- The ranges for the physico-chemical parameters of coastal seawater in 08 & 09 January, February and March 2019 were 22.7 to 23.7°C, 23.5 to 24.1 °C and 25 to 25.90 °C for temperature, 32.07 to 32.68 ppt, 31.05 to 33.2 ppt and 33.15 to 33.8 pptfor salinity, 8.07 to 8.21, 8 to 8.15 and 7.95 to 8.14 to 8.14 for pH and 6.05 to 6.35, 5.17 to 6.7 and 6.07 to 6.5 mg/L for DO respectively.
- The ranges for the physico-chemical parameters of coastal seawater in 08 & 09 January, February and March 2019 were 22.6 to 23.2 °C, 23.3 to 24 °C and 24.8 to 25.90 °C for temperature, 32.15 to 32.68, 31.9 to 33.3 and 33.35 to 33.9ppt for salinity, 8.11 to 8.24, 8.02 to 8.16 and 7.95 to 8.18 for pH and 5.95 to 6.28, 5.3 to 6.23 and 5.75 to 6.42 mg/L for DO respectively.
- The temperature, salinity, pH and DO of coastal water are higher than offshore seawater.
- The maximum DO is found in north and east sides of the Saint Martin's Island but lowest DO is found at the west-southern side which connects the open ocean.
- The salinity and pH of 5m deep seawater are higher than surface seawater but temperature of surface seawater is higher than 5m deep seawater.

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Occurrence and identification of Micro-plastics in the beach sediment of Saint Martin's Island

Sultan Al Nahian
Scientific Officer

Mir Kashem
Scientific Officer

Abu Sharif Md. Mahbub-E-Kibria
Senior Scientific Officer

Abstract

The existence of micro-plastic particles (particles size ≤5mm) is assessed on beaches along the Saint Martin's Island coast from 14 different locations. Density separation method was adopted for isolation of micro-plastics from beach sediment using Zinc chloride (1.5 g cm_3). Micro-plastics were categorized into two size classes (1-5mm and<1mm). In this study, only 1-5mm range of micro-plastic particles was considered for analysis. Identification of the 1-5 mm category micro-plastics type as foam, filament, fragment, line and pellet was done visually and they were counted. Concentration of micro-plastics in beach sediment varied from 9 particles kg_1 to 181 particles kg_1 of dry sand. The most frequent micro-plastics dimensions ranged from 1.0 to 2.0 mm, and fragments were predominant. Polymer type identification was conducted using Fourier-transform infrared spectroscopy (FT-IR). The abundance of plastic polymer type was polyethylene (45%), polypropylene (38%) , polystyrene (15%) and polyurethane (2%) and very similar profile was observed for all locations. Density of Polymer appears an important factor influencing micro-plastics dispersion. Low density plastic debris usually recirculates between beach sediments and seawater in a greater extent than higher density debris. Density of polymer assumed as significant findings of qualitative research of micro-plastics which provide the basis for conclusions about the sources of micro-plastics in the marine environment.

Introduction

Marine debris constitutes, "any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes," (UNEP, 2009). Anthropogenic litter is found all over the ocean, even in Isolated Island faraway from human contact and obvious sources of pollution (Barnes et al., 2009; Derraik, 2002). The increase in discarded trash, along with very slow degradation rates, is leading to the gradual increase of marine litter found at sea, on the ocean floor, and along the shore. In 2010 between 4.8 and 12.7 million metric tons of plastic litter reached the oceans and an estimated 5 trillion pieces of plastic are currently floating in the ocean (Cozar et al., 2014; Eriksen et al., 2014, Jambeck et al., 2015). Plastics are a diverse group of manufactured materials derived from petrochemicals, and they are lightweight, inexpensive, durable, strong, corrosion resistant, and designed to be disposable. The first plastic polymer (Bakelite) was developed in 1907 and in the 1940s, with the commercialization of plastic products, mass production increased dramatically. One increasingly abundant type of plastic marine debris is micro-plastics. They come in a wide range of sizes smaller than 5 mm and have many different shapes (e.g. pellets, fragments, scrubbers; Frias et al., 2010). Micro-plastics are plastic fragments smaller than 5 mm in size that are now present as a pollutant in the marine environment - in beach sediment, on the sea floor and floating on the sea surface. Primary micro-plastics are plastics that are released into the marine environment in their 'micro' size either because they have been manufactured that way (such as micro-beads used in cosmetics, air-blasting media used for cleaning machinery and boats, and plastic pellets known as 'nurdles' that are the raw material for plastic products) or resulting from abrasion during manufacturing or product use (such as micro-fibres released from clothes during washing). Secondary micro-plastics are plastic fragments formed when larger plastic items are broken down in the marine environment by abrasion or UV radiation. The present study investigated, for the first time, the assessment of micro-plastic contamination (occurrence and physic characteristics) on beaches in the Saint Martin's island.

Materials and methods

Study area

The Saint Martin's Island, locally called 'NarikelJinjira' is located in the northeast of the Bay of Bengal.Saint Martin's Island is situated between 20°34´ to 20°39´ N latitude and 92°18´ to 92°2´ E longitude. Unplanned tourism, marine pollution and illegal man-made structures are posing a serious threat to the environment of the island. Pollution due to plastic materials especially micro-plastic pollution is emerging as a big threat for the coastal area. To identify the status of micro-plastic, sediment samples from the coastal area of the island has been analysed. 15 sediment samples from the beach have been collected for laboratory analysis. Sampling location is illustrated at the figure 1.

Figure 1: Study Area Saint Martin's Island

Collection and Extraction of Micro-plastic from sediment sample

Micro-plastics in sediments or beaches are currently more frequently analysed than micro-plastics in the water column (Hidalgo-Ruz et al. 2012). Referring to the size ranges, the plastic debris was termed micro- (< 5mm), meso- (5mm to 2.5 cm), or macro-plastic (> 2.5 cm), since they have been adopted by UNEP (Cheshire et al. 2009), MSFD Technical Subgroup on Marine Litter (2013), and NOAA (Lippiatt et al. 2013). The high-tide line where flotsam accumulates is sampled mostly (Browne et al. 2010). Any non-plastic sampling tool (tablespoon, trowel or small shovel) and a 06 square inch with 3 cm depth on-plastic frame will use for beach sampling. Approximately 500g top 3 cm sediment will consider as a beach sample. After drying at 90 °C the samples were screened over a 01 mm metal sieve to obtain two size fractions of micro-plastics. The material passing through the sieve was homogenized and analysed. For the extraction of micro-plastics 10 gm of each sediment sample were treated with 50 ml 30% hydrogen peroxide overnight to remove natural organic material. After a second drying step, micro-plastic particles were extracted via density separation in zinc chloride solution (1.5 gcm^3) in a 100-ml glass beaker. After stirring the sample, the beaker kept covered overnight for the sedimentation of sand particles. Potential micro-plastic particles that accumulated at the surface of the zinc chloride solution were collected.

FT-IR Analysis

For larger micro-plastics (1 to 5 mm) visual sorting is an accepted approach and one of the most commonly used methods for the identification of micro-plastics (using type, shape, degradation stage, and color as criteria). Fourier transform infrared (FTIR) micro-spectroscopy was used to polymer identification (Maes, T. et al 2017). To identify the chemical composition and polymer origin, 300 pieces selected samples will be raised for the FT-IR analysis.

Results and Discussion

In this study, for the first time the existence of micro-plastics on beaches in the Saint Martin's island were confirmed (Figure 01). A total of 477 (primary micro-plastics 01% and secondary micro-plastics 99%) plastic particles were sampled in this survey. Fifteen 15 quadrats in seven 07 location were contaminated. The identifiable micro-plastics (diameter 1–5 mm) were sorted into six groups: (1) Fragments; (2) Foam; (3) filaments; (4) Line; (5) pellets and (6) Expanded Polystyrene (EPS). Among the identifiable micro-plastic fragments and Expanded Polystyrene (EPS) were the most commonly found, which contribute to 65% and 16% of the total observed micro-plastics. Line, filaments, foam and pellets accounted for the remaining 8%, 7%, 2% and 2% respectively (figure 2a & 3).

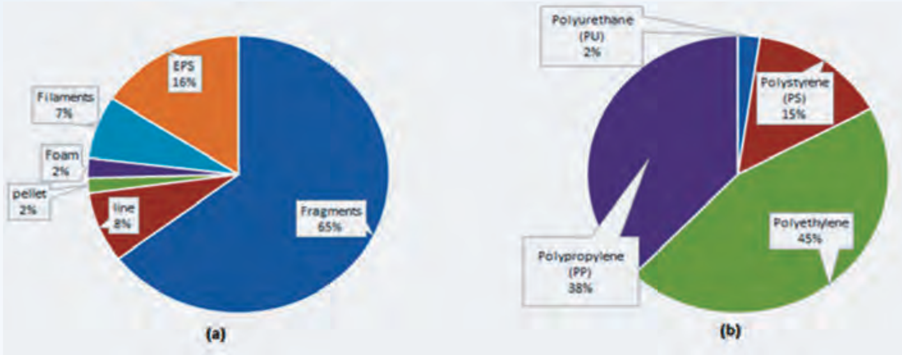

Figure 2: Proportion of micro-plastics by (a) groups and (b) polymer properties

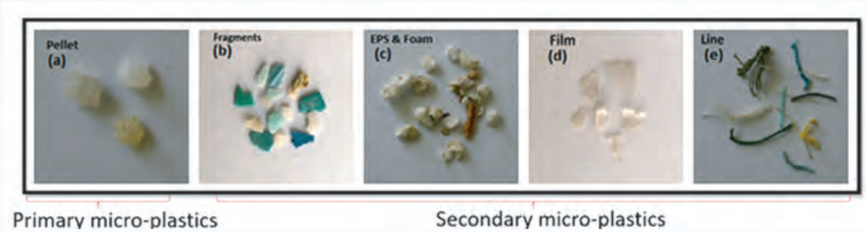

Figure 3: Micro-plastics discovered in Saint Martin's island

More than sixty percent of the sorted micro-plastics were selected randomly for ATR-FTIR analysis. Fourier transform infrared spectroscopy (ATR-FTIR; Perkin Elmer Frontier; Llantrisant, UK) technique was used to characterize the sorted micro-plastics based on polymer type. The ATR unit is equipped with a diamond top-plate. The spectra range between 4000 and 600 cm^{-1} was adopted for the FTIR analysis. Samples were classified into 4 types according to their composition: (1) polyethylene (PE); (2) polypropylene (PP); (3) polystyrene (PS); (4) Polyurethane (PU). Among the total collected micro-plastic items, polyethylene (PE) accounted for the majority of polymer types (45%), followed by polypropylene (PP) (38%), polystyrene (PS) 15% and Polyurethane (PU) 2% (figure 2b). All of the polymers were found more often at marine influenced locations than riverine locations and the differences inferred for particle density between more and less marine-influenced locations correspond well with differences in micro-plastic composition. More dense polymers (i.e. polystyrene, density=0.45–1.04 g/cm^3; polyester, density=0.96–1.37 g/cm^3) have lower prevalence than less dense polymers (i.e. polypropylene, density = 0.92 g/cm^3; polyethylene, density = 0.975 g/cm^3; polyurethane, density= 0.08 g/cm^3) in the area studied. Polyethylene and polypropylene, the two most abundant polymers in this study, have many applications. Polypropylene is commonly used to produce single use items such as, bottle caps, food wrappers, and straws, while polyethylene is used for products such as, bottles, plastic bags, packaging, and fishing line. The breakdown rate on beaches is accelerated by the action of ultraviolet (UV) radiation, temperature, waves and wind. In contrast, plastics sitting on beaches can absorb much more UV light, which is the catalyst of photo-degradation (EU, 2018). Saint Martin's island, Bangladesh is situated in the north of the Tropic of Cancer, where summer is hot with high UV radiation on sunny days, and both of these characteristics can accelerate the breakdown of plastics in beach sediments.

The differences in polymer composition are partly due to the concentrations of the micro-plastics themselves. The identifiable micro-plastics in the beach sediment are less dense than sea water (d = 1.02–1.03 g/cm^3). The amount of micro-plastic debris present along the top southern part of the island is massive. Rocky beach with little patch of mangrove trap the micro debris which leads the presence of micro-plastics. Fragments and foam are predominated rather than line and others micro-plastics.

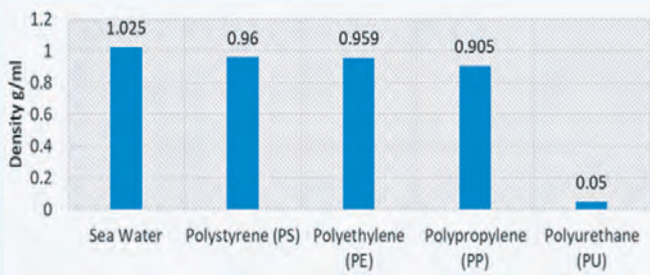

Figure 4: Density of plastic materials found in study area that floats in relation to seawater density

From the study south western part of the island is less polluted in place of southern part of the island (Figure 5). Both south and south western beach of the island were rich of fragments (polypropylene and polyethylene) and foam (polystyrene). Pellets commonly known as primary micro-plastic also present in the south and south-western beach of the island. In the North and eastern beach micro-plastics (1-5mm) were completely absent probably due to leeward and sedimentary budget which may remove all the sand,

and consequently plastics, from beaches. Micro-plastic (1-5mm) were totally absent in the Chera-dweep may due to sedimentary budget (Figure 5). Geographically South and western part of the island is windward and north and eastern part of the island is leeward. Quantitatively, windward beaches were more contaminated by plastic particles than the leeward beaches. This result confirmed the direct influence of surface currents and winds in the transport of initially buoyant plastics in the open ocean (Ivar do Sul et al., 2009).

Figure 5: Spatial distribution of micro-plastic density

Conclusion

Micro-plastic pollution was assessed at 15 location along the coast of Saint Martin's Island. The relationships of micro-plastic distribution with environmental and source-related factors were investigated. The characteristics of micro-plastics differed according to their size, polymer type and density. In this study micro-plastic distribution fully govern by geological location of the island, coast type, wind direction, surface current and sedimentary budget. Polyethylene and polypropylene are the two most abundant polymers in this study. Spatial variation in micro-plastic concentration was observed in the island due to environment and plastic source related factors. Recently, new methods to sample, quantify and/or identify micro-plastics on sediments have been developed by several research groups. Since a range of different methods have been applied, a direct comparison of data from different studies is rare. Thus, a precise and comprehensive diagnosis of micro-plastic contamination on sedimentary habitats remains to be done.

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Mr. Abu Sharif Md. Mahbub-E-Kibria has been working as Senior Scientific Officer at BORI since January 2018. Mr. Kibria graduated from Soil, Water & Environment Department at Dhaka University. He completed his 1st Masters degree from Xiamen University, China in 'Marine Affairs' then he obtained his 2nd Masters degree from the Department of Oceanography, University of Dhaka. He has written research books and research papers in national and international journals. He has strong research interest in Marine Pollution, Climate Change, Coastal Disaster and EIA.

Image: @ justinhofman

Mr. Mir Kashem is a Scientific Officer of Environmental Oceanography and Climate Division in BORI. He completed his B.Sc in 'Environmental Science and Resource Management' from Mawlana Bhashani Science and Technology University and MS in Oceanography from University of Dhaka. His research interest is Air-sea interactions, Marine Pollution, EIA, Aerosol and Dust particles, Ocean Forecasting, Tropical Cyclones, Storm Surge, and Climate Change. He is very interested in Upper Ocean Dynamics. He got trainings in oceanography from China and India. He has research publications in reputed national and international journals.

Mr. Sultan Al Nahian has joined Bangladesh Oceanographic Research Institute (BORI) in January 2018 as scientific officer. Prior to that, he got NAM S&T fellowship and served as a visiting scientist in NIO, Goa. He received his education in Environmental Science and Management from Independent University, Bangladesh and MS in Oceanography from University of Dhaka. Nahian's research interests are in Marine pollution (e.g. Marine Litter, Oil spill and Ballast water), EIA and Marine Conservation. His current research is on marine litter with a special emphasis on micro-plastics.

Oceanographic Data Center

Image: @ Josh Hilliker

Chapter 7

Oceanographic Data Center

Preface

With the establishment of Bangladesh Oceanographic Research Institute (BORI), Oceanographic Data Centre (ODC) has been established as a countries first Oceanographic data centre. Oceanographic Data Centre of BORI is serving as a ``data-primer'' for students and those in other fields of research who are interested in carrying out research involving the analyses of data in the oceanographic sciences. The datasets include observations from conventional oceanographic sources such as stations and ships, from satellites, and analyzed grids produced at operational weather forecast centers. Rather, the focus is upon the broad characteristics of the data sources and the datasets. The characteristics of ODC are not only including the observed variables and their spatial and temporal extent but also common problems, data limitations and sources of error of oceanographic data.

Data Center

A data center is a facility composed of networked computers and storage that businesses or other organizations use to organize process, store and disseminate large amounts of data.In case of Oceanography "Data" in general refer to digital or analogue records of marine environmental observations; and “information" refers to inventories, catalogues, data products, analyses, selected bibliographies, reports and publications of the data centre or to similar products of other centers or organizations.

Advances in marine sciences and technology depend to a significant degree upon the effective flow of data/information from the collectors to various types of users. The principal purpose of an Oceanographic Data Centre is to provide on a long-term continuing basis data/information in a usable form to the so-called "secondary user" community, i.e. to individuals or organizations in the nation which have or will in the future need for data, after the primary purposes for which the data were collected have been satisfied.

Oceanographic Data

There is a broad range of oceanographic data types. Oceanographic data are collected using both in situ methods and remote sensing. The most obvious remote sensing platforms are satellites, but scientific aircraft, some special buoys, and even some ships use instruments (e.g., radiometers) to remotely sample the ocean surface. Useful in situ ocean observations come from different sources, with varying degrees of quality. The highest quality data are collected during scientific research programs, by instrumented buoys (both moored and free drifting), by ships specifically designed to collect environmental data, and by coastal or island stations that function in a manner similar to standard land stations. Lower quality data, but nevertheless quite valuable, are regularly collected aboard merchant ships as they traverse shipping routes, and by fishing fleet vessels during commercial fishing operations.

Scientific research programs collect the widest variety of in situ data. Typical ship board activities will collect sea surface data (SST, salinity, wave height, wave direction, etc.), near-surface meteorological conditions (air temperature, wind speed, wind direction, dew point temperature, barometric pressure, cloudiness, etc.) and, often, subsurface sea water characteristics (e.g., vertical profiles of temperature, salinity, dissolved nutrients, dissolved gases, anthropogenic tracers, ocean currents, and ocean bottom depth). Some research programs also deploy surface drifting buoys whose locations are monitored by satellite. These provide buoy trajectories (that approximate surface ocean circulation), and usually a few other geophysical variables (e.g., SST, barometric pressure, etc.). To a lesser extent, some free drifting buoys are located below the ocean surface. These buoys are tracked acoustically or they periodically rise to the surface for satellite tracking. Buoys of this type are used to monitor subsurface oceanic flow as well as subsurface sea water properties. Moored surface buoys with subsurface instruments below are also used by science programs. The surface instrumentation collects many types of data relevant to ocean-atmosphere boundary layer processes, while the subsurface instruments normally focus on water temperature, salinity, pressure, and ocean currents.

Data Type

- Ocean-Atmosphere Boundary Layer Data
- Subsurface Observations Data
- Sea Level, Topography Data
- Research Project Datasets
- Ancillary Datasets
- Analyzed and Model Data
- Reanalysis Datasets

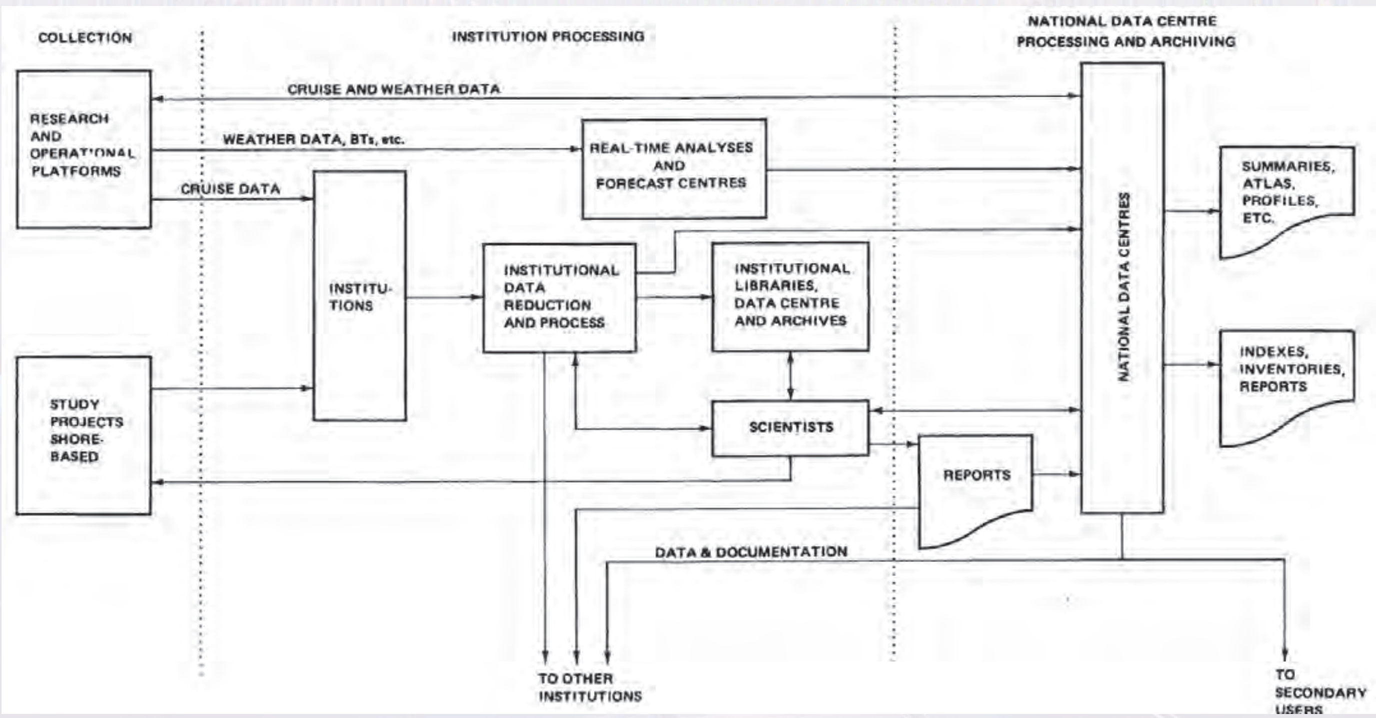
Data format

Atmospheric and oceanographic data may be archived in several different computer forms: character format, native format, packed binary or in one of several "standard" scientific data formats. Users of datasets must be aware of how the data are stored. There are different methods for storing both character and numeric values. Normally, detailed descriptions of data formats are provided and, often, software to access the data is readily available.

There are a number of "standard" scientific data formats. Documentation and software necessary to implement these formats are generally available via computer networks. Architecture independent standard formats commonly used for atmospheric and oceanographic datasets include:

1. GRIB (GRId in Binary)
2. CDF (Common Data Format)
3. netCDF (network CDF)
4. HDF (Hierarchical Data Format)
5. BUFR (Binary Universal Format Representation)

Marine Data Flow



Source: Guide for establishing a national oceanographic data centre, IOC, UNESCO, 1975

Figure: Generalized Marine Data Flow for Oceanographic Data Center

Data Center of BORI

With the establishment of Bangladesh Oceanographic Research Institute (BORI), Oceanographic Data Centre has been established as a countries first Oceanographic data centre. Oceanographic Data Centre of BORI (ODC-BORI) is serve as a "data-primer" for students and those in other fields of research who are interested in carrying out research involving the analyses of data in the oceanographic sciences. This ODC-BORI will describe, in very general terms, the datasets most commonly used to study the ocean system and the formats used for archival. The datasets include observations from conventional oceanographic sources such as stations and ships, from satellites, and analyzed grids produced at operational weather forecast centers. Rather, the focus is upon the broad characteristics of the data sources and the datasets. The characteristics of ODCOB are not only including the observed variables and their spatial and temporal extent but also common problems, data limitations and sources of error of oceanographic data.

Key Activity of the ODC

Its primary activity is to manage the data collected from Ocean.

- Collecting Oceanographic Data from National, Regional & International programs
- Verifying the quality of the Data
- Ensuring the long term preservation of the Data & associated information required for correct interpretation of the Data
- Making Data available nationally & internationally according to govt. rules & regulations

Targeted Function of the ODC

National

- Receiving data from researchers, performing quality control, and archiving.
- Receiving data from buoys, ships and satellites on a daily basis, processing the data in a timely way, and providing outputs to various researches and/or to other centers according to the govt. rules & regulations.
- Reporting the results of quality control directly to data collectors as part of the quality assurance module for the system.
- Participating in the development of data management plans and establishing systems to support major experiments, monitoring systems etc.
- Disseminating data on the Internet and through other means (and on CD-ROM, DVD, etc) according to the govt. rules & regulations.
- Publishing statistical studies and atlases of oceanographic variables.

International

- Participating in the development of international standards and methods for data management through international body (such as IODE and JCOMM);
- Participating in international oceanographic data and information exchange through international body (such as IODE and JCOMM);
- Assisting with data management aspects of global or regional programmes or pilot projects;
- Operating as a data assembly and quality control centre for part of an international science experiment;

Goal of ODC

- Achieve capability to provide Marine Information and Advisory Service (MIAS) nationally & internationally.
- Develop the archive of marine data & National Oceanographic Database (NODB).
- Creating and publishing the General Bathymetric Chart of the Oceans (Bay of Bengal).
- Become the country's apex center for Database Management, Data Capacity, Data Analysis & Maintenance on Oceanography.
- Collect Super Computer to develop vast size international standard Data management system & Analysis.

Research Activity of 2018-2019 FY

Trend detection of temperature and rainfall in coastal region of Bangladesh

Mst. Tania Islam
Scientific Officer

Preface

To identify and quantify the impact of climate change on socio-economic sectors and ecosystems, many global studies have been carried out and policy changes for mitigation and adaptation were recommended. In order to investigate the behavior of climatic and hydrological variables, several statistical and stochastic techniques are currently applied to time series.In the present study a statistical analysis of annual rainfall, maximum temperature, minimum temperature has been performed 69 years of data observed in 16 coastal area of Bangladesh. The research was aimed at addressing the national coastal area issues of climate change and was done by analyzing trend analysis of maximum temperature, minimum temperature and rainfall trends of 16 coastal area of Bangladesh.

Objectives of the Study

The overall objective of this study is to characterize the spatial and temporal changes of the long-term rainfall and temperature pattern in coastal region. The specific objective of this study is:

- Analyze and evaluate the long-term changes of rainfall and temperature (maximum and minimum) in coastal region.
- To detect trend of coastal area.
- To estimate future projections and uncertainties.
- To collect climate data such as Rainfall & temperature for Data Center for future study.

To attain the above objectives, rainfall, minimum temperature and maximum temperature data has been collected from Bangladesh Meteorological Department (BMD).

Study Area

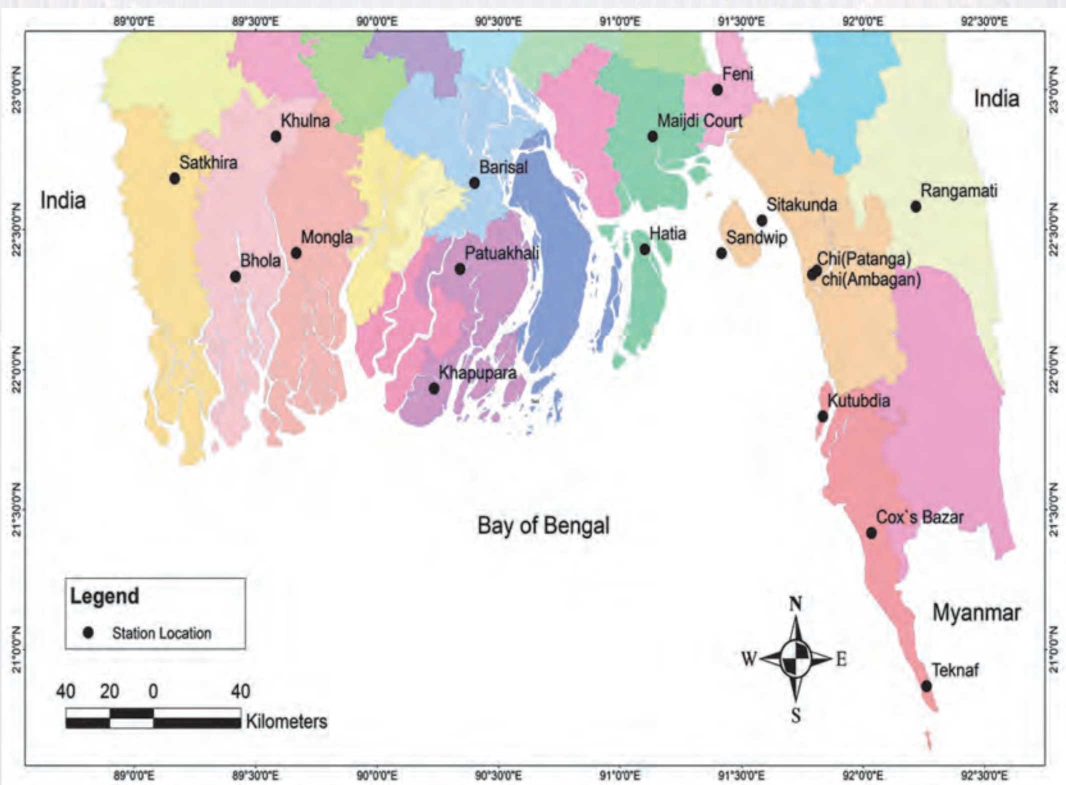


Figure1: 16 Coastal Area Stations for Rainfall and Temperature data of Bangladesh

Methodology

The data Trend analyses have been made by using both nonparametric (Mann–Kendall test) and parametric (linear regression analysis) procedures. And correlation analysis was conducted to find statistical relationship between of the dependent variables: rainfall and predictor variables: annual maximum and annual minimum temperature.

Multiple Regression Analysis: Multiple regression analysis is a powerful technique used for predicting the unknown value of a variable from the known value of two or more variables- also called the predictors.

More precisely, multiple regression analysis helps us to predict the value of Y for given values of X_1, X_2, …,X_k. For example the yield of rice per acre depends upon quality of seed, fertility of soil, fertilizer used, temperature, rainfall. If one is interested to study the joint affect of all these variables on rice yield, one can use this technique.

The Multiple Regression Model:

In general, the multiple regression equation of Y on X_1, X_2, …,X_k is given by:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + \dots\dots\dots\dots\dots\dots + b_k X_k$$

Pearson r Correlation: Pearson r correlation is the most widely used correlation statistic to measure the degree of the relationship between linearly related variables. The following formula is used to calculate the Pearson r correlation:

$$r_{xy} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - \left(\sum x_i\right)^2}\sqrt{n\sum y_i^2 - \left(\sum y_i\right)^2}}$$

r_{xy} = Pearson r correlation coefficient between x and y
n = number of observations
x_i = value of x (for ith observation)
y_i = value of y (for ith observation)

Mann-Kendall Test for Monotonic Trend: The Mann-Kendall Test is used to determine whether a time series has a monotonic upward or downward trend. It does not require that the data be normally distributed or linear. It does require that there is no autocorrelation.

The null hypothesis for this test is that there is no trend, and the alternative hypothesis is that there is a trend in the two-sided test or that there is an upward trend (or downward trend) in the one-sided test. For the time series x_1, ..,x_n, the MK Test uses the following statistic:

$$s = \sum_{i=1}^{n-1} \sum_{n=k+1}^{n} sign(x_j - x_i)$$

Note that if S> 0 then later observations in the time series tend to be larger than those that appear earlier in the time series, while the reverse is true if S< 0.

The variance of S is given by: $$var = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_t f_t(f_t - 1)(2f_t + 5)\right]$$

Where t varies over the set of tied ranks and f_t is the number of times that the rank t appears.

The MK Test uses the following test statistic: $$z = \begin{cases} (s-1)/se, & s > 0 \\ 0, & s = 0 \\ (s+1)/se, & s < 0 \end{cases}$$

Where *se* = the square root of var. If the there is no monotonic trend (the null hypothesis), then for time series with more than 10 elements, z~N(0, 1), i.e. z has a standard normal distribution.

Results of statistical analysis

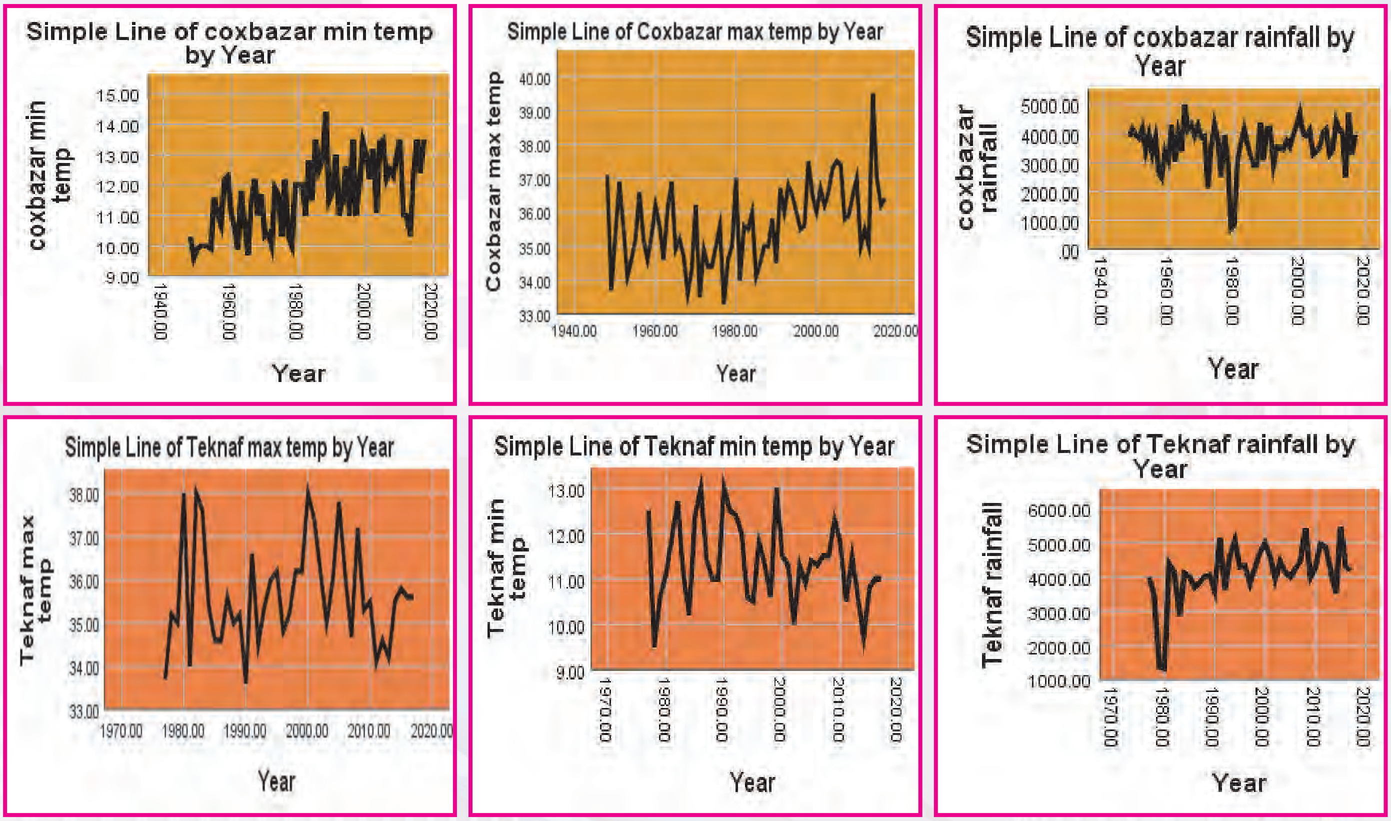


Figure 2: Mann-Kendall's trend test of Max temperature, Min temperature and Rainfall

By the application of the mentioned procedures, it is found increasing trend for annual rainfall exists in Khulna, Patuakhali, Khepupara, Bhola, Feni, Hatiya, Sandwip, Sitakunda, Kutubdia and Teknaf area where no decreasing trends of annual rainfall are exists in 16 coastal areas and no monotonic trend exists in those stations which are Satkhira, Mongla, Barishal, M.court, Patenga and Cox's Bazar.

Increasing trend of annual maximum temperature exists in Monla, Patuakhali, M.court, Hatiya, Sandwip, Sitakunda, and Cox's bazar area where no decreasing trends of annual maximum temperature are existed in 16 coastal areas and no monotonic trend exists in those stations which are Khulna, Satkhira, Barishal, Khepupara, Bhola, Feni, Patenga, Kutubdia and Teknaf. Increasing trend of annual minimum temperature exists in Khulna, M.court and Cox's bazar area. Decreasing trend of annual minimum temperature exists in Barisal, Patuakhali, Khepupara, Hatiya, Sandwip, Sitakunda area in 16 coastal areas. No monotonic trend exists in those stations which are Satkhira, Mongla, Bhola, Feni, Patenga, Kutubdia and Teknaf. To conclude, development planners should design strategies and plans by taking into account an increasing rainfall and decreasing minimum temperature impacts on agriculture and rural livelihoods.

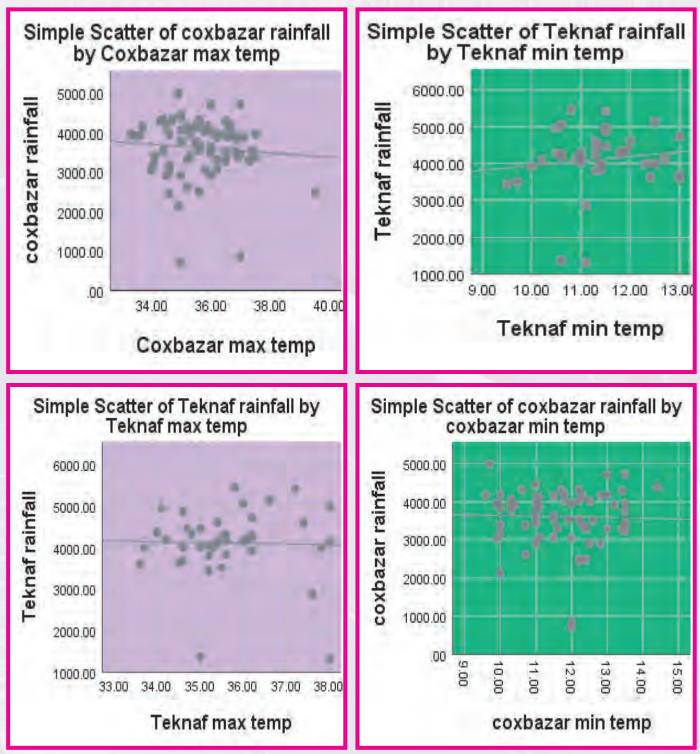


Figure 3: Correlation of Max temperature, Min temperature and Rainfall

Some findings

Through the careful evaluation of long-term change in rainfall and air temperature (maximum, minimum) of 16 coastal stations the major findings of the study can be concluded as below:

- We see that doesn't show much of anything happening (and it shouldn't, since its correlation is very close to 0). We can say that, there is not strong positive or negative relationship exists between maximum temperature and rainfall, and minimum temperature and rainfall.
- From the multiple regression analysis we can say that, statistical significant between minimum temperature and rainfall at Khulna, M. Court, Feni stations. And statistical significant between maximum temperature and rainfall at Barishal and Patuakhali stations which means rainfall depends on maximum temperature and minimum temperature of those stations.
- From the results, It has been clearly revealed from this study, high intensity of rainfall and temperature for short duration is increasing or decreasing of 16 coastal stations.

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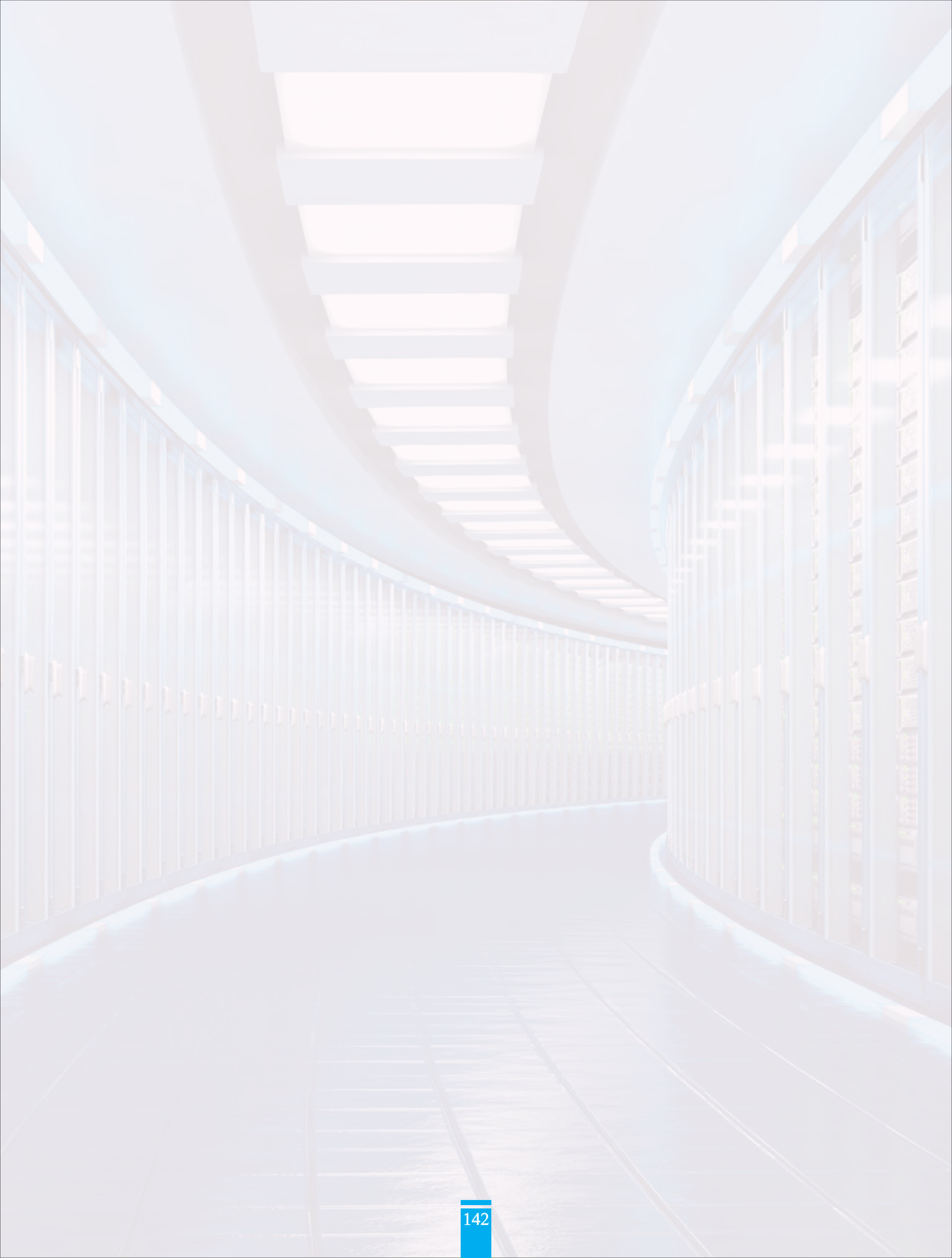
Mst. Tania Islam is a 2nd child of Md. Rafiqul Islam and Beauty Islam, born in Sirajganj district. She passed B.Sc and M.Sc degree in Statistics from Jahangirnagar University. From childhood she was very inclined to the social issues. During her study she was the director for two terms in the Leo Club of Liberty, Jahangirnagar University unit during 2010-2012. Also she was assistant researcher about stop child marriage of UNFPA programme. In 2018, she joined as a scientific officer in the Oceanographic Data Center of BORI. She completed oceanography training in NOAMI, NIO-CSIR, India, RS & GIS and so on. She has expertise on data analysis, database management, data modeling and programming. She published 3 (three) research.

Image: @ 2020 AMCO Enclosures



Chapter 8

Blue Economy and Bangladesh Oceanographic Research Institute (BORI)

Blue Economy: Blue economy is a sustainable development of the ocean economy. This definition is based on the World Bank and UN DESA (2017) framework for a blue economy, as well as FAO's (2014) definition, to be consistent with the three-dimensional sustainable development paradigm (social, environmental and economic dimensions) underpinning the Sustainable Development Goals (*Toward a Blue Economy: A Pathway for Bangladesh's Sustainable Growth, 2018).*

The status of ocean ecosystems will define how productive and efficient the future ocean economy will be (OECD 2016). Concerned by the magnitude of these changes, the UN General Assembly adopted Sustainable Development Goal (SDG) 14 in 2015 focused on ocean conservation and sustainable use. The Global Ocean Commission estimated the market value of marine and coastal resources at US$3 trillion annually (Global Ocean Commission, 2014), and annual gross revenues have been estimated on the order of US$2.6 trillion (Golden et al. 2017).

Potential research Sector for the Blue Economy spport of Bangladesh: There are six major research field in oceanography can be revealed in Bangladesh for Blue Economy development is summarized below-

- Physical and space oceanography branches have very potentiality to monitor physical parameter such as sea surface temperature, tide, wave, current, nutrition, chlorophyll etc to find out potential resource of fisheries and renewable energy from ocean sources. Space oceanography can be applied to measure potential fishing zone identification in Bay of Bengal.
- Geological oceanography research activity can done to find out marine mineral resources as well as source of industrial materials such Bay of Bengal have the potential zone for Phosphorite and Yttrium deposit which is very important source of Rare Earth Element (REE), the coastal and nearshore area have potentiality of heavy mineral deposit. Besides Lime Mud, Carbonated sand and construction sand can be collected form Bay of Bengal. There have possible source of Gas Hydrate in the Bay of Bengal (assumed 300 TCF reserve present in the continental shelf and continental slope zone of Bay of Bengal.
- Chemical oceanography branches is very potential sector for the development of ocean based medicine, cosmetics and minerals in Bay of Bengal. Besides several service such as oil spill management, chemical pollution and ocean acidification measurement and monitoring can be done in this field.
- Biological oceanography is most potential sector in the oceanography field of Bangladesh. Because of river discharge lots of nutrition comes with the sediment in the Bay of Bengal, which can be used for the potential development of mericulture in the coastal and nearshore area. Besides biochemical composition of marine organism, fisheries development, seaweed culture (marine algae) field have very potentiality in this area.
- Environmental measurement and monitoring of ocean, plastic and microplastic pollution monitoring, EIA support etc can be taken under controlled by environmental oceanography research. Besides Oceanographic data management, application, dissemination and ensure the information of ocean baseline data can be arranges. Ocean observation system (data buoy) and monitoring of ocean can give us surveillance opportunity of ocean parameter and change.

Activities of BORI:

In the context of winning the maritime boundary delimitation with Myanmar and India, Bangladesh achieved sovereign right over all types of living and non-living resources within 1,18,813 square kilometers of sea area, 200 nautical miles Exclusive Economic Zone (EEZ) and 354 nautical miles Continental Shelf from the coast of the seafront. Development of Blue Economy is the electoral manifesto of present Government and as a newly opened sector there is huge probability of Blue Economy in Bangladesh. Bangladesh Oceanographic Research Institute (BORI) is working to conduct all the activities as a focal point of Bangladesh at national and international levels in the field of oceanography and Blue Economy in the context of research and development. BORI developed different types future plan based on Election Manifesto, 2018 (Chapter 3.22), Short-mid-long term plan based on Blue Economy and future plan based on the year of 2021, 2030 and 2041.

Blue Economy Plan of BORI: Research activity of BORI started with the joining of scientist during 16 January, 2018. Before starting research activity, BORI make a short-mid-long term plan for the development of Blue Economy focused on-

- Physical and space oceanography related baseline development such as measurement of the coastal and nearshore tide, wave, current data, ocean physical parameter (temperature, salinity, pressure etc), chlorophyll and nutrition
- Potential fishing zone identification, application of remote sensing on oceanography
- Geological oceanography related baseline data collection such as bathymetry, coastal and nearshore sedimentation process, measurement of heavy mineral deposit and find out potential area of mineral resources.
- Biological oceanography related research such as taxonomic identification of seaweed, marine phytoplankton and zooplankton, seawed culture, identification of potential zone for mericulture etc
- Development of marine chemical baseline data, monitoring of ocean acidification
- Identification of the source and cause of coastal and marine area pollution, plastic and micro-plastic occurrence and prevention measures.
- Development of oceanographic data center to ensure marine data flow.
- Development of skilled manpower in marine sector and awareness programme on ocean resources.

Bangladesh has huge potential in the Blue Economy sector. It needs sufficient research and baseline database on oceanography to take proper measurement of the Blue Economy sector of Bangladesh. BORI is doing such work as a key institute in the field of oceanography.

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Admin, Planning & finance Division

Image: @ TheAmericanCEO

Chapter 8

Admin, Planning & Finance Division

Administrative Division

The administrative division is involved in managing the overall activities of the organization. Activities include document management, correspondence management, procurement activity management, maintenance of inventory, ensure security, management of manpower, recruitment activity, library and information services etc. Besides, administrative division coordinates overall work of the institute such as conducting meetings, workshops, seminars, conferences etc. as well as communicating with other government, non-government and international bodies.

Training: To motivate and build up skillful human resources Bangladesh Oceanographic Research Institute (BORI) emphasizes on customized training programs and developed different training modules. The scenario of training programs is given below:

Foreign training: BORI arranged some foreign training to get hands on experience.

Title of the training	Number of participants	Date	Country
China-Bangladesh cooperation training workshop	04	April, 2018	China
Training program co-ordinate with CSIR-NIO	12	August, 2018	India
Training program co-ordinate with CSIR-NIO	08	March, 2019	India
Techniques for coastal mapping & monitoring using QGIS	01	November, 2018	India

Local Training: The employees of BORI are participating to different training program to enhance their skill at particular subject.

Title of the Training	Number of Participants
Public Service Innovation	02
Project Appraisal EIA and Formulation of DPP	01
Public Procurement Management	01
Training Course of Marine Spatial Planning for Bangladesh in Dhaka	02
APAMS software version-2	02
Electrical Services for buildings and Industries	01
GRS software training	02
Training on Remote Sensing, GIS, GNSS and Drone Technology	03
Plumbing Technology	01
Fundamental Training (2nd& 3rd class)	33
Foundation Training (1st class officer)	13
CompTIA A+ Hardware maintenance and Trouble shooting	01
Training on Goggle Earth Engine Operation	01
Sub-soil investigation	02
Training on Internal Audit	03
Pile Foundation: Design and Construction	01
Training on Research Methodology	02
EIA Training	01
Weather & Research Forecasting (WRF) Training	01
Welding Technology (Level-II) Training	01

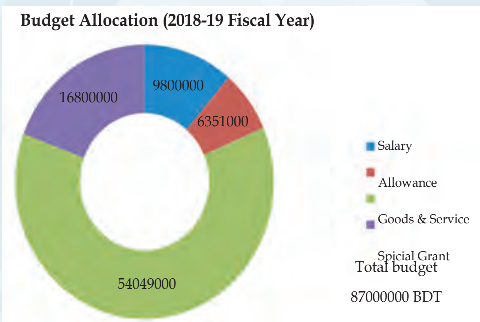
In house training: BORI is conducting various in house trainings for capacity development.

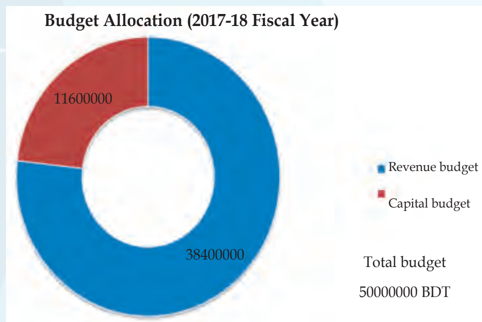
Title of the training	Number of participants
MATLAB and R Programming Training	13
e-filing training	18
Training on Service Innovation	10
Office Management Training	37
Training on Introduction to Observational Physical Oceanography	15
Training on CTD	18
Hands on training on heavy mineral separation	05

Organizational Manpower: As per existing organizational structure the workforce is given below:

S. N.	Approved post	Appointed manpower				Total Manpower	Progress
		1st class	2nd class	3rd class	Outsourcing		
1	1st phase =137 (2015-2017 FY)	18	24	12	49	103	Completed
2	2nd phase =31 (2017-2019 FY)	34	-	-	-	34	Recruitment process is going on
3	3rd phase=55 (2019-2021 FY)	-	-	-	-		-

Budgeting & Fund Management: The overall outline of financial costs of BORI for the last 2017-18 & 2018-2019 fiscal years is-





Audit: BORI has an internal auditing system. The auditor audits all kinds of purchases to ensure transparency and accountability. Besides auditors from Comptroller and Auditor General Office periodically conducts auditing of BORI accounts.

Medical Center: BORI has a Medical Center with preliminary treatment facilities. The clinic has Ultra Sonogram, ECG and other equipment. At present, there are one medical technician and one medical attendant. Rests of the vacant posts are in the process of recruitment including one medical officer.

Engineering Division

Engineering Division has been established along with other divisions at BORI realizing the importance of scientific research, development and maintenance purposes. Engineering division is responsible for valuable utility services, maintenance of buildings, renovation and construction works for various tasks to the scientific effort for strengthening and expanding research and development activities in BORI.

Objectives

- To look after through repairing and refurbishing buildings, boat, ship, vessel in the long run.
- To establish a permanent sub-station inside Institute Campus.
- To construct and run an Engineering Workshop inside BORI Campus to assist scientists and for other domestic engineering services.
- To do regular maintenance of electric power management and solar system.

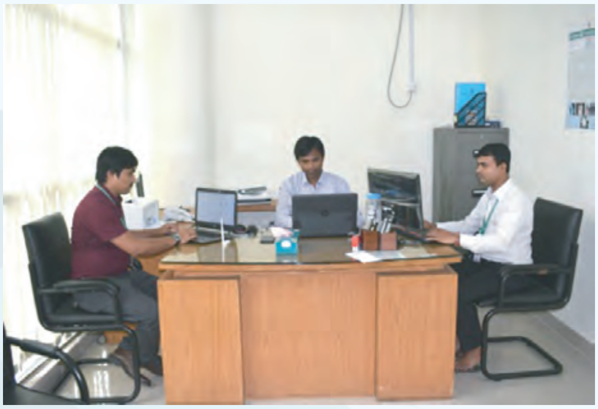
Activities

- Division is now ensuring utility facilities like uninterrupted electricity, water supply, sewerage management etc. and liable for repairing of pumps, valves, generators, machineries and lab equipment.

· Establishment of dedicated feeder line from REB to reduce load shedding,
· Carry out maintenance and repairing work.
· Establishment solar energy to lessen load shedding problem.
· Assistscientists regarding their electric equipment.

Information Management Division

ICT Cell



ICT Cell is responsible for directing, planning and implementing a global Information Technology (IT), information systems and communication strategy to assist the Organization to achieve its goals and objectives. ICT Cell coordinates IT and communication development initiatives in all levels, ensuring consistency with the Organization's overall strategy. ICT Cell conceptualizes implements and delivers IT projects and establishes strategic relationships with key suppliers and external partners. ICT Cell provides technological solutions that enhance the Organization's effectiveness. Where necessary, ICT Cell develops and provides training to users to ensure the effective use of existing and new technologies, while continuing to explore and identify opportunities to increase productivity and efficiency.

Activities of ICT Division of BORI

· Develop ideas to digitalize manual system and proper monitoring by an efficient vendor.
· Maintain BORI website, design, develop and upload new contents, notices, reports in regular basis.
· Monitor Maintenance, Troubleshoot Servers, Workstations, Routers, Network switch etc.
· Keep tracking of IT assets.
· Assist scientific officers to process data using programming language, big data set analysis etc.
· Monitor e-filing activities in regular basis. Organize in house training on e-filing.
· Prepare tender document for procurement, publish the tender in E-GP website, complete the whole procedure in timely manner.
· Maintaining E-hazira for all employees, take report in daily basis and backup E-hazira database daily.

Future Plan of ICT cell

· Design and develop central Local Area Network (LAN) for whole institute.
· Implement Active directory, Application Server, File server by creating domain network to monitor and provide any types of IT support to any workstation centrally.
· Develop user friendly and efficient web/Desktop application for office's day-to-day activities depends on users' requirement to reduce bulk use of paper.

Library Cell

Bangladesh Oceanographic Research Institute (BORI) has a Library with hundreds of books of different categories including Physical, Chemical, Biological, Geological and Environmental Oceanography. The fully air-conditional library at BORI is enriching the collection of books on various aspects of research and technology. Library facilities are available for all employees of BORI.

Diving into Memory Lane

Image: @ Center Blog

Chapter 10

Diving into Memory Lane

1st Class Officers with Honorable DG & Director of BORI on 16 January 2018
(1st Recruitment of BORI)

Architect Yeafesh Osman, Honorable Minister, Ministry of Science & Technology, visited Development Project of National Oceanographic Research Institute (NORI) on 15 November 2015.

Architect Yeafesh Osman, Honorable Minister, Ministry of Science & Technology, visited Bangladesh Oceanographic Research Institute (BORI) on 04 May 2019.

Mr. Md. Anwar Hossain, Honorable Senior Secretary, Ministry of Science & Technology, attended seminar at BORI- "Presentation of Research Result and Future Research Proposal" as Chief Guest on 28 July 2018.

Mr. Md. Anwar Hossain, Honorable Senior Secretary, Ministry of Science & Technology, attended seminar at BORI- "Sustainable use of Marine Resources for Socioeconomic Development" as Chief Guest on 20 January 2019.

'International Mother Language Day' Celebration at BORI (21 February 2018)

'International Mother Language Day' Celebration at BORI (21 February 2019)

Independence Day Celebration at BORI
(26 March 2018)

Independence Day Celebration at BORI
(26 March 2019)

Victory Day Celebration at BORI
(16 December 2018)

Teachers & Students of Different Universities from the country frequently visit BORI to acquire knowledge on oceanography

Teachers & Students of Different Universities from the country frequently visit BORI to acquire knowledge on oceanography

Seminar with a Team from National Oceanographic And Maritime Institute (NOAMI) at BORI

Seminar with the Scientists of National Institute of Biotechnology (NIB) at BORI

A Team from NIO, India visited BORI on May, 2018

BORI Scientists got 14 days training at NIO, India August, 2018

BORI Officers with Architect Yeafesh Osman, Honorable Minister, Ministry of Science & Technology, Government of People's Republic of Bangladesh

BORI Officers with Mr. Md. Anwar Hossain, Honorable Senior Secretary, Ministry of Science & Technology and with other Honorable Board Members

Contact Address
Bangladesh Oceanographic Research Institute
Cox's Bazar-4730, Bangladesh
www.bori.gov.bd