MUNICIPAL CORPORATION OF GREATER MUMBAI

No. Ch.E/ / Coastal Road, date:

Office of
Chief Engineer (Coastal Road),
3rd Floor, Engineering Hub building,
Dr E Moses Road, Worli,
Mumbai 400 018
Email: che.coastalroad@mcgm.gov.in

To,
Mr.Suresh Kumar Adapa
Scientist –D
Ministry of Environment, Forest & Climate Change,
Regional office (WCZ), Ground floor, East wing
New Secretariat Building, Civil Lines Nagpur – 440001
apccfcentral-ngp-mef@gov.in

Sub: Mumbai Coastal Road Project (South) from Princess Street Flyover to Worli end of BWSL

Ref:
1. MoEF&CC letter no. 19-74/2016-IA.III dated 11.05.2017
2. Ch.E/1000 (v) /Coastal Road Project date 08.06.2017
3. F. No. EC-427/RON/2017-NGP/1975 dated 27.06.2017
4. Ch.E/1237/Coastal Road Project date 03.10.2017
5. Ch.E/1357/Coastal Road Project date 25.10.2018
6. Ch.E/1901/Coastal Road Project date 28.05.2019
7. Ch.E/3222/Coastal Road Project date 29.06.2019
8. Ch.E/9246/Coastal Road Project date 4.02.2020
9. Ch.E/1092/Coastal Road Project date 17.08.2020

Sir,

With reference to above referred CRZ clearance dated 11.05.2017, the half yearly compliances report for the period of April 2020 to September 2020 is submitted herewith. The data sheets are attached herewith accompanying with the required information.

1. Present status of work:-

Work is divided into three Packages as mentioned below and present status of work is attached as Annexure I.

Sr.No	Package	Description	Contractors	Date of Commencement
1	Package - I	Priyadarshani Park to Baroda Palace	M/s L&T Limited	13.10.2018
2	Package - II	Baroda Palace to Worli end of BWSL	M/s HCC-HDC	16.10.2018
3	Package -IV	Princess Street flyover to Priyadarshani Park	M/s L&T Limited	13.10.2018

2. Copies of Consent to Establish/Operate from MPCB:-
   Attached as Annexure II.

3. The information in the enclosed data sheet :-
   The information in the Standard format is attached herewith

4. Copy of EIA/EMP report :-
   The EIA/EMP report including EMP prepared by DPR consultant is submitted to MoEF&CC while obtaining CRZ clearance. The salient features of EMP is attached as Annexure III

This information is submitted as a status of Compliance. Copy of the same is also sent through mail on email id apccfcentral-ngp-mef@gov.in .

Yours Faithfully,

19/01/2021

(Vijay Nighot)

Chief Engineer (Coastal Road) I/c

CC to

1.The Member Secretary,
Maharashtra Pollution Control Board,
Kalpataru Point, 3rd and 4th floor,
Opp. PVR Cinema, Sion Circle, Mumbai-400 022.

2. The Regional Director, Vadodara
Regional office of CPCB
Parivesh Bhawan, Opp. Ward No. 10
VMC Office Subhanpura, Vadodara – 390 023
STD code: 0265, EPABX Number: 0265 – 2392831 Fax No. 0265-2392987
Direct: 0265 – 2392603-04

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Monitoring the Implementation of Environmental Safeguards
Ministry of Environment, Forest & Climate Change
Regional Office (West Central Zone), Nagpur

Monitoring Report

Part -1

DATA SHEET

1.	Project Type: River-Valley / Mining / Industry / Thermal / Nuclear /Other (Specify)	Mumbai Coastal Road (South)
2.	Name of the Project	Mumbai Coastal Road (South) from Princes Street Flyover to Worli End of Bandra worli sea link. 1) Package I: Priyadarshini Park to Baroda Palace. 2) Package II: Baroda Palace to Worli End of BWSL. 3) Package IV: Princess Street Flyover to Priyadarshini Park.
3.	Clearance Letter (S) /OM No.&date	F. No. 19-74/2016-IA-III dated 11th May 2017
4.	Location a. District (S) b. State (S) c. Latitude (S) d. Longitude (S)	Mumbai City Maharashtra
5.	Address for correspondence a. Address of concerned Project Chief Engineer (with Pin Code & Telephone / Telex/Fax Numbers) & address of Executive Project Engineer / Manager (with pin code/fax numbers)	Chief Engineer (Coastal Road), Municipal Engineering Hub Building, 3rd Floor, Dr. E. Moses Road, Worli Naka, Worli, Mumbai-400 018, Maharashtra, India. Telephone No. 022-24958211
6	Salient Features a. Of the project	Mumbai Coastal Road Project (South): As per EC • Length- 9.98 km • Length of Tunnel- 3.452 km 02 Tubes each having lanes 02+01 (emergency) • Number of Interchanges : 03 No's • Total Reclamation: approx 90 Ha. • Road : 4+4 lanes • Project Cost: 5303.00 Crs.
	b. Of the Environment Management Plan	The Salient Features of Environment Management Plan submitted as Annexure III along with this data sheet
7.	Breakup of the Project Area a. Submergence Area Forest & Non-Forest	Not Applicable being Coastal Road Project.

	b. Others	
	a. Total plot Area	As submitted earlier
	b. Built – up Area (Including Road)	Not applicable since Coastal Road Project
	c. Open Space Available	Not Applicable since Coastal Project Road
	d. Green belt Area	Green Belt 70 Ha. Area
8.	Breakup of the Project affected population with enumeration of those losing houses / dwelling units & both dwelling units & agricultural land & landless laborers / artisan a. SC, ST/Adivasis b. Others (Please indicate whether these figures are based on any scientific and systematic survey carried out or only provisional figures, if a survey carried out gives details and years of survey).	Nil
9.	Financial details a. Project costs as originally planned & subsequent revised estimates and the year of price reference.	As per EC : Rs. 5303.00 Cr As per present Construction cost : Rs. 8429.44 Crs. Project Cost : Rs. 12,721.59, Cr
	b. Allocation made for Environmental Management Plan with item wise & Year wise breakup.	April 2020 to March 2021 =Rs. 4.03 (Cr)
	c. Benefits Cost Ration / Internal rate of Return and the year of assessment.	Benefit Cost Action: 1.15 (2016-2017)
	d. Whether (C) includes the cost of Environmental Management as shown in the above	Yes
	e. Actual expenditure incurred on the Project so far	1276.14.(Cr)
	f. Actual expenditure incurred on the Environmental Management Plan so far	7.51 (Cr)
10.	Forest land Requirement a. The status of approval for diversion of forestland for non-forestry use. b. The status of clearing felling. c. The Status of compensatory afforestation program in the light of actual field experience.	NIL

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11.	The status of clear felling in non-forest area (such as submergence area of reservoir, approach roads), if any with quantitative information.	NIL
12.	Status of Construction a. Date of Commencement (Actual and/or Planned)	1. Contractors for Package – I and Package IV-M/s L & T Limited . Date of Commencement – 13.10.2018. Construction Work is in progress 2. Contractors for Package – II- M/s HCC – HDC. Date of Commencement – 16.10.2018. Construction work is in progress
	b. Date of Completion (Actual and/or Planned)	15.10.2022 (Planned)
13.	Reasons for the delay if the project is yet to start	Not applicable
14.	Date of site visits a. The dates on which the Project was monitored by Regional Office on previous occasions, if any b. Date of site visit for this monitoring Report	Nil Nil
15.	Details of correspondence with project authorities for obtaining action plan /information on status of compliance to safeguard other than the routine letters for logistic support for site visit. (Monitoring report may obtain the details of all the letters issued so far but the later reports may cover only the letters issued subsequently)	1. Monitoring Report (EMP-Report) (April 2020 till September 2020) for three Packages are attached as Annexure IV. 2. MoEF&CC- CRZ Clearance compliance report & MCZMA – Compliance report attached as Annexure V

07/01/21

Chief Engineer (Coastal Road) I/c
MCGM, Mumbai -18

06/01/2021
EE(CR)

C-55

Annexure 01

Project Progress Report
April 2020 - September 2020

Mumbai Coastal Road Package - 01

Present Status of the Work Progress (Annexure 01)

						Apr-20 - Sep-20				Till Sep-20		
S. No.	**Description**	**Unit**	**Scope**	**Planned till 25th Sep 20**	**Achieved till 25th Sep 20**	**Planned**	**Achieved**	**Planned %**	**Achieved %**	**Planned % till 25th Sep 20**	**Achieved % till 25th Sep 20**	**% completion w.r.t cumulative plan**
1	GTI Works	nos	329	329	311	-	6	0.00	1.82	100.0	94.5	94.5
2	Temporary Jetty Construction- Piling & Deck	Rm	317	317.0	160.0	-	150.0	0.00	47.32	100.0	50.5	50.5
3	Piling Gantry Erection & Commissioning at Amarson garden	LS	1	1	1	-	-	0.00	0.00	100.0	100.00	100.0
4	Piling Gantry Erection & Commissioning at Haji Ali	LS	1	1	1.0	-	0.4	0.00	40.00	100.0	100.0	100.0
5	1st Set Test Piles- Amarsons Garden	nos	2	2	2	-	-	0.00	0.00	100.0	100.0	100.0

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6	2nd Set Test Piles- Amarsons Garden	nos	3	3	3	-	-	0.00	0.00	100.0	100.0	100.0
7	3rd Set Test Piles- Haji Ali	nos	3	3	2	-	-	0.00	0.00	100.0	66.7	66.7
8	4th Set Test Piles- Haji Ali	nos	3	3	3	-	-	0.00	0.00	100.0	100.0	100.0
9	Amarsons Garden Interchange TAB & Fingers- Piling & Deck	Rm	803.0	803.0	-	-	-	0.00	0.00	100.0	0.0	0.0
10	Haji Ali Interchange TAB & Fingers- Piling & Deck	Rm	621.6	621.6	50.0	-	50.0	0.00	8.04	100.0	8.0	8.0
11	Main bridge TAB & Fingers- Piling & Deck	Rm	691.2	631.2	-	350.0	-	50.64	0.00	91.3	0.0	0.0
12	Piling	nos	924	569	34	91	30	9.85	3.25	61.6	3.7	3.7
13	Pile cap	nos	231	107	-	33	-	14.29	0.00	46.3	0.0	0.0
14	Pier	nos	231	112		32	-	13.85	0.00	48.5	0.0	0.0

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15	Pier cap	nos	231	88		30	-	12.99	0.00	38.1	0.0	0.0
16	Superstructure spans	nos	217	56		29	-	13.36	0.00	25.8	0.0	0.0
17	**Seawall**											
17.1	Core placement- Stage 1 upto +5.5m CD	Rm	3,800	2,700	1,425	700	335	18.42	8.82	71.1	37.5	37.5
17.2	Armour placement- Stage 1 upto +6.59m CD	Rm	3,800	2,400	1,086	500	520	13.16	13.68	63.2	28.6	28.6
17.3	Core placement- Stage 2 upto +6.59m CD	Rm	3,800	2,410	1,086	510	575	13.42	15.13	63.4	28.6	28.6
17.4	Crown wall PCC	Rm	3,800	1,920	-	1,120	-	29.47	0.00	50.5	0.0	0.0
17.5	Crown wall Raft	Rm	3,800	1,550	-	950	-	25.00	0.00	40.8	0.0	0.0
17.6	Crown wall Vertical	Rm	3,800	1,400	-	900	-	23.68	0.00	36.8	0.0	0.0
17.7	Reclamation upto +4.42m CD	Sqm	603,000	414,102	316,454	108,823	260,540	18.05	43.21	68.7	52.5	52.5
17.8	Reclamation above HWL	Sqm	603,000	132,793	92,442	132,793	92,442	22.02	15.33	22.0	15.3	15.3

	(upto 6.1 m CD)											

Mumbai Coastal Road Package - 02

S.NO.	ITEM DESCRIPTION	TOTAL SCOPE		Works Till March' 20	FTM Apr' 20	FTM May' 19	FTM Jun' 19	FTM July' 20	FTM Aug' 20	FTM Sep' 20	Cumilative till Sep'20.
		Unit	Qty								
1	GEO TECHNICAL INVESTIGATIONS	NOS	194	138	13	4	1	0	0	0	187
2	SEAWALL-QUARRY RUN	Cum	239020	108028	456	82	164	0	11626	12560	132916
3	Seawall - Bedding Layer	CUM	7336	5215	0	364.3	41	0	0	147	5767
4	Sea wall - Geotextile Layer	SQ.M	28096	7215	2340	900	0	0	0	0	10455
5	Sea wall - Armour Layer	CUM	99258	14162	3701.2	7573.8	3044	722	0	272	29475
6	Reclamation Works +1.92 MSL	CUM	530000	175860	6226	50086	18401	9500	0	13644	273717
7	Selected Fill +6.00MSL	CUM	567573	65433	0	11488	25958	17309	22196	18980	161364
8			5050	623	0	0	0	0	0	0	623

	Car Park-1 Excavation	CU M									

MUMBAI COASTAL ROAD PROJECT PKG II ★ JV ★ EGIS INDIA-CGR (UK)

AECOM Asia Company Limited MUMBAI

Mumbai Coastal Road Package - 04

Physical Progress Status as on 30-09-2020

Description	Scope	Status
Bathymetry Survey	0.144 sq.km	Completed.
Topographic Survey	44 Hectare	Completed.
Hydro Graphical Survey	3.93 km	Scope finalization in progress
Existing Building Survey	3.93 km	Completed
Utilities Survey	3.93 km	Completed
Geotechnical Investigation	33 Nos	33 Nos Completed
Sea wall – Core Rock	685 RM	300 RM Completed
Sea wall – Armour Rock	685 RM	230 RM Completed
Secant Piling – Launching Shaft	547 Nos	547 Nos Completed
Secant Piling – Retrieval Shaft	186 Nos	141 Nos Completed
Secant Piling – Cut and Cover Tunnel – Chowpatty	2137 Nos	536 Nos Completed
Secant Piling – Cut and Cover Tunnel – Priyadarshini Park	590 Nos	545 Nos Completed
Secant Piling – Ramp – Priyadarshini Park	466 Nos	249 Nos Completed
Cantilever Promenade – Secant Piles	52 Nos	16 Nos Completed

AECOM Asia Company Limited MUMBAI

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

ANNEXURE -2

CONSENT TO ESTABLISH/OPERATE

MAHARASHTRA POLLUTION CONTROL BOARD

Phone : 02225505928
Fax : 02225505926
Email : romumbai@mpcb.gov.in
Visit At : http://mpcb.gov.in

Regional Office, Mumbai,
Raikar Chambers, "A" Wing, 216, 2nd Floor,
Deonar Gaon Road, Near Jain Mandir,
Govandi (E), Mumbai-400088

Green/S.S.I **Date:** 22 /07/2020

Consent No: RO-MUMBAI/2007001351

Consent to Establish under Section 25 of the Water (Prevention & Control of Pollution) Act, 1974 & under Section 21 of the Air (Prevention & Control of Pollution) Act, 1981 and Authorization / Renewal of Authorization under Rule 5 of the Hazardous Wastes (Management, Handling & Transboundary Movement) Rules 2008

[To be referred as Water Act, Air Act and HW (M&H) Rules respectively].

.....

CONSENT is hereby granted to

M/s. Larsen & Toubro Ltd.,
Near Haji Ali, Mumbai Coastal Road Project
PKG 1, Mumbai – 400 026.

Located in the area declared under the provisions of the Water Act, Air act and Authorization under the provisions of HW (M&H) Rules and amendments thereto subject to the provisions of the Act and the Rules and the Orders that may be made further and subject to the following terms and conditions:

1. **The Consent to Establish is granted for a period up to Commissioning of the Project r 5 years whichever is earlier.**

2. **The Consent is valid for the manufacture of –**

Sr. No.	Product Name	Maximum Quantity	UOM
1	Ready Mix Concrete	1200	M3/D
	(Only for Captive purpose of Mumbai Coastal Road Project)		

3. **CONDITIONS UNDER WATER ACT:**

(i) The daily quantity of trade effluent from the factory shall not exceed **08.00 M³.**

(ii) The daily quantity of sewage effluent from the factory shall not exceed **03.20 M³**

(iii) **Trade Effluent Treatment :** The waste water generated from the source like batching plant, washing of transit mixture, floor washing, vehicle washing, two lever tyre washing area shall be collected through well designed drainage system in collection tank and shall provide comprehensive treatment system as is warranted to meet with disposal standards mentioned below.

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AECOM Asia Company Limited MUMBAI

Sr. No.	Parameter	Concentration	Limit
1	pH	between	5.5 to 9.0
2	BOD	Not to exceed	30 mg/l
3	COD	Not to exceed	150 mg/l
4	SS	Not to exceed	100 mg/l
5	O & G	Not to exceed	10 mg/l
6	TDS	Not to exceed	2100 mg/l

(iv) **Trade Effluent Disposal:** The treated effluent shall be reuse/recycle in the process, gardening/plantation and water sprinkling purpose only. There shall not be any discharge outside from the plant.

(iii) **Sewage Effluent Treatment:** The applicant shall provide comprehensive treatment system as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of treated effluent to the following standards.

(1)	Suspended Solids	Not to exceed	100	mg/l.
(2)	BOD 3 days 27o C.	Not to exceed	100	mg/l.

(iv) **Sewage Effluent Disposal:** The treated domestic effluent shall be soaked in a soak pit, which shall be got cleaned periodically. Overflow, if any, shall be used on land for gardening / plantation only.

(v) **Non-Hazardous Solid Wastes:**

Sr. No.	Type Of Waste	Quantity	UOM	Treatment & Disposal
1	Aggregates	---	MT/M	Either reused through recovery unit/Reclaiming system OR disposed off at designated approved site by local body, for derbies / construction waste.

4. **The applicant shall comply with the provisions of the Water (Prevention & Control of Pollution) Cess Act, 1977 (to be referred as Cess Act) and amendment Rules, 2003 there under:**

The daily water consumption for the following categories is as under:

(i)	Domestic purpose	...	10.00 CMD
(ii)	Water gets Polluted & Pollutants are Biodegradable	...	120.00 CMD
(iii)	Water gets Polluted, Pollutants are not Biodegradable & Toxic	...	00.00 CMD
(iv)	Industrial Cooling, spraying in mine pits or boiler feed	...	00.00 CMD

5. **CONDITIONS UNDER AIR ACT:**

The applicant shall install a comprehensive control system consisting of control equipments as is warranted with reference to generation of emission and operate and maintain the same continuously so as to achieve the level of pollutants to the following standards:

1)	**Particulate Matter PM_{10}**	**Not to Exceed**	**100 µg/m³**
2)	**Particulate Matter PM 2.5**	**Not to Exceed**	**60 µg/m³**
3)	**SO2**	**Not to Exceed**	**80 µg/m³**
4)	**NOx**	**Not to Exceed**	**80 µg/m³**

Control Equipment:

Air Pollution Control:-

i) In-house measures:-

1. All material transfer points should be covered
2. The dust containment system shall be provided incorporating either of the following.

- Barricading all around the periphery of the plot boundary of height minimum 20 feet or 5 feet above free fall air emission area, whichever is higher with tin sheets. Same may extend above with netlon clothing whenever required
- Water sprinkling/Chemical dust stabilizing agent spraying system along the periphery inside the premises of RMC.

3. Internal work area shall be, cement concreted/Asphalted.
4. Daily cleaning / Removal of dust accumulation inside the plant (dry/wet) shall be carry out, with industrial vacuum cleaner.
5. Two level tyre washing facility shall be provided at entry and exit points, for transit mixture vehicle.

(ii) Raw material Storage, Handling & Others:-

1. Storage silos of cement & fly-ash shall be equipped with adequate capacity of dust Collection system such as multi- cyclone followed by bag house assembly.
2. Handling of Cement, sand, fly ash and aggregates shall be carried out with mechanical closed system only.
3. Manual operations shall be permitted only in a closed shed, equipped with dust control system at the loading point as well as roof top secondary dust control system.
4. All Conveyor belts of Sand, aggregate shall be covered with tin sheets and at transfer points dust collection system to be installed to avoid secondary fugitive emissions.
5. Mixing section of cement, aggregate & sand shall be equipped with adequate capacity dust collection system, such as multi-cyclone followed by bag house, so as to limit dust emissions.
6. Storage area of sand & aggregate shall be equipped with roof top water sprinkler system.
7. The air pollution control devices shall be operated regularly.
8. Alternative power supply system, should cover both the production and Air pollution control system.
9. Industry shall provide treatment facility industrial effluent.
10. Industry shall provide disposal facility for treated effluent.
11. Industry shall provide disposal facility for solid waste.
12. Industry shall provide proper exhaust system in the premises.

6. CONDITIONS UNDER HAZARDOUS WASTE (MANAGEMENT, HANDLING & TRANSBOUNDRY MOVEMENT) RULES, 2008:

(i) The Industry shall not generate any type of hazardous wastes.

7. Noise Pollution control Measures:-

The Industry shall comply with the provision under the Noise (Regulation and Control) Rule- 2000, to control noise pollution.

Maharashtra Pollution Control Board Regional Officer Mumbai

Louis Berger Consulting Pvt. Ltd.

AECOM Asia Company Limited MUMBAI

8. **Industry shall comply with following additional conditions:**

i. The applicant shall maintain good housekeeping and take adequate measures for control of pollution from all sources so as not to cause nuisance to surrounding area / inhabitants.

ii. The applicant shall bring minimum 33% of the available open land under green coverage/ tree plantation.

iii. Solid waste – The non hazardous solid waste arising in the factory premises, sweepings, etc., be disposed of scientifically so as not to cause any nuisance / pollution. The applicant shall take necessary permissions from civic authorities for disposal to dumping ground.

iv. The applicant shall provide for an alternate electric power source sufficient to operate all pollution control facilities installed by he applicant to maintain compliance with the terms and conditions of the consent. In the absence, the applicant shall stop, reduce or otherwise, control production to abide by terms & conditions of this consent regarding pollution levels.

v. The applicant shall not change or alter quantity, quality, the rate of discharge, temperature or the mode of the effluent / emissions or hazardous wastes or control equipments provided for without previous written permission of the Board.

vi. The applicant shall provide facility for collection of environmental samples and samples of trade and sewage effluents, air emissions and hazardous wastes to the Board staff at the terminal or designated points and shall pay to the Board for the services rendered in this behalf.

vii. **The applicant shall obtain Consent to Operate from Maharashtra Pollution Control Board before actual commencement of the Unit/ Activity.**

viii. The firm shall submit to this office, the 30th day of September every year, the Environmental Statement Report for the financial year ending 31st March in the prescribed Form-V as pre the provisions of rule 14 of the Environment (Protection) (Second Amendment) Rules, 1992.

ix. As inspection book shall be opened and made available to the Board's officers during their visit to the applicant.

x. The applicant shall install a separate electric meter showing the consumption of energy for operation of domestic and industrial effluent treatment plants and air pollution control system. A register showing consumption of chemicals used for treatment shall be maintained.

xi. Separate drainage system shall be provided for collection of trade and sewage effluents. Terminal manholes shall be provided at the end of collection system with arrangement for measuring the flow. No effluent shall be admitted in the pipes / sewers down- stream of the terminal manholes. No effluent shall find its way other than in designed and provided collection System.

xii. Neither storm water nor discharge from other premises shall be allowed to mix with the effluents from the factory.

9. **The consent is issued subject to direction issued by CPCB under section 18(1) (b) of Water (Prevention and Control of Pollution) Act, 1974, regarding classification of Industries dated 07th March 2016.**

10. **Operation of RMC plant shall be in day time only. The Day time is reckoned in between 6 a.m. and 6 p.m. i.e. from sun rise to sunset.**

11. **The Board may make the standards stringent for the RMC/batching plants located within Corporation areas.**

12. **Commercial plants shall install continuous ambient air quality monitoring station (CAAQMS) within the premises.**

Maharashtra Pollution Control Board

Regional Officer Mumbai

Louis Berger Consulting Pvt. Ltd.

AECOM Asia Co. Pvt. Ltd. Mumbai

ARD

13. **Captive plants shall carryout ambient air quality monitoring twice in a week for 24 hours.**
14. **The industry shall comply with the siting criteria as per RMC Notification dtd 16.10.2016.**
15. **The entire RMC Plant should be enclosed.**
16. **The Capital investment of the industry is Rs. 286.75/- Lakhs.**
17. **Industry shall operate water sprinkling facility with fogging facility provided at raw material storage area.**
18. **Industry shall provide two level tyre washing facility at entry/exit points within 15 days period.**
19. **Industry shall provide Industrial vacuum cleaner for cleaning of internal roads/removal of dust within 7 days period.**
20. **Industry shall provide asphalted/concreted roads inside the plant premises within 1 month period.**
21. **Industry to submit BG's of Rs. 2/- Lakhs against compliance of consent conditions. The BG shall be valid upto 31.08.2021 which shall be submitted in favor of Regional Officer, Mumbai, within 7 days period.**
22. **This consent is issued without prejudice to the order issued by Hon'ble Supreme Court of India vide dtd 17.12.2019.**
23. The Board reserve right to revoke, amend or suspend the consent granted.

For and on behalf of the
Maharashtra Pollution Control Board

(Dr. A. N. Harshvardhan)
Regional Officer, Mumbai

To,
M/s. Larsen & Toubro Ltd.,
Near Haji Ali, Mumbai Coastal Road Project
PKG 1, Mumbai – 400 026.

Maharashtra Pollution Control Board Regional Officer Mumbai

Received Consent fee of –

Sr. No.	Amount (Rs.)	Transaction Number	Transaction Date
1.	15,000/-	NEFT	22.03.2019

Copy Submitted to:
1. Sub Regional Officer, Mumbai-II, M.P.C. Board, Mumbai

Louis Berger Consulting Pvt. Ltd.
AECOM Asia Company Limited MUMBAI

C-69

MAHARASHTRA POLLUTION CONTROL BOARD

Phone : 02225505928
Fax : 02225505926
Email : romumbai@mpcb.gov.in
Visit At : http://mpcb.gov.in

Regional Office, Mumbai,
Raikar Chambers, "A" Wing, 216, 2nd Floor,
Deonar Gaon Road, Near Jain Mandir,
Govandi (E), Mumbai-400088

Green/S.S.I

Date: 22/07/2020

Consent No: RO-MUMBAI/ 2007001454

Consent to Establish under Section 25 of the Water (Prevention & Control of Pollution) Act, 1974 & under Section 21 of the Air (Prevention & Control of Pollution) Act, 1981 and Authorization / Renewal of Authorization under Rule 5 of the Hazardous Wastes (Management, Handling & Transboundary Movement) Rules 2008

[To be referred as Water Act, Air Act and HW (M&H) Rules respectively].

.....

CONSENT is hereby granted to

M/s. Larsen & Toubro Ltd.,
Near Amarsons Garden, Mumbai Coastal Road Project
PKG 1, Mumbai – 400 026.

Located in the area declared under the provisions of the Water Act, Air act and Authorization under the provisions of HW (M&H) Rules and amendments thereto subject to the provisions of the Act and the Rules and the Orders that may be made further and subject to the following terms and conditions:

1. **The Consent to Establish is granted for a period up to Commissioning of the Project r 5 years whichever is earlier.**

2. **The Consent is valid for the manufacture of –**

Sr. No.	Product Name	Maximum Quantity	UOM
1	Casting Bridge Elements	180	M3/D
	(Only for Captive purpose of Mumbai Coastal Road Project)		

3. **CONDITIONS UNDER WATER ACT:**

(i) The daily quantity of trade effluent from the factory shall not exceed **08.00 M³.**

(ii) The daily quantity of sewage effluent from the factory shall not exceed **03.20 M³**

(iii) **Trade Effluent Treatment :** The waste water generated from the source like batching plant, washing of transit mixture, floor washing, vehicle washing, two lever tyre washing area shall be collected through well designed drainage system in collection tank and shall provide comprehensive treatment system as is warranted to meet with disposal standards mentioned below.

Maharashtra Pollution Control Board Regional Officer Mumbai

Louis Berger Consulting Pvt. Ltd.

AECOM Asia Company Limited MUMBAI ARP

Sr. No.	Parameter	Concentration	Limit
1	pH	between	5.5 to 9.0
2	BOD	Not to exceed	30 mg/l
3	COD	Not to exceed	150 mg/l
4	SS	Not to exceed	100 mg/l
5	O & G	Not to exceed	10 mg/l
6	TDS	Not to exceed	2100 mg/l

(iv) **Trade Effluent Disposal:** The treated effluent shall be reuse/recycle in the process, gardening/plantation and water sprinkling purpose only. There shall not be any discharge outside from the plant.

(iii) **Sewage Effluent Treatment:** The applicant shall provide comprehensive treatment system as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of treated effluent to the following standards.

(1)	Suspended Solids	Not to exceed	100	mg/l.
(2)	BOD 3 days 27o C.	Not to exceed	100	mg/l.

(iv) **Sewage Effluent Disposal:** The treated domestic effluent shall be soaked in a soak pit, which shall be got cleaned periodically. Overflow, if any, shall be used on land for gardening / plantation only.

(v) **Non-Hazardous Solid Wastes:**

Sr. No.	Type Of Waste	Quantity	UOM	Treatment & Disposal
1	Aggregates	---	MT/M	Either reused through recovery unit/Reclaiming system OR disposed off at designated approved site by local body, for derbies / construction waste.

4. The applicant shall comply with the provisions of the Water (Prevention & Control of Pollution) Cess Act, 1977 (to be referred as Cess Act) and amendment Rules, 2003 there under:

The daily water consumption for the following categories is as under:

(i)	Domestic purpose	...	10.00 CMD
(ii)	Water gets Polluted & Pollutants are Biodegradable	...	120.00 CMD
(iii)	Water gets Polluted, Pollutants are not Biodegradable & Toxic	...	00.00 CMD
(iv)	Industrial Cooling, spraying in mine pits or boiler feed	...	00.00 CMD

5. CONDITIONS UNDER AIR ACT:

The applicant shall install a comprehensive control system consisting of control equipments as is warranted with reference to generation of emission and operate and maintain the same continuously so as to achieve the level of pollutants to the following standards:

1)	**Particulate Matter PM_{10}**	**Not to Exceed**	**100 µg/m³**
2)	**Particulate Matter $PM_{2.5}$**	**Not to Exceed**	**60 µg/m³**
3)	**SO2**	**Not to Exceed**	**80 µg/m³**
4)	**NOx**	**Not to Exceed**	**80 µg/m³**

Control Equipment:

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Air Pollution Control:-

i) In-house measures:-

1. All material transfer points should be covered
2. The dust containment system shall be provided incorporating either of the following.

- Barricading all around the periphery of the plot boundary of height minimum 20 feet or 5 feet above free fall air emission area, whichever is higher with tin sheets. Same may extend above with netlon clothing whenever required
- Water sprinkling/Chemical dust stabilizing agent spraying system along the periphery inside the premises of RMC.

3. Internal work area shall be, cement concreted/Asphalted.
4. Daily cleaning / Removal of dust accumulation inside the plant (dry/wet) shall be carry out, with industrial vacuum cleaner.
5. Two level tyre washing facility shall be provided at entry and exit points, for transit mixture vehicle.

(ii) Raw material Storage, Handling & Others:-

1. Storage silos of cement & fly-ash shall be equipped with adequate capacity of dust Collection system such as multi- cyclone followed by bag house assembly.
2. Handling of Cement, sand, fly ash and aggregates shall be carried out with mechanical closed system only.
3. Manual operations shall be permitted only in a closed shed, equipped with dust control system at the loading point as well as roof top secondary dust control system.
4. All Conveyor belts of Sand, aggregate shall be covered with tin sheets and at transfer points dust collection system to be installed to avoid secondary fugitive emissions.
5. Mixing section of cement, aggregate & sand shall be equipped with adequate capacity dust collection system, such as multi-cyclone followed by bag house, so as to limit dust emissions.
6. Storage area of sand & aggregate shall be equipped with roof top water sprinkler system.
7. The air pollution control devices shall be operated regularly.
8. Alternative power supply system, should cover both the production and Air pollution control system.
9. Industry shall provide treatment facility industrial effluent.
10. Industry shall provide disposal facility for treated effluent.
11. Industry shall provide disposal facility for solid waste.
12. Industry shall provide proper exhaust system in the premises.

6. CONDITIONS UNDER HAZARDOUS WASTE (MANAGEMENT, HANDLING & TRANSBOUNDRY MOVEMENT) RULES, 2008:

(i) The Industry shall not generate any type of hazardous wastes.

7. Noise Pollution control Measures:-

The Industry shall comply with the provision under the Noise (Regulation and Control) Rule- 2000, to control noise pollution.

Maharashtra Pollution Control Board Regional Officer Mumbai

Louis Berger Consulting Pvt. Ltd.

AECOM Asia Company Limited MUMBAI

AFD

8. **Industry shall comply with following additional conditions:**

i. The applicant shall maintain good housekeeping and take adequate measures for control of pollution from all sources so as not to cause nuisance to surrounding area / inhabitants.

ii. The applicant shall bring minimum 33% of the available open land under green coverage/ tree plantation.

iii. Solid waste – The non hazardous solid waste arising in the factory premises, sweepings, etc., be disposed of scientifically so as not to cause any nuisance / pollution. The applicant shall take necessary permissions from civic authorities for disposal to dumping ground.

iv. The applicant shall provide for an alternate electric power source sufficient to operate all pollution control facilities installed by he applicant to maintain compliance with the terms and conditions of the consent. In the absence, the applicant shall stop, reduce or otherwise, control production to abide by terms & conditions of this consent regarding pollution levels.

v. The applicant shall not change or alter quantity, quality, the rate of discharge, temperature or the mode of the effluent / emissions or hazardous wastes or control equipments provided for without previous written permission of the Board.

vi. The applicant shall provide facility for collection of environmental samples and samples of trade and sewage effluents, air emissions and hazardous wastes to the Board staff at the terminal or designated points and shall pay to the Board for the services rendered in this behalf.

vii. **The applicant shall obtain Consent to Operate from Maharashtra Pollution Control Board before actual commencement of the Unit/ Activity.**

viii. The firm shall submit to this office, the 30th day of September every year, the Environmental Statement Report for the financial year ending 31st March in the prescribed Form-V as pre the provisions of rule 14 of the Environment (Protection) (Second Amendment) Rules, 1992.

ix. As inspection book shall be opened and made available to the Board's officers during their visit to the applicant.

x. The applicant shall install a separate electric meter showing the consumption of energy for operation of domestic and industrial effluent treatment plants and air pollution control system. A register showing consumption of chemicals used for treatment shall be maintained.

xi. Separate drainage system shall be provided for collection of trade and sewage effluents. Terminal manholes shall be provided at the end of collection system with arrangement for measuring the flow. No effluent shall be admitted in the pipes / sewers down- stream of the terminal manholes. No effluent shall find its way other than in designed and provided collection System.

xii. Neither storm water nor discharge from other premises shall be allowed to mix with the effluents from the factory.

9. **The consent is issued subject to direction issued by CPCB under section 18(1) (b) of Water (Prevention and Control of Pollution) Act, 1974, regarding classification of Industries dated 07th March 2016.**

10. **Operation of RMC plant shall be in day time only. The Day time is reckoned in between 6 a.m. and 6 p.m. i.e. from sun rise to sunset.**

11. **The Board may make the standards stringent for the RMC/batching plants located within Corporation areas.**

12. **Commercial plants shall install continuous ambient air quality monitoring station (CAAQMS) within the premises.**

13. **Captive plants shall carryout ambient air quality monitoring twice in a week for 24 hours.**
14. **The industry shall comply with the siting criteria as per RMC Notification dtd 16.10.2016.**
15. **The entire RMC Plant should be enclosed.**
16. **The Capital investment of the industry is Rs. 3161/- Lakhs.**
17. **Industry shall operate water sprinkling facility with fogging facility provided at raw material storage area.**
18. **Industry shall provide two level tyre washing facility at entry/exit points within 15 days period.**
19. **Industry shall provide Industrial vacuum cleaner for cleaning of internal roads/removal of dust within 7 days period.**
20. **Industry shall provide asphalted/concreted roads inside the plant premises within 1 month period.**
21. **Industry to submit BG's of Rs. 2/- Lakhs against compliance of consent conditions. The BG shall be valid upto 31.08.2021 which shall be submitted in favor of Regional Officer, Mumbai, within 7 days period.**
22. **This consent is issued without prejudice to the order issued by Hon'ble Supreme Court of India vide dtd 17.12.2019.**
23. The Board reserve right to revoke, amend or suspend the consent granted.

For and on behalf of the
Maharashtra Pollution Control Board

(Dr. A. N. Harshvardhan)
Regional Officer, Mumbai

Maharashtra Pollution Control Board Regional Officer Mumbai

To,
M/s. Larsen & Toubro Ltd.,
Near Amarsons Garden, Mumbai Coastal Road Project
PKG 1, Mumbai – 400 026.

Received Consent fee of –

Sr. No.	Amount (Rs.)	Transaction Number	Transaction Date
1.	75,000/-	TXN2006000858	17.06.2020

Copy Submitted to:
1. Sub Regional Officer, Mumbai-I, M.P.C. Board, Mumbai

Louis Berger Consulting Pvt. Ltd.

AECOM Asia Company Limited Mumbai

MAHARASHTRA POLLUTION CONTROL BOARD

Phone : 022-24016239
Fax : 022-24015269
Email : Sromumbai1@mpcb.gov.in
Visit At : http://www.mpcb.gov.in

Kalpataru point, 1st floor, Sion Circle,
Opp. PVR Cinema, Sion (East),
Mumbai- 400 022.

Green/S.S.I

Consent No: SRO-MUMBAI – I/CONSENT/ 2007001477 Date: 24.07.2020

Consent to Operate under Section 26 of the Water (Prevention & Control of Pollution) Act, 1974 & under Section 21 of the Air (Prevention & Control of Pollution) Act, 1981 and Authorization / Renewal of Authorization under Rule 5 of the Hazardous Wastes (Management, Handling & Transboundry Movement) Rules 2008

[To be referred as Water Act, Air Act and HW (M&H) Rules respectively].

.....

CONSENT is hereby granted to

M/s. HCC HDC JV MUMBAI COASTAL ROAD PROJECT PACKAGE - II , WORLI ,
Address - HCC HDC JV MUMBAI COASTAL ROAD PROJECT PACKAGE - II , WORLI
Worli Seaface , KHAN ABDUL GAFFAR KHAN ROAD, SEA FACE, Opposite WORLI DAIRY – 400018.

located in the area declared under the provisions of the Water Act, Air act and Authorization under the provisions of HW(M&H) Rules and amendments thereto subject to the provisions of the Act and the Rules and the Orders that may be made further and subject to the following terms and conditions:

1. **The Consent to Operate is granted up to: 31.07.2023.**

24/7/2020

2. **The Consent is valid for the manufacture of –**

Sr. No.	Product Name	Maximum Quantity	UOM
1.	Ready Mix Concrete (Captive Purpose Use Only)	10000	M³/ Month

3. **CONDITIONS UNDER WATER ACT:**

(i) The daily quantity of trade effluent from the factory shall be **0.25 M³.**
(ii) The daily quantity of sewage effluent from the factory shall not exceed **2.0 M³.**
(iii) **Trade Effluent :**
Treatment: The applicant shall provide , comprehensive treatment system consisting of primary / secondary or tertiary treatment as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of the treated effluent to the following standards:

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(iv) **Trade Effluent Disposal:** The treated effluent shall be 100 percent recycled into process again .

(v) **Sewage Effluent Treatment:** The applicant shall provide comprehensive treatment system as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of treated effluent to the following standards.

(1)	Suspended Solids	Not to exceed	100	mg/l.
(2)	BOD 3 days 27o C.	Not to exceed	100	mg/l.

(vi) **Sewage Effluent Disposal:** The treated domestic effluent shall be soaked in a soak pit, which shall be got cleaned periodically. Overflow, if any, shall be used on land for gardening / plantation only.

(vii) **Non-Hazardous Solid Wastes:**

Sr. No.	Type Of Waste	Quantity	UOM	Treatment	Disposal
1	Aggregates	200.00	MT/M	Disposed in low lying area approved by MCGM	---

(viii)**Other Conditions:** Industry should monitor effluent quality regularly.

4. **The applicant shall comply with the provisions of the Water (Prevention & Control of Pollution) Cess Act, 1977 (to be referred as Cess Act) and amendment Rules, 2003 there under**
The daily water consumption for the following categories is as under:

(i) Domestic purpose	3.00 CMD
(ii) Water gets Polluted & Pollutants are Biodegradable(Mixing) ...	95.0 CMD
(iii) Water gets Polluted, Pollutants are not Biodegradable & Toxic ...	0.00 CMD
(iv) Industrial Washing , Spraying of Vehicles , Water Sprinkling for dust suppressions	2.0 CMD

The applicant shall regularly submit to the Board the returns of water consumption in the prescribed form and pay the Cess as specified under Section 3 of the said Act.

4. **CONDITIONS UNDER AIR ACT :**

(i) The applicant shall install a comprehensive control system consisting of control equipments as is warranted with reference to generation of emission and operate and maintain the same continuously so as to achieve the level of pollutants to the following standards:

5. **Control Equipment:**

a) Air Pollution Control;

(i) In-house measures;

1. All material transfer points should be covered

24/7/2020

2. The dust containment system shall be provided incorporating either of the following
   - Barricading all around the periphery of the plot boundary of height
     minimum 20 feet or 5 feet above free fall air emission area, whichever is higher with tin sheets. Same may extend above with netlon clothing whenever required
   - Water sprinkling/Chemical dust stabilizing agent spraying system along the periphery inside the premises of RMC.
3. Internal work area shall be, cement concreted/Asphalted.
4. Daily cleaning / Removal of dust accumulation inside the plant (dry/wet) shall be carry out, with industrial vacuum cleaner.
5. Two level tyre washing facility shall be provided at entry and exit points, for transit mixture vehicle.
6. Industry has to install fogger system, to suppress dust emissions inside RMC Premises.

(ii) Raw material storage & handling;

1. Storage silos of cement & fly-ash shall be equipped with adequate capacity of dust Collection system such as multi-cyclone followed by bag house assembly.
2. Handling of Cement, sand, fly ash and aggregates shall be carried out with mechanical closed system only.
3. Manual operations shall be permitted only in a closed shed, equipped with dust control system at the loading point as well as roof top secondary dust control system.
4. All Conveyor belts of Sand, aggregate shall be covered with tin sheets and at transfer points dust collection system to be installed to avoid secondary fugitive emissions.
5. Mixing section of cement, aggregate & sand shall be equipped with adequate capacity dust collection system, such as multi-cyclone followed by bag house, so as to limit dust emissions.
6. Storage area of sand & aggregate shall be equipped with roof top water sprinkler system.
7. The air pollution control devices shall be operated regularly.
8. Alternative power supply system, should cover both the production and Air pollution control system.

6.Standards for Air Emission

Ambient air quality at a distance of 10 mtr from source OR the plant Boundary, whichever is nearer, shall meet the following standards

Particulate Matter PM $_{10}$	**Not to Exceed**	**100**	**$\mu g/m^3$**
Particulate Matter PM $_{2.5}$	**Not to Exceed**	**60**	**$\mu g/m^3$**

7.Standards for Stack Emissions:

(i) The applicant shall observe the following fuel pattern:-

Sr. No.	Type Of Fuel	Quantity	UOM
1.	HSD	95	Lit/D

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(ii) The applicant shall erect the chimney(s) of the following specifications:-

Sr. No.	Chimney Attached To	Height in mt
1.	D.G. Set (200 KVA)	3.0 (above roof)

(iii) The applicant shall provide ports in the chimney/(s) and facilities such as ladder, platform etc. for monitoring the air emissions and the same shall be open for inspection to/and for use of the Board's Staff. The chimney(s) vents attached to various sources of emission shall be designated by numbers such as S-1, S-2, etc. and these shall be painted/ displayed to facilitate identification.

(iv) The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standard in respect of noise to less than 75 dB(A) during day time and 70 dB(A) during night time. Day time is reckoned in between 6 a.m. and 10 p.m. and night time is reckoned between 10 p.m. and 6 a.m.

(v) **Other Conditions:**

1) The industry should not cause any nuisance in surrounding area.
2) The industry should monitor stack emissions and ambient air quality regularly.

8.CONDITIONS UNDER HAZARDOUS WASTE (MANAGEMENT, HANDLING & TRANSBOUNDRY MOVEMENT) RULES, 2008:

(i) The Industry shall handle hazardous wastes as specified below.

Sr. No.	Type Of Waste	Quantity	UOM	Disposal
----------	NIL	----------		

(ii) Treatment: - NIL

1. The authorization is hereby granted to operate a facility for collection, storage, transport & disposal of hazardous waste.
2. The industry should comply with the Hazardous Waste (M&H) Rules, 2003.

a. Whenever due to any accident or other unforeseen act or even, such emissions occur or is apprehended to occur in excess of standards laid down, such information shall be forthwith Reported to Board, concerned Police Station, office of Directorate of Health Services, Department of Explosives, Inspectorate of Factories and Local Body. In case of failure of pollution control equipment, the production process connected to it shall be stopped.

b. The unit has to display and maintain the data online outside the factory main gate in Marathi & English both on a 6'x4' display board in the

24/7/2020

Maharashtra Pollution Control Board

Sub Regional Office Mumbai I

COASTAL ROAD PROJECT PKG II

AECOM Asia Company Limited MUMBAI

manner and the report of the compliance along with photograph shall be submitted to this office & concerned Regional Office/ Sub Regional Office.

c. It shall be ensured that the Hazardous waste is handled, managed & disposed of strictly in accordance with the Hazardous Waste (Management & Handling) Rules, 1989 as amended on 2003 and shown & submitted to the Board as & when asked for.

9.Industry shall comply with following additional conditions:

i. The applicant shall maintain good housekeeping and take adequate measures for control of pollution from all sources so as not to cause nuisance to surrounding area / inhabitants.

ii. Solid waste – The non hazardous solid waste arising in the factory premises, sweepings, etc., be disposed of scientifically so as not to cause any nuisance / pollution. The applicant shall take necessary permissions from civic authorities for disposal to dumping ground.

iii. The applicant shall provide for an alternate electric power source sufficient to operate all pollution control facilities installed by he applicant to maintain compliance with the terms and conditions of the consent. In the absence, the applicant shall stop, reduce or otherwise, control production to abide by terms & conditions of this consent regarding pollution levels.

iv. The applicant shall not change or alter quantity, quality, the rate of discharge, temperature or the mode of the effluent / emissions or hazardous wastes or control equipment's provided for without previous written permission of the Board.

v. The applicant shall provide facility for collection of environmental samples and samples of trade and sewage effluents, air emissions and hazardous wastes to the Board staff at the terminal or designated points and shall pay to the Board for the services rendered in this behalf.

vi. The applicant shall make an application for renewal of the consent at least 60 days before the date of the expiry of the consent.

vii. The firm shall submit to this office, the 30th day of September every year, the Environmental Statement Report for the financial year ending 31st March in the prescribed Form-V as pre the provisions of rule 14 of the Environment (Protection) (Second Amendment) Rules, 1992.

viii. As inspection book shall be opened and made available to the Board's officers during their visit to the applicant.

ix. The applicant shall install a separate electric meter showing the consumption of energy for operation of domestic and industrial effluent treatment plants and air pollution control system. A register showing consumption of chemicals used for treatment shall be maintained.

x. Separate drainage system shall be provided for collection of trade and sewage effluents. Terminal manholes shall be provided at the end of

24/7/2020

collection system with arrangement for measuring the flow. No effluent shall be admitted in the pipes / sewers down- stream of the terminal manholes. No effluent shall find its way other than in designed and provided collection System.

xi. Neither storm water nor discharge from other premises shall be allowed to mix with the effluents from the factory.

10. **The consent is issued subject to direction issued by CPCB under section 18(1) (b) of Water (Prevention and Control of Pollution) Act, 1974, Regarding classification of Industries dated 07th March 2016.**
11. **Operation of RMC Plant plant shall be in day time only. The Day time is reckoned in between 6 A.M. and 6 P.M. i.e from Sunrise to sunset.**
12. **The Board may make the standards stringent for the RMC / Batching plants located within Corporation areas.**
13. **The Capital investment of the industry is Rs. 490.52 Lakhs**
14. **The Board reserve right to revoke, amend or suspend the consent Granted.**
15. **The consent should not be construed as any exemption from Obtaining necessary NOC from other govt. agencies as may deemed fit necessary .**
16. **This Consent is issued as per Permission of MCGM Chief Engineer Coastal Road Vide Letter No. 1720 dated 1.1.2019.**
17. **PP has submitted BG of Rs. 1 Lakh on dated 15.7.2020 which is Valid for the Period upto 20.7.2025.**
18. **PP has submitted letter dated 15.7.2020 regarding self-declaration of site ,machineries and equipment along with site photographs.**

For and on behalf of the
Maharashtra Pollution Control Board

29/7/2020
(T.G. Yadav)
Sub Regional Officer, Mumbai-I

To,
M/s. HCC HDC JV MUMBAI COASTAL ROAD PROJECT PACKAGE - II , WORLI ,
Address - HCC HDC JV MUMBAI COASTAL ROAD PROJECT PACKAGE - II , WORLI Worli Seaface , KHAN ABDUL GAFFAR KHAN ROAD, SEA FACE, Opposite WORLI DAIRY – 400018

Received Consent fee of –

Sr. No.	Amount(Rs.)	Transaction number	Transaction Type	Transaction Date & Approved Date
1	15000/-	TXN2006001790	Online Payment	30.06.2020

Copy Submitted to :-
1. Chief Account officer, MPCB, Sion, Mumbai-22.,
2. Regional Officer, MPCB, Mumbai.

MAHARASHTRA POLLUTION CONTROL BOARD

Phone : 022-25505928
Fax : 022-25505926
Email : Sromumbai1@mpcb.gov.in
Visit At : http://www.mpcb.gov.in

Raikar Chambers, A- Wing, 216, 2nd floor Deonar Gaon Road,Near Jain Mandir,Govandi (E)

Mumbai - 400088

Green/S.S.I

Consent No: SRO-MUMBAII/CONSENT/1904000649
Date: 15.4.2019

Consent to Operate under Section 25 of the Water (Prevention & Control of Pollution) Act, 1974 & under Section 21 of the Air (Prevention & Control of Pollution) Act, 1981 and Authorization / Renewal of Authorization under Rule 5 of the Hazardous Wastes (Management, Handling & Transboundry Movement) Rules 2008

[To be referred as Water Act, Air Act and HW (M&H) Rules respectively].

.....

CONSENT is hereby granted to

M/s. Larsen & Toubro Limited
Mumbai Coastal Road Pkg 4
Nepean Sea Road, Next to Priya Darshni Park
Malbar Hill Mumbai City

located in the area declared under the provisions of the Water Act, Air act and Authorization under the provisions of HW(M&H) Rules and amendments thereto subject to the provisions of the Act and the Rules and the Orders that may be made further and subject to the following terms and conditions:

1. **The Consent to Establish is granted up to: commissioning of the Unit Or 5 Years which ever is Earlier .**

2. **The Consent is valid for the manufacture of –**

Sr. No.	Product Name	Maximum Quantity	UOM
1.	**Tunnel Lining Pre-cast Segment (Casting)** **(Category G11 Cement products (without using asbestos / boiler / steam curing) like pipe,pillar, jafri, well ring, block/tiles etc.(should be done in closed covered shed to control fugitive emissions)**	200	Nos/Month

3. CONDITIONS UNDER WATER ACT:

(i) The daily quantity of trade effluent from the factory shall be **NIL** M^3.
(ii) The daily quantity of sewage effluent from the factory shall not exceed **5.0** M^3.

AECOM Asia Company Limited MUMBAI

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

C-81

(iii) **Trade Effluent :**
Treatment: The applicant shall provide , comprehensive treatment system consisting of primary / secondary or tertiary treatment as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of the treated effluent to the following standards:

(iv) **Trade Effluent Disposal:** The treated effluent shall be 100 percent recycled into process again .

(v) **Sewage Effluent Treatment:** The applicant shall provide comprehensive treatment system as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of treated effluent to the following standards.

(1)	Suspended Solids	Not to exceed	100	mg/l.
(2)	BOD 3 days 27o C.	Not to exceed	100	mg/l.

(vi) **Sewage Effluent Disposal:** The treated domestic effluent shall be soaked in a soak pit, which shall be got cleaned periodically. Overflow, if any, shall be used on land for gardening / plantation only.

(vii) **Non-Hazardous Solid Wastes:**

Sr. No.	Type Of Waste	Quantity	UOM	Disposal
1	Bentonite Muck	440	M3/M	Landfilling .

(viii) **Other Conditions:** Industry should monitor effluent quality regularly.

4. **The applicant shall comply with the provisions of the Water (Prevention & Control of Pollution) Cess Act, 1977 (to be referred as Cess Act) and amendment Rules, 2003 there under**
The daily water consumption for the following categories is as under:

(i)	Domestic purpose ...	5.5 CMD
(ii)	Water gets Polluted & Pollutants are Biodegradable(Mixing) ...	00 CMD
(iii)	Water gets Polluted, Pollutants are not Biodegradable & Toxic ...	0.00 CMD
(iv)	Industrial Washing of Vehicles , Water Sprinkling for dust suppressions	00 CMD

The applicant shall regularly submit to the Board the returns of water consumption in the prescribed form and pay the Cess as specified under Section 3 of the said Act.

4. **CONDITIONS UNDER AIR ACT :**
(i) The applicant shall install a comprehensive control system consisting of control equipments as is warranted with reference to generation of emission and operate and maintain the same continuously so as to achieve the level of pollutants to the following standards:

5. **Control Equipment:**
a) Air Pollution Control- NIL

6.Standards for Air Emission

Ambient air quality at a distance of 10 mtr from source OR the plant Boundary, whichever is nearer, shall meet the following standards

Particulate Matter PM $_{10}$	**Not to Exceed**	**100**	**$\mu g/m^3$**
Particulate Matter PM $_{2.5}$	**Not to Exceed**	**60**	**$\mu g/m^3$**

7.Standards for Stack Emissions:

(i) **The applicant shall observe the following fuel pattern:-**

Sr. No.	Type Of Fuel	Quantity	UOM
----------	NIL	----------	

(ii) **The applicant shall erect the chimney(s) of the following specifications:-**

Sr. No.	Chimney Attached To	Height in mt
----------	NIL	----------

(iii)The applicant shall provide ports in the chimney/(s) and facilities such as ladder, platform etc. for monitoring the air emissions and the same shall be open for inspection to/and for use of the Board's Staff. The chimney(s) vents attached to various sources of emission shall be designated by numbers such as S-1, S-2, etc. and these shall be painted/ displayed to facilitate identification.

(iv)The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standard in respect of noise to less than 75 dB(A) during day time and 70 dB(A) during night time. Day time is reckoned in between 6 a.m. and 10 p.m. and night time is reckoned between 10 p.m. and 6 a.m.

(v) **Other Conditions:**

1) The industry should not cause any nuisance in surrounding area.

2) The industry should monitor stack emissions and ambient air quality regularly.

8.CONDITIONS UNDER HAZARDOUS WASTE (MANAGEMENT, HANDLING & TRANSBOUNDRY MOVEMENT) RULES, 2008:

(i) The Industry shall handle hazardous wastes as specified below.

Sr. No.	Type Of Waste	Quantity	UOM	Disposal
	NIL			

(ii) Treatment: - NIL

1. The authorization is hereby granted to operate a facility for collection, storage, transport & disposal of hazardous waste.
2. The industry should comply with the Hazardous Waste (M&H) Rules, 2003.

a. Whenever due to any accident or other unforeseen act or even, such emissions occur or is apprehended to occur in excess of standards laid down, such information shall be forthwith Reported to Board, concerned Police Station, office of Directorate of Health Services, Department of Explosives, Inspectorate of Factories and Local Body. In case of failure of pollution control equipments, the production process connected to it shall be stopped.

b. The unit has to display and maintain the data online outside the factory main gate in Marathi & English both on a 6'x4' display board in the manner and the report of the compliance along with photograph shall be submitted to this office & concerned Regional Office/ Sub Regional Office.

c. It shall be ensured that the Hazardous waste is handled, managed & disposed of strictly in accordance with the Hazardous Waste (Management & Handling) Rules, 1989 as amended on 2003 and shown & submitted to the Board as & when asked for.

9.Industry shall comply with following additional conditions:

i. The applicant shall maintain good housekeeping and take adequate measures for control of pollution from all sources so as not to cause nuisance to surrounding area / inhabitants.

ii. Solid waste – The non hazardous solid waste arising in the factory premises, sweepings, etc., be disposed of scientifically so as not to cause any nuisance / pollution. The applicant shall take necessary permissions from civic authorities for disposal to dumping ground.

iii. The applicant shall provide for an alternate electric power source sufficient to operate all pollution control facilities installed by he applicant to maintain compliance with the terms and conditions of the consent. In the absence, the applicant shall stop, reduce or otherwise, control production to abide by terms & conditions of this consent regarding pollution levels.

iv. The applicant shall not change or alter quantity, quality, the rate of discharge, temperature or the mode of the effluent / emissions or hazardous wastes or control equipments provided for without previous written permission of the Board.

v. The applicant shall provide facility for collection of environmental samples and samples of trade and sewage effluents, air emissions and hazardous wastes to the Board staff at the terminal or designated points and shall pay to the Board for the services rendered in this behalf.

vi. The firm shall submit to this office, the 30th day of September every year, the Environmental Statement Report for the financial year ending 31st March in the prescribed Form-V as pre the provisions of rule 14 of the Environment (Protection) (Second Amendment) Rules, 1992.

vii. As inspection book shall be opened and made available to the Board's officers during their visit to the applicant.

viii. The applicant shall install a separate electric meter showing the consumption of energy for operation of domestic and industrial effluent treatment plants and air pollution control system. A register showing consumption of chemicals used for treatment shall be maintained.

ix. Separate drainage system shall be provided for collection of trade and sewage effluents. Terminal manholes shall be provided at the end of collection system with arrangement for measuring the flow. No effluent shall be admitted in the pipes / sewers down- stream of the terminal manholes. No effluent shall find its way other than in designed and provided collection System.

xi. Neither storm water nor discharge from other premises shall be allowed to mix with the effluents from the factory.

10. The consent is issued subject to direction issued by CPCB under section 18(1) (b) of Water (Prevention and Control of Pollution) Act, 1974, regarding classification of Industries dated 07th March 2016. 11.

12. This is issued as per NOC given by Chief Engineer (Coastal Road of MCGM vide letter no. Ch.E/3932 Coastal Road dated – 16.2.2019

13. The Capital investment of the industry is Rs. 2490.0 Lakhs

14. The Board reserve right to revoke, amend or suspend the consent granted

15. applied for consent to operate application after commissioning of the unit .

For and on behalf of the
Maharashtra Pollution Control Board

(Sanjay R. Bhosale)
Sub Regional Officer, Mumbai-I

To,
M/s. Larsen & Toubro Limited
Mumbai Coastal Road Pkg 4
Nepean Sea Road, Next to Priya Darshni Park
Malbar Hill Mumbai City

Received Consent fee of –

Sr. No.	Amount(Rs.)	Transaction number	Transaction number	Approved Date
1	200000/-	TXN1903002085	19.3-2019	20.032019

Copy Submitted to :-
1. Chief Account officer, MPCB, Sion, Mumbai-22.,
2. Regional Officer, MPCB, Mumbai.

AECOM Asia Company Limited MUMBAI ARD

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

MAHARASHTRA POLLUTION CONTROL BOARD

Phone : 022-25505928
Fax : 022-25505926
Email : sromumbai1@mpcb.gov.in
Visit At : http://www.mpcb.gov.in

Raikar Chambers, A- Wing, 216, 2nd floor,
Deonar Gaon Road, Near Jain Mandir,
Govandi (E), Mumbai - 400088

Green/S.S.I

Consent No: SRO-MUMBAI I/CONSENT/1904000454 **Date: 10/04/2019**

Consent to Establish under Section 25 of the Water (Prevention & Control of Pollution) Act, 1974 & under Section 21 of the Air (Prevention & Control of Pollution) Act, 1981 and Authorization / Renewal of Authorization under Rule 5 of the Hazardous Wastes (Management, Handling & Transboundry Movement) Rules 2008

[To be referred as Water Act, Air Act and HW (M&H) Rules respectively].

.....

CONSENT is hereby granted to

M/s. Larsen And Toubro Limited, (RMC Plant),
Mumbai Coastal Road Project Pkg 4
Near Priyadarshani Park, Nepean Sea Road,
Malabar Hill, Mumbai-400006

located in the area declared under the provisions of the Water Act, Air act and Authorization under the provisions of HW(M&H) Rules and amendments thereto subject to the provisions of the Act and the Rules and the Orders that may be made further and subject to the following terms and conditions:

1. **The Consent to Establish is granted for a period up to: Commissioning of the unit /5 year whichever is earlier.**

2. **The Consent is valid for the manufacture of –**

Sr. No.	Product Name	Maximum Quantity	UOM
1.	Ready Mix Concrete (For Captive purpose only)	18000	M^3/M

3. CONDITIONS UNDER WATER ACT:

(i) The daily quantity of trade effluent from the factory shall be **6.00 M^3**.

(ii) The daily quantity of sewage effluent from the factory shall not exceed **10 M^3**.

(iii) **Trade Effluent :NIL**

Treatment: The applicant shall provide comprehensive treatment system consisting of primary / secondary or tertiary treatment as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of the treated effluent to the following standards:

Sr. No	Parameter	Limits	
1	pH	Between	5.5 to 9.0
2	BOD,3 Days 27 degree C	Not to exceed	100 mg/l.
3	COD	Not to exceed	250 mg/l.
4	Oil & Grease	Not to exceed	10 mg/l.
5	Suspended Solids	Not to exceed	100 mg/l.
21	TDS	Not to exceed	2100 mg/l.

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(iv) **Trade Effluent Disposal:** The treated effluent is recycled into the process again.

(v) **Sewage Effluent Treatment:** The applicant shall provide comprehensive treatment system as is warranted with reference to influent quality and operate and maintain the same continuously so as to achieve the quality of treated effluent to the following standards.

(1)	Suspended Solids	Not to exceed	100	mg/l.
(2)	BOD 3 days 27o C.	Not to exceed	100	mg/l.

(vi) **Sewage Effluent Disposal:** The treated domestic effluent shall be soaked in a soak pit, which shall be got cleaned periodically. Overflow, if any, shall be used on land for gardening / plantation only.

(vii) **Non-Hazardous Solid Wastes:**

Sr. No.	Type Of Waste	Quantity	UOM	Treatment	Disposal
1	NIL				

(viii) **Other Conditions:** Industry should monitor effluent quality regularly.

4. The applicant shall comply with the provisions of the Water (Prevention & Control of Pollution) Cess Act, 1977 (to be referred as Cess Act) and amendment Rules, 2003 there under

The daily water consumption for the following categories is as under:

(i) Domestic purpose	...	10.00 CMD
(ii) Water gets Polluted & Pollutants are Biodegradable(Mixing)	...	20.00 CMD
(iii) Water gets Polluted, Pollutants are not Biodegradable & Toxic	...	00.00 CMD
(iv) Industrial Washing, spraying` in mine pits or boiler feed	...	00.00 CMD

4. CONDITIONS UNDER AIR ACT :

(i) The applicant shall install a comprehensive control system consisting of control equipment as is warranted with reference to generation of emission and operate and maintain the same continuously so as to achieve the level of pollutants to the following standards:

5. Control Equipment:

a) Air Pollution Control;

(i) In-house measures;

1. All material transfer points should be covered
2. The dust containment system shall be provided incorporating either of the following
   - Barricading all around the periphery of the plot boundary of [illegible] Minimum 20 feet or 5 feet above free fall air emission area, whichever is higher with tin sheets. Same may extend above with netlon clothing whenever required
   - Water sprinkling/Chemical dust stabilizing agent spraying system along the periphery inside the premises of RMC.

AECOM Asia Company Limited MUMBAI

PROJECT MANAGER (PKG-4) MCR (PKG-4)

3. Internal work area shall be, cement concreted/Asphalted.
4. Daily cleaning / Removal of dust accumulation inside the plant (dry/wet) shall be carry out, with industrial vacuum cleaner.
5. Two level tyre washing facility shall be provided at entry and exit points, for transit mixture vehicle.
6. Industry has to be install fogger system, to suppress dust emissions inside RMC premises.

(ii) Raw material storage & handling;

1. Storage silos of cement & fly-ash shall be equipped with adequate capacity of dust Collection system such as multi- cyclone followed by bag house assembly.
2. Handling of Cement, sand, fly ash and aggregates shall be carried out with mechanical closed system only.
3. Manual operations shall be permitted only in a closed shed, equipped with dust control system at the loading point as well as roof top secondary dust control system.
4. All Conveyor belts of Sand, aggregate shall be covered with tin sheets and at transfer points dust collection system to be installed to avoid secondary fugitive emissions.
5. Mixing section of cement, aggregate & sand shall be equipped with adequate capacity dust collection system, such as multi-cyclone followed by bag house, so as to limit dust emissions.
6. Storage area of sand & aggregate shall be equipped with roof top water sprinkler system.
7. The air pollution control devices shall be operated regularly.
8. Alternative power supply system should cover both the production and Air pollution control system.

6. Standards for Air Emission

Ambient air quality at a distance of 10 mtr from source OR the plant Boundary, whichever is nearer, shall meet the following standards

Particulate Matter PM $_{10}$	**Not to Exceed**	**100**	**$\mu g/m^3$**
Particulate Matter PM $_{2.5}$	**Not to Exceed**	**60**	**$\mu g/m^3$**

a. A proper routine and preventive maintenance procedure for DG set should be set and followed in consultation with the DG manufacturer which would help to prevent noise levels of DG set from deteriorating with use.

b. D.G. Set shall be operated only in case of power failure

c. The applicant should not cause any nuisance in the surrounding area due to operation of D.G. Set

7. Standards for Stack Emissions:

(i) **The applicant shall observe the following fuel pattern:-**

Sr. No.	Type Of Fuel	Quantity	UOM
	.....NA.....		

(ii) **The applicant shall erect the chimney(s) of the following specifications:-**

Sr. No.	Chimney Attached To	Height in mt
	.....NA.....	

(iii) The applicant shall provide ports in the chimney/(s) and facilities such as ladder, platform etc. for monitoring the air emissions and the same shall be open for inspection to/and for use of the Board's Staff. The chimney(s) vents attached to various sources of emission shall be designated by numbers such as S-1, S-2, etc. and these shall be painted/ displayed to facilitate identification.

(iv) The industry shall take adequate measures for control of noise levels from its own sources within the premises so as to maintain ambient air quality standard in respect of noise to less than 75 dB(A) during day time and 70 dB(A) during night time. Day time is reckoned in between 6 a.m. and 10 p.m. and night time is reckoned between 10 p.m. and 6 a.m.

(v) **Other Conditions:**

1) The industry should not cause any nuisance in surrounding area.

2) The industry should monitor stack emissions and ambient air quality regularly.

8. CONDITIONS UNDER HAZARDOUS WASTE (MANAGEMENT, HANDLING & TRANSBOUNDRY MOVEMENT) RULES, 2008:

(i) The Industry shall handle hazardous wastes as specified below.

Sr. No.	Type Of Waste	Quantity	UOM	Disposal
		NIL		

(ii) Treatment: - NIL

a. Whenever due to any accident or other unforeseen act or even, such emissions occur or is apprehended to occur in excess of standards laid down, such information shall be forthwith Reported to Board, concerned Police Station, office of Directorate of Health Services, Department of Explosives, Inspectorate of Factories and Local Body. In case of failure of pollution control equipment, the production process connected to it shall be stopped.

9. Industry shall comply with following additional conditions:

i. The applicant shall maintain good housekeeping and take adequate measures for control of pollution from all sources so as not to cause nuisance to surrounding area / inhabitants.

ii. Solid waste – The nonhazardous solid waste arising in the factory premises, sweepings, etc., be disposed of scientifically so as not to cause any nuisance / pollution. The applicant shall take necessary permissions from civic authorities for disposal to dumping ground.

iii. The applicant shall provide for an alternate electric power source sufficient to operate all pollution control facilities installed by the applicant to maintain compliance with the terms and conditions of the consent. In the absence, the applicant shall stop, reduce or otherwise, control production to abide by terms & conditions of this consent regarding pollution levels.

AECOM Asia Company Limited MUMBAI

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

iv. The applicant shall not change or alter quantity, quality, the rate of discharge, temperature or the mode of the effluent / emissions or hazardous wastes or control equipment provided for without previous written permission of the Board.

v. The applicant shall provide facility for collection of environmental samples and samples of trade and sewage effluents, air emissions and hazardous wastes to the Board staff at the terminal or designated points and shall pay to the Board for the services rendered in this behalf.

vi. The applicant shall make an application for renewal of the consent at least 60 days before the date of the expiry of the consent.

vii. The firm shall submit to this office, the 30th day of September every year, the Environmental Statement Report for the financial year ending 31st March in the prescribed Form-V as pre the provisions of rule 14 of the Environment (Protection) (Second Amendment) Rules, 1992.

viii. As inspection book shall be opened and made available to the Board's officers during their visit to the applicant.

ix. The applicant shall install a separate electric meter showing the consumption of energy for operation of domestic and industrial effluent treatment plants and air pollution control system. A register showing consumption of chemicals used for treatment shall be maintained.

x. Separate drainage system shall be provided for collection of trade and sewage Effluents. Terminal manholes shall be provided at the end of collection system with arrangement for measuring the flow. No effluent shall be admitted in the pipes / sewers down- stream of the terminal manholes. No effluent shall find its way other than in designed and provided collection System.

xi. Neither storm water nor discharge from other premises shall be allowed to mix with the effluents from the factory.

10. **The consent is issued subject to direction issued by CPCB under section 18(1) (b) of Water (Prevention and Control of Pollution) Act, 1974, regarding Classification of Industries dated 07th March 2016.**

11. **Operation of RMC plant shall be in day time only. The Day time is Reckoned in between 6 a.m. and 6 p.m. i.e from sun rise to sunset.**

12. **The Capital investment of the industry is Rs. 376.00 Lakhs.**

13. **The Board reserve right to revoke, amend or suspend the consent granted.**

14. **The Board may make the standards stringent for the RMC / batching Plants located within Corporation areas.**

AECOM Asia Company Limited MUMBAI

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

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15. **The consent is issued on the basis of undertaking submitted by industry and NOC issued by MCGM vide No. Ch.E./1098/Costal Road dated 28/09/2018, for temporary activity.**

For and on behalf of the
Maharashtra Pollution Control Board

(Sanjay R. Bhosale)
Sub Regional Officer, Mumbai-I

To,
M/s. L&T Construction (RMC Plant),
Mumbai Coastal Road Project Pkg 4
Near Priyadarshani Park, Nepean Sea Road,
Malabar Hill, Mumbai-400006

Received Consent fee of –

Sr. No.	Amount(Rs.)	DD. No.	Date
1	60000/-	TXN1903002078	19.03.2019

Copy Submitted to:-
1. Chief Account officer, MPCB, Sion, Mumbai-22.,
2. Regional Officer, MPCB, Mumbai.

AECOM Asia Company Limited MUMBAI

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

Pradip Suresh Patil

From: SANDEEP SINGH
Sent: 22 September 2020 06:58
To: Pradip Suresh Patil; Utkarsh Bhakare; Manik Bhatnagar; R.Muthuraman
Subject: FW: Application Receipt

From: MPCB Web Portal <portalsupport@mpcb.gov.in>
Sent: 21 September 2020 16:08
To: SANDEEP SINGH <sandeepsingh@lntecc.com>
Subject: Application Receipt

Greeting LARSEN AND TOUBRO LIMITED.

Your application has been received.

Your Unique application number (UAN) **MPCB-ENVIRONMENT_STATEMENT-0000026730**

Please use the UAN in all your correspondence with respect to this application

You may view your application details on your Application dashboard

Thanks for your application.

Disclaimer

- This is an auto generated mail with if you are not a valid recipient please discard the same. This is not the spam.
- In case of dispute, jurisdiction with respect to Maharashtra jurisdiction
- Date: 21-09-2020

AECOM Asia Company Limited MUMBAI APP

TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

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Annexure 3:

Salient Features of Site Environment Management Plan

Salient Features of Site Environment Management Plan for the Project

Project: Mumbai Coastal Road (South) from Princes Street Flyover to Worli End of Bandra worli sea link.

MCGM has awarded all three Coastal Road Packages Civil Contracts to recognized International Contractors like L&T, HCC-HDC (JV) etc. with experienced International joint venture partners.

These contractors are having ISO 14001 (Environmental Management System) and OHSAS 18001 (Occupational Health and Safety Assessment Series) certifications prior to award of formal contract. (Certificate Photos for each package are attached in appendix).These steps will ensure almost all Environmental Related Compliances are compiled by these contractors. In addition to these following compliances are done or already in progress by all contractors regarding Environmental Compliances mentioned in Site specific Environment Plan as well as stipulated in Legal Requirements applicable to them

1) Preconstruction Air & Noise Monitoring is going on in sites to establish Base Line Air and Noise Monitoring Results. These results will establish Air Pollution Levels and Noise Levels on Coastal Road Project alignment before start of Actual Major Construction Activities. Actual Air and Noise Monitoring results during major Construction works will be compared with Preconstruction results and Standards mentioned legally by MOEF and CPCB. Consent to Establish are being taken by Contractors from MPCB to establish Casting Yard and Batching Plant.

2) For controlling dust on sites Contractors are doing Water Sprinkling on their sites during their work. Wheel Wash Facilities will also be provided at every Main Entrance and Exit of site where Vehicle Movement is there. Wastewater will be treated and will be used for Water Sprinkling and Wheel Washing. Maximum recycling and Reuse of Water will be done.

3) For Controlling Noise , following precautions are being taken on sites:
   a) Noise Barriers will be provided at all Critical Locations like Near Schools and Hospitals etc. At some locations, provision of Noise Barriers is under progress and started as per requirement. Please refer attached appendix for compliance photos.
   b) All Construction vehicles are provided with Noise Mufflers, Good Silencers on sites. Please refer pictures shown in attached appendix.
   c) All Construction sites barricaded by 2m X 2.5 m barricading boards in addition to Noise Barriers to Control Noise and demarcate site from General Public and

AECOM Asia Company Limited MUMBAI

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

Road users. Please refer picture shown in appendix. These boards are provided as per IRC SP 55 , Type IV (Board) .

d) All Contractors are using acoustically enclosed DG sets. Sample photos of DG sets are attached in appendix. Presently DG sets provided on site are between range of 62.5 KVa to 225 KVa.

e) Preventive Maintenance schedule for all construction Machinery at site are maintained. All construction machinery is having PUC certificates and they are with in limit. Preventive Maintenance of Machinery will also reduce noise from Machinery. Sample PUC certificate photo is shown in attached appendix.

f) All rotating parts of construction machineries will be provided with canopies and grills to control rotating parts noise during construction phase.

4) All Environmental Monitoring Data will be displayed on sites at conspicuous places like Casting Yard, all site offices and Entry and Exit of sites. This Environmental Monitoring date will contain, Air and Noise Monitoring Results for Month, Drinking Water Testing Results, Wastewater Monitoring Results.

5) Every Contractor is having dedicated Environmental Team as stipulated in contract. They have specially dedicated and qualified Environmental Manager along with enough subordinates on sites.

6) All Environmental Monitoring is carried by third party Environmental Monitoring Agency approved by MoEF&CC and NABL. Details of agencies are attached in appendix.

7) Contractors have provided Bio-Toilets on sites. Photos for the same are attached in appendix.

8) All Trucks are covered with Tarpaulin Sheets to avoid fall of soil/material on public Roads. Road cleaning will be done regularly to control dust on public roads.

9) Compliances with evidence photos are attached in Appendix 1, 2 and 3 as Pkg 1, Pkg 2 and Pkg 4.

MCRP Package -1 (Appendix 1)

Compliance Status of Environmental Issues

S. No.	Description	Sample Photograph	Remarks

Louis Berger Consulting Pvt. Ltd.

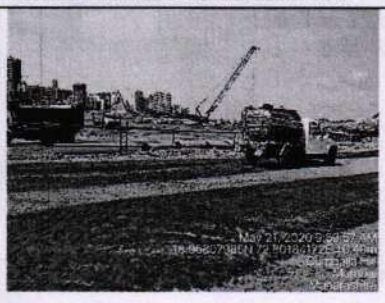
YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

AECOM Asia Company Limited

1.	L&T is ISO 14001 (Environmental Management System) and ISO 45001 (EHS Management) certified. M/s. DNV.GL is a third party certification agency and validity of certificate is until; • ISO 45001:2018 – 25 March 2022. • ISO 14001:2018 – 25 March 2022.	 DNV·GL MANAGEMENT SYSTEM CERTIFICATE Larsen & Toubro Limited (L & T Construction - Heavy Civil Infrastructure Independent Company) ISO 14001:2015  DNV·GL MANAGEMENT SYSTEM CERTIFICATE Larsen & Toubro Limited (L & T Construction - Heavy Civil Infrastructure Independent Company) ISO 45001:2018	
2.	Preconstruction Air & Noise Monitoring is going on in sites to establish Base Line Air and Noise Monitoring Results. These results will establish Air Pollution Levels and Noise Levels on Coastal Road Project alignment before start of Actual Major Construction Activities. Actual Air and Noise Monitoring results during major Construction works will be compared with		Environment Monitoring is being carried out at site; 1. Ambient Air quality is being monitored at two locations on site, based on the activity. 2. Noise level is being monitored at two locations on site based on the activity.

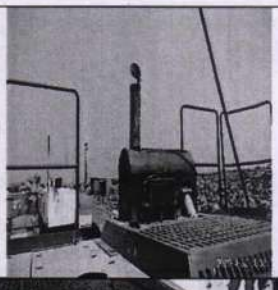
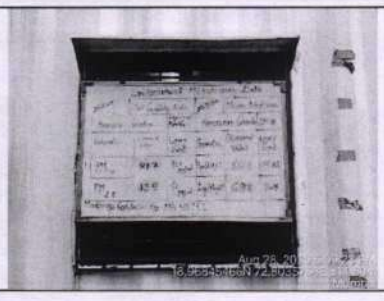
Louis Berger Consulting Pvt. Ltd.

AECOM Asia Company Limited MUMBAI

	Preconstruction results and Standards mentioned legally by MOEF and CPCB.		
3.	For controlling Dust: 1. On-site Water Sprinkling is being carried out on regular basis. The frequency is defined as three times a day. 2. Load carrying vehicles are covered to control the spread of dust particles while transportation. 3. Wheel wash facility is provided. 4. Sedimentation tank (two chambered) will be provided to maximum recycling and Reuse of Water. 5. Green net is placed along the boundary to arrest dust.	  	
4.	For Controlling Noise, following precautions are being taken on sites:		
	1. Noise Barriers at all Critical Locations like Near Schools and Hospitals etc. will be provided.		Noise Barrier is under erection along the Breach Candy Hospital.

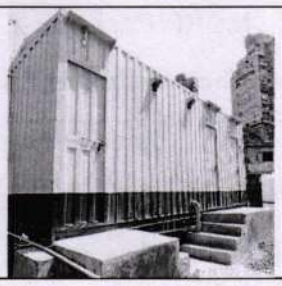
Louis Berger Consulting Pvt. Ltd.

AECOM Asia Company Limited APD MUMBAI

	2. All Construction vehicles are provided with Noise Mufflers, Good Silencers on sites.		
	3. All Construction sites barricaded by 2m X 2.5 m barricading boards at site in order to demarcate site from General Public and Road users.		As per IRC SP 55 type IV (Board).
	4. DG is provided with acoustic enclosures. Noise reduced up to 75 dB at 1m distance.		
	5. All rotating parts of construction machineries will be provided with canopies and grills to control rotating parts noise.	Presently no machines are placed with rotating part open, however, in future, it will be protected against entangled hazard.	
5.	The Environmental Monitoring Data is displayed on sites at conspicuous places like site & offices. This Environmental Monitoring date will contain, Air and Noise Monitoring Results.		
6.	All Environmental Monitoring is carried by third party Environmental Monitoring Agency approved by MoEF & CC and NABL.		M/s. Netel (India) Limited is MoEF & CC and NABL accredited lab. The copy of MoEF&CC is displayed.

Louis Berger Consulting Pvt. Ltd.

AECOM Asia Company Limited MUMBAI

7.	Bio-Toilets are provided at site.		

MCRP Package -2 (Appendix 2)

Compliance Status of Environmental Issues

S. No.	Description	Sample Photograph	Remarks
8.	HCC is ISO 14001 (Environmental Management System) and OHSAS 18001 certified. M/s. DNV.GL is a third party certification agency and validity of certificate is until; • ISO 14001:2015 – 19 March 2020. • BS OSHAS 18001:2007 – 19 March 2020.	 	

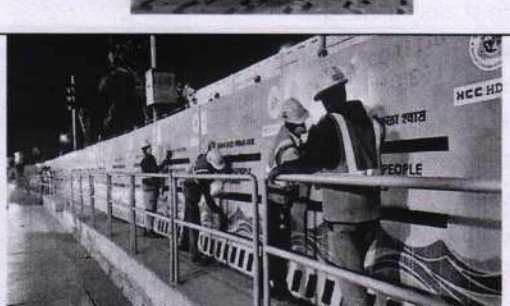
MUMBAI COASTAL ROAD PROJECT PKG II ★ EGIS INDIA-EGR (UK) JV

AECOM Asia Company Limited MUMBAI

9.	Preconstruction Air & Noise Monitoring is going on in sites to establish Base Line Air and Noise Monitoring Results. These results will establish Air Pollution Levels and Noise Levels on Coastal Road Project alignment before start of Actual Major Construction Activities. Actual Air and Noise Monitoring results during major Construction works will be compared with Preconstruction results and Standards mentioned legally by MOEF and CPCB.		Environment Monitoring is being carried out at site; 1. Ambient Air quality is being monitored at 4 locations on site, based on the activity. 2. Noise level is being monitored at 4 locations on site based on the activity.
10.	For controlling Dust: 6. On-site Water Sprinkling is being carried out on regular basis. The frequency is defined as two times a day. 7. Load carrying vehicles are covered to control the spread of dust particles while transportation. 8. Wheel wash facility will be provided. 9. Sedimentation tank (two chambered) will be provided maximum recycling and Reuse of Water.	 	

MUMBAI COASTAL ROAD PROJECT PKG II ★ EGIS INDIA-CGR (UK) JV ★

AECOM Asia Company Limited MUMBAI

			
11.	For Controlling Noise, following precautions are being taken on sites:		
	6. Noise Barriers at all Critical Locations like Near Schools and Hospitals etc. will be provided.		
	7. All Construction vehicles are provided with Noise Mufflers, Good Silencers on sites.		Vehicles are provided with mufflers and silencers and the same is given in reference
	8. All Construction sites barricaded by 2m X 2.5 m barricading boards at site in order to demarcate site from General Public and Road users.		IRC SP 55 type IV (Board).

MUMBAI COASTAL ROAD PROJECT PKG II
EGIS INDIA-CGR (I&T) JV

AECOM Asia Company Limited
MUMBAI

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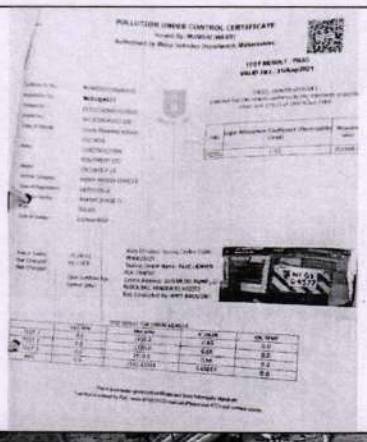
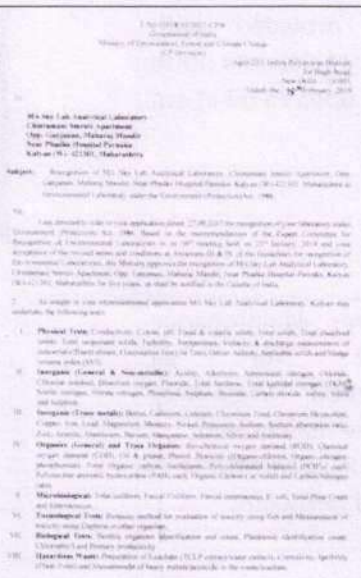
	9. DG is provided with acoustic enclosures noise reduced upto 75 dB at 1m distance		DG set Provided in acoustic enclosure and the same is given in reference
	10. Preventive Maintenance schedule for all construction Machinery at site are maintained. Copy of PUC certificate is provided herewith.		PUC certificate for the machineries operating in the site
	11. All rotating parts of construction machineries will be provided with canopies and grills to control rotating parts noise.		Rotating part machineries in the site are provided with canopies and control covers to control noise generation.
	The Environmental Monitoring Data is displayed on sites at conspicuous places like site & offices. This Environmental Monitoring date will contain, Air and Noise Monitoring Results.	Will be provided in future	

MUMBAI COASTAL ROAD PROJECT PKG II ★ EGIS INDIA-CGR (UK) JV ★

AECOM Asia Company Limited MUMBAI APD

	All Environmental Monitoring is carried by third party Environmental Monitoring Agency approved by MoEF & CC and NABL.		M/s. Sky Lab Analytical Laboratory has be accredited by NABL/ MOEFCC and the same is given in reference
	Bio Toilets are provided at site.	-	No bio toilets in MCRP Pkg – II

MUMBAI COASTAL ROAD PROJECT PKG II
EGIS INDIA-CGR (UK) JV

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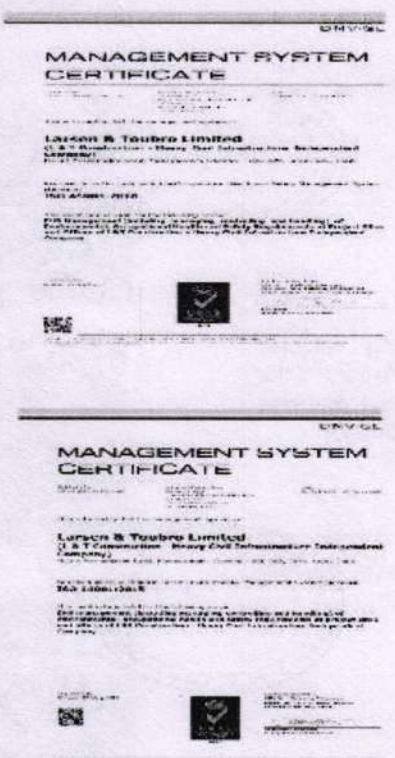
MCRP Package -4 (Appendix 3)

Compliance Status of Environmental Issues

S. No.	Description	Sample Photograph	Remarks
12.	L&T is ISO 14001 (Environmental Management System) and ISO 45001 (Safety Standard) certified. M/s. DNV.GL is a third party certification agency and validity of certificate is until; • ISO 45001:2018 – 25 March 2022. • ISO 14001:2018 – 25 March 2022.		
13.	Preconstruction Air & Noise Monitoring is going on in sites to establish Base Line Air and Noise Monitoring Results. These results will establish Air Pollution Levels and Noise Levels on Coastal Road Project alignment before start of Actual Major Construction Activities. Actual Air and Noise Monitoring results during major Construction works will be compared with Preconstruction results and Standards mentioned legally by MOEF and CPCB.	 	Environment Monitoring is being carried out at site; 1. Ambient Air quality is being monitored at two locations on site, based on the activity. 2. Noise level is being monitored at two locations on site based on the activity.

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14.	For controlling Dust: 10. On-site Water Sprinkling is being carried out on regular basis. The frequency is defined as once a day.		
	11. Road cleaning is being carried out on regular basis.		
	12. Load carrying vehicles are covered to control the spread of dust particles while transportation.		
	13. Wheel wash facility will be provided.		
	14. Sedimentation tank (two chambered) will be provided maximum recycling and Reuse of Water.	Under Progress	
	15. Noise barrier along the residential apartments also restrict the dust to mix in the outer environment.		
15.	For Controlling Noise, following precautions are being taken on sites:		

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YOOSHIN TEC-4 PROJECT MANAGER (PM) MCR (PKG-4)

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	12. Noise Barriers at all Critical Locations like Near Schools and Hospitals etc. will be provided.		Noise barrier erection work is in progress.
	13. All Construction vehicles are provided with Noise Mufflers, Good Silencers on sites.		
	14. All Construction sites barricaded by 2m X 2.5 m barricading boards at site in order to demarcate site from General Public and Road users.		IRC SP 55 type IV (Board).
	15. DG is provided with acoustic enclosures noise reduced up to 75 dB at 1 m distance		
	16. Preventive Maintenance schedule for all construction Machinery/vehicle at site are maintained. Copy of PUC certificate is provided herewith.		
	17. All rotating parts of construction machineries will be provided with canopies and grills to control rotating parts noise.		

AECOM Asia Company Limited MUMBAI APD

YOOSHIN TEC-4 PROJECT MANAGER (PMC) MCR (PKG-4)

5	The Environmental Monitoring Data is displayed on sites at conspicuous places like site & offices. This Environmental Monitoring date will contain, Air and Noise Monitoring Results.		
6	All Environmental Monitoring is carried by third party Environmental Monitoring Agency approved by MoEF & CC and NABL.		M/s Horizon Service engaged for the environmental monitoring work. Company having MoEF & CC and NABL accredited lab facility.
7	Bio Toilets are provided at site.		

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PROJECT MANAGER (PMC) TEC-4 MCR (PKG-4)

Ambient Air Quality Monitoring- MCRP (Pkg-1)

Amarson Garden			
Date	PM2.5	Date	PM 10
16.06.2020	18.1	16.06.2020	48.1
19.06.2020	10.1	-	-
24.06.2020	20.8	24.06.2020	52.9
26.06.2020	16.9	26.06.2020	52.9
30.06.2020	19.50	30.06.2020	48.40
07.07.2020	22.10	07.07.2020	58.1
11.07.2020	19.10	11.07.2020	58.2
17.07.2020	20.80	17.07.2020	58.4
21.07.2020	18.70	21.07.2020	66.7
24.07.2020	19.40	24.07.2020	63.5
29.07.2020	20.80	29.07.2020	61.20
31.07.2020	17.80	31.07.2020	52
11.08.2020	16.50	11.08.2020	49.7
25.08.2020	13.90	25.08.2020	43.7
28.08.2020	23	28.08.2020	64
01.09.2020	23.9	01.09.2020	70.3
04.09.2020	23	04.09.2020	66
08.09.2020	18.2	08.09.2020	69.8
11.09.2020	21.7	11.09.2020	60.3
15.09.2020	18.2	15.09.2020	68
22.09.2020	16.5	22.09.2020	53.2

Haji Ali			
Date	PM2.5	Date	PM 10
16.06.2020	15.6	16.06.2020	45.1
19.06.2020	12.6	19.06.2020	40.9
24.06.2020	11.7	24.06.2020	39.5
26.06.2020	17.8	26.06.2020	49.8
30.06.2020	14.30	30.06.2020	56.80
07.07.2020	18.00	07.07.2020	61.80
11.07.2020	27.30	11.07.2020	53.30
17.07.2020	24.30	17.07.2020	55.40
21.07.2020	20.00	21.07.2020	49.70
24.07.2020	24.50	24.07.2020	53.90
29.07.2020	20.00	29.07.2020	54.20
31.07.2020	21.30	31.07.2020	54.90
11.08.2020	20.40	11.08.2020	47.30
18.08.2020	23.00	18.08.2020	60.30
25.08.2020	18.70	25.08.2020	58.30
28.08.2020	20.40	28.08.2020	55.30
01.09.2020	20.80	01.09.2020	61.50
04.09.2020	22.60	04.09.2020	64.30
08.09.2020	22.60	08.09.2020	65.90
11.09.2020	17.80	11.09.2020	59.80
15.09.2020	26.90	15.09.2020	62.80
22.09.2020	21.30	22.09.2020	61.30

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Ambient Noise Level Monitoring- MCRP (Pkg-1)							
Amarson Garden				Haji Ali			
Date	Leq-Day	Date	Leq-Day	Date	Leq-Day	Date	Leq-Day
16.06.2020	48	16.06.2020	40.1	16.06.2020	49.6	16.06.2020	43.4
24.06.2020	49.3	24.06.2020	46.3	24.06.2020	56.3	24.06.2020	52
30.06.2020	62.6	30.06.2020	56	30.06.2020	57.6	30.06.2020	56.1
07.07.2020	70.6	07.07.2020	65.3	07.07.2020	59.8	07.07.2020	63
17.07.2020	56	17.07.2020	54.1	17.07.2020	61.8	17.07.2020	60.5
21.07.2020	65	21.07.2020	57.7	21.07.2020	60.3	21.07.2020	56.9
29.07.2020	66.5	29.07.2020	65.7	29.07.2020	63.3	29.07.2020	66.2
11.08.2020	64.8	11.08.2020	63.3	11.08.2020	66.4	11.08.2020	67.5
18.08.2020	68.4	18.08.2020	65.7	18.08.2020	60.9	18.08.2020	62.4
25.08.2020	65.6	25.08.2020	63.8	25.08.2020	69.4	25.08.2020	56.6
01.09.2020	71.7	01.09.2020	68.4	01.09.2020	63.2	01.09.2020	56.5
08.09.2020	61.7	08.09.2020	58.4	08.09.2020	62	08.09.2020	58
15.09.2020	59.9	15.09.2020	55.8	15.09.2020	57	15.09.2020	49.9
22.09.2020	62.3	22.09.2020	57.9	22.09.2020	56.9	22.09.2020	49.1

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Mumbai Coastal Raod Project Pkg-2						
Ambient Air Quality Monitoring						
S. No	Worli Sea Face Garden- Leq-Day			Worli Sea Face Garden - Leq-Night		
	Date	Value	Standard	Date	Value	Standard
1	05.06.2020	71.9	75	05.06.2020	69.6	70
2	08.06.2020	73.1	75	08.06.2020	63.6	70
3	12.06.2020	68.9	75	12.06.2020	62.5	70
4	15.06.2020	72		15.06.2020	63.4	
5	19.06.2020	63.8	75	19.06.2020	58.9	70
6	22.06.2020	57.5	75	22.06.2020	52.2	70
7	26.06.2020	71.2	75	26.06.2020	60	70
8	29.06.2020	72.1	75	29.06.2020	66.4	70
9	06.07.2020	71.7	75	06.07.2020	66.1	70
10	13.07.2020	67.3	75	13.07.2020	62	70
11	20.07.2020	70.6	75	20.07.2020	64.5	70
12	27.07.2020	69.9	75	27.07.2020	64.1	70
13	04.08.2020	72.5	75	04.08.2020	68.5	70
14	10.08.2020	70.1	75	10.08.2020	67	70
15	17.08.2020	71.5	75	17.08.2020	64.3	70
16	24.08.2020	83.2	75	24.08.2020	70	70
17	31.08.2020	71.8	75	31.08.2020	66.1	70
18	07.09.2020	82.5	75	07.09.2020	68	70
19	14.09.2020	68.3	75	14.09.2020	64.6	70
20	22.09.2020	74	75	22.09.2020	68	70
21	25.09.2020	70.9	75	25.09.2020	67	70
22	28.09.2020	73.5	75	28.09.2020	62.9	70

Mumbai Coastal Raod Project Pkg-2						
Ambient Air Quality Monitoring						
S. No	Worli Dairy - Leq-Day			Worli Dairy - Leq-Night		
	Date	Value	Standard	Date	Value	Standard
1	05.06.2020	75.2	75	05.06.2020	72.8	70
2	08.06.2020	67.5	75	08.06.2020	60.9	70
3	12.06.2020	70.9	75	12.06.2020	65.4	70
4	15.06.2020	63.4		15.06.2020	56.8	
4	19.06.2020	74.7	75	19.06.2020	65.7	70
5	22.06.2020	74.4	75	22.06.2020	70.2	70
6	26.06.2020	69.8	75	26.06.2020	64.1	70
7	29.06.2020	72.4	75	29.06.2020	65.8	70
8	06.07.2020	70.6	75	06.07.2020	64.5	70
9	13.07.2020	72.6	75	13.07.2020	69.1	70
10	20.07.2020	74.2	75	20.07.2020	68.5	70
12	27.07.2020	65.3	75	27.07.2020	59	70
14	04.08.2020	67.9	75	04.08.2020	64.9	70
16	10.08.2020	70	75	10.08.2020	65.4	70
18	17.08.2020	65.7	75	17.08.2020	61.7	70
20	24.08.2020	64.6	75	24.08.2020	57.5	70
22	31.08.2020	69.9	75	31.08.2020	61.2	70
24	07.09.2020	54.6	75	07.09.2020	47.5	70
26	14.09.2020	65.1	75	14.09.2020	60.4	70
28	22.09.2020	60.4	75	22.09.2020	57.4	70
29	25.09.2020	72.6	75	25.09.2020	69.8	70
30	28.09.2020	72.9	75	28.09.2020	67	70

MUMBAI COASTAL ROAD PROJECT PKG II ★ JV (M/S EGIS INDIA-CGR (UK) JV

AECOM Asia Company Limited MUMBAI

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Mumbai Coastal Raod Project Package -4								
Ambient Air Quality Monitoring								
#	Date	Parameters (24 Hrs) & Unit	Result	NAAQS Limit	Parameters (24 Hrs) & Unit		Result	NAAQS Limit
Location: Priyadarshini Park					Location: Priyadarshini Park			
1	24.06.20	PM 2.5 µg/m3	42.58	60	PM 10 µg/m3	24.06.20	90.86	100
2	25.06.20		37.25	60		25.06.20	80.16	100
3	29.06.20		36.27	60		29.06.20	82.46	100
4	30.06.20		38.57	60		30.06.20	71.43	100
5	06.07.20		45.21	60		06.07.20	93.25	100
6	07.07.20		40.39	60		07.07.20	82.47	100
7	20.07.20		37.49	60		20.07.20	76.35	100
8	21.07.20		33.12	60		21.07.20	68.95	100
9	27.07.20		28.64	60		27.07.20	60.28	100
10	28.07.20		23.49	60		28.07.20	52.31	100
11	03.08.20		22.43	60		03.08.20	48.67	100
12	10.08.20		39.64	60		10.08.20	82.23	100
13	12.08.20		33.15	60		12.08.20	72.64	100
14	17.08.20		34.64	60		17.08.20	70.48	100
15	19.08.20		33.81	60		19.08.20	68.27	100
16	24.08.20		30.19	60		24.08.20	63.28	100
17	26.08.20		29.86	60		26.08.20	60.18	100
18	02.09.20		24.19	60		02.09.20	53.28	100
19	04.09.20		26.73	60		04.09.20	47.69	100
20	09.09.20		18.36	60		09.09.20	42.49	100
21	11.09.20		22.73	60		11.09.20	48.11	100
22	16.09.20		19.16	60		16.09.20	46.18	100
23	18.09.20		16.25	60		18.09.20	38.43	100
24	25.09.20		18.23	60		25.09.20	40.69	100
25	26.09.20		15.18	60		26.09.20	35.26	100
26	30.09.20		25.19	60		30.09.20	53.28	100

YOOSHIN TEC-4 PROJECT MANAGER (PMC)

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Mumbai Coastal Raod Project Pkg-2								
Ambient Air Quality Monitoring								
#	Date	Parameters (24 Hrs) & Unit	Result	NAAQS Limit	Parameters (24 Hrs) & Unit		Result	NAAQS Limit
	Location	Worli Sea Face Public Toilet			Location : Worli Sea Face Public Toilet			
1	05.06.2020		36.2	60		05.06.2020	69.6	100
2	08.06.2020		32.3	60		08.06.2020	65.8	100
3	12.06.2020		28.6	60		12.06.2020	60.4	100
4	15.06.2020		31.5	60		15.06.2020	64.3	100
5	19.06.2020		36.5	60		19.06.2020	71.8	100
6	22.06.2020		32.4	60		22.06.2020	64.6	100
7	26.06.2020		34.8	60		26.06.2020	67.4	100
8	29.06.2020		32.4	60		29.06.2020	64.6	100
9	03.07.2020		26.6	60		03.07.2020	58.4	100
10	06.07.2020		23.4	60		06.07.2020	49.2	100
11	10.07.2020		22.6	60		10.07.2020	46.8	100
12	13.07.2020		18.3	60		13.07.2020	39.7	100
13	17.07.2020		23.6	60		17.07.2020	47.5	100
14	20.07.2020		21.4	60		20.07.2020	44.3	100
15	24.07.2020		18.5	60		24.07.2020	36.8	100
16	27.07.2020	PM 2.5 µg/m3	17.2	60	PM 10 µg/m3	27.07.2020	40.5	100
17	31.07.2020		16.6	60		31.07.2020	35.2	100
18	04.08.2020		15.7	60		04.08.2020	32.3	100
19	07.08.2020		24.2	60		07.08.2020	48.7	100
20	10.08.2020		22.5	60		10.08.2020	48.6	100
21	13.08.2020		23.4	60		13.08.2020	46.7	100
22	17.08.2020		21.5	60		17.08.2020	44.3	100
23	20.08.2020		18.3	60		20.08.2020	39.4	100
24	24.08.2020		17.3	60		24.08.2020	41.3	100
25	28.08.2020		18.8	60		28.08.2020	39.3	100
26	31.08.2020		14.7	60		31.08.2020	33.4	100
27	04.09.2020		23.6	60		04.09.2020	53.4	100
28	07.09.2020		18.4	60		07.09.2020	44.8	100
29	11.09.2020		29.4	60		11.09.2020	62.6	100
30	14.09.2020		16.1	60		14.09.2020	36.3	100
31	18.09.2020		12.8	60		18.09.2020	28.6	100
32	22.09.2020		14.9	60		22.09.2020	33.1	100
33	25.09.2020		19.2	60		25.09.2020	41.5	100
34	28.09.2020		23.6	60		28.09.2020	48.2	100

MUMBAI COASTAL ROAD PROJECT PKG II ★ EGIS INDIA-EGIS (UK) JV ★

Company Limited

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Mumbai Coastal Raod Project Pkg-2

Ambient Air Quality Monitoring

#	Date	Parameters (24 Hrs) & Unit	Result	NAAQS Limit	Parameters (24 Hrs) & Unit		Result	NAAQS Limit
Location		Worli Sea Face Garden			Location : Worli Sea Face Garden			
1	05.06.2020		40.5	60		05.06.2020	74.8	100
2	08.06.2020		35.7	60		08.06.2020	71.4	100
3	12.06.2020		32.3	60		12.06.2020	67.8	100
4	15.06.2020		34.6	60		15.06.2020	73.8	100
5	19.06.2020		32.7	60		19.06.2020	68.4	100
6	22.06.2020		38.3	60		22.06.2020	72.4	100
7	26.06.2020		35.6	60		26.06.2020	75.2	100
8	29.06.2020		36.3	60		29.06.2020	68.7	100
9	03.07.2020		29.4	60		03.07.2020	63.8	100
10	06.07.2020		26.3	60		06.07.2020	54.4	100
11	10.07.2020		24.3	60		10.07.2020	50.4	100
12	13.07.2020		21.7	60		13.07.2020	45.4	100
13	17.07.2020		19.4	60		17.07.2020	38.8	100
14	20.07.2020		16.8	60		20.07.2020	40.7	100
15	24.07.2020		22.6	60		24.07.2020	43.4	100
16	27.07.2020	PM 2.5 µg/m3	22.6	60	PM 10 µg/m3	27.07.2020	49.7	100
17	31.07.2020		18.4	60		31.07.2020	39.8	100
18	04.08.2020		22.2	60		04.08.2020	43.6	100
19	07.08.2020		30.3	60		07.08.2020	66.4	100
20	10.08.2020		18.4	60		10.08.2020	39.1	100
21	13.08.2020		16.4	60		13.08.2020	37.6	100
22	17.08.2020		19.7	60		17.08.2020	41.6	100
23	20.08.2020		18.3	60		20.08.2020	36.5	100
24	24.08.2020		17.3	60		24.08.2020	34.5	100
25	28.08.2020		18.8	60		28.08.2020	32.4	100
26	31.08.2020		14.7	60		31.08.2020	26.4	100
27	04.09.2020		23.6	60		04.09.2020	49.2	100
28	07.09.2020		18.4	60		07.09.2020	45.3	100
29	11.09.2020		29.4	60		11.09.2020	75.4	100
30	14.09.2020		16.1	60		14.09.2020	75.4	100
31	18.09.2020		12.8	60		18.09.2020	32.4	100
32	22.09.2020		25.8	60		22.09.2020	54.7	100
33	25.09.2020		22.1	60		25.09.2020	47.6	100
34	28.09.2020		18.6	60		28.09.2020	40.4	100

MUMBAI COASTAL ROAD PROJECT PKG II ★ EGIS INDIA-CGR (JV) ★

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Mumbai Coastal Raod Project Package-4								
Ambient Air Quality Monitoring								
#	Date	Parameters (24 Hrs) & Unit	Result	NAAQS Limit		Parameters (24 Hrs) & Unit	Result	NAAQS Limit
Location		Girgaon Chowpatty				Location : Girgaon Chowpatty		
1	24.06.20	PM 2.5 µg/m3	90.25	60		PM 10 µg/m3	90.25	100
2	25.06.20		85.12	60			85.12	100
3	29.06.20		37.10	60			76.34	100
4	30.06.20		34.18	60			71.36	100
5	06.07.20		34.29	60			70.14	100
6	07.07.20		32.10	60			76.37	100
7	20.07.20		31.29	60			64.25	100
8	21.07.20		28.37	60			60.19	100
9	27.07.20		35.18	60			76.39	70.32
10	28.07.20		36.19	60			70.32	100
11	03.08.20		26.18	60			55.21	100
12	05.08.20		20.47	60			45.89	100
13	10.08.20		31.64	60			70.67	100
14	12.08.20		28.52	60			61.70	100
15	17.08.20		27.49	60			61.25	100
16	19.08.20		32.15	60			68.73	100
17	24.08.20		35.47	60			69.83	100
18	26.08.20		32.10	60			65.36	100
19	02.09.20		25.46	60			52.39	100
20	04.09.20		20.69	60			43.15	100
21	09.09.20		28.31	60			60.22	100
22	11.09.20		34.18	60			62.94	100
23	16.09.20		23.25	60			52.67	100
24	18.09.20		14.58	60			35.97	100
25	25.09.20		20.17	60			43.91	100
26	26.09.20		18.10	60			36.55	100
27	30.09.20		26.49	60			52.10	100

PROJECT MANAGER (PMC) TEC-4 (PKG-4)

AECOM Asia Company Limited MUMBAI APD

Mumbai Coastal Raod Project Package 4						
Ambient Noise Quality Monitoring						
S. No	Priyadarshini Park Project Area - Leq-Day			Priyadarshini Park Project Area - Leq Night		
	Date	Value	Standard	Date	Value	Standard
1	25.06.20	74.76	75	25.06.20	66.6	70
2	29.06.20	74.56	75	29.06.20	64.95	70
3	07.06.20	72.44	75	07.06.20	62.85	70
4	21.07.20	52.14	75	21.07.20	45.41	70
5	28.07.20	58.02	75	28.07.20	48.07	70
6	10.08.20	73.33	75	10.08.20	61.95	70
7	17.08.20	72.86	75	17.08.20	63.14	70
8	24.08.20	72	75	24.08.20	59.15	70
9	02.09.20	72.73	75	02.09.20	61.5	70
10	09.09.20	71.97	75	09.09.20	61.05	70
11	16.09.20	73.14	75	16.09.20	60.46	70
12	26.09.20	72.04	75	26.09.20	57.5	70

Mumbai Coastal Raod Project Package 4						
Ambient Noise Quality Monitoring						
Girgaon Chowpatty						
S. No	Near Bal Bhavan/Police Chowki- Leq-Day			Near Bal Bhavan/Police Chowki- -Leq-Night		
	Date	Value	Standard	Date	Value	Standard
1	25.06.20	72.36	75	25.06.20	62.3	70
2	29.06.20	73.73	75	29.06.20	62.68	70
3	07.06.20	71.09	75	07.06.20	64.06	70
4	21.07.20	71.38	75	21.07.20	66.73	70
4	27.07.20	74.73	75	27.07.20	67.31	70
5	03.08.20	74.73	75	03.08.20	70.3	70
6	12.08.20	75.7	75	12.08.20	62.06	70
7	19.08.20	75.47	75	19.08.20	64.96	70
8	26.08.20	74.53	75	26.08.20	67.88	70
9	04.09.20	73.37	75	04.09.20	64.41	70
10	12.09.20	67.09	75	12.09.20	56.18	70
12	18.09.20	75.20	75	18.09.20	59.46	70
14	25.09.20	74.97	75	25.09.20	62.64	70
16	30.09.20	70.74	75	30.09.20	55.9	70

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Mumbai Coastal Raod Project Package 4						
Ambient Noise Quality Monitoring						
Girgaon Chowpatty						
S. No	Near Mafatlal Sweeming Pool - Leq-Day			Near Mafatlal Sweeming Pool - Leq-Night		
	Date	Value	Standard	Date	Value	Standard
1	25.06.20	72.36	75	25.06.20	62.3	70
2	29.06.20	73.73	75	29.06.20	62.68	70
3	07.06.20	71.09	75	07.06.20	64.06	70
4	21.07.20	71.38	75	21.07.20	66.73	70
4	27.07.20	72.03	75	27.07.20	63.51	70
5	03.08.20	77.66	75	03.08.20	66.09	70
6	13.08.20	71.65	75	13.08.20	64.12	70
7	20.08.20	72.31	75	20.08.20	62.63	70
8	24.08.20	73.41	75	24.08.20	64.09	70
9	05.09.20	73.28	75	05.09.20	61.09	70
10	11.09.20	72.07	75	11.09.20	60.13	70

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MUNICIPAL CORPORATION OF GREATER MUMBAI

Compliances of the Specific and General Conditions Stipulated in CRZ Clearance Accorded by MoEF & CC for "Coastal Road (South) from Princess Street Flyover to Worli end of Sea Link in Mumbai by Municipal Corporation of Greater Mumbai"

A. Specific Conditions:

Sr. No.	Condition	Compliance
i	All the terms and conditions stipulated by the MCZMA in their letter No.CRZ 2016/CR 1/TC 4, dated 04th January, 2017, shall be strictly complied with and the status of implementation shall be submitted to all concerned agencies including regional office of the Ministry of Environment, Forest and Climate Change.	Details of compliances submitted to the Ministry on regular basis
ii	The project/activity shall be carried out strictly be in accordance with the provisions of CRZ Notification, 2011, and shall render the coastal ecology of the area including flora and fauna at its original state after completion of the project.	The work is being executed as per the provisions of CRZ Notification 2011 & the clearance granted
iii	The project proponent shall not undertake any blasting activities during night hours. Blasting activity (if any) shall be carried out strictly in conformity with applicable statutory requirements.	The Norms of Statutory Regulatory Authority are followed in Blasting activities.
iv	The project proponent shall ensure that during construction phase no adverse impact on tidal behaviour is attracted. It shall also be ensured that no human access/interventions in the CRZ area beyond the reclaimed land is made by preventing any access to the area.	Noted, during construction human access/interventions in the CRZ area beyond the reclaimed land is being controlled. National Institute of Oceanography (NIO) Dona Paula, Goa is engaged to assess the actual impact (in comparison with the projected impacts as stated in EIA) on shore morphology of adjacent areas during and after the construction of the coastal road. Copy of the Interim report 2 by NIO is submitted herewith.

Sr. No.	Condition	Compliance
v	Break up of 90 ha of land to be reclaimed shall be submitted with *six months* of receipt of the clearance to the regional office of the Ministry and to concerned agencies in the State Government along with justification thereof with a written undertaking that the reclaimed land shall not be used for any commercial or residential purpose.	The break up of reclamation land is submitted in previous compliances. Revised break up of reclamation will be submitted after approval of amendment of CRZ Clearance.
vi	The project proponent will ensure that open spaces created by reclamation as well as any ancillary facilities related to road maintenance are fully protected against encroachment, illegal parking, public events/processions of any kind, hawkers, religious structures, street vendors or any illegal occupants etc. Violation of this will amount to revocation of clearance. A clearly drafted prevention plan with necessary budget allocations shall be submitted to the concerned authority, including the regional office of the Ministry *within 30 days of receipt* of the clearance.	MCGM has issued circular in this regard. Copy of the same is attached in previous reply.
vii	The green spaces as proposed should be done in eco-friendly manner by developing it with open air nature information centre with novel concepts as open air butterfly garden, marine and coastal biodiversity display and dioramas, or botanical theme based information walkways as such that these spaces also carry educational value on environment to general public. *A specific allocation of Rs 10 crores shall be earmarked for the same.* A blue print of the same including timeline shall be developed within *six months* from the date of receipt of this clearance and submitted to regional office of the Ministry and implemented in a time bound manner.	Development of open air butterfly garden will be examined for feasibility. Marine and Coastal Biodiversity Display will be done through reputed Institution. Any other activity will be carried out as per MCGM's Policy, Rules & Regulations. The project already involves fund provision for landscaping, plantation and various green works on proposed reclaimed land wherein it is proposed to develop butterfly garden. This will be developed on reclaimed land after construction of super structure and reclamation to the design levels, as final activity.

Sr. No.	Condition	Compliance
viii	The project proponent shall provide alternative arrangement for Fish Drying beds with prior consultation with the fishing community, in the event, the project entails damages/destruction to the existing fish drying beds located in the project area. In addition, the project proponent shall ensure rehabilitation and resettlement of the fishermen communities in the event the project impacts existing livelihood pattern of these communities. Bridges with navigable spans will be provided by the project proponent as committed, so that there are no obstructions to fishing boats.	There are no Fish drying beds along proposed alignment of Mumbai Coastal Road (South). The issue of rehabilitation and resettlement of the fishermen communities does not arises since project does not entail damages /destruction to the existing fish drying beds. CMFRI is engaged for studying the impact on livelihood pattern of fishermen communities & they have submitted completion report of year long survey (May2019-may2020) in Oct. 2020. Copy enclosed herewith please and suitable policy is being formulated accordingly. A Committee in this regard for compensation to fishermen is already formed. The office order copy is attached herewith please. At present navigational span of existing Bandra Worli Sea link is 29m. However, adequate navigational spans of 60m are proposed in Coastal Road. For smooth maneuvering of fishermen boats.
ix	The project proponent shall develop a marine biodiversity conservation plan for the region from an institute which has expertise in the field of marine biodiversity of the region. The plan will be submitted to the Ministry within one year and implementation shall be monitored by the Ministry.	Marine biodiversity conservation plan for the region has been prepared by CSIR-National Institute of Oceanography, Versova , Mumbai and copy of the final report by NIO is submitted in previous compliances.

Sr. No.	Condition	Compliance
x	The project proponent shall periodically carry out studies through the National Institute of Oceanography (NIO) during and after the construction of the coastal road to assess the actual impact (in comparison with the projected impacts as stated in EIA) on human habitations and shore morphology of adjacent areas and shall report its findings and mitigating steps taken every six months to the MCZMA, the State Pollution Control Board and the regional office of the Ministry.	National Institute of Oceanography (NIO) Dona Paula, Goa is engaged to assess the actual impact (in comparison with the projected impacts as stated in EIA) on shore morphology of adjacent areas during and after the construction of the coastal road and its findings and mitigating steps report will be submitted. Copy of the Interim report 2 by NIO is submitted herewith.
xi	The project proponent shall ensure that noise barriers all along the coastal road on areas facing residential areas are erected and maintained.	Noise barriers all along the coastal road on areas facing residential areas are proposed to be provided as per IRC guidelines. Work in progress. During construction phase also noise barriers are provided wherever required.
xii	The project proponent shall deposit 2% of the total cost of the project for conservation of coastal and marine biodiversity, to the Mangrove Foundation of Maharashtra. Interest from the fund must be used exclusively to improve coastal and marine biodiversity of Mumbai and Thane region and as such be clearly earmarked in annual budget of the Foundation. The funds to be transferred on or before commencement of the construction work and a report in this regard to be forwarded to regional office of Ministry.	The total Cost of project was Rs.5303.00Cr at the time of CRZ clearance. Accordingly 2% cost of project Rs106.06cr was demanded by Mangrove Cell vide letter dated 10.6.2017. Now the construction cost of project has increased to Rs. 8429.44 crs + 4% physical contingency = Rs.8766.61crs from Rs5303.00crs. Accordingly 2% cost of project is Rs 175.33crs. out of which the MCGM has already deposited Rs.25.00 Crs on 10.06.2019 to the Mangrove Foundation of Maharashtra and the sanction of competitive authority has already been obtained to pay the balance amount of Rs. 150.33cr. The payment of this balance amount is deposited to Mangrove Cell.

Sr. No.	Condition	Compliance
xiii	In case tree cutting is unavoidable, three times the number of trees cut shall be planted along the ROW and its survival ensured.	It will be complied as directed. The proposal for tree cutting (140 nos) and transplantation (460 nos)has submitted to tree authority The permission is obtained for 41 nos of tree cutting and 332 nos of transplantation. Balance permission will also be sought shortly. Accordingly new plantation is also started in the ratio of 1:3
xiv	Adequate public access to the natural waterfront areas shall be provided and maintained free of cost by the project proponent without affecting . road traffic.	Public access to the natural waterfront area is proposed to be provided at convenient locations.
xv	The proposed coastal road will be permanently toll free.	Noted.
xvi	The muck produced during tunnel digging should be tested for suitability for reclamation purpose prior to its use. A certificate in this regard from competent authority shall be submitted to the concerned authority in the State including the regional office of Ministry.	Noted. Tunnel digging is not yet started, hence no mucks is produced, so far. As per suitability of the same, can be used for reclamation.
xvii	There shall be no disposal of solid or liquid wastes on the coastal area. Solid waste management shall be as per Solid Wastes Management Rules, 2016. A team comprising of members of the EAC and others with expertise in the subject may visit the project site periodically during the construction phase to supervise and suggest additional measures if desire.	Solid and Liquid Waste Disposal plan will be as per Site Environmental Plan.
xviii	A dedicated BRTS lane as stated by the project proponent must be maintained and will be used exclusively for public transport as well as medical and fire evacuation or other rescue operations. Under no circumstances this lane will be used for general, commercial or VIP transport.	Dedicated BRTS lane is proposed to be developed which will be utilized during medical as well as other emergencies including disasters.

Sr. No.	Condition	Compliance
xix	The project proponent shall ensue that the quality of the coastal road must be of high international standard and shall be rigorously maintained ensuring free of pot holes at all times. A severe fine will be levied on the project proponents if the quality of work is found/ reported compromised.	The international standards for measuring riding quality of road are "Roughness Indices". The care is taken in RFP documents as per IRC and high International standards to measure riding quality and construction is supervised as per the best standard procedures.

B. General Conditions:

Sr. No.	Condition	Compliance
i	Adequate provision for infrastructure facilities including water supply, fuel and sanitation must be ensured for construction workers during the construction phase of the project to avoid any damage to the environment.	The contractors have adhered.
ii	Full support shall be extended to the officers of this Ministry/Regional Office at Nagpur by the project proponent during inspection of the project for monitoring purposes by furnishing full details and action plan including action taken reports in respect of mitigation measures and other environmental protection activities.	Noted and will be ensured.
iii	A six-Monthly monitoring report shall need to be submitted by the project proponents to the Regional Office of this Ministry at Nagpur regarding the implementation of the stipulated conditions.	Environmental Monitoring is being done. Reports are attached as Annexure III.
iv	The Ministry of Environment, Forest &- Climate Change or any other competent authority may stipulate any additional conditions or modify the existing ones, if necessary in the interest of environment and the same shall be complied with.	Noted.

v	The Ministry reserves the right to revoke this clearance if any of the conditions stipulated are not complied with to the satisfaction of the Ministry.	Noted.
vi	In the event of a change in project profile or change in the implementation agency, a fresh reference shall be made to the Ministry.	Noted.
vii	The project proponents shall inform the Regional Office of the Ministry, the date of financial closure and final approval of the project by the concerned authorities and the date of start of land development work.	Being complied.
viii	A copy of the clearance letter shall be marked to concerned Panchayat/ local NGO, if any, from whom any suggestion/ representation has been made received while processing the proposal.	Complied and reported in earlier correspondence.
ix	A copy of the CRZ Clearance letter shall also be displayed on the website of the concerned State Pollution Control Board. The Clearance letter shall also be displayed at the Regional Office, District Industries centre and Collector's Office/Tehsildars Office for 30 days.	Complied and reported in earlier correspondence.

Other Conditions:

Sr. No.	Condition	Compliance
7.	The above stipulations would be enforced among others under the provisions of Water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and Control of Pollution) Act 1981, the Environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991 and EIA Notification 1994, including the amendments and rules made thereafter.	Noted.
8	All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, and clearances under the Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.	Noted. Will be obtained as applicable from competent authority. The clearance under Wild life (Protection) Act, 1972,has been sought. Copy attached.

9.	The project proponent shall advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded CRZ Clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen on the website of the Ministry of Environment, Forest & Climate Change at http://www.envfor.nic.in. The advertisement should be made within Seven days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the Regional office of this Ministry at Nagpur.	Complied and reported in earlier correspondence.
10.	This Clearance is subject to final order of the Hon'ble Supreme Court of India in the matter of Goa Foundation Vs. Union of India in Writ Petition (Civil) No.460 of 2004 as may be applicable to this project.	Noted.
11.	Any appeal against this clearance shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.	Noted
12.	Status of compliance to the various stipulated environmental conditions and environmental safeguards will be uploaded by the project proponent on its website.	Noted
13.	A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zilla Parishad/Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions/representations, if any, were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent.	Complied.
14.	The proponent shall upload the status of compliance of the stipulated EC conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB.	Noted, will be complied.

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15.	The project proponent shall also submit six monthly reports on the status of compliance of the stipulated EC conditions including results of monitored data (both in hard copies as well as by e-mail) to the respective Regional Office of MoEFCC, the respective Zonal Office of CPCB and the SPCB.	Report Submitted as follows • Ch.E/1000 (v) /Coastal Road Project date 08.06.2017 • Ch.E/1237/Coastal Road Project date 03.10.2017 • Ch.E/1357/Coastal Road Project date 25.10.2018 • Ch.E/1901/Coastal Road Project date 28.05.2019 • Ch.E/3222/Coastal Road Project date 29.06.2019 • Ch.E/9246/Coastal Road Project date 4.02.2020 • Ch.E/1092/Coastal Road Project date 17.08.2020
16.	The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of EC conditions and shall also be sent to the respective Regional Offices of MoEFCC by e-mail.	Noted, being complied.

07/01/21

Chief Engineer (Coastal Road) I/c
MCGM

06/01/2021
EE(Z)

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ANNEXURE-5.1

MCZMA conditions compliance status

(APRIL-2020 TO SEPTEMBER-2020)

Compliance Status against MCZMA Conditions as per Minutes of 114th meeting of Maharashtra Coastal Zone Management Authority held on 2nd and 3rd November, 2016

Sr. No	Conditions	Present Status
1	MCGM to ensure that proposed construction of coastal road is as per provisions of CRZ notification, 2011 (amended time to time)	All the construction work will be carried out as per the CRZ notification, 2019.
2	MCGM to ensure that all construction equipment are fully fitted with mufflers and exhaust silencers to contain the noise levels. Machinery used during construction should be properly maintained to minimize the air and noise emissions	The Environment Management Plan is in place. Noise control measures mentioned in the plan is in place as follows. 1. Well maintained construction equipments and vehicles used for the construction activities. Vehicle with valid PUC certificate is allowed to work at project area. 2. Equipment & Vehicle inspection done periodically. 3. Equipment's are with mufflers and exhaust silencers. 4. Noise barrier installation adjacent to residential apartment is under progress. 5. Ear muff/plug are provided to workmen working in noise prone areas. 6. Ambient air and noise monitoring carried out periodically.
3	MCGM as proposed, to set aside an amount of about 2% of the project cost towards mitigation measures; restoration & conservation of mangroves/birds/flora/fauna and mudflats restoration.	MCGM
4	MCGM to ensure that no fishing activity is hampered during construction and operation phase of the project	MCGM
5	MCGM to submit the impact of clearing of mangroves if any on surrounding low lying areas from flood. However post construction such areas should be restored with mangroves plantation if affected.	No mangrove in the project region

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6	MCGM to obtain prior high court permission for clearing of mangrove, if any.	No mangrove in the project region
7	MCGM to undertake green belt development as suggested in the EMP	MCGM
8	For road safety, guidelines in respect of road signage, service roads, bus bays, inter-sections, pedestrians crossing etc. shall be strictly adhered to.	Noted and will be complied.
9	Dust suppression measure during construction and operation phase	Following dust suppression measure are taken during construction phase, 1. Monitoring for environment and health effects. This requires sampling of ambient concentrations of defined particle size fractions (such as PM2.5 & PM10) at Construction activities.  2. Load carrying vehicles are covered to control the spread of dust particles while transportation.  3. Speed limit of vehicles are restricted to 10 KM/Hr at construction site.

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		 4. Regular water sprinkling is being done through tankers or manually to supress dust.  5. Road cleaning done on daily basis  6. Wheel wash facility will be placed for checking and controlling mud/soil from vehicles. These vehicles will be washed before leaving site. 
10	MCGM to implement Green Belt Development plan	MCGM
11	MCGM to implement all suggestions /recommendation given in the EIA, EMP, DMP studies for the project.	Noted

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12	All other required permissions should be obtained before the commencement of the project	Noted. Will be obtained as applicable from competent authority.

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Investigations on impact of Phase 1 Coastal Road project on waves, water levels, and seawater quality

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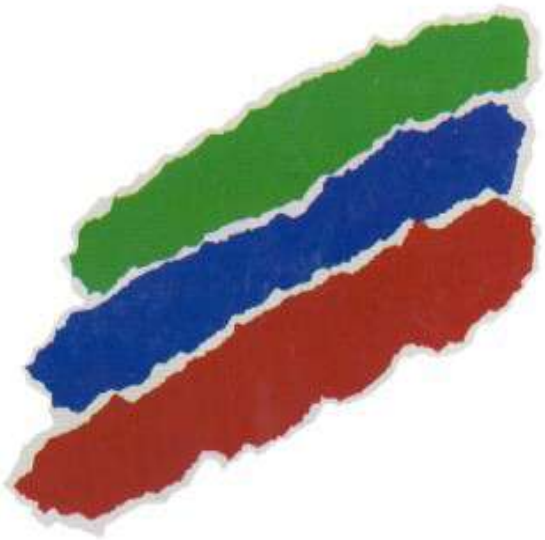
Municipal Corporation Greater Mumbai (MCGM)
Mumbai



Interim Report - 2

July 2020

सीएसआईआर – राष्ट्रीयसमुद्रविज्ञानसंस्थान
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2.1.2 Variation of pH in the coastal waters off Mumbai during March and December 2019

2.1.3 Variation of salinity in the coastal waters off Mumbai during March and December 2019

2.1.4 Variation of suspended solids in the coastal waters off Mumbai during March and December 2019.

2.1.5 Variation of turbidity in the coastal waters off Mumbai during March and December 2019

2.1.6 Variation of chloride in the coastal waters off Mumbai during March and December 2019

2.1.7 Variation of dissolved oxygen (left) and biochemical oxygen demand (right) in the coastal waters off Mumbai during March and December 2019

2.1.8(*i*) Variation of phosphate in the coastal waters off Mumbai during March and December 2019

2.1.8 (*ii*) Variation of nitrate in the coastal waters off Mumbai during March and December 2019.

2.1.8 (*iii*) Variation of nitrite in the coastal waters off Mumbai during March and December 2019.

2.1.8 (*iv*) Variation of ammonium in the coastal waters off Mumbai during March and December 2019

1.1.9 (a) Variation of sulphate in the coastal waters off Mumbai during March and December 2019.

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2.2.3 Variation of Petroleum hydrocarbon in sediment in the coastal waters off Mumbai during March and December 2019

2.2.4 Variation of Organic Carbon in sediments in the coastal waters off Mumbai during March and December 2019.

2.2.5 Variation of Total Phosphorus in sediments in the coastal waters off Mumbai during March and December 2019.

2.3.1 TVC counts in the coastal waters off Mumbai during March and December 2019.

2.3.2 TVC counts in the coastal waters off Mumbai during March and December 2019

2.3.3 Chlorophyll *a* distribution in the coastal waters off Mumbai during March and December 2019

2.3.4 Tidal variation in the chlorophyll *a* distribution in the coastal waters off Mumbai during March and December 2019

2.3.5 Phytoplankton cell count distribution in the coastal waters off Mumbai during March and December 2019

2.3.6 Tidal variation in chlorophyll *a* distribution in the coastal waters off Mumbai during March and December 2019

2.3.7 Phytoplankton total genera distribution in the coastal waters off Mumbai during March and December 2019

2.3.8 Phytoplankton species diversity index in the coastal waters off Mumbai during March and December 2019

2.3.9 Mesozooplankton biomass distribution in the coastal waters off Mumbai during March and December 2019

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2.3.11 Tidal variation of mesozooplankton in the coastal waters off Mumbai during March 2019

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2.3.13 Macrobenthic biomass distribution in the coastal waters off Mumbai during March and December 2019

2.3.14 Macrobenthic population distribution in the coastal waters off Mumbai during March and December 2019

2.3.15 Macrobenthic total group distribution in the coastal waters off Mumbai during March and December 2019

2.3.16 Meiobenthic biomass distribution in the coastal waters off Mumbai during March and December 2019

2.3.17 Meiobenthic population distribution in the coastal waters off Mumbai during March and December 2019

2.3.18 Meiobenthic total group distribution in the coastal waters off Mumbai during March and December 2019

1. STUDIES CONDUCTED

Measurements of waves, currents and tides are planned to be carried out by deploying integrated coastal met-ocean buoys that can measure wave parameters, current parameters along with coastal winds. Two coastal met-ocean buoys were procured which were received by the Vendor in Mumbai on 31st January 2020. These buoys were tested and NIO personnel underwent training by 06th March 2020. The GSM network coverage at the possible deployment location was tested during 5th and 8th March 2020, as the data transmission would be through GSM network. The system was ready for deployment and we were awaiting for requisite permissions. Letters for permissions for deployment were sent to various authorities in February 2020 for which the permission from MMB was received on 17th March 2020, which was communicated to NIO vide MCGM letter no Ch.E/166/Coastal Road dated 6th May 2020. The nation went into lockdown from 22nd March 2020 which has hampered movement of personnel and equipment for deployment. Furthermore, the onset of monsoon has made it difficult to operate any boat for deploying these equipment. The deployment of these buoys is planned in October 2020 after withdrawal of monsoon and availability of boats for deployment is restored.

This report includes the results on the water quality studies carried out in the nearshore waters of Mumbai extending from Rajiv Gandhi Sea Link in the north to Nariman Point in the south. About thirteen locations positioned in a grid like manner covering the coastal waters at different distances (1km, 3km, and 8km) from the area of development were sampled. The field observations were made from 03.12.2019 to 07.12.2019 and the results are presented.

1.1 Sampling locations

A total of 13 subtidal stations were selected for the assessment of marine environment of the western Mumbai coast as illustrated in Figure 1.1.1. The total area covered by these sampling stations works out to be ~ 80 km^2. The geographical positions of the sampling stations, sampling depths and their distance from the coastline are given in the Table 1.1.1.

Table 1.1.1: Geographical co-ordinates of sampled locations in the coastal waters off Mumbai with sampling depth and distance from the coastline.

Station Code	Latitude	Longitude	Station Depth (m)	Distance from coastline (km)
1	19°0'56.72"N	72°48'23.14"E	9.0	1.0
2	18°59'9.21"N	72°47'55.79"E	5.5	
3	18°57'16.52"N	72°47'17.21"E	9.0	
4	18°56'25.73"N	72°48'11.91"E	9.0	
5	18°55'34.92"N	72°47'49.36"E	6.0	
6	19°01'7.45"N	72°47'0.07"E	12.0	3.0
7	18°59'17.14"N	72°46'48.20"E	11.0	
8	18°57'27.28"N	72°45'58.35"E	12.0	
9	18°55'38.61"N	72°46'1.80"E	15.0	

10	19° 1'30.10"N	72°44'10.09"E	14.0	8.0
11	18°59'34.92"N	72°43'56.93"E	18.0	
12	18°57'44.34"N	72°43'1.72"E	19.0	
13	18°55'35.94"N	72°43'11.67"E	16.0	

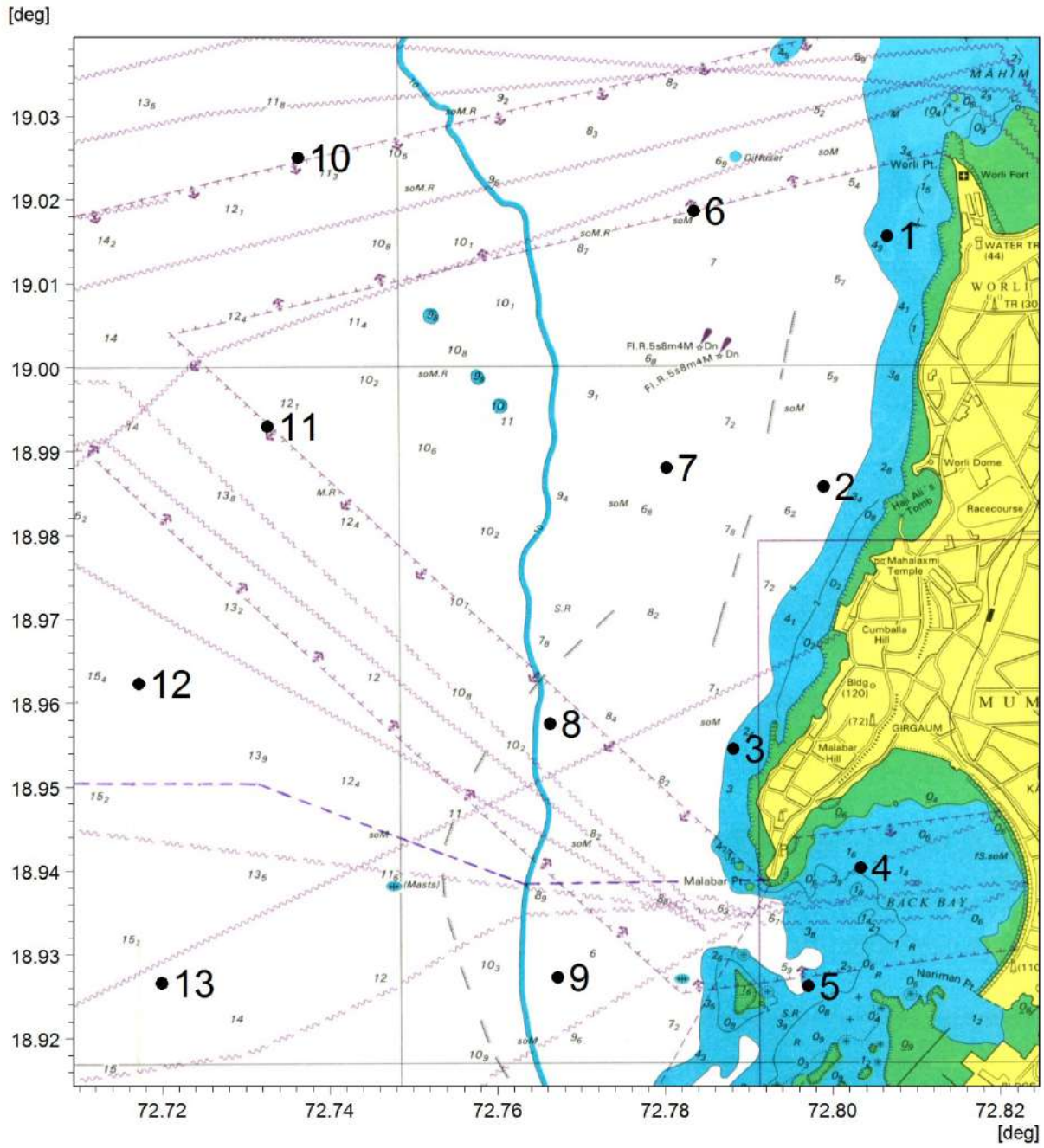

Figure 1.1.1: Study area with sampling locations

1.2 Sampling frequency

Water samples were collected during high tide (HT) and low tide (LT) at stations within 1 km distance from coastline (herein after referred as 1 km zone) in order to check the variability in water quality parameters with respect to tidal conditions. The stations at 3 km and 8 km distance from coastline were sampled twice and the average values of water quality parameters measured at these locations were reported. Water, sediment and selected biological characteristics were assessed at all stations. Subtidal sediments were collected in quadruplicate at each station.

1.3 Water quality parameters

1.3.1 Sampling procedure

Surface and bottom water samples for general analyses were collected using Niskin samplers. Water samples at 1 m below the surface were also collected for the estimation of PHc.

1.3.2 Methods of analyses

Majority of the water quality parameters were analysed within 24 h of collection in the laboratory of CSIR-NIO, RC Mumbai. Concentrations of dissolved inorganic nutrients were determined by colorimetric method sing a UV-visible spectrophotometer (Model:Shimadzu 1240). The concentrations of petroleum hydrocarbon (PHc) in water and sediment were determined by solvent extraction technique, thereafter measured in a Spectrofluorophotometer (Model: Shimadzu RF-5301 PC).

i) Temperature: Temperature was measured immediately after sample collection using the centigrade mercury thermometer with a graduation of 0–50 ºC (Precision ±0.05).

ii) pH: pH of water sample was measured onboard using a portable pH meter (Eutech Tutor) with an accuracy of 0.1 pH units. The instrument was first calibrated with standard pH buffers of pH 7.0 and pH 9.0 and then the measurements were made.

iii)Salinity: Salinity was measured using AUTOSAL salinometer. The instrument was standardized with IAPSO standard sea water (OSIL, UK).

iv)Total Suspended Solids (TSS): Total Suspended solids of a known volume of water sample were measured by filtration using filtration pump (Aspirator Vacuum) (Preston and Summers, 1997). Seawater samples were filtered through pre-weighed membrane filter papers (diameter 47 mm; nominal pore size, 0.45 μm; Make: Millipore) using Vacuum Pump (Make: Millipore). The filter papers were then dried (45°C) and weighed again. TSS was calculated from the difference of initial and final weights of the filter paper and expressed as mg/l.

(v) Turbidity: Turbidity was determined by nephalometric method using a turbidity meter (Model: Orion AQ4500; Make: Thermo Scientific). The instrument was calibrated with known standards before taking the sample readings.

(vi)Chloride (Cl^-): Chloride content was measured using an AUTOSAL salinometer (Make: GUILDLINE Instruments Ltd., Canada). The instrument was calibrated with standard seawater obtained from International Association for the Physical Sciences of the Oceans (IAPSO; Make: OSIL, UK).

vii) Dissolved Oxygen (DO) and Biochemical Oxygen demand (BOD): DO concentration in seawater was estimated by Winkler's method. A known volume of seawater sample was first fixed onboard by adding the Winkler's reagents A (manganous chloride) and B(alkaline potassium iodide) immediately after collection. The precipitate so formed was then decomposed with 50% Hydrochloric Acid (HCl) and the released iodine was titrated against $Na_2S_2O_3$. End point of titration was determined using starch indicator. Concentrations of DO are expressed in mg/l. Samples for the determination of Biochemical Oxygen Demand (BOD_3) were collected in triplicate. The DO concentration was determined first using one of the triplicate samples according to the Winkler's method. The remaining bottles were incubated in BOD incubator for 3 days at 27 ºC. DO concentration in these samples were determined by Winkler's method after fixing the samples immediately on completion of 3 days incubation period. The difference in the DO concentrations on the 1st and 3rd day yielded the measure of BOD_3 and expressed in mg/l. BOD of the samples having DO <0.3 mg/l was analysed by seeded method.

viii) Phosphate-Phosphorous (PO_4^{3-}-P): Dissolved reactive phosphate was measured by the method of Murphy & Riley (1962), modified by Grasshoff et al., 1999, in which the samples were made to react with acidified molybdate reagent and reduced using ascorbic acid. The absorbance of the resultant blue complex was measured at 882 nm using Shimadzu UV mini 1240 spectrophotometer. The instrument performance was evaluated using international seawater standard for nutrient (OSIL, UK)

ix) Nitrite-Nitrogen (NO_2^--N): Nitrite was determined by the method of Grasshoff et al., 1999wherein the nitrite in the samples was measured after diazotizing it with sulfanilamide and coupling with N (1-Naphthy)-ethylene diamine dihydrochloride. The absorbance of the resultant azo dye was measured at 543 nm using a Shimadzu UV mini 1240 spectrophotometer.

x) Nitrate-Nitrogen (NO_3^--N): Nitrate in the samples was first reduced to nitrite by passing each through an amalgamated cadmium reduction column and the resultant nitrite was determined as above. The measured absorbance was due to the initial nitrite in the sample and the nitrite obtained after the reduction of nitrate. Necessary correction was therefore made for any nitrite initially present in the sample.

xi) Ammonia-Nitrogen (NH_4^+-N): Ammonia-nitrogen was determined by the Indophenol blue method based on the principle that in a moderately alkaline medium, ammonia was allowed to react with hypochlorite in the presence of catalytic amounts of nitroprusside to form indophenol blue.

The formation of monochloramine requires a pH between 8 and 11.5. The resultant blue complex was measured at 630 nm by spectrophotometer.

xii) Sulphate (SO_4^{2-}): Sulphate was analyzed using gravimetric method by precipitating with barium chloride as described in Grasshoff,1983.

xiii) Petroleum Hydrocarbons (PHc): Dissolved petroleum hydrocarbons (PHc) were extracted from seawater with n-hexane and quantified by using Shimadzu RF-5301PC spectrofluorophotometer with excitation at 310 nm and emission at 360 nm (Ehrhardt, M. 1983). Reference material used for quantifying hydrocarbons was the Saudi Arabia mixed (SAM) crude oil.

1.4 Sediment quality parameters

1.4.1 Sampling procedure

Subtidal surfacial bed sediment from all locations was collected by a van Veen grab of 0.04 m^2 area in quadruplicate. The sample after retrieval was transferred to a polyethylene bag and preserved for further analysis.

1.4.2 Methods of analyses

i) Texture: Dried sediment (25 g) mixed with deionised water and 10 ml sodium hexametaphosphate (6.2 g/l) was sieved through 63 μm sieve to retain sand and the passed material was dispersed in deionised water (1 l). The fractions (20 ml) collected at 20 and 10 cm depths immediately and after 2 h 30 min were considered as silt and clay, respectively. Collected sediment fractions were dried separately and weighed. Different fractions of sediment are expressed as percentage (%).

ii) Metals: Sediment was brought into solution by treatment with conc. HF-$HClO_4$-HNO_3-HCl and the metals were estimated on an ICP-OES (PerkinElmer). Mercury was estimated by flameless AAS technique (FIMS-400, PerkinElmer) after digesting the sediment with aquaregia. Accuracy of methods was ascertained by simultaneous analysis of PACS-2 and BCSS-2, certified reference material (CRM, NRC-Canada) for trace metals and mercury in sediment.

iii) PHc: Sediment after refluxing with KOH-methanol mixture was extracted with hexane. After removal of excess hexane, the residue was subjected to clean-up procedure by silica gel column chromatography. The hydrocarbon content was then estimated by measuring the fluorescence as described under water quality analysis for PHc.

iv) C_{org}: Percentage (%) of C_{org} in the dry sediment was determined by oxidising organic matter in the sample by chromic acid and estimating excess chromic acid by titrating against ferrous ammonium sulphate with ferroin as an indicator.

v) Total Phosphorus: Digested samples for metal analysis were used for estimating total phosphorus in the sediment. The method used was similar to that described under water quality analysis for PO_4^{3-}-P**.**

1.5 Flora and fauna

1.5.1 Sampling procedure

For microbiological analyses, surface water samples were collected using the Niskin water sampler into sterilised PP bottles at each sampling location in the coastal waters of Mumbai**.** Small portions of the sediment samples obtained by van-Veen grab from all the sampling locations were aseptically transferred into fresh polythene bags with a sterile spatula before disturbing the sediment samples for other analyses. Immediately after collections, both water and sediment samples were stored in ice in an insulated icebox. They were transported to an adequately clean room (microbiology laboratory) for microbiological analysis. Samples were stored in ice until they were processed for enumeration of various groups of bacteria.

Polyethylene bucket and Niskin sampler respectively, were used for sampling surface and near bottom waters for the estimation of phytoplankton pigments and population. Samples for enumeration of phytoplankton cell count were fixed in Lugol's iodine and a few drops of 3% buffered formaldehyde. Mesozooplankton samples were collected by oblique hauls using Heron Tranter net (mesh size 0.20 mm, mouth area 0.25 m^2) attached with a calibrated flow meter. All collections were of 5 min duration. Samples were preserved in 5% buffered formaldehyde. Sediment samples for subtidal macrobenthos were collected using a van Veen grab of 0.04 m^2 area. Samples were preserved in 5% buffered formaldehyde- Rose Bengal.

1.5.2 Methods of analyses

Microbiology

To detect the presence of faecal contamination in seawater certain microbial indicators such as Faecal indicator bacteria (FIBs) were used. These FIBs are part of normal intestinal flora. The two important bacteria that form the indicator system are *Escherichia coli* and faecal *Streptococci.* As detection of every pathogenic bacterium from water is a tedious and expensive task, detection of indicator bacteria offers a faster approach. Bacteriological analyses for present study included the enumeration of total viable counts (TVC), total coliforms (TC), faecal coliforms (FC), *Escherichia coli* like organisms (ECLO) and *Streptococcus faecalis* like Organism (SFLO).

a) Total Viable Counts (TVC)

Water Samples: 0.5 ml of the water sample was added to 4.5 ml of autoclaved sea water in order to get a dilution of 10^{-1}, after vigorous shaking by hand for 30 seconds, 0.1ml of the sample was spread plated on to full strength Zobell marine agar plates and incubated for 24-48hours. Sediment Samples: 1 gm of the sediment sample was suspended in 99 ml of autoclaved seawater. The suspension was vortexed for two minutes. The sediment was then allowed to settle, and serial dilutions were carried out by serially transferring 0.5 ml of the sample to 4.5 ml autoclaved

seawater, serial dilutions were carried out up to 10^{-3}. Then 0.1 ml of the sample was spread plated onto full strength Zobell marine agar and incubated for 24-48hours.

b) Indicator Bacterial Groups

Samples were analyzed by plating for Total Viable Counts (TVC), Total Coliform (TC), *Escherichia coli* like organisms (ECLO), Faecal Coliform (FC), *Streptococcus faecalis* like Organism (SFLO). Colonies of TC, ECLO, FCLO and SFLO were counted separately. The media employed for growth of bacteria were as follows:

Sr. No.	Parameter	Growth medium (Agar)
1	Total Viable Count	Marine Agar
2	Total Coliform	Mac-Conkey's Agar
3	Fecal Coliforms	m-FC Agar
4	*Escherichia coli* like organisms (ECLO)	M7HRFC Agar
5	*Streptococcus faecalis* like organisms (SFLO)	M-Enterococcus Agar

ii) Phytoplankton pigments

Water samples for phytoplankton analysis were collected using Niskin water samplers (5 L capacity) from two depths (surface and near bottom)**.** The samples were analysed for phytoplankton cell counts, composition and biomass (Chlorophyll *a* and Phaeophytin) as per the JGOFS Protocols (UNESCO, 1994).

a) Phytoplankton Biomass (Chlorophyll a and Phaeophytin): For the estimation of the concentrations of chlorophyll *a* (Chl *a)* and phaeophytin (Phaeo), a known volume of water sample (500 ml) was filtered through Whatman GF/F Glass fibre filter paper (47 mm diameter; nominal pore size, 0.7 µm) and extracted in 90% acetone overnight at 5 °C. The extracts were used for the estimation of fluorescence before and after acidification using Turner Designs Fluorometer following Parsons *et al*. (1984). The fluorescence values were converted to chlorophyll *a* and phaeophytin using appropriate calibration factors.

b) Phytoplankton Abundance and Composition: For phytoplankton cell counts, a known volume of water was transferred to a plastic bottle (250 ml) and preserved in Lugol's iodine and formalin. The fixed and preserved samples were transported to laboratory for identification and counting. The supernatant water was removed without disturbing sedimented particles and the final volume was made to 10 ml. One ml of this was counted using Sedgewick Rafter counting chamber, under inverted microscope. Total cells were counted and organisms were identified using standard manuals of diatoms, dinoflagellates and blue green algae. The counts are expressed as cells per litre basis for comparison. For taxonomic identification, a research microscope (Olympus, Japan, 400x) was used and the identification was carried out according to available literature (Subrahmanyam, 1946; UNESCO, 1978, Tomas et al., 1997).

iii) Zooplankton parameters

Zooplankton samples were collected from surface waters by horizontally towing a Heron-Tranter net (mesh size, 200 µm) attached with a calibrated digital flow meter (General Oceanics, USA) at the mouth to record the value of water. After the haul (5 minutes), the net was carefully washed with seawater and the samples were collected in a plastic bottle. The samples were then preserved in 4% buffered formalin prepared in seawater for further analysis in the laboratory. Zooplankton biomass was estimated by displacement volume method and expressed as ml/100m^3 (ICES, Zooplankton Methodology, 2000) and the concentrated samples were diluted to an aliquot of 6.25% using a Folson plankton splitter and were then examined under the stereoscopic binocular microscope (Leica, Germany) for numerical counts and group identification.

iv) Macrobenthos

Sediment samples for macrofauna were washed through a 500 µm mesh sieve with copious amount of seawater. After sieving, the fauna (live animals) were carefully separated and together with residual sediment, if any, the samples were fixed in 5% buffered formalin solution with Rose Bengal stain. All samples were labeled and stored for further examination. In the laboratory, the sediments were washed again under tap water and the materials were preserved in 5% buffered formaldehyde containing Rose Bengal stain. For qualitative enumeration, each sample was examined under a binocular microscope. The organisms were separated into different taxonomic groups for further identification. All taxa were identified to their species level to the extent possible with the help of standard taxonomic references and available expertise. Macrofaunal abundance was expressed as ind./m^2. Macrofaunal biomass was determined by taking weight measurements on an electronic balance and was expressed as g/m^2 wet weight. From the grab, sub-samples for meiofauna were collected using an acrylic core (Ø = 2.5 cm; 10 cm long) for meiobenthic study. Sediment length of the core was measured. The samples from the core were *in toto* transferred to polythene containers, labeled and preserved in 5% neutral formalin mixed with Rose Bengal for further examination. In the laboratory, the meiobenthic sediments were passed through 300 µm and 63 µm sieves and organisms retained on finer mesh sieve were considered as meiofauna. All the meiobenthic organisms were counted and identified up to group level under a stereo-zoom microscope. The density counts of meiofauna were converted to ind./10 cm^2.

1.6 Data presentation

In order to identify changes, if any, in the ecology of the marine segment off Mumbai due to the ongoing construction works for the coastal road project, the data of the stations were clubbed as per their distance from the coast as presented below and compared. The present data (December 2019) is compared with March 2019 to understand the seasonal variations.

Distance from coastline (km)	Stations
1 km	1-5
3 km	6-9
8 km	10-13

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2. PREVAILING ENVIRONMENT

2.1 Water quality

2.1.1 Temperature

Water temperature generally regulates distribution, composition and activity of living organism sin aquatic environment. It regulates metabolism, survival ability and reproduction efficiency in major aquatic animals. In general, the water temperature varies with prevalent air temperature in shallow coastal areas. The ranges of air temperature in the study area during March and December 2019 were 26.0−32.0°C (av.28.9°C) and 24.0−32.0 °C (av. 29.3°C), respectively. The limits of water temperature closely followed the variation of air temperature and values ranged between 25.5−29.0°C (av. 27.3°C) during March and 26.0−29.5°C (av. 28.3°C) during December(Table 2.1.1-2.1.13). Like air temperature, the average water temperature during December was higher than that in March. There was roughly a unit degree variation of water temperature observed between surface (av. 27.6°C) and bottom water (av. 28.5°C) during March,

as well as in surface (av. 27.0°C) and bottom (av. 27.9°C) water during December. The average values of water temperature were nearly similar at the 1 km, 3 km and 8 km zones indicating limited spatial variability during both sampling periods. Such variation is related to the air temperature variation, also to the diurnal changes in temperature. Overall, the temperature in this study did not exceed 35°C (considered as threshold limit for tropical aquatic species), therefore unlikely to have any significant impact on aquatic organisms. The zone wise comparison of average air and water temperatures during March and December 2019 are presented in Figure 2.1.1.

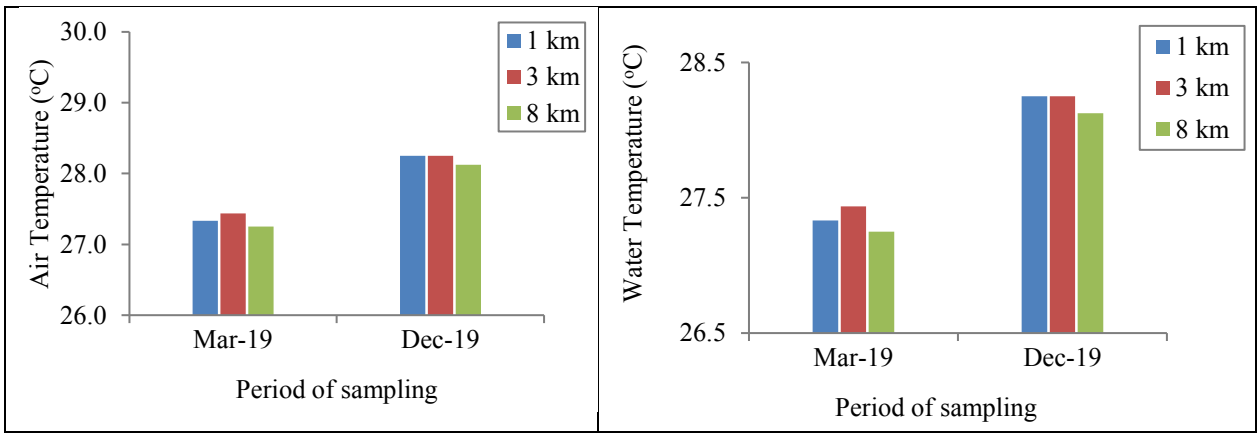


Figure 2.1.1: Air temperature (left) and water temperature (right) variation in the coastal waters off Mumbai during March and December 2019.

Average air temperature during December was slightly higher than that in March. The average water temperatures at all three zones were higher during December which was mainly attributed to short-term diurnal variation.

2.1.2 pH

Seawater pH is mainly regulated by carbonate system (CO_2, HCO_3^- and CO_3^{2-}), salt content and borate alkalinity. In general, seawater pH varies between 7.8 and 8.3, but due to increased HCO_3^- ions in industrial era, pH can broadly vary between 7.9 and 9.0. In shallow and biologically active tropical coastal waters, diurnal pH can vary between 7.3 and 9.5, that is conducive to the photosynthesis process. Mixing of freshwater in nearshore environment during monsoon and release of low pH water from anthropogenic activities mainly affect the buffering capacity, which cause reduction of pH (below 8.0). A pH range of 5 to 9 is not directly harmful to aquatic life but the rapid change in pH can turn common pollutants into more toxic in marine waters. The ranges of pH around the study area during March and December 2019 were 8.0−8.4 (av. 8.1) and 7.7−8.1 (av. 7.9), respectively (Table 2.1.1-2.1.13). The pH ranged from 8.0−8.1 and 8.0−8.4 in surface and bottom waters respectively, during March 2019. Similarly, pH ranged from 7.7−8.1 and 7.7−8.0 in surface and bottom waters respectively during December 2019. The pH variation between surface and bottom water was not significant, which apparently indicated towards a well-mixed water column during both the sampling campaigns.

The comparison of average pH during March and December 2019 is presented in Figure 2.1.2

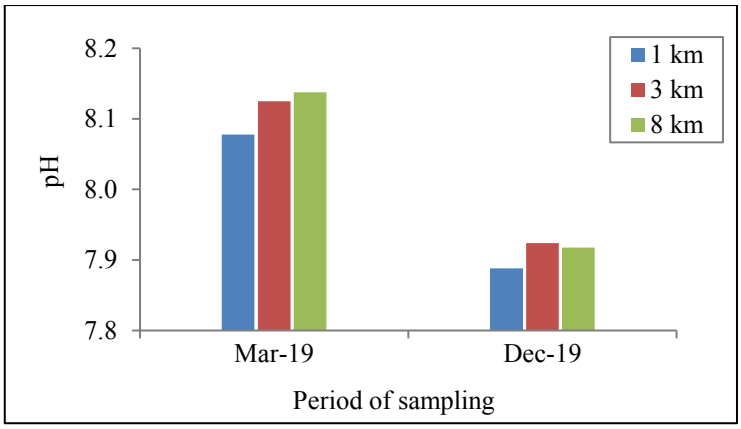


Figure 2.1.2: Variation of pH in the coastal waters off Mumbai during March and December 2019.

Average limits of pH in all the three zones were nearly similar during March as well as December as indicated in the figure. This highlighted the limited spatial variability of pH in the study area. However, the limits of pH were roughly half a unit lower in December (post monsoon) as compared to those in March (pre monsoon), that may be attributed to seasonal changes of pH in the study area.

2.1.3 Salinity

Seawater salinity levels are dependent upon the balance between evaporation and precipitation averages at 35.5 psu. Salinity is an important ecological factor for the organisms that live in marine water. The organisms are acclimatized to a certain range of salinity, however, large variation in the salinity levels can result in adoption and/or dominance of selected organisms in the lower order, while higher order organisms may migrate. In coastal and nearshore waters, abrupt changes in salinity are generally caused during high saline effluent discharges from the anthropogenic activities. Sudden changes in salinity may cause high mortality of biota including fish due to salinity shock.

The ranges of salinity during March and December 2019 were 35.7−36.6 psu (av. 36.3 psu) and 33.1−35.0 psu (av. 34.3 psu) respectively (Table 2.1.1-2.1.13).Salinity values in surface and bottom ranged between 35.7−36.5 psu and 36.2−36.6 psu respectively in March 2019. Similarly, salinity ranges in surface and bottom were 33.1−34.6 psuand 34.1−35.0 psu respectively, in December 2019. The average salinity between surface and bottom waters during both the sampling periods were comparable indicating well mixed water column. The average salinity at high tide (36.6 psu) and low tide (36.2 psu) were nearly similar during March 2019. Similarly, the high tide and low tide averages of salinity in December 2019 were same i.e.34.2 psu. The average salinity values during March and December 2019 is represented in Figure 2.1.3.

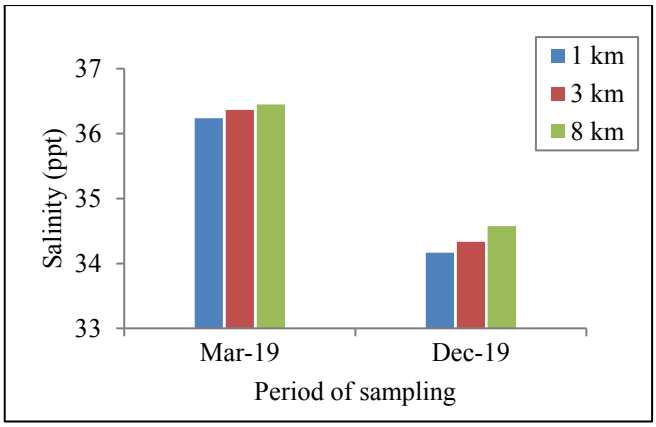


Figure 2.1.3: Variation of salinity in the coastal waters off Mumbai during March and December 2019.

The average salinity values roughly increased from 1 km zone towards 8 km zone as shown in the figure. Also, the average salinity levels at all the zones were lower during December, which is a characteristic seasonal feature of post monsoon season and indicated the effect of freshwater runoff into the nearshore coastal regions off Mumbai. The change in salinity during both the campaigns did not indicate any abrupt change, and signified natural variation.

2.1.4 Suspended Solids (SS)

Suspended Solids (SS) are mainly made up of inorganic and organic materials from hinterland soils, degraded and fresh residues of plant, plankton and algae etc. that float in the water column and eventually sink into sediment due to effects of physicochemical properties of seawater. They contribute to the turbidity of seawater and higher concentrations of SS can affect health of the aquatic animals and submerged vegetation by reducing photosynthesis. The reduced rates of photosynthesis cause less dissolved oxygen production by the plants. In case of complete blockage of light by turbidity, the photosynthesis by bottom dwelling plants will cease; therefore they die and start to degrade. The bacteria act up on the degrading plant by using up the dissolved oxygen. SS in the water column also adversely affects certain sensitive populations through mortality, reducing growth rate and resistance to diseases, preventing proper development of fish eggs and larvae, modifying natural movement and migration and reducing abundance of available food. SS settling on the bed can damage the benthic invertebrate population, block spawning etc.

Ranges of SS during March and December 2019 were 9−74 mg/l (av. 34 mg/l) and 7−94 mg/l (av. 38 mg/l) respectively (Table 2.1.1-2.1.13). The SS concentrations were ranged at 9−41 mg/l and 10−74 mg/l in the surface and bottom waters respectively during March 2019. Similarly, SS ranged at 7−48 mg/l and 23−94 mg/l in surface and bottom waters respectively during December 2019. During both the sampling periods, higher SS values were always at the bottom waters. The values of SS varied within a narrow range during high and low tides, with averages 38 mg/l and 44 mg/l respectively during March 2019 and 35 mg/l and 33 mg/l respectively during December 2019. The average SS values of the three zones during March and December 2019 are presented in Figure 2.1.4.

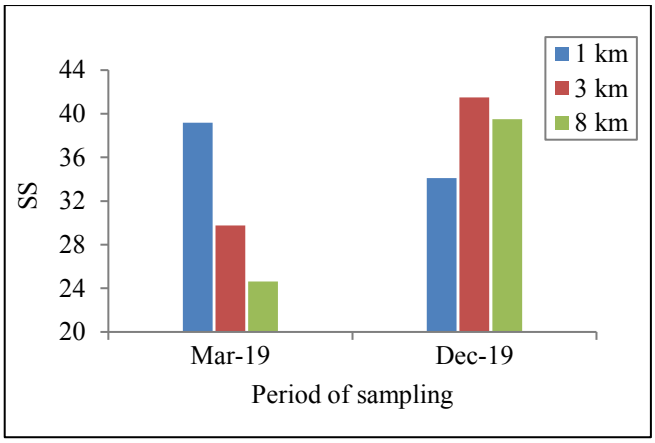


Figure 2.1.4: Variation of suspended solids in the coastal waters off Mumbai during March and December 2019.

The average SS values decreased from 1 km zone towards 8 km zone, indicating settling of SS in the marine water during March 2019 and the opposite trend was observed during December 2019 as presented below. The SS values at 3 km and 8 skm zones were higher during December as compared that in March, indicative of the impact of natural transport of nearshore turbid waters during post monsoon season.

2.1.5 Turbidity

Turbidity of water relates to optical clearness and is affected by contents of dissolved matter and SS present in it. In general, turbidity has direct relationship with SS in water. However, some deviations may occur as SS includes silt, sediment, non-settleable solids, bacteria, clay, algae and settleable solids, whereas turbidity may be the contribution of these plus dyes, coloured dissolved organic matter and humic acids excluding settle able solids. Measurement of turbidity is one of key parameter in deciding the quality of water as high turbidity can harm fish and other aquatic life by reducing food supplies, degrading spawning beds, and affecting gill function.

Turbidity values were ranged at 1.3−22.4 NTU (av. 11.5 NTU) and 2−55 NTU (av. 28.5 NTU), during March and December 2019 respectively (Table 2.1.1-2.1.13). The turbidity levels in surface and bottom were ranged at 1.3−19.7 NTU and 1.6−22.4 NTU respectively during March 2019. During December, turbidity in surface and bottom water was ranged at 2−14 NTU and 9−55 NTU respectively. Like SS, average values of turbidity varied within a narrow range during high and low tides, with averages 8 and 10 NTU, respectively in March 2019 and 13 and 14 NTU in December 2019. The average limits of turbidity at different zones during March and December 2019 are presented in Figure 2.1.5.

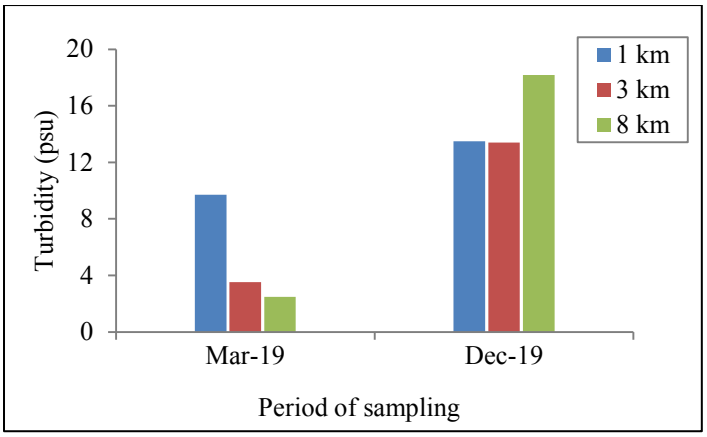


Figure 2.1.5: Variation of turbidity in the coastal waters off Mumbai during March and December 2019

As expected, the variation of turbidity closely followed the distribution trends of SS.

2.1.6 Chloride (Cl^-)

The Chloride, in the form Cl^- ion, is one of the major inorganic anions or negative ions in saltwater. Seawater (salinity 35 ppt) has natural Cl^- concentration of 19.4µg/kg. Natural spikes in chloride concentration can occur during summer and/or "low-flow" periods, when the evaporation exceeds precipitation. The Cl^- in the environment can come from sodium chloride (NaCl) or from other chloride salts such as potassium chloride (KCl), calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$) and anthropogenic factors such as road salt and due to contamination by the sewage.

Concentrations of Cl^- ranged at 19.8−20.2 µg/kg (av. 20.1 µg/kg) and 18.3−19.4 µg/kg (av. 19.0µg/kg), respectively during March and December 2019 (Table 2.1.1-2.1.13). The average Cl^- concentration in surface and bottom waters were similar i.e. 20.1µg/kg during March. Similarly, the surface and bottom limits were varied between18.9 and 19.1 µg/kg, respectively in December, which could be the natural variation of Cl^- in the region. There was no significant variation in Cl^- among all the three zones of the study. The comparative Cl^-values of the three zones during March and December 2019 are presented in the Figure 2.1.6.

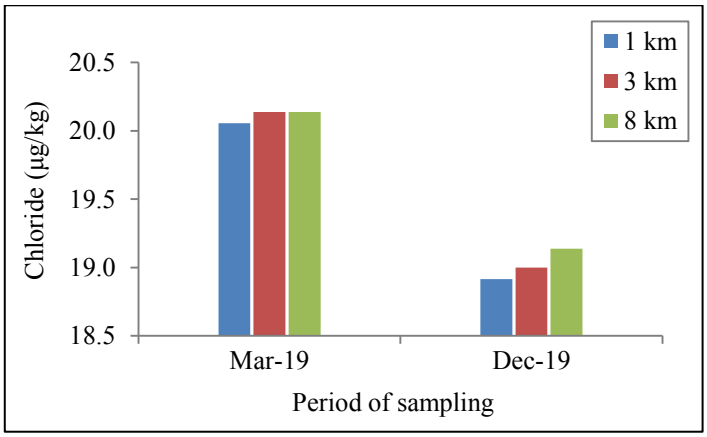


Figure 2.1.6: Variation of chloride in the coastal waters off Mumbai during March and December 2019

As can be discerned from the above figure, the average Cl^- values were higher in March 2019 as compared to December 2019.

2.1.7 Dissolved Oxygen (DO) and biochemical oxygen demand (BOD)

DO is an important parameter of water quality and its concentration in water highlights the ability of a water body to support aquatic life. The sources of DO in aquatic environments such as bay, nearshore and offshore are photosynthesis, atmosphere exchange and addition of oxygen-rich water by river runoff. Consumption of DO during heterotrophic oxidation of oxidizable organic matter and respiration by aquatic flora and fauna gives rise to biochemical oxygen demand (BOD). It is difficult to attain the threshold limit of DO for aquatic life, since environmental conditions, waste loading and natural levels of DO vary considerably and the existent composite aquatic life has variable demand for DO depending on their composition, age, activity, nutritional status etc. However, it has been observed that below 3 mg/l concentration of DO, good and diversified aquatic life may not sustain since feeding of many organisms is stopped and their growth is retarded at low DO levels. Embryonic and larval stage of aquatic life are especially vulnerable to reduced oxygen conditions, may result in retarded development and even partial mortality. It is considered that the level should not fall below 4 mg/l consistently for a longer period of time.

Ranges of DO during March and December 2019 were 3.9−7.7 mg/l (av. 6.3 mg/l) and 3.1−7.5 mg/l (av. 5.9 mg/l) respectively (Table 2.1.1-2.1.13). The DO values in surface and bottom were ranged at 4.9−7.7 mg/l and 3.9−7.5 mg/l respectively during March 2019. Similarly, the DO in surface and bottom waters during December ranged at 4.9-7.5 mg/l and 3.1-7.4 mg/l respectively. There was no marked variation of DO found between surface and bottom waters during both the sampling campaigns. The high and low tide averages of DO at 1 km zone were 6.3 mg/l and 5.8 mg/l respectively in March 2019. During December 2019, the high tide and low tide DO averages were 5.8 mg/l and 6.4 mg/l respectively. The zonal average values of DO and BOD during March and November 2019 are presented in Figure 2.1.7.

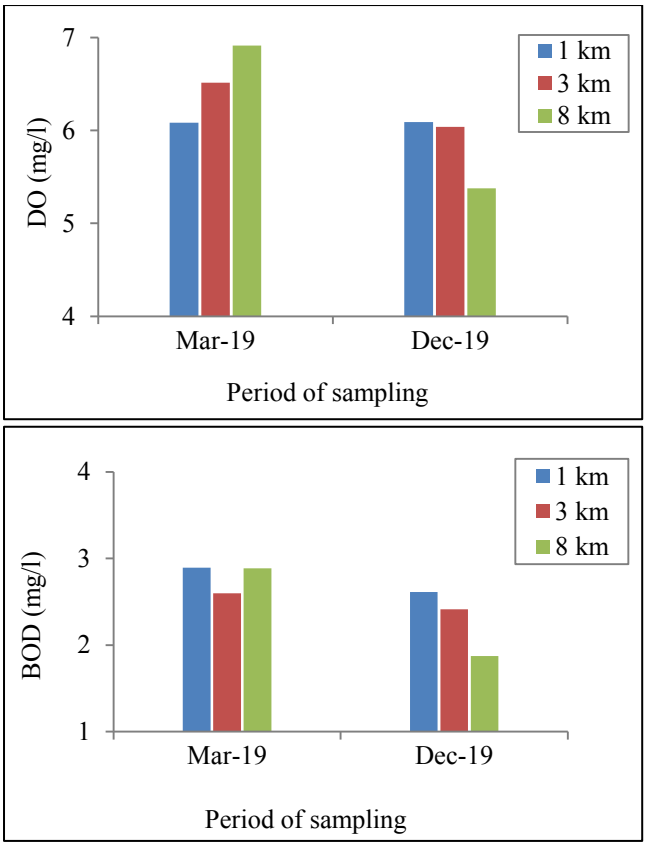


Figure 2.1.7: Variation of dissolved oxygen (top) and biochemical oxygen demand (bottom) in the coastal waters off Mumbai during March and December 2019

The average DO values increased towards the offshore (8 km) zone in March. However, the average DO around the 8 km zone was slightly lower as compared to the other two zones in December. On an average, DO limits remained >5 mg/l throughout, which indicated that well oxygenated water column, prevailed for the healthy aquatic life. Consumption of DO during heterotrophic degradation of oxidizable organic matter creates oxygen demand referred as BOD, measured after incubation of DO samples for 3 days at 27°C soon after the collection. Presence of sufficient DO through replenishment keeps this demand low. However, input of oxidizable organic matter often causes enhancement of BOD, which is the indicator of unfavorable conditions for the aquatic life.

Ranges of BOD during March and December 2019 were 0.8−4.6 mg/l (av. 2.8 mg/l) and 0.3−5.0 mg/l (av. 2.4 mg/l) respectively (Table 2.1.1-2.1.13). The BOD values in surface and bottom were ranged at 1.2−4.6 mg/l and 0.8−4.3 mg/l, respectively in March 2019, whereas it ranged at 0.9-5.0 mg/l and 0.3-4.6 mg/l in surface and bottom, respectively during December 2019. The high and low tide averages of BOD at 1 km zone were 2.5 mg/l and 3.1 mg/l respectively during March 2019. Average BOD during high and low tides were 2.4 mg/l and 2.8 mg/l, respectively during December 2019. As indicated in Figure 2.1.7, average BOD values were nearly similar in all the three sampled zones of this study during March 2019. The average BOD levels decreased from 1 km to 8 km during December 2019, indicating impact of potential land runoff on nearshore coastal waters during post monsoon season. BOD of>4 mg/l associated with fairly high DO (>7 mg/l) observed in the northern transect, could be related with efficient biochemical

oxidation by the heterotrophs present in those waters or could be due to localized impact of sewage, which were absent in other regions.

2.1.8 Nutrients

The nutrients such as forms of phosphate, nitrogen and silicon, along with trace metals are used by phytoplankton during primary productivity. Amongst these, nitrogen and phosphorus occur in estuarine and coastal water mainly in forms of nitrate (NO_3^- ; oxidation state +5) and ammonium (NH_4^+; oxidation state -3) along with other compounds. The dominant forms of nitrogen that exist in seawater are nitrate (NO_3^--N), nitrite (NO_2^--N) and ammonium (NH_4^+-N). NH_4^+-N is produced during the oxidation of organic matter, which is later oxidized to produce NO_3^--N via NO_2^--N, in the presence of sufficient quantities of DO in the environment. NO_2^--N is an intermediate product of oxidation of NH_4^+-N and reduction of NO_3^--N and is thermodynamically unstable. Nitrogen cycle involving elementary dissolved nitrogen; oxides: NO_3^-, NO_2^- and reduced forms: NH_4^+, play a significant role in sustaining life within the aquatic environment. NO_3^--N is the end product of oxidation and most stable form at pH 7. The principal source of nitrogen in marine environment is fixation of atmospheric N_2. NO_2^- occurs in seawater as an intermediate product of NO_3^- reduction in microbial processes i.e. denitrification at low oxygen level at which NO_2^- is further transformed into N_2 under anoxic conditions. Inorganic phosphorus occurs most often as the phosphate (PO_4^{3-}-P). Though these nutrients are essential for life support in the aquatic environment, their enrichment in nearshore regions may hamper the coastal nutrient status and in extreme cases it can lead to eutrophication. Collectively, the compounds of phosphate, nitrogen and silicon are prime nutrients used for primary productivity.

(i) Phosphate (PO_4^{3-}-P)

Phosphorus as phosphate (PO_4^{3-}-P) is an essential nutrient required for plant nutrition. Anthropogenic sources of PO_4^{3-}-Pin coastal marine environment include domestic sewage, detergents, effluents from agro-based and fertilizer industries, agricultural runoff, organic detritus such as leaves, cattle waste etc.

The ranges of PO_4^{3-}-P in the study area during March and December 2019 were 0.4−5.0 µmol/l (av. 1.6 µmol/l) and 0.3−2.8 µmol/l (av. 1.2 µmol/l) respectively (Table 2.1.1-2.1.13). The extremely higher value (5 µmol/l), was at the nearshore region in the North, also associated with high BOD and could be related with localized discharges. During March 2019, PO_4^{3-}-P concentrations in surface and bottom waters were ranged at 0.4-5.0 µmol/l and 0.8-2.3 µmol/l respectively. Similarly, during December 2019, PO_4^{3-}-P ranges in surface and bottom were 0.3-2.8 µmol/l and 0.7-2.0 µmol/l respectively. The average limits of PO_4^{3-}−P during high and low tides were 1.8 µmol/l and 2.0µmol/l respectively during March 2019, whereas the high and low tide averages were 1.2 µmol/l, 1.4 µmol/l respectively during December 2019. The average PO_4^{3-}-P values at different zones during March and December 2019 are presented in Figure 2.1.8 (*i*)

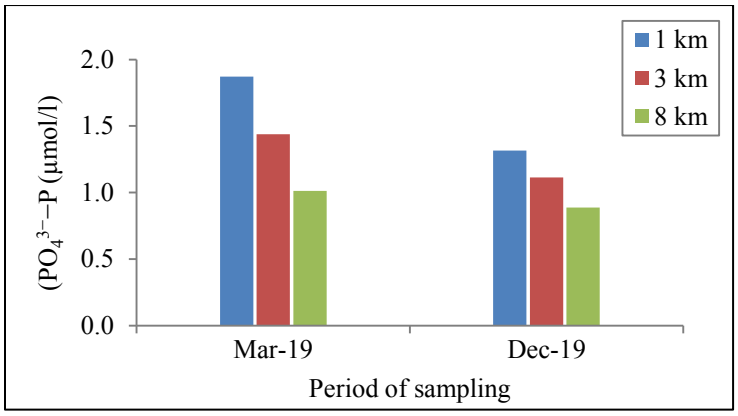


Figure 2.1.8(*i*): Variation of phosphate in the coastal waters off Mumbai during March and December 2019.

As presented in the above figure, the average concentrations of PO_4^{3-}-P decreased from 1 km to 8 km zone in this study indicating spatial variability. PO_4^{3-}-P values were lower during December as compared to March.

(ii) Nitrate (NO_3^--N)

The ranges of NO_3^-N during March and December 2019 were 0.2−17.1 µmol/l (av. 8.3µmol/l) and 0.7−12.0 µmol/l (av. 4.1µmol/l) respectively (Table 2.1.1-2.1.13). The ranges of NO_3^-Nin surface water was between 0.2 and 17.1µmol/l during March 2019 and 0.7-12.0 µmol/l during December 2019.NO_3^-N concentration ranged between 0.2 and 13.5 µmol/l during March 2019 and 1.0-7.9 µmol/l during December 2019 in bottom water. There were distinct seasonal variations in the average NO_3^-N concentrations seen in the study area, with lower averages being recorded during the post monsoon period. The average limits of NO_3^-N during high and low tides were 8.2 and 10.9 µmol/l, respectively during March 2019. Similarly, high and low tide averages of NO_3^-N were 6.0 µmol/l and 4.7 µmol/l during December 2019. The average values of NO_3^--N of all three zones during the two sampling periods are presented in Figure 2.1.8 (*ii*)

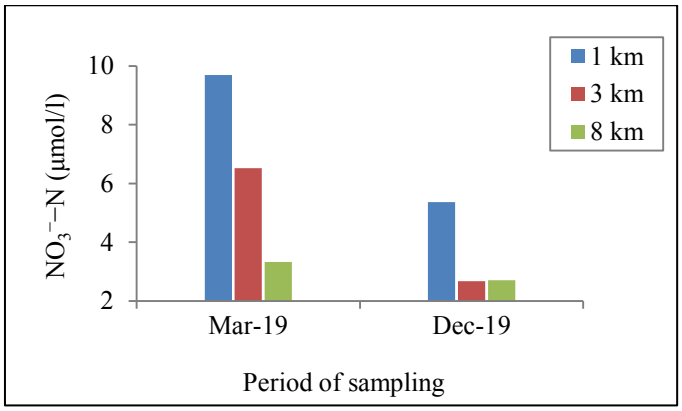


Figure 2.1.8 (*ii*): Variation of nitrate in the coastal waters off Mumbai during March and December 2019.

A decreasing trend in the average concentrations of NO_3^-N was observed from the 1 km (nearshore) to 8 km zone (offshore) in this study. Also, NO_3^--N values were lower in December as compared to March.

(iii) Nitrite (NO_2^--N)

Ranges of NO_2^-Nduring March and December 2019 were ~0−5.5 µmol/l (av. 2.6 µmol/l) and 0.2−3.0 µmol/l (av. 1.0 µmol/l), respectively (Table 2.1.1-2.1.13). NO_2^-N in surface and bottom waters were ranged at 0.1−5.5 µmol/land ~0−3.7 µmol/l respectively in March 2019. Similarly, surface and bottom water NO_2^--N concentrations were 0.2-3.0 µmol/l and 0.5-2.0 µmol/l respectively in December 2019. The average limits of NO_2^-N during high and low tides were 2.5µmol/l and 3.2 µmol/l respectively in March 2019. The high and low tide averages were 1.0 µmol/l and 1.3µmol/l, respectively in December 2019. The average NO_2^-N values at different zones during March 2019 and December 2019 are presented in Figure 2.1.8 (*iii*)

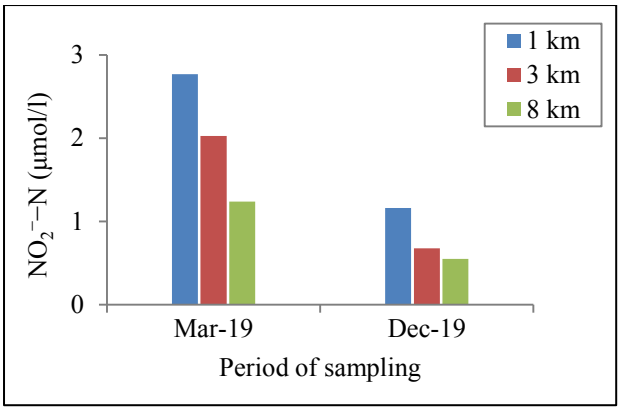


Figure 2.1.8 (*iii*): Variation of nitrite in the coastal waters off Mumbai during March and December 2019.

As in the case of NO_3^--N, the average NO_2^--N levels too indicated a decreasing trend from 1 km (nearshore) to 8 km zone (offshore) in this study and were lower during December.

(iv) Ammonium (NH_4^+-N)

The NH_4^+-N is unstable in natural surface waters, therefore further oxidized to NO_3^--N via NO_2^--N. The concentrations of NH_4^+-N in surface and bottom water column were ranged at 0.5–5.8µmol/l and 0.7-3.8µmol/l respectively during March 2019 (Table 2.1.1-2.1.13). The surface and bottom water averages of NH_4^+-N were 0.3-2.1µmol/l and 0.5-3.6 µmol/l respectively during December 2019. The average limits of NH_4^+-N during high and low tides were 1.6 µmol/l and 2.2 µmol/l respectively during March 2019. Similarly, average values during high and low tides were 1.4 µmol/l and 1.1µmol/l respectively during December 2019. The average NH_4^+-N values at different zones during March 2019 and December 2019 are presented in Figure 2.1.8 (*iv*)

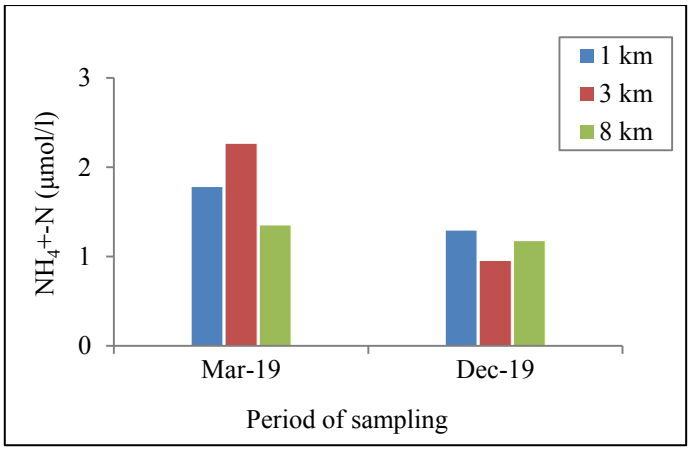


Figure 2.1.8 (*iv*): Variation of ammonium in the coastal waters off Mumbai during March and December 2019.

Thus, the mean values of NH_4^+-N at all the three zones were nearly similar and on an average the values were lower in December as compared to March. Collectively, the nitrogenous component such as nitrate, nitrite and ammonium were lower during December, which was indicative of their limitation. The spatial variability of nitrate and nitrite were significant, with higher limits in nearshore waters. There was no substantial enrichment of these nutrients found during both the campaigns. Overall, higher levels of DO in all the three zones associated with lower BOD suggested a natural nutrient variability in the region.

(v) Sulphate (SO_4^{2-})

Sulphate (SO_4^{2-})is one of the conservative elements, which co-varies with chlorinity in seawater with a constant ratio of SO_4^{2-}: Cl is 0.14 (Morris and Riley 1966). The principal source of sulphur in coastal marine environment could be from sea salt during rain and continental and anthropogenic sources (Kroopnick, 1977). The SO_4^{2-}: Cl ratio may vary with the addition or removal of SO_4^{2-}. Hence, the addition of SO_4^{2-} rich substance can enhance the concentration of SO_4^{2-} and thereby the SO_4^{2-}: Cl ratio. Furthermore, reduction due to removal or dilution of SO_4^{2-} salts can cause decrease of SO_4^{2-}: Cl ratio. Ranges of sulphate during March and December 2019 were 2.8−3.1 g/kg (av. 2.9 g/kg) and 2.0−2.8 g/kg (av. 2.5 g/kg) respectively (Table 2.1.1-2.1.13). On an average there was no significant variation in sulphate values found between surface and bottom water column during both the sampling campaigns. The average limits of surface and bottom were similar and were 2.9 g/kg and 2.5 g/kg during March and December 2019 respectively. The zonal average SO_4^{2-}values during March and December 2019 are presented in Figure 1.1.9 (a)

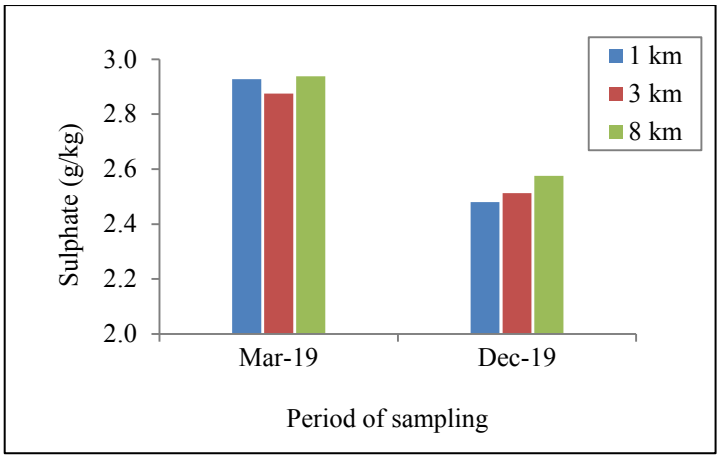


Figure 1.1.9 (a): Variation of sulphate in the coastal waters off Mumbai during March and December 2019.

There was no significant variation in average sulphate levels among all the sampled zones during both the campaigns. Likewise, the SO_4^{2-}: Cl ratio varied within a very narrow range in surface as well as bottom water samples i.e. between 0.13 and 0.15. From the Table it is evident that the averageSO_4^{2-}: Cl at all the stations was nearly identical and, in the range observed for natural seawater. The SO_4^{2-} vs. Cl plot for all data collected during March 2019 and December 2019 around off Mumbai waters is presented in Figure1.1.9 (b)

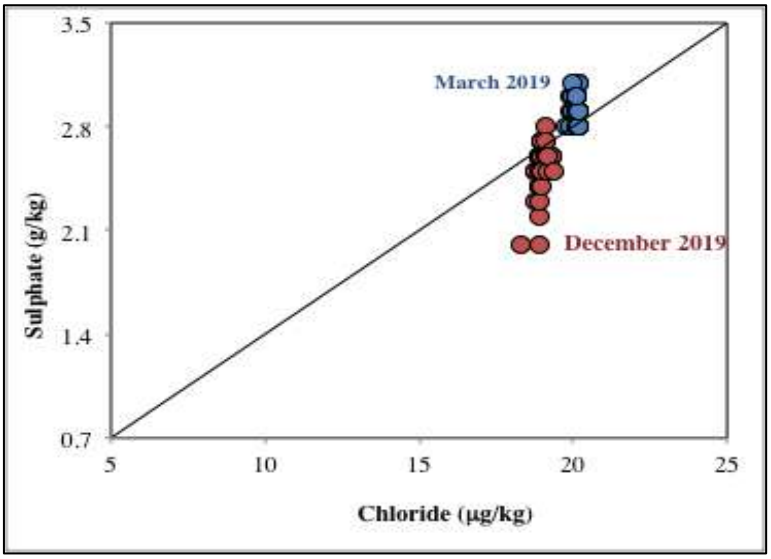


Figure 1.1.9 (b): Inter-relationship between chloride and sulphate contents in the coastal waters off Mumbai during March and December 2019

The results indicated that all the data points (2σsv.) are in line with the average SO_4^{2-}: Cl ratio of sea water (i.e. 0.14; Morris and Riley 1966). Few of the observations indicated higher or lower SO_4^{2-}: Cl ratio, which may be due to natural variation of Cl in water samples. The Cl enrichment in nearshore and coastal areas are normal, however, the processes such as sulphate

reduction is ruled out as indicated by fairly normal DO values. Therefore, it appears that there was no accumulation or removal of sulphate in the study area.

2.1.9 Petroleum hydrocarbon (PHc)

Naturally occurring hydrocarbons in aquatic environment are in trace amounts of simple forms produced by microbes. PHc derived from crude oil and its products are added to marine environment by anthropogenic activities namely production of crude oil and its products, their transport, ship traffic, etc. Prominent land-based sources are domestic and industrial effluents, atmospheric fallout of fuel combustion products, condensed vapors etc. PHc can cause severe damage to the aquatic life when there are sudden discharges in large quantities during accidents such as tanker collision, pipeline rupture, fire etc. Samples for PHc were collected 1m below the surface water. The concentration of PHc measured in the surface water layer (1m water depth) around off Mumbai were ranged at 1.6–9.6µg/l (av. 3.3µg/l) during March 2019 and 1.4 -8.0 µg/l (av. 2.6µg/l) during December 2019 (Table 2.1.1-2.1.13). The comparative averages of PHc during March and December 2019 for all three zones are presented in Figure 2.1.10.

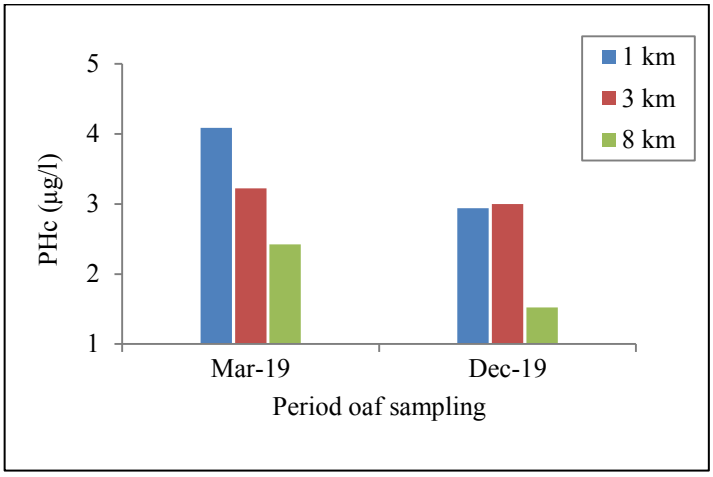


Figure 2.1.10: Variation of PHc in the coastal waters off Mumbai during March and December 2019

The average values of PHc were observed to decrease from 1 km zone towards 8 km zone during the both study periods, indicating minimal contamination due to petroleum compound in the 8 km zone off Mumbai. The PHc values were lower in December as compared to March 2019.

2.2 Sediment quality

The sedimentary bed in coastal aquatic systems act as an eventual sink of SS, which often carries significant amount of chemical substance (metals, organic carbon and pollutants) from the source region via water column. The pollutants are removed through adsorption and attached to the SS. In several instances, it is observed that even close to a location of effluent release, the metal content in receiving water often decreases to a normal value making assessment of contamination through analysis of water, a difficult task.

The concentrations of metals, organic carbon (C_{org}) and pollutants increase over a period of time at the sediment-water interface dependent upon the balance between their receiving fluxes,

accumulation and removal rates. Moreover, the accumulation of metals, C_{org} and pollutants in sediments over a period of time can substantially indicate the quality of sediment. A good quality sediment substratum is essential for a sustainable healthy benthic ecosystem. The contents of metals and other sedimentary parameters varied among different zones off Mumbai during this study and presented in Table 2.2.1.

2.2.1 Texture

Overall, the bed sediment within the off Mumbai region showed a wide range of texture property (clay, silt and sand) but mainly dominated by the silty fraction. The average percentage of silt was higher in the 1 km zone, whereas the average clay content in sediment increased from the 1 km zone towards the 8 km zone as can be observed in Figure 2.2.1.

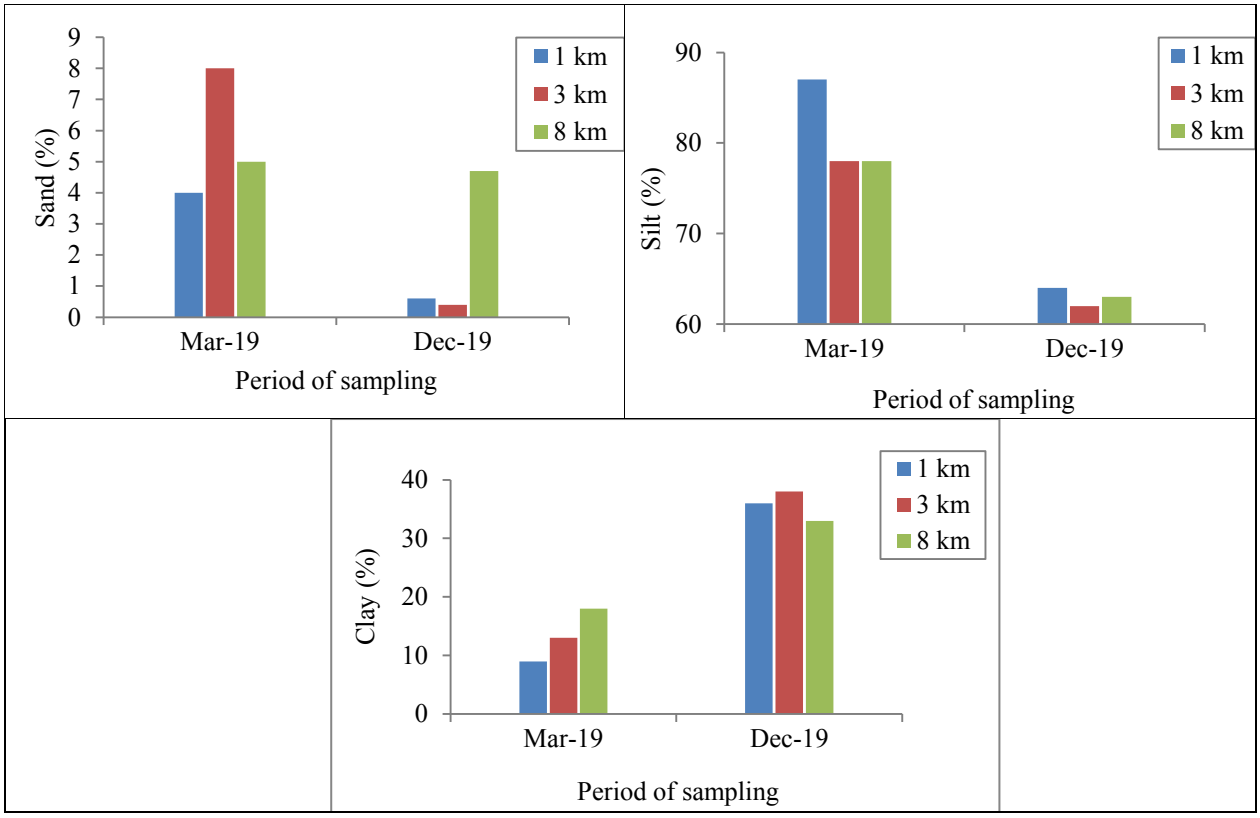
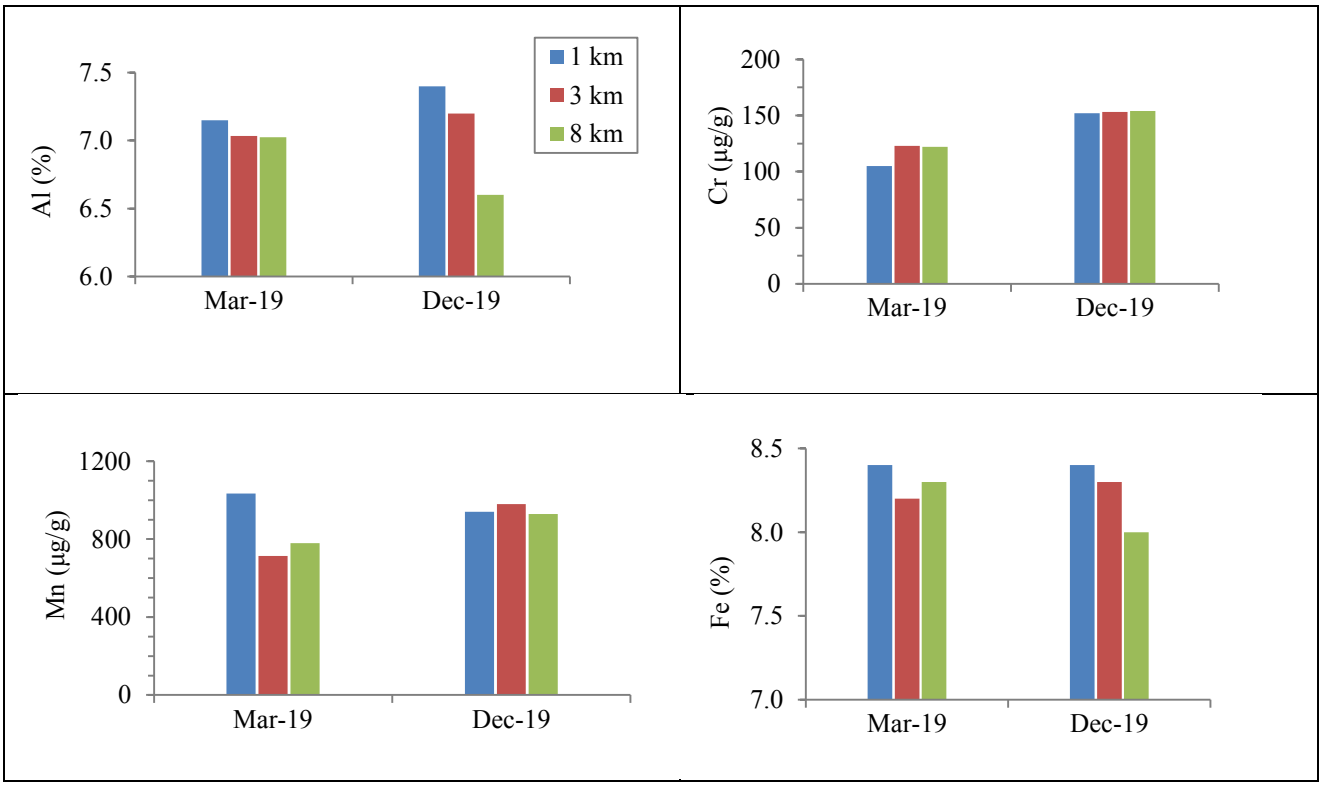


Figure 2.2.1: Texture (sand (upper-left), silt (upper-right) and clay (lower)) properties of sediments in the coastal waters off Mumbai during March and December 2019.

The distribution of sediment texture indicated that in March 2019, predominantly silty sediments with fairly low clay content was observed. In December 2019, increased clay fraction in the sediment was observed which may be attributed to seasonal change. This broadly highlights lateral transport of finer sediment that caused limited variation in the sediment texture probably during monsoon season.

2.2.2 Metals

Bed sediments in uncontaminated areas has lithogenic metal concentrations, which are derived from rocks and soils encountered. However, these levels can get altered when the coastal waters receive discharges of anthropogenic effluents. The forms of metals in sediment namely hydroxides, sulfides, carbonates associated with organic substances entering through aqueous phase are influenced by several factors that determine their residence time in thermo-dynamically metastable phase. They are enriched as detrital minerals, chemically absorbed and complexed, co-precipitated, flocculated eventually settled in sediment. The variation of metal content largely depends upon the texture of bed sediment. Studies have demonstrated that marine sediments from industrialized coastal areas are greatly contaminated by metals; therefore, the evaluation of metal distribution in surface sediments is useful to assess the pollution in the marine environment. The results of metal content in sediments from the subtidal regions off Mumbai during March and December 2019 are presented in Table 2.2.1. The average contents of different metals in three different zones during March and April 2019 are presented in Figure 2.2.2.



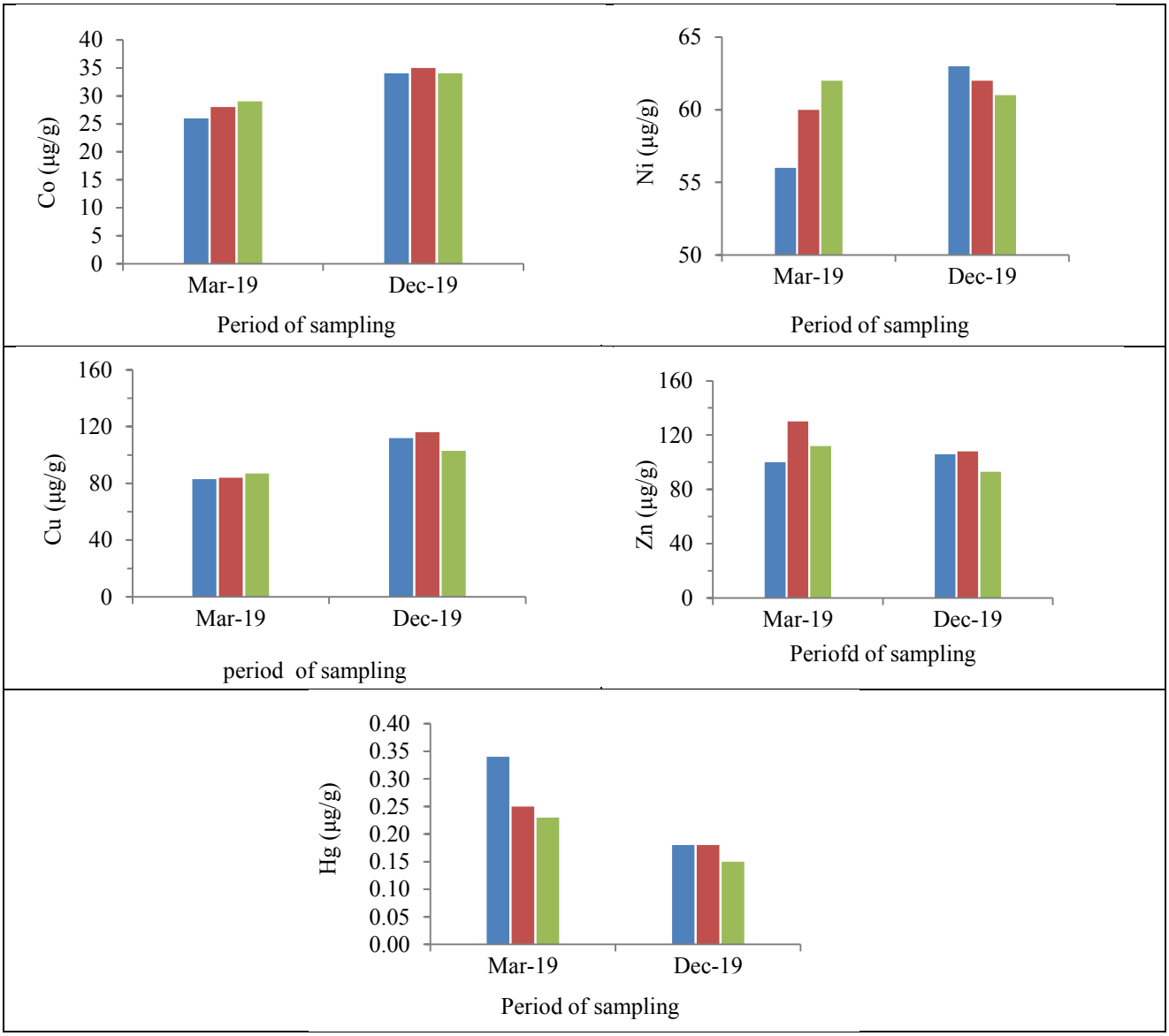


Figure2.2.2: Variation in Aluminium (Al), Manganese (Mn), Cobalt (Co), Copper (Cu), Chromium (Cr), Iron (Fe) , Nickel (Ni), Zinc (Zn), Mercury (Hg) in sediment in the coastal waters off Mumbai during March and December 2019

Results indicated that the metal contents along the dispersal pathways e.g. from 1 km to 8 km zone off Mumbai did not follow any significant trend. Exceptions were Al and Fe, which showed marked decrease from 1 km to 8 km zone during December, could be an indication of terrigenous export. Variations in lithogenic fractions of metals in sediments across the eastern Arabian Sea often commonly noticed due to various factors such as variable inputs of SS through land drainage, littoral transport and continental sediment movement during tidal epochs etc. The variations in the concentration of trace metals could also be due to changing levels of Al and Fe, which generally influence the concentration of trace metals. The average levels indicated towards slightly higher values in all the three zones for metals such as Cr, Co, Cu during December, which is attributed to addition of these metals during the seasonal epoch and may be invariably associated

with Al and/or Fe contents. The average levels of Hg were lower in December as compared to the March campaign in all the three zones.

2.2.3 Petroleum hydrocarbon (PHc)

The concentration of PHc in sediments off Mumbai is a vital parameter in the context of operations and activities such as operational fishing boats, ships and barges. The petroleum residue left after their release into water either due to transportation activity or major oil spillage adsorbed by SS, is eventually deposited in the sediments. Hence, PHc levels in sediment serve as a useful indicator of cumulative effect of oil contamination. The average concentration of PHc in sediments from different zone is presented below. The PHc in sediments ranged from 0.1 to 2.5 µg/g during March 2019 and 0.2 to 6.0 µg/g during December 2019 in the study area (Table 2.2.1). The zone wise averages of PHc in sediments during both sampling periods are presented in Figure 2.2.3.

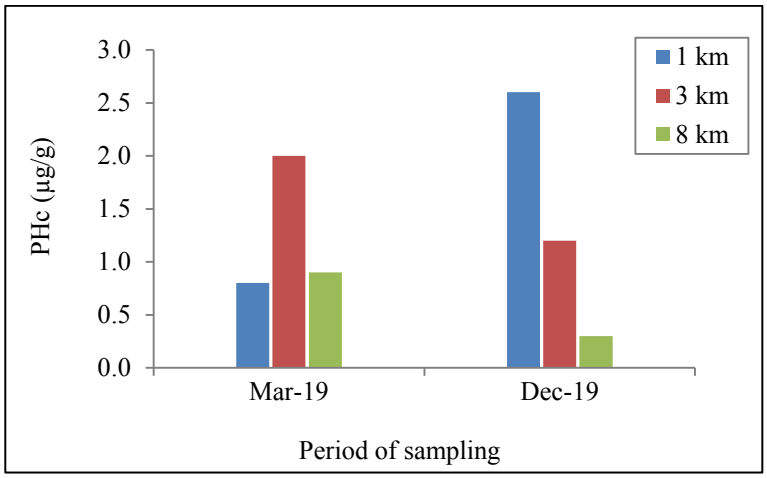


Figure 2.2.3: Variation of Petroleum hydrocarbon in sediment in the coastal off Mumbai during March and December 2019

There was no definite trend of spatial variation observed in PHc sediments during March 2019, however a decreasing trend was seen from 1 km to 8 km during December 2019. The average PHc limits were relatively lower at the 1 km and 8 km zones as compared to the 3 km zone during March 2019. During December 2019, average PHc limits were lowest at 8 km zone than the 1 km and 3 km zones. Overall the PHc levels found in the study area were lower, which therefore did not indicate any major contamination due to petroleum compounds.

2.2.4 Organic carbon (C_{org})

Organic matter in nearshore and coastal sediments are mainly sourced from terrestrial runoff. Anthropogenic organic matter inputs can be reflected through abnormal increase in C_{org}, which can disturb the ecosystem. C_{org} present in the bed sediments are utilized by benthic organisms to a large extent. A fraction is also decomposed in the presence of DO by heterotrophic microorganisms. Hence, DO in sediment-interstitial water is continuously consumed and anoxic conditions develop if the organic matter is more than that can be oxidised through oxygen as an oxidant. Such anoxic conditions are harmful to benthic fauna. The average contents of C_{org} insubtidal sediments from all the three zones of this study are presented below. The C_{org} values

ranged from 0.2-1.7% during March 2019 and 1.4-1.9 % during December 2019. The comparative zonal C_{org} averages of both sampling periods are presented in Figure 2.2.4.

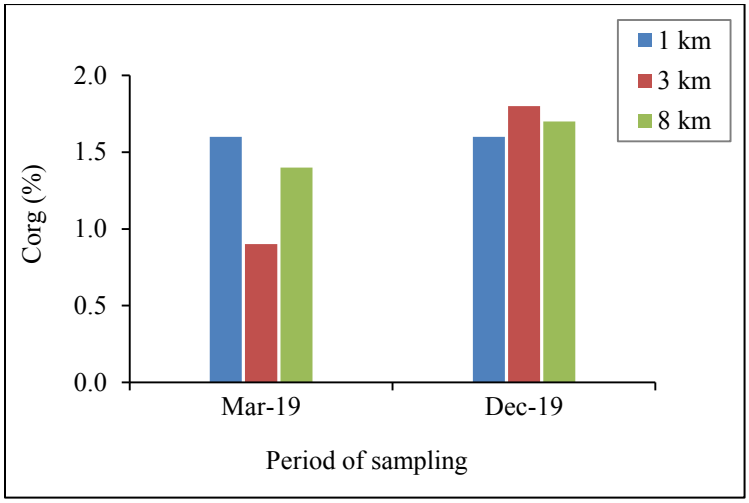


Figure 2.2.4: Variation of Organic Carbon in sediments in the coastal waters off Mumbai during March and December 2019.

The average content of C_{org} did not vary significantly from 1 km zone towards the 8 km zone, which may be due to their similar source or origin. On an average, the limits of C_{org} at all the three zones were slightly higher during December as compared to March, which was indicative of the deposition of fresh organic matter during the monsoon season. The content of C_{org} varied negatively with sand fraction of the sediments during this study. The contents of C_{org} often corresponds to their nature and origin, however the content itself may not represent any specific source but when compared along with other parameters such as total nitrogen content and the isotopic signatures, the potential C_{org} sources can be identified.

2.2.5 Total Phosphorus (P)

Lithogenic phosphorus in nearshore marine sediments is mostly derived from the geological sources through river flows, while, the anthropogenic phosphorus is the result of sewage and industrial discharges, agricultural runoff etc. The ranges of phosphorous in sediments were comparable between March 2019 (1059-1866 µg/g) and December 2019 (882-1997 µg/g). The average contents of sedimentary P in all the three zones of this study are presented in Figure 2.2.5.

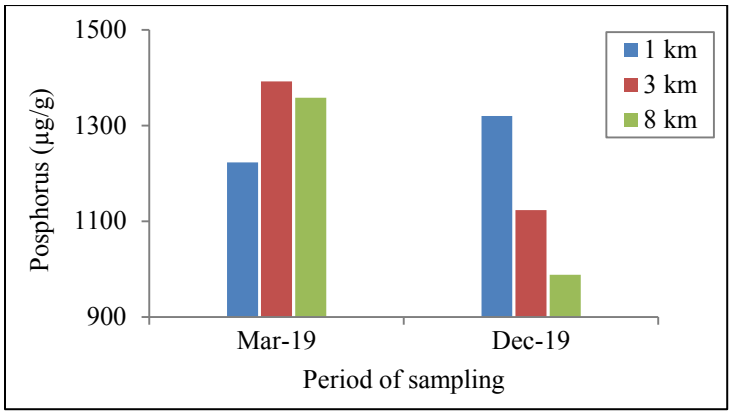


Figure 2.2.5: Variation of Total Phosphorus in sediments in the coastal waters off Mumbai during March and December 2019.

The average content of sedimentary P around all the three zones off Mumbai region did not vary significantly. Relatively higher average P in 3 km and 8 km zone as compared to 1 km zone could be related with accumulation of P during sedimentation during March 2019. The average content of sedimentary P during December 2019 showed decreasing pattern from 1 km to 8 km zone, indicative of the addition of P from the nearshore region.

In summary, it was considered that the sedimentary parameters such as texture, metals, PHc, C_{org} and P in the subtidal sediments off Mumbai varied within the region, but hardly indicated any abrupt rise in values as compared to the previous monitoring results across the same region. Also, clear seasonal trends with less spatial variability are seen for geo-chemcial elements such as C_{org}, certain metal and P etc. Nevertheless, regular periodic monitoring of ecology off Mumbai is desirable to establish the trends in variation of sediment quality in future.

References

Kroopnick, P. 1977. The SO_4: Cl Ratio in Oceanic Rainwater. Pacific Science 31, 91-100.
Morris, A.W. and Riley, P. 1966. Bromide / chlorinity and sulphate chlorinity ratio in sea water. Deep Sea Research 13, 699-705.

Table 2.1.1: Water quality at station 1 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar-2010	Dec- 2019
Temperature (°C)	S	27.5 - 27.5 (27.5)	27.0 - 27.5 (27.3)
	B	26.5 - 27.0 (26.8)	26.5 - 27 (26.8)
	AT	27.0 - 28.0 (27.5)	24.0 - 28.5 (26.3)
pH	S	8.0 - 8.1 (8.0)	7.7 - 7.7 (7.7)
	B	8.1 - 8.3 (8.2)	7.8 - 7.8 (7.8)
SS (mg/l)	S	33 - 41 (37)	25 - 48 (37)
	B	45 - 47 (46)	39 - 44 (41)
Turbidity (NTU)	S	3.0 - 6.1 (4.6)	12 - 14 (13)
	B	3.5 - 5.2 (4.3)	16 - 26 (21)
Salinity (ppt)	S	36.2 - 36.2 (36.2)	33.1 - 34.1 (33.6)
	B	36.2 - 36.4 (36.3)	34.1 - 34.1 (34.1)
DO (mg/l)	S	7.5 - 7.7 (7.6)	5.3 - 6.0 (5.6)
	B	6.8 - 7.1 (6.9)	5.0 - 5.0 (5)
BOD (mg/l)	S	4.1 - 4.6 (4.3)	4.3 - 5.0 (4.6)
	B	3.0 - 4.1 (3.6)	0.3 - 1.1 (0.7)
PO_4^{3-}-P (µmol/l)	S	0.8 - 5.0 (2.9)	0.3 - 2.8 (1.6)
	B	1.6 - 1.9 (1.7)	1.4 - 1.6 (1.5)
NO_3^--N (µmol/l)	S	1.6 - 5.9 (3.7)	5.4 - 8.5 (6.9)
	B	3.1 - 4.1 (3.6)	5.7 - 6.8 (6.3)
NO_2^--N (µmol/l)	S	0.7 - 2.6 (1.7)	1.0 - 3.0 (2)
	B	1.2 - 1.4 (1.3)	1.0 - 1.1 (1)
NH_4^+-N (µmol/l)	S	1.9- 2.3 (2.1)	0.4 - 1.2 (0.8)
	B	0.7 - 0.9 (0.8)	1.7 - 3.6 (2.7)
PHc (µg/l)	1m	2.7 - 5.7 (4.2)	2.1 - 2.5 (2.3)
Sulphate (g/kg)	S	2.9 - 3.0 (2.9)	2.0 - 2.5 (2.2)
	B	2.8 - 2.9 (2.8)	2.2 - 2.6 (2.4)
Chloride (µg/kg)	S	20.1 – 20.0 (20.0)	18.3– 18.9 (18.6)
	B	20.1– 20.0 (20.1)	18.9 – 18.9 (18.9)

AT: Air temperature. Values are presented as Min.-Max. (Average).
Ranges are based on sampling done during two different tidal condition of sea.

Table 2.1.2: Water quality at station 2 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar -2019	Dec -2019
Temperature (°C)	S	27.0 - 29.0 (28.0)	29.0 - 29.0 (29.0)
	B	26.5 - 28.5 (27.5)	28.5 - 28.5 (28.5)
	AT	29.0 - 32.0 (30.5)	29.5 - 30.0 (29.8)
pH	S	8.1 - 8.1 (8.1)	7.7 - 7.7 (7.7)
	B	8.1 - 8.1 (8.1)	7.7 - 7.7 (7.7)
SS (mg/l)	S	30 - 41 (36)	22 - 35 (29)
	B	46 - 74 (60)	37 - 52 (45)
Turbidity (NTU)	S	3.2 - 3.6 (3.4)	4 - 7 (5)
	B	4.6 - 4.9 (4.7)	9 - 15 (12)
Salinity (ppt)	S	36.0 - 36.1 (36.0)	34.0 - 34.1 (34.0)
	B	36.4 - 36.5 (36.4)	34.1 - 34.1 (34.1)
DO (mg/l)	S	4.9 - 5.9 (5.4)	6.0 - 6.6 (6.3)
	B	3.9 - 4.8 (4.4)	6.0 - 6.9 (6.4)
BOD (mg/l)	S	1.7 - 3.6 (2.6)	3.6 - 4.3 (3.9)
	B	0.8 - 2.0 (1.4)	1.3 - 4.6 (2.9)
PO_4^{3-}-P (µmol/l)	S	1.6 - 2.4 (2.0)	1.3 - 1.5 (1.4)
	B	1.1 - 1.5 (1.3)	1.1 - 1.5 (1.3)
NO_3^--N (µmol/l)	S	13.8 - 17.1 (15.4)	4.9 - 4.9 (4.9)
	B	8.5 - 11.8 (10.2)	3.4 - 3.5 (3.5)
NO_2^--N (µmol/l)	S	4.6 - 5.5 (5.1)	0.8 - 0.9 (0.8)
	B	3.5 - 3.7 (3.6)	0.5 - 0.6 (0.5)
NH_4^+-N (µmol/l)	S	1.2 - 1.4 (1.3)	1.4 - 1.6 (1.5)
	B	1.0 - 1.7 (1.4)	1.4 - 1.9 (1.6)
PHc (µg/l)	1m	3.9 - 9.6 (6.8)	2.0 - 2.2 (2.1)
Sulphate (g/kg)	S	3.0 - 3.0 (3.0)	2.5 - 2.6 (2.5)
	B	2.8 - 2.8 (2.8)	2.3 - 2.4 (2.4)
Chloride (µg/kg)	S	19.9 - 20.0 (19.9)	18.8 - 18.9 (18.8)
	B	20.2 - 20.2 (20.2)	18.9 - 18.9 (18.9)

AT: Air temperature. Values are presented as Min.-Max. (Average).
Ranges are based on sampling done during two different tidal condition ofsea.

Table 2.1.3: Water quality at station 3 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar -2019	Dec -2019
Temperature (°C)	S	25.5 - 28.5 (27)	28.5 - 29.5 (29.0)
	B	25.5 - 27.5 (26.5)	28.5 - 28.5 (28.5)
	AT	26.0 - 30.0 (28)	28.5 - 31.5 (30.0)
pH	S	8.0 - 8.1 (8.0)	8.0 - 8.1 (8.1)
	B	8.0 - 8.2 (8.1)	8.0 - 8.0 (8.0)
SS (mg/l)	S	29 - 37 (33)	26 - 26 (26)
	B	42 - 44 (43)	30 - 73 (51)
Turbidity (NTU)	S	9.6 - 19.7 (14.7)	2 - 3 (3)
	B	11.6 - 22.4 (17.0)	37 - 42 (40)
Salinity (ppt)	S	35.7 - 36.3 (36.0)	34.2 - 34.2 (34.2)
	B	36.2 - 36.3 (36.2)	34.3 - 34.3 (34.3)
DO (mg/l)	S	5.9 - 6.2 (6.0)	5.6 - 6.8 (6.2)
	B	5.4 - 6.0 (5.7)	5.4 - 5.7 (5.6)
BOD (mg/l)	S	3.0 - 4.5 (3.8)	1.5 - 2.9 (2.2)
	B	2.6 - 2.7 (2.6)	0.4 - 0.7 (0.6)
PO_4^{3-}-P (µmol/l)	S	2.1 - 2.4 (2.3)	0.5 - 0.7 (0.6)
	B	2.0 - 2.0 (2.0)	1.0 - 1.3 (1.1)
NO_3^--N (µmol/l)	S	12.4 - 13.3 (12.8)	1.9 - 3.7 (2.8)
	B	10.0 - 13.5 (11.8)	1.0 - 2.6 (1.8)
NO_2^--N (µmol/l)	S	3.1 - 4.5 (3.8)	0.2 - 0.5 (0.3)
	B	2.9 - 3.0 (3.0)	0.9 - 1.1 (1.0)
NH_4^+-N (µmol/l)	S	2.3 - 5.8 (4.0)	0.7 - 1.4 (1.1)
	B	3.0 - 3.8 (3.4)	0.6 - 2.3 (1.4)
PHc (µg/l)	1m	2.0 - 4.2 (3.1)	1.7 - 3.1 (2.4)
Sulphate (g/kg)	S	2.8 - 2.9 (2.8)	2.4 - 2.6 (2.5)
	B	3.1 - 2.9 (3.0)	2.5 - 2.7 (2.6)
Chloride (µg/kg)	S	19.8 - 20.1 (19.9)	18.9 - 18.9 (18.9)
	B	20.0 - 20.1 (20.0)	19.0 - 19.0 (19.0)

AT: Air temperature. Values are presented as Min.-Max. (Average).
Ranges are based on sampling done during two different tidal condition ofsea.

Table 2.1.4: Water quality at station4 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar -2019	Dec -2019
Temperature (°C)	S	28.5	29.0 - 29.5 (29.3)
	B	27.5	28.0 - 28.5 (28.3)
	AT	29.0	29.0 - 31.0 (30.0)
pH	S	8.0	8.0 - 8.1 (8.1)
	B	8.0	8.0 - 8.0 (8.0)
SS (mg/l)	S	16	12 - 27 (20)
	B	32	36 - 43 (40)
Turbidity (NTU)	S	12	5 - 7 (6)
	B	13	9 - 15 (12)
Salinity (ppt)	S	36.3	34.2 - 34.4 (34.3)
	B	36.2	34.3 - 34.4 (34.3)
DO (mg/l)	S	6.4	7.2 - 7.4 (7.3)
	B	5.9	5.7 - 7.4 (6.5)
BOD (mg/l)	S	2.3	3.0 - 3.9 (3.5)
	B	2.9	2.5 - 3.4 (2.9)
PO_4^{3-}-P (µmol/l)	S	1.6	0.4 - 1.1 (0.7)
	B	1.9	1.7 - 1.7 (1.7)
NO_3^--N (µmol/l)	S	10.5	4.0 - 6.9 (5.5)
	B	11.3	5.3 - 7.5 (6.4)
NO_2^--N (µmol/l)	S	2.4	0.8 - 1.1 (0.9)
	B	2.4	1.7 - 2.0 (1.8)
NH_4^+-N (µmol/l)	S	0.5	0.8 - 0.9 (0.8)
	B	0.7	1.0 - 1.2 (1.1)
PHc (µg/l)	1m	3.7	1.7 - 8.0 (4.8)
Sulphate (g/kg)	S	3.0	2.0 - 2.7 (2.3)
	B	2.9	2.4 - 2.5 (2.4)
Chloride (µg/kg)	S	20.1	18.9 - 19.0 (19.0)
	B	20.0	19.0 - 19.0 (19.0)

AT: Air temperature. Values are presented as Min.-Max. (Average).

* Average of two samples collected in duplicate.

** Ranges are based on sampling done during two different tidal condition ofsea.

Table 2.1.5: Water quality at station 5 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar-2019	Dec-2019
Temperature (°C)	S	26.5 -28.5 (27.5)	28.0 - 29.0 (28.5)
	B	26.5 - 28.0 (27.3)	26.5 -28.5 (27.5)
	AT	27.0 - 31.0 (29.0)	29.5 - 30.5 (30.0)
pH	S	8.0 - 8.1 (8.0)	7.9 - 8.0 (7.9)
	B	8.0 - 8.1 (8.0)	7.9 - 8.0 (8.0)
SS (mg/l)	S	18 - 29 (23)	22 - 25 (23)
	B	38 - 63 (51)	23 - 37 (30)
Turbidity (NTU)	S	8.1 - 10.1 (9.1)	4 - 7 (5)
	B	16.3 - 17.8 (17.1)	18 - 19 (18)
Salinity (ppt)	S	36.3 - 36.3 (36.3)	34.2 - 34.5 (34.3)
	B	36.3 - 36.4 (36.3)	34.4 - 34.5 (34.4)
DO (mg/l)	S	5.9 - 6.8 (6.4)	5.8 - 7.0 (6.4)
	B	5.9 - 6.5 (6.2)	5.2 - 5.8 (5.5)
BOD (mg/l)	S	2.0 - 3.0 (2.5)	3 - 3.3 (3.1)
	B	2.3 - 2.9 (2.6)	1.2 - 2.0 (1.6)
PO_4^{3-}-P (µmol/l)	S	0.4 - 1.9 (1.1)	0.9 - 1.9 (1.4)
	B	1.2 - 2.3 (1.7)	1.7 - 1.9 (1.8)
NO_3^--N (µmol/l)	S	8.3 - 10.5 (9.4)	5.7 - 12 (8.8)
	B	7.5 - 11.2 (9.4)	5.7 - 7.9 (6.8)
NO_2^--N (µmol/l)	S	1.8 - 2.8 (2.3)	1.3 - 1.8 (1.6)
	B	1.5 - 2.2 (1.9)	1.4 - 1.5 (1.5)
NH_4^+-N (µmol/l)	S	0.7 - 2.1 (1.4)	0.8 - 1.0 (0.9)
	B	0.8 - 1.2 (1.0)	0.8 - 1.1 (0.9)
PHc (µg/l)	1m	2.7 - 2.3 (2.5)	3.0 - 3.1 (3.0)
Sulphate (g/kg)	S	3.0 - 3.0 (3.0)	2.6 - 2.7 (2.7)
	B	2.9 - 3.0 (2.9)	2.6 - 2.8 (2.7)
Chloride (µg/kg)	S	20.1 - 20.1 (20.1)	18.9 - 19.1 (19.0)
	B	20.1 - 20.1 (20.1)	19.0 - 19.1 (19.1)

AT: Air temperature. Values are presented as Min.-Max. (Average).
Ranges are based on sampling done during two different tidal condition ofsea.

Table 2.1.6: Water quality at station 6 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar-2019	Dec-2019
Temperature (°C)	S	26.5	27.0
	B	26.0	26.5
	AT	27.5	27.0
pH	S	8.1	7.9
	B	8.1	8.0
SS (mg/l)	S	34	20
	B	36	41
Turbidity (NTU)	S	3	5
	B	2	22
Salinity (ppt)	S	36.5	34.0
	B	36.5	34.5
DO (mg/l)	S	6.2	6.1
	B	6.1	3.9
BOD (mg/l)	S	2.3	4.7
	B	1.3	1.8
PO_4^{3-}-P (µmol/l)	S	1.0	1.1
	B	1.0	1.2
NO_3^--N (µmol/l)	S	1.2	4.1
	B	0.2	5.9
NO_2^--N (µmol/l)	S	0.7	1.2
	B	0.3	1.0
NH_4^+-N (µmol/l)	S	1.8	0.4
	B	2.1	1.3
PHc (µg/l)	1m	2.7	3.6
Sulphate (g/kg)	S	2.9	2.3
	B	2.9	2.6
Chloride (µg/kg)	S	20.2	18.8
	B	20.2	19.1

AT: Air temperature. * Average of two samples collected in duplicate.

Table 2.1.7: Water quality at station 7 in the coastal waters off Mumbai during different periods.

Parameter	Level	Mar-2019	Dec-2019
Temperature (°C)	S	29.0	28.5
	B	28.5	28.0
	AT	31.0	30.0
pH	S	8.1	7.8
	B	8.1	7.7
SS (mg/l)	S	34	42
	B	39	49
Turbidity (NTU)	S	1	3
	B	4	18
Salinity (ppt)	S	36.4	34.0
	B	36.4	34.5
DO (mg/l)	S	6.6	7.5
	B	6.2	5.5
BOD (mg/l)	S	1.2	4.0
	B	2.9	2.2
PO_4^{3-}-P (µmol/l)	S	1.4	1.7
	B	1.7	1.3
NO_3^--N (µmol/l)	S	8.7	1.8
	B	7.1	4.2
NO_2^--N (µmol/l)	S	3.4	0.5
	B	2.9	0.5
NH_4^+-N (µmol/l)	S	1.3	1.1
	B	1.0	0.9
PHc (µg/l)	1m	3.4	2.1
Sulphate (g/kg)	S	3.1	2.5
	B	2.9	2.7
Chloride (µg/kg)	S	20.2	18.8
	B	20.1	19.1

AT: Air temperature. * Average of two samples collected in duplicate.

Table 2.1.8: Water quality at station 8 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar-2019	Dec-2019
Temperature (°C)	S	27.5	29.0
	B	26.5	28.5
	AT	29.0	31.0
Ph	S	8.1	8.0
	B	8.2	8.0
SS (mg/l)	S	24	24
	B	29	66
Turbidity (NTU)	S	2	4
	B	4	33
Salinity (ppt)	S	35.9	34.2
	B	36.4	34.3
DO (mg/l)	S	6.8	6.4
	B	6.2	4.9
BOD (mg/l)	S	3.9	0.9
	B	2.8	1.1
PO_4^{3-}-P (µmol/l)	S	1.9	0.8
	B	1.4	1.1
NO_3^--N (µmol/l)	S	13.5	0.7
	B	8.2	1.3
NO_2^--N (µmol/l)	S	4.0	0.4
	B	2.5	0.7
NH_4^+-N (µmol/l)	S	5.8	1.5
	B	3.0	1.0
PHc (µg/l)	1m	3.3	3.2
Sulphate (g/kg)	S	2.8	2.5
	B	2.8	2.5
Chloride (µg/kg)	S	19.9	18.9
	B	20.2	19.0

AT: Air temperature. * Average of two samples collected in duplicate.

Table 2.1.9: Water quality at station 9 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar-2019	Dec-2019
Temperature (°C)	S	28.5	29.5
	B	27.0	29.0
	AT	31.0	31.5
pH	S	8.1	8.0
	B	8.2	8.0
SS (mg/l)	S	14	39
	B	28	51
Turbidity (NTU)	S	6	5
	B	7	18
Salinity (ppt)	S	36.3	34.6
	B	36.5	34.6
DO (mg/l)	S	7.1	7.5
	B	6.9	6.5
BOD (mg/l)	S	3.2	2.9
	B	3.2	1.7
PO_4^{3-}-P (µmol/l)	S	0.9	0.7
	B	2.2	1.0
NO_3^--N (µmol/l)	S	7.3	1.4
	B	6.0	2.0
NO_2^--N (µmol/l)	S	1.5	0.4
	B	0.9	0.7
NH_4^+-N (µmol/l)	S	1.4	0.6
	B	1.7	0.8
PHc (µg/l)	1m	3.5	3.1
Sulphate (g/kg)	S	2.8	2.5
	B	2.8	2.5
Chloride (µg/kg)	S	20.1	19.1
	B	20.2	19.2

AT: Air temperature. * Average of two samples collected in duplicate.

Table 2.1.10: Water quality at station 10 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar-2019	Dec-2019
Temperature (°C)	S	26.5	26.5
	B	25.5	26.0
	AT	27.0	26.0
pH	S	8.1	7.9
	B	8.4	7.9
SS (mg/l)	S	31	25
	B	32	94
Turbidity (NTU)	S	2	5
	B	2	50
Salinity (ppt)	S	36.5	34.4
	B	36.6	34.9
DO (mg/l)	S	7.7	5.2
	B	7.5	3.1
BOD (mg/l)	S	4.5	3.5
	B	4.3	1.0
PO_4^{3-}-P (µmol/l)	S	0.7	0.4
	B	0.8	1.5
NO_3^--N (µmol/l)	S	0.2	2.5
	B	0.2	4.5
NO_2^--N (µmol/l)	S	0.1	0.7
	B	0.0	0.8
NH_4^+-N (µmol/l)	S	2.2	0.3
	B	0.9	2.1
PHc (µg/l)	1m	3.1	1.6
Sulphate (g/kg)	S	2.9	2.5
	B	2.9	2.6
Chloride (µg/kg)	S	20.2	19.0
	B	20.2	19.3

AT: Air temperature. * Average of two samples collected in duplicate.

Table 2.1.11: Water quality at station 11 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar-2019	Dec-2019
Temperature (°C)	S	29.0	29.5
	B	28.5	28.5
	AT	31.0	32.0
pH	S	8.1	7.8
	B	8.1	7.7
SS (mg/l)	S	34	7
	B	39	75
Turbidity (NTU)	S	1	2
	B	4	55
Salinity (ppt)	S	36.4	34.2
	B	36.4	34.8
DO (mg/l)	S	6.6	4.9
	B	6.2	5.0
BOD (mg/l)	S	1.2	2.7
	B	2.9	1.7
PO_4^{3-}-P (µmol/l)	S	1.4	0.3
	B	1.7	2.0
NO_3^--N (µmol/l)	S	8.7	1.9
	B	7.1	3.7
NO_2^--N (µmol/l)	S	3.4	0.4
	B	2.9	0.5
NH_4^+-N (µmol/l)	S	1.3	2.1
	B	1.0	1.4
PHc (µg/l)	1m	3.4	1.6
Sulphate (g/kg)	S	3.1	2.5
	B	2.9	2.6
Chloride (µg/kg)	S	20.2	18.9
	B	20.1	19.3

AT: Air temperature. * Average of two samples collected in duplicate.

Table 2.1.12: Water quality at station 12 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar-2019	Dec-2019
Temperature (°C)	S	27.0	29.0
	B	26.0	28.0
	AT	29.0	29.0
pH	S	8.1	8.0
	B	8.1	8.0
SS (mg/l)	S	9	24
	B	10	27
Turbidity (NTU)	S	3	3
	B	2	16
Salinity (ppt)	S	36.4	34.3
	B	36.4	34.7
DO (mg/l)	S	7.0	6.6
	B	6.4	5.3
BOD (mg/l)	S	3.1	1.2
	B	2.0	0.3
PO_4^{3-}-P (µmol/l)	S	0.9	0.8
	B	1.0	0.7
NO_3^--N (µmol/l)	S	4.3	2.0
	B	3.0	3.2
NO_2^--N (µmol/l)	S	2.7	0.3
	B	0.3	0.8
NH_4^+-N (µmol/l)	S	1.6	1.2
	B	0.9	0.8
PHc (µg/l)	1m	1.6	1.5
Sulphate (g/kg)	S	2.9	2.6
	B	2.9	2.6
Chloride (µg/kg)	S	19.9	19.0
	B	20.2	19.2

AT: Air temperature. * Average of two samples collected in duplicate.

Table 2.1.13: Water quality at station 13 in the coastal waters off Mumbai during different periods.

Parameters	Level	Mar-2019	Dec-2019
Temperature (°C)	S	28.0	29.0
	B	27.5	28.5
	AT	30.0	29.5
pH	S	8.1	8.1
	B	8.1	8.0
SS (mg/l)	S	17	29
	B	25	35
Turbidity (NTU)	S	2	3
	B	5	10
Salinity (ppt)	S	36.5	34.3
	B	36.4	35.0
DO (mg/l)	S	7.2	6.8
	B	6.7	6.1
BOD (mg/l)	S	3.0	2.4
	B	2.1	2.2
PO_4^{3-}-P (µmol/l)	S	0.6	0.5
	B	1.0	0.9
NO_3^--N (µmol/l)	S	2.1	2.1
	B	1.0	1.7
NO_2^--N (µmol/l)	S	0.2	0.2
	B	0.3	0.7
NH_4^+-N (µmol/l)	S	1.3	1.0
	B	1.6	0.5
PHc (µg/l)	1m	1.6	1.4
Sulphate (g/kg)	S	2.9	2.7
	B	3.0	2.5
Chloride (µg/kg)	S	20.2	19.0
	B	20.1	19.4

AT: Air temperature. * Average of two samples collected in duplicate

Table 2.2.1: Sediment quality in the coastal waters off Mumbai during different periods.

Station Code	Period	Sand (%)	Silt (%)	Clay (%)	Al (%)	Cr (µg/g)	Mn (µg/g)	Fe (%)	Co (µg/g)	Ni (µg/g)	Cu (µg/g)	Zn (µg/g)	Hg (µg/g)	C_{org} (%)	P (µg/g)	PHc* (µg/g)
1	Mar-19	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	Dec-19	0.5	50.0	49.0	7.6	153	925	8.5	35	65	111	98	0.20	1.4	1997	1.9
2	Mar-19	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	Dec-19	0.6	84.0	16.0	7.2	156	951	8.4	35	62	119	114	0.20	1.8	1072	1.5
3	Mar-19	1.0	91.8	7.2	7.6	116	807	8.8	28	59	87	105	0.35	1.5	1274	1.5
	Dec-19	0.1	40.0	60.0	7.4	146	894	8.2	33	63	106	106	0.20	1.5	1084	0.8
4	Mar-19	7.5	82.1	10.4	6.7	93	1260	8.0	23	52	78	94	0.33	1.6	1171	0.1
	Dec-19	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
5	Mar-19	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	Dec-19	1.2	80.0	18.0	7.4	152	990	8.3	34	63	114	107	0.10	1.7	1128	6.0
6	Mar-19	0.6	94.0	5.5	7.1	104	730	8.3	26	56	79	87	0.32	1.4	1109	2.5
	Dec-19	0.2	91.0	9.0	7.1	144	954	8.0	32	60	115	109	0.20	1.9	1109	0.5
7	Mar-19	19.8	57.3	22.9	6.8	150	650	8.0	30	65	92	190	0.18	0.2	1866	1.5
	Dec-19	1.1	50.0	49.0	7.1	163	1022	8.5	37	62	122	114	0.20	1.7	1060	1.2
8	Mar-19	1.3	88.4	10.3	7.2	109	769	8.4	27	56	78	94	0.24	1.3	1059	1.9
	Dec-19	0.1	46.0	54.0	7.5	156	980	8.4	36	64	118	110	0.10	1.8	1251	2.1
9	Mar-19	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
	Dec-19	0.3	59.0	40.0	7.2	150	963	8.2	35	62	109	100	0.20	1.9	1071	1.0
10	Mar-19	7.8	86.2	6.0	7.4	102	883	8.6	25	56	84	91	0.30	1.4	1095	2.1
	Dec-19	0.1	57.0	43.0	7.1	144	939	8.0	33	60	111	101	0.10	1.6	1057	0.2
11	Mar-19	10.5	74.8	14.7	7.0	168	682	8..4	38	78	108	164	0.16	1.2	1848	0.1
	Dec-19	0.2	50.0	50.0	6.3	138	814	7.2	30	54	96	86	0.20	1.7	903	0.3
12	Mar-19	0.7	62.6	36.7	7.0	103	797	8.4	26	54	76	87	0.22	1.4	1155	0.6
	Dec-19	0.2	75.0	24.0	7.3	154	930	8.3	34	64	107	95	0.10	1.6	1109	0.2
13	Mar-19	0.7	90.8	8.4	6.7	96	748	8.0	24	53	74	84	0.24	1.7	1107	0.1
	Dec-19	18.1	68.0	14.0	5.5	181	1035	8.6	40	65	97	90	0.20	1.8	882	0.4

NC: No collection; *wet weight

2.3 Biological characteristics

Evaluation of the biological components of an ecosystem is integral to any environmental monitoring study as the consequences of any fluctuation in physico-chemical parameters is eventually on the biotic components. The important natural factors which influence fauna in coastal areas are tides, currents, freshwater flow, water quality and sediment characteristics. Faunal components in coastal waters are highly diverse inhabiting a variety of ecosystems. The basic process in an aquatic ecosystem is the production of organic carbon by photosynthesis. The anthropogenic stress may cause the communities to exhibit low biomass and high metabolism. In addition, due to depressed functions of less tolerant predators, there may be also a significant increase of dead organic matter deposited in sediments of ecosystems modified under stress. Depending upon the type, strength and extent of a stress factor, the ecosystem will react to either re-establish the previous equilibrium or establish a new one, or it may remain in prolonged disequilibrium.

Important biological parameters which are considered for assessment in the present study are bacterial counts; phytoplankton pigments, cell counts and generic diversity; zooplankton biomass, density and group diversity; macrobenthic and meiobenthic biomass, density and group diversity. The first three reflect the productivity of water column at the primary and the secondary levels. Benthic organisms being sedentary animals associated with the seabed, provide information regarding the integrated effects of stress, if any, and hence are good indicators of early warning of potential damage. A collective evaluation of all the above components is a reliable approach to predict the state of equilibrium of aquatic life of coastal area off the study area. The results are given in Tables 2.3.1- 2.3.24.

2.3.1 Microbial studies

Microbial ecology is on the forefront of developing and applying a new generation of indicators of environmental stress and ecological change. The roles played by marine microorganisms are profound in the overall normal functioning, stability and continuance of the marine ecological processes. Despite their small size marine micro-organisms are far more important as they are linked to water column and sediment (benthic) processes. Marine microorganisms occupy the base of the food web, and form food for protozoa, invertebrate larvae and many large zooplankton and regenerate dissolved nutrients for marine photosynthesis and formation of newer organic biomass. Bacteria are major links to many biological and non-biological events in the oceans. In order to bring into focus the importance of marine bacteria at base of the food web, an assessment of their abundance and distribution are essential. The microbial diversity of coastal waters can be influenced by anthropogenic activities also besides oceanic processes.

Coliform bacteria such as *Escherichia coli* and Faecal streptococci (Genus: *Streptococcus*) are the two most important groups of non-pathogenic bacteria found in sewage. Because of number of problems associated with the determination of populations of individual pathogens, non-pathogenic bacteria (such as coliforms) are used as indicators of water pollution. Untreated domestic waste-water has about 3 million coliforms/100 ml. Because pathogens originate from the same source, the presence of high numbers of coliforms indicates potential danger. Bacteriological analyses for present study included the enumeration of total viable bacterial counts (TVC) and coliforms at 13 stations in the coastal waters off Mumbai. Total Viable Counts (TVC), Total Coliform (TC), Faecal Coliforms (FC), *Escherichia coli* like organisms (ECLO) and *Streptococcus faecalis* like Organism (SFLO) were studied. The microbiological results for water and sediments are given in Tables 2.3.1-2.3.4.

a) Water

The average TVC at different stations was in the range of 10 x 10^3 – 960 x 10^3 CFU/ml during March 2019 and 10 x 10^3 – 80 x 10^3 CFU/ml during December 2019 (Table 2.3.1-2.3.2). TVC was particularly high in the vertical transect off Haji Ali. The total coliforms (TC) were observed at 1 and 3 km zones and was completely absent at 8 km zone during March 2019. During December 2019, TC was observed at all zones. Pathogenic bacteria like ECLO, SFLO were completely absent at 8 km distance during both sampling periods. Their presence at 1 and 3 km zones could be due to the influence of nearshore seawater. Fecal coliforms (FC) were comparatively higher during December 2019 as compared to March 2019 and was found at all the three zones with high counts at 1 km distance. In March 2019, FC was observed only at 1 and 3 km zones(Table 1 & 2). The comparative average values of microbial counts at the three zones during March and December 2019 are presented in Figure 2.3.1

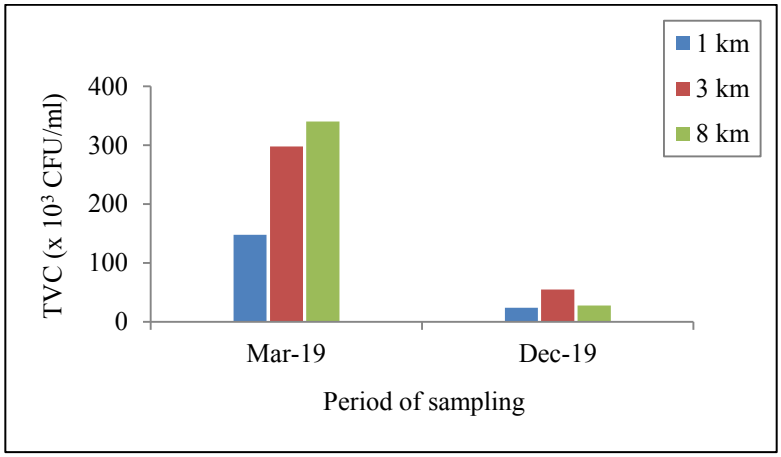


Figure 2.3.1: TVC counts in the coastal waters off Mumbai during March and December 2019.

The microbial study demonstrated that the average Total Viable Count (TVC) of bacteria was high at all the three transects with an increasing trend towards offshore during March 2019. whereas during December 2019, TVC showed 3 to 7 times lesser count at all the three transects (Figure 2.3.1).

b) Sediment

The average TVC counts in the sediments off Mumbai ranged from 10 x 10^4 to 520 x 10^4 CFU/g during March 2019 and 10 x 10^4 – 110 x 10^4 CFU/g during December 2019 (Table 2.3.3 -2.3.4). TC, FC, ECLO and SFLO were completely absent in the sediments of the study region. The comparative TVC in coastal sediments of the three zones during March and December 2019 are presented in Figure 2.3.2.

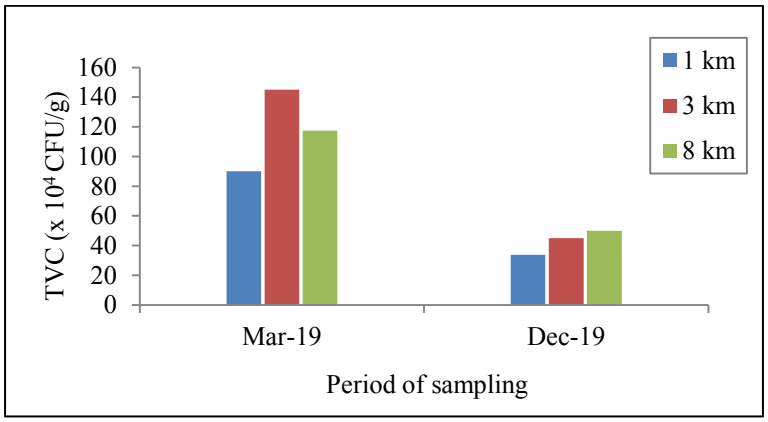


Figure 2.3.2: TVC counts in the coastal waters off Mumbai during March and December 2019.

The average TVC counts in sediments were higher at 3 km zone during March 2019 whereas in December 2019 the values were higher at the 8 km zone. Also, the average TVC counts during December 2019 were found to be 2-3 fold lower at all the three transects (Figure 2.3.2).

Table 2.3.1: Microbial counts in the coastal waters (CFU/ml) off Mumbai during March 2019

Type of Bacteria	**1**		**2**		**3**		**4**	**5**		**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
	1 km									**3 km**				**8 km**			
Tide	Ebb	Fld	Ebb	Fld	Ebb	Fld	Spot	Ebb	Fld	Spot	Spot	Spot	Spot	Spot	Spot	Spot	Spot
TVC $x10^3$	20	30	620	190	270	110	10	60	20	80	960	30	120	130	550	650	30
TC	NG	NG	80	NG	100	NG	NG	NG	NG	NG	NG	100	NG	NG	NG	NG	NG
FC	NG	NG	50	NG	20	NG	NG	NG	NG	NG	NG	20	NG	NG	NG	NG	NG
ECLO	NG	NG	10	NG	10	NG	NG	NG	NG	NG	NG	20	NG	NG	NG	NG	NG
SFLO	NG	NG	50	NG	20	NG	NG	10	NG	NG	NG	30	NG	NG	NG	NG	NG

Table 2.3.2: Microbial counts in the coastal waters (CFU/ml) off Mumbai during December 2019

Type of Bacteria	**1**		**2**		**3**		**4**		**5**		**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
	1 km										**3 km**				**8 km**			
Tide	Ebb	Fld	Ebb	Fld	Ebb	Fld	Ebb	Fld	Ebb	Fld	Spot	Spot	Spot	Spot	Spot	Spot	Spot	Spot
TVC $x10^3$	10	20	50	20	40	20	80	50	50	60	50	20	10	10	10	30	60	20
TC	NG	NG	NG	NG	10	110	NG	NG	NG	NG	NG	NG	50	NG	NG	NG	20	NG
FC	NG	NG	NG	NG	90	130	NG	NG	NG	NG	NG	NG	20	NG	NG	NG	10	NG
ECLO	NG	NG	NG	NG	10	120	NG	NG	NG	NG	NG	NG	10	NG	NG	NG	10	NG
SFLO	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG

Table 2.3.3: Microbial counts in sediments (CFU/g) in the coastal waters off Mumbai during March 2019

Type of bacteria	1	2	3	4	5	6	7	8	9	10	11	12	13
	1 km					3 km				8 km			
TVC x10^4	No collection	No collection	40	140	No collection	**40**	520	20	No collection	10	360	60	40
TC			NG	NG		NG	NG	NG		NG	NG	NG	NG
FC			NG	NG		NG	NG	NG		NG	NG	NG	NG
ECLO			NG	NG		NG	NG	NG		NG	NG	NG	NG
SFLO			NG	NG		NG	NG	NG		NG	NG	NG	NG

Table 2.3.4: Microbial counts in sediments (CFU/g) in the coastal waters off Mumbai during December 2019

Type of bacteria	1	2	3	4	5	6	7	8	9	10	11	12	13
	1 km					3 km				8 km			
TVC x10^4	20	40	50	No collection	10	20	40	110	50	30	30	40	10
TC	NG	NG	NG		NG	NG	NG	NG	NG	NG	NG	NG	NG
FC	NG	NG	NG		NG	NG	NG	NG	NG	NG	NG	NG	NG
ECLO	NG	NG	NG		NG	NG	NG	NG	NG	NG	NG	NG	NG
SFLO	NG	NG	NG		NG	NG	NG	NG	NG	NG	NG	NG	NG

2.3.2 Phytoplankton

Phytoplankton are a variety of microscopic plants passively drifting in natural waters and mostly confined to the illuminated zone. In an ecosystem these organisms constitute primary producers forming the first link in the food chain by synthesizing organic carbon using inorganic nutrients, carbon dioxide and sunlight in the marine environment. Because of their short life cycles, phytoplankton responds quickly to environmental changes. Hence their standing crop in terms of biomass, cell counts and species composition are more likely to indicate the quality of the water mass in which they are found. A normal ecosystem with a natural balance between different trophic levels viz. primary, secondary and tertiary productions gets disturbed and imbalanced of its food chain due to anthropogenic pollutants. Generally, phytoplankton standing crop is studied in terms of biomass by estimating chlorophyll *a* and primary productivity and in terms of population by counting total number of cells and their generic composition. When under stress or at the end of their life cycle, chlorophyll in phytoplankton decomposes with phaeophytin as one of the major products. The range and average of phytopigments in coastal waters off Mumbai are given in Tables 2.3.3-2.3.4.

a. Phytoplankton biomass

Chlorophyll *a* in the study region ranged between 1.2-13.5 mg/m^3 (av. 4.4 mg/m^3) during March 2019 and 0.6 -9.1 mg/m^3 (av. 3.3 mg/m^3) during December 2019 (Table 2.3.5- 2.3.6). Chlorophyll *a* in surface and bottom waters were ranged at 1.5 -13.5 mg/m^3 (av. 4.9 mg/m^3) and 1.2 - 8.1 mg/m^3 (av. 3.7mg/m^3) respectively during March 2019. Similarly, chlorophyll *a* in the surface and bottom water were ranged at 1.1 - 9.1mg/m^3 (av. 4.3 mg/m^3) and 0.6 -9.0 mg/m^3 (av. 2.3 mg/m^3) respectively during December 2019. Phaeophytin in the study region ranged between 0.2-1.7 mg/m^3 (av. 0.6 mg/m^3) during March 2019 and 0.2 -1.9 mg/m^3 (av. 1.8 mg/m^3) during December 2019. Phaeophytin in the surface and bottom waters were ranged at 0.2-1.4 mg/m^3 (av. 0.6 mg/m^3) and 0.3– 1.7 mg/m^3 (av. 0.7 mg/m^3) respectively during March 2019. Similarly, phaeophytin in the surface and bottom waters were ranged at 0.2– 1.7 mg/m^3 (av. 0.8 mg/m^3) and 0.3 -1.9 mg/m^3 (av. 1.0 mg/m^3) respectively during December 2019. The average values of chlorophyll *a* across the three zones during March and April 2019 are presented in Figure 2.3.3.

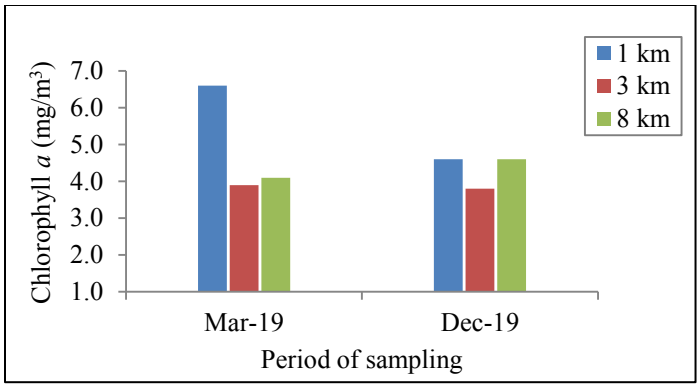


Figure 2.3.3: Chlorophyll *a* distribution in the coastal waters off Mumbai during March and December 2019.

The above figure revealed that chlorophyll *a* was found to be highest at the 1 km zone compared to 3 and 8 km zones during March 2019. The enhanced concentration of chlorophyll *a* at 1 km zone (March 2019) could be probably because the area received nutrients from the nearshore waters. On the other hand, chlorophyll *a* during December 2019 was relatively less at 1 km stretch. The lower chlorophyll *a* concentrations at the 1 km zone in December 2019 could be attributed to the seasonal variation, additionally it could also be due to the difference in phytoplankton taxa. The chlorophyll *a* concentration was comparable at the 3 and 8 km zones during both sampling periods. The chlorophyll *a*: phaeophytin ration which indicates the health of the phytoplankton cells revealed that the cells were not under any kind stress as the ratio was >1 at all stations (Table 2.3.5- 2.3.6).

Impact of tidal variation on chlorophyll *a* was also studied along the 1 km stretches of coastal waters of Mumbai (Figure 2.3.4). The tidal variation in chlorophyll *a* showed that station 1 had high chlorophyll *a* during full ebb (F.Ebb), whereas at station 3 contribution of chlorophyll *a* was more during the full flood (F.Fld). Least tidal variability in chlorophyll *a* was observed at station 5 during both the sampling periods (March and December 2019) (Figure 2.3.4). Enhanced chlorophyll *a* during full flood could be probably due to the contribution from coastal waters and during full ebb period it could be due to re-suspension.

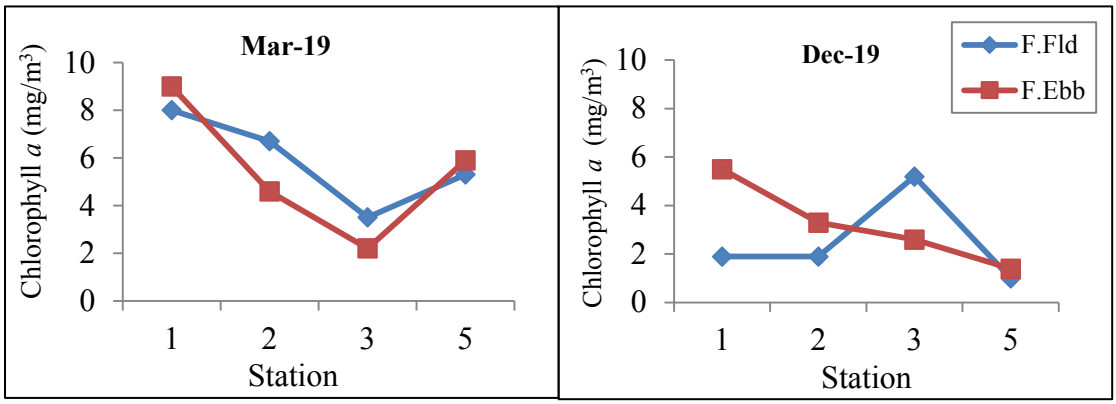


Figure 2.3.4: Tidal variation in the chlorophyll *a* distribution in the coastal waters off Mumbai during March and December 2019.

Phytoplankton cell count (population) and total genera from 1 to 8 km stretch were studied during March and December 2019. Phytoplankton cell count in the study region ranged between 60.4 – 4232.0 x 10^3 cells/ l (av. 11195.6x 10^3 cells/ l) during March 2019 and 33.0 – 456.0 x 10^3 cells/ l (av. 153.9x10^3 cells/ l) during December 2019 (Table 2.3.7-2.3.8). Phytoplankton cell count in surface and bottom water were ranged at 86.2 – 3975.4 x 10^3 cells/ l (av. 1375.9 x 10^3 cells/ l) and 60.4 – 4232.0 x 10^3 cells/ l (av. 1015.3 x 10^3 cells/ l) respectively during March 2019. Similarly, phytoplankton cell count in surface and bottom waters ranged at 43.0 – 456.0 x 10^3 cells/ l (av. 185.9 x 10^3 cells/ l) and 33.0 – 241.0 x 10^3 cells/ l (av. 122.1 x 10^3 cells/ l) during December 2019 (Table 2.3.7- 2.3.8). The average phytoplankton counts of the three zones during March and April 2019 are presented in Figure 2.3.5

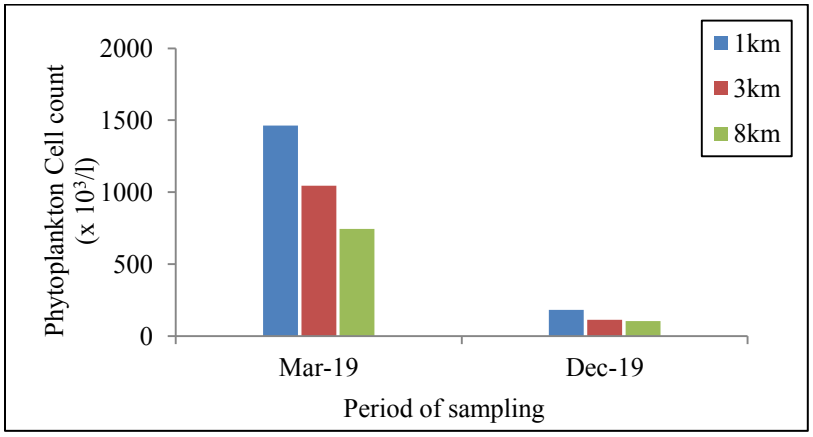


Figure 2.3.5: Phytoplankton cell count distribution in the coastal waters off Mumbai during March and December 2019

The above figure indicated that the phytoplankton cell counts were higher in the 1 km zone and also the cell densities were found to be 4 to 7 fold lower during December 2019 when compared to March 2019. Impact of tidal variation on phytoplankton cell count was studied along the 1 km stretch of coastal waters of Mumbai (Figure. 2.3.6).

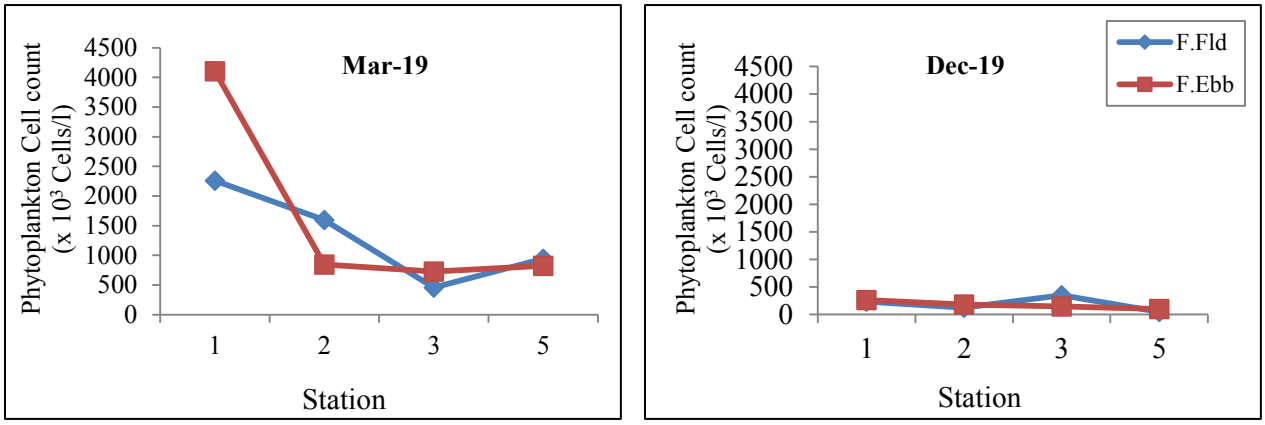


Figure 2.3.6: Tidal variation in chlorophyll *a* distribution in the coastal waters off Mumbai during March and December 2019

The tidal variation in phytoplankton cell count showed that station 1 was with high cell count during full ebb (F.Ebb) during March 2019, while during December 2019 impact of tidal variability on phytoplankton cell count was least.

Phytoplankton genera (no) in the study region varied considerably in a range of 6 – 20 (av. 12) during March 2019 and 8 – 22 (av. 15) during December 2019. Phytoplankton genera (no) in surface and bottom waters were ranged at 6 – 20 (av. 13) and 6 – 20 (av. 12) respectively during March 2019 (Table 2.3.7-2.3.10). Similarly, phytoplankton genera (no) in surface and bottom water ranged at 8 – 22 (av. 17) and 8 – 22 (av. 14) during December 2019.

During March 2019, a total of 46 nos. of phytoplankton species were encountered with diatoms as the major class followed by dinoflagellates. The distribution of phytoplankton species was in the order of: *Thalassiosira subtilis>Skeletonema costatum>Chaetoceros lorenzianus>Dactyliosolen fragilissimus>Thalassionema nitzschioides>Psuedo-nitzschia seriata*(Table 2.3.9). During December 2019, total 61 nos. of phytoplankton species were encountered with diatoms as the major class followed by dinoflagellates. During December 2019, difference in phytoplankton species arrangement was found and was in the order of: *Skeletonema costatum>Rhizosolenia setigera>Nitzschia* sp.*>Thalassiosira* sp.*>Cylindrotheca closterium>Asterionellopsis glacialis* (Table 2.3.10). The only common species was *Skeletonema costatum* in both the sampling periods. The difference in floral distribution could be one of the

reasons for low chlorophyll *a* during December 2019. The comparative account of phytoplankton genera during March and December 2019 is presented in Figure 2.3.7.

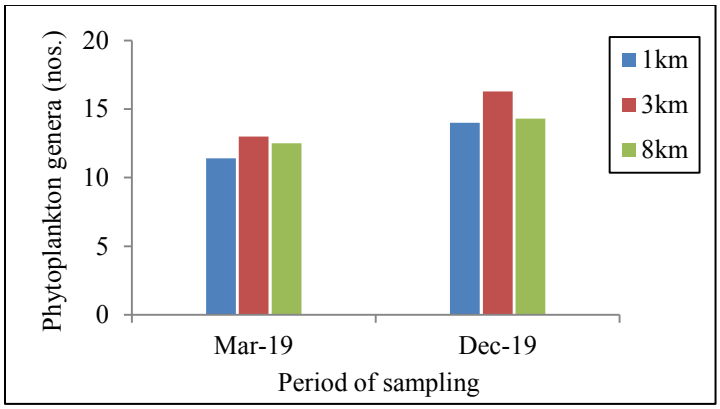


Figure 2.3.7: Phytoplankton total genera distribution in the coastal waters off Mumbai during March and December 2019

As can be seen from the above figure, phytoplankton genera remained more or less the same during both the sampling periods. The Shannon-Wiener diversity index was calculated for both the sampling period (March and December 2019) and are presented in Figure 2.3.8.

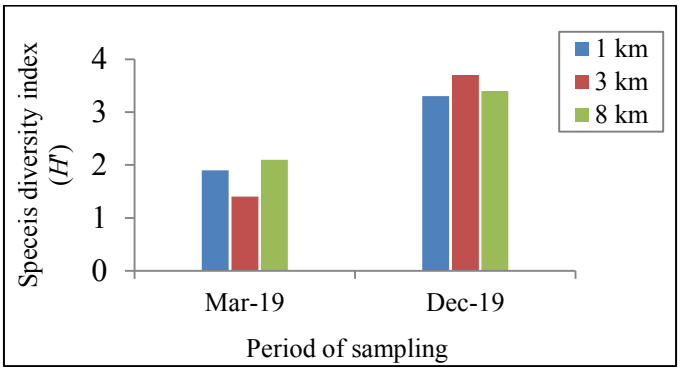


Figure 2.3.8: Phytoplankton species diversity index in the coastal waters off Mumbai during March and December 2019

The diversity index *H'* was almost comparable between the zones during both periods. The counts were relatively higherduring December 2019 observation as compared to March 2019.

Table 2.3.5: Range and average (parenthesis) of phytopigments in the coastal waters off Mumbai during March 2019.

Station	Distance	Chlorophyll				Phaeophytin				Ratio			
		S		B		S		B		S		B	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1	**1 km**	9.9-13.5 (11.7)		2.5-8.1 (5.3)		1.0-1.4 (1.2)		0.5-0.9 (0.7)		9.6-9.8 (9.7)		4.7-9.3 (7.0)	
2		3.9-9.0 (6.4)		4.4-5.3 (4.9)		0.5-1.0 (0.7)		0.6-1.7 (1.1)		8.0-9.3 (8.6)		3.2-8.1 (5.6)	
3		1.5-3.4 (2.5)		2.8-3.5 (3.2)		0.6-1.2 (0.9)		0.7-1.0 (0.8)		1.3-5.8 (3.6)		3.7-3.9 (3.8)	
4		5.2-6.2 (5.7)		4.2-5.4 (4.8)		0.7-0.8 (0.7)		0.7-0.9 (0.8)		7.4-7.8 (7.6)		6.4-6.4 (6.4)	
5		6.4-7.0 (6.7)		4.3-4.8 (4.5)		0.6-0.8 (0.7)		1.2-1.3 (1.2)		9.3-10.0 (9.6)		3.5-3.8 (3.7)	
6	**3 km**	3.5-3.7 (3.6)		3.8-4.4 (4.1)		0.4-0.4 (0.4)		0.4-0.5 (0.4)		9.5-9.9 (9.7)		8.6-9.7 (9.2)	
7		4.3-4.5 (4.4)		7.5-7.7 (7.6)		0.6-0.6 (0.6)		0.8-0.8 (0.8)		7.7-7.7 (7.7)		9.7-9.9 (9.8)	
8		1.9-2.2 (2.1)		2.6-2.6 (2.6)		0.2-0.2 (0.2)		0.3-0.4 (0.4)		8.8-9.3 (9.0)		7.1-8.0 (7.5)	
9		5.4-5.5 (5.5)		2.9-3.1 (3.0)		0.6-0.6 (0.6)		1.1-1.4 (1.3)		9.2-9.4 (9.3)		2.0-2.8 (2.4)	
10	**8 km**	3.0-3.2 (3.1)		3.3-3.4 (3.3)		0.4-0.4 (0.4)		0.4-0.4 (0.4)		7.3-7.6 (7.5)		7.7-8.0 (7.9)	
11		7.8-8.4 (8.1)		1.2-1.2 (1.2)		0.8-0.9 (0.8)		0.3-0.3 (0.3)		9.4-9.8 (9.6)		4.0-4.9 (4.5)	
12		2.6-2.6 (2.6)		1.5-1.6 (1.6)		0.3-0.3 (0.3)		0.4-0.4 (0.4)		9.6-9.7 (9.6)		4.1-4.1 (4.1)	
13		2.5-2.6 (2.5)		2.5-2.6 (2.6)		0.3-0.3 (0.3)		0.6-0.7 (0.7)		8.6-8.8 (8.7)		3.6-4.0 (3.8)	

Table 2.3.6: Range and average (parenthesis) of phytopigments in the coastal waters off Mumbai during December 2019.

Station	Date	Chlorophyll *a*				Phaeophytin				Ratio			
		S		B		S		B		S		B	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1	**1 km**	1.9-9.1 (5.5)		1.9-1.9 (1.9)		0.7-1.0 (0.8)		0.7-1.2 (1.0)		2.7-9.5 (6.1)		1.6-2.5 (2.0)	
2		1.6-2.9 (2.3)		2.3-3.8 (3.0)		0.3-0.6 (0.5)		1.0-1.2 (1.1)		4.6-5.1 (4.8)		2.2-3.1 (2.7)	
3		3.3-8.9 (6.1)		1.5-2.0 (1.7)		0.3-0.9 (0.6)		0.8-1.1 (0.9)		9.6-10.4 (10.0)		1.3-2.5 (1.9)	
4		7.5-8.3 (7.9)		5.5-9.0 (7.2)		1.4-1.7 (1.6)		1.4-1.4 (1.4)		5.0-5.3 (5.1)		4.0-6.5 (5.3)	
5		1.1-1.5 (1.3)		0.9-1.3 (1.1)		0.2-0.2 (0.2)		0.3-0.5 (0.4)		4.9-8.8 (6.9)		1.9-3.8 (2.9)	
6	**3 km**	2.6-2.6 (2.6)		2.2-2.6 (2.4)		0.6-0.6 (0.6)		1.1-1.3 (1.2)		4.4-4.6 (4.5)		2.0-2.1 (2.0)	
7		4.3-4.7 (4.5)		1.8-2.2 (2.0)		0.5-0.7 (0.6)		0.6-0.6 (0.6)		6.4-8.8 (7.6)		3.2-3.9 (3.6)	
8		4.4-4.5 (4.4)		1.7-1.9 (1.8)		1.1-1.1 (1.1)		1.0-1.5 (1.3)		4.0-4.1 (4.0)		1.2-1.7 (1.5)	
9		3.3-3.8 (3.6)		2.5-2.7 (2.6)		0.8-0.9 (0.9)		0.8-0.9 (0.8)		4.2-4.2 (4.2)		3.0-3.3 (3.2)	
10	**8 km**	3.0-3.2 (3.1)		1.7-2.1 (1.9)		0.4-0.6 (0.5)		1.6-1.7 (1.7)		5.4-7.9 (6.6)		1.1-1.2 (1.1)	
11		3.7-3.9 (3.8)		1.6-2.4 (2.0)		1.0-1.1 (1.0)		1.1-1.9 (1.5)		3.5-3.9 (3.7)		1.3-1.5 (1.4)	
12		4.0-4.0 (4.0)		1.3-1.5 (1.4)		0.6-0.7 (0.6)		0.4-1.2 (0.8)		5.8-7.0 (6.4)		1.2-3.3 (2.2)	
13		7.2-7.3 (7.3)		0.6-0.7 (0.6)		0.8-0.9 (0.8)		0.4-0.5 (0.4)		8.5-9.3 (8.9)		1.4-1.5 (1.5)	

Table 2.3.7: Distribution of phytoplankton population (cell count) and genera in the coastal waters off Mumbai during March 2019.

Station	Distance (km)	Time & Tide	Cell count (no x 10^3 Cells/ l)		Total genera (no.)	
			S	B	S	B
1	1 km	1105 F.Ebb	3975.4	4232.0	20	20
		1715 F.Fld	3446.2	1072.0	19	16
2		1000 F.Ebb	571.8	1120.2	13	6
		1600 F.Fld	2269.6	921.4	20	14
3		930 F.Ebb	582.4	872.6	9	11
		1500 F.Fld	612.4	297.6	9	8
4		1600 Fld-Eb	1260.4	1398.0	6	6
5		945 F.Ebb	1117.2	698.8	8	11
		1450 F.Fld	1352.2	530.6	10	11
6	3 km	915 Fld-Eb	173.2	415.4	12	14
7		1140 Eb-Fld	2394.4	3473.8	15	17
8		1215 Eb-Fld	138.4	351.4	13	13
9		1330 Eb-Fld	890.6	530.2	9	11
10	8 km	830 Fld-Eb	442.6	881.0	16	16
11		1240 Eb-Fld	3136.0	60.4	16	8
12		1100 Eb-Fld	942.0	280.4	11	13
13		1215 Eb-Fld	86.2	124.6	10	10

Table 2.3.8: Distribution of phytoplankton population (cell count) and genera in the coastal waters off Mumbai during December 2019

Station	Distance (km)	Time & Tide	Cell count (no x 10^3 Cells/ l)		Total genera (no.)	
			S	B	S	B
1	**1 km**	645 F.Fld	267.0	204.0	11	16
		1310 F.Ebb	337.0	192.0	16	17
2		1113 F.Ebb	176.0	182.0	15	19
		1700 F.Fld	139.0	108.0	22	13
3		1300 Ebb-Fld	161.0	130.0	18	13
		1620 Fld-Ebb	456.0	241.0	16	22
4		1400 Ebb-Fld	212.0	210.0	17	11
		1545 Fld-Ebb	304.0	180.0	15	11
5		1300 Ebb-Fld	126.0	81.0	16	9
		1620 Fld-Ebb	48.0	53.0	8	8
6	**3 km**	1000 Fd-Ebb	180.2	70.0	21	17
7		1012 Fld-Ebb	206.2	111.0	22	18
8		1235 Ebb-Fld	43.0	56.0	17	10
9		1220 Ebb-Fld	103.0	139.4	16	21
10	**8 km**	833 Fld-Ebb	89.0	43.0	14	11
11		1232 Ebb-Fld	102.8	59.6	17	15
12		1125 Ebb-Fld	108.0	33.0	21	10
13		1030 Ebb-Fld	288.0	104.0	19	9

Table 2.3.9:Composition (%) of phytoplankton population in the coastal waters off Mumbai during March 2019.

Species name	1	2	3	4	5	6	7	8	9	10	11	12	13	Av.
	1 km					3 km				8 km				
Diatoms														
Achnanthes sp.	<0.1													<0.1
Amphiprora alata		<0.1	<0.1		<0.1		<0.1							<0.1
Asterionella japonica	0.18							0.41	<0.1	<0.1	0.13			<0.1
Asteromphalusflabellatus							<0.1							
Bacteriastrumhyalinum	1.63	1.15					0.20			<0.1	0.25	1.15		0.34
Chaetoceros lorenzianus	7.15	<0.1	0.68			4.42	0.61	0.33	2.39	12.99	3.07	4.42	22.77	4.53
Corethron sp.	<0.1				<0.1		<0.1							<0.1
Coscinodiscusgranii		<0.1	<0.1	<0.1	<0.1			0.45	<0.1			0.16		<0.1
Cyclotella sp.					0.16									<0.1
Cylindrothecaclosterium	0.31	1.80	1.61	0.30	0.32	<0.1	0.31	1.63	0.28	0.15	0.19	1.64	<0.1	0.67
Dactyliosolen fragilissimus	4.40	<0.1				13.25	0.11	<0.1	0.56	16.92	2.94	0.82	0.19	3.02
Diploneis sp.	<0.1	<0.1	<0.1	<0.1	0.22	<0.1	<0.1	<0.1	0.14					<0.1
Distephanus sp.		<0.1			<0.1	<0.1			0.28	0.30				<0.1
Ditylum brightwellii	0.11	0.29	0.45	<0.1	0.27		0.17	0.82	0.28		0.13	0.82	2.85	0.48
Eucampia zodiacus										0.30				<0.1
Guinardia striata	0.38					2.04				1.96				0.34
Gyrosigma sp.												0.16		<0.1
Hemiaulus sp.	<0.1					0.10				0.15				<0.1
Lauderia annulata	0.16									0.30				<0.1
Leptocylindrus danicus	3.44	1.56	0.34			1.36	0.49			2.12	0.56			0.76
Lithodesmium sp.	<0.1				<0.1		<0.1	0.41						<0.1
Navicula distans	<0.1		<0.1			<0.1	<0.1	0.41					<0.1	<0.1
Odontella sinesis	0.23	0.22	<0.1		0.49	1.02	<0.1	1.63	0.32	0.91	0.26	0.33	4.74	0.79
Pleurosigma elongatum	<0.1	<0.1	0.25	<0.1	0.39	0.10	<0.1	1.22	0.14	0.30	0.63	0.49	2.94	0.51
Pseudo-nitzschiaseriata	6.59	0.34	0.52	<0.1	0.11	0.68	0.34	2.04	0.28	2.27	2.13	2.78	5.69	1.83
Rhizosolenia	0.27	0.21	0.09		0.11	1.36	0.11	<0.1	0.14	0.60	0.25	<0.1		0.24
Skeletonema costatum	43.36	41.53	44.31	12.71	15.57	72.04	38.00	19.60	15.20	59.23	18.58	35.83	14.14	33.09

Species name	1	2	3	4	5	6	7	8	9	10	11	12	13	Av.
	1 km					3 km				8 km				
Streptotheca	<0.1													<0.1
Surirella exima	<0.1			<0.1										<0.1
Synedra ulna									<0.1			0.16	0.95	<0.1
Thalassionema nitzschioides	0.22		<0.1		22.76				0.11				11.39	2.65
Thalassiosira subtilis	30.88	52.30	51.25	86.67	58.61	2.04	59.23	70.40	79.81	0.76	70.64	50.72	32.26	49.66
Thalassiothrix longissima	0.16	<0.1			<0.1	0.75		0.41		0.32			1.90	0.27
Trachyneis					<0.1									
Dinoflagellates														
Alexandrium sp.	<0.1	0.14	<0.1				<0.1	<0.1						<0.1
Ceratium furca	<0.1	<0.1			0.59									<0.1
Dinophysis acuminate										0.15				<0.1
Gonyaulax sp.		<0.1									<0.1			<0.1
Gymnodinium fuscum		<0.1									0.13			<0.1
Gyrodinium aureolum	0.13	0.20	<0.1		<0.1	0.68	0.10			<0.1	<0.1	0.16		0.11
Podolampas sp.										0.15		<0.1		<0.1
Prorocentrumnana	<0.1	<0.1	<0.1									0.16		<0.1
Protoperidinium sp.	<0.1	<0.1	<0.1			<0.1	<0.1							<0.1
Others														
Dictyocha sp.												0.16		<0.1
Eutreptiella marina										<0.1				<0.1
Teleaulax acuta	<0.1	<0.1												<0.1

Table 2.3.10: Composition (%) of phytoplankton population in the coastal waters off Mumbai during December 2019

Species name	1	2	3	4	5	6	7	8	9	10	11	12	13	Av.
	1 km					3 km				8 km				
Diatoms														
Achnanthes sp.						0.40								<0.1
Actinocyclus normanii	0.30	0.17			1.95	0.40					1.23	2.84	0.51	0.57
Asterionellopsis glacialis	3.00	1.65	1.21	0.11	0.32	1.60	2.52	2.02	0.41	1.52	11.08	3.55		2.23
Bacteriastrum hyalinum			0.10											<0.1
Bacteriastrum sp.		0.33									5.54			0.45
Chaetoceros sp.	0.20	2.64	1.62	0.77		3.60	1.26	3.03					0.26	1.03
Chaetoceros curvisetus				0.33			0.32	1.01	0.41					0.16
Chaetoceros decipiens	1.60	0.99	1.32	2.21	1.30	2.40	1.58		0.41	2.27	4.93		0.26	1.48
Corethron hystrix	0.70	0.83	0.71			0.80	2.21			0.76	0.62	1.42		0.62
Coscinodiscus sp.		0.17		0.11										<0.1
Cyclotella sp.	0.10													<0.1
Cylindrotheca closterium	1.20	1.82	3.44	1.43	4.55	0.40	2.84	6.06	4.95		2.46			2.24
Dactyliosolen fragilissmus	1.60	0.50	0.61				0.32		2.06	3.03	0.62	2.13	0.26	0.85
Diploneis sp.							0.32							<0.1
Ditylum brightwelli	0.30	1.16	0.20	0.55	0.65	3.60	0.63		0.41		8.13	1.42	0.77	1.37
Ditylum sol	0.90	0.83	0.30	0.66	0.97	0.80	0.95	1.01	2.48	2.27		2.84	0.77	1.14
Lauderia annulata					0.32		0.95							0.10
Leptocylindrus danicus		0.33	0.10			1.60	1.89		0.08				0.26	0.33
Leptocylindrus sp.		0.17	0.71		0.97									0.14
Lithodesmium undulatum	0.10	0.50		0.11	0.32	2.80	0.95		1.24	1.52		2.13	0.51	0.78
Navicula delicatula			0.30											<0.1
Navicula directa		0.17			0.97									<0.1
Navicula distans	0.30						0.95	3.03	0.41					0.36
Navicula sp.	0.60	3.47			0.97									0.39
Navicula transitans	0.30	0.17	0.61		0.32		0.63	1.01	0.83	0.76	1.23	2.13	0.51	**0.65**

Species name	1	2	3	4	5	6	7	8	9	10	11	12	13	Av.
	1 km					3 km				8 km				
Nitzchia linearis	5.10		20.9											2.00
Nitzschia sp.	10.9	10.74	1.52	34.11	14.94	12.39	27.74	5.05	9.08			14.89	42.60	14.15
Odontella mobiliensis	0.40	1.16	0.20	0.88	0.65	1.20	1.26		2.48	2.27	1.23	0.71	0.51	1.00
Odontella sinensis		0.17	0.40					1.01	0.41	0.76	0.12	1.42	0.26	0.35
Pleurosigma angulatum		0.66		0.33				3.03	2.06					0.47
Pleurosigma directum	1.40		0.10	0.11										0.12
Pleurosigma elongatum		0.17			0.65	0.08	0.32	2.02	0.41					0.28
Pleurosigma sp.	0.50	0.83	0.30	0.11	0.65				0.41			1.42	0.26	0.34
Pseudo-nitzschia australis	6.50	0.66		0.11	0.32	9.99	5.36	3.03	6.60		1.85	0.71		2.70
Pseudo-nitzschia delicatissima		3.80				0.80				1.52	1.23	4.96		0.95
Pseudo-nitzschia pungens	1.70	4.13	4.25	1.66	2.27	2.80								1.29
Pseudo-nitzschia sp.			1.21		1.95		1.58							0.36
Rhizosolenia setigera	2.70	1.16	0.71	0.33		3.20	1.58		0.83	2.27	1.85			1.12
Skeletonema costatum	31.80	28.43	17.3					7.07		49.24	22.17	24.82	39.03	16.91
Skeletonema sp.			25.2	36.5	35.06	28.38	21.75	29.29	35.89					16.32
Taballaria tabulate			0.20											0.02
Thalassioisra anguste-lineata	10.40		3.44											1.06
Thalassionema nitzschioides	3.40	3.64	1.42	0.33	0.32	1.20			1.65	6.06	3.69	3.55	0.26	1.96
Thalassionema sp.		0.66	0.81		1.95	3.60	3.15	6.06	0.83	0.76	0.62			1.42
Thalassiosira rotula	6.30											18.44		1.90
Thalassiosira sp.	3.40	21.98	7.79	12.58	24.03	10.39	13.56	15.15	21.04	12.88	20.32	4.26	9.44	13.60
Thalassiothrix nitzschioides	1.10	0.99		0.22	0.65	1.20		2.02			3.69	1.42	1.02	0.95
Thalassiothrix sp.		0.83	0.51	0.44	0.32	1.60	3.78	2.02	2.48	7.58	5.54			1.93
Triceratium sp.											0.12			<0.1
Tropidoneis sp.								1.01	0.41	0.76	0.12	0.71	0.77	0.29
Dinoflagellates														
Alexandrium sp.												0.71		<0.1

Species name	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
	1 km					3 km				8 km				
Ceratium furca		0.83	0.10						0.41	0.76			0.77	0.22
Gymnodinium sp.							0.32							<0.1
Gyrodinium spirale		0.99	0.20	0.33		0.40					0.12	0.71	0.26	0.23
Prorocentrum lima		0.83	0.20	1.21	0.65	1.60		2.02				0.71		0.56
Prorocentrum micans	0.10		0.40	1.66	0.97				0.41		0.25			0.29
Protoperidinium depressum	0.30	0.66	0.20	0.11				1.01	0.41				0.26	0.23
Protoperidinium pentagonum							<0.1							<0.1
Scrippsiella trochoidea	2.10	0.17	1.11	1.88		0.40		2.02	0.41		0.62	1.42	0.26	0.80
Others														
Mallomonas sp.	0.70	0.66	0.20	0.77	0.97	2.40	1.26	1.01	<0.1	2.27	0.62	0.71	0.26	0.91
Dityocha sp.										0.76				<0.1

2.3.3 Zooplankton

Zooplankton (Greek: Zoon, animal; planktos, wandering) are myriads of diverse floating and drifting animals with limited power of locomotion. Zooplankton includes arrays of organisms, varying in size from the microscopic protozoans of a few microns to some jelly organisms with tentacles, several meters long. Majority of them are microscopic, unicellular or multicellular forms with size ranging from a few microns to a millimetre or more. In addition to size variations, there are differences in morphological features and taxonomic position. Zooplankton by virtue of its food value to higher animals forms a vital link between phytoplankton and fish and hence is an indicator of fish productivity of a marine area. The zooplankton plays an important role to study the faunal bio-diversity of aquatic ecosystems. They include representatives of almost every taxon of the animal kingdom and occur in the pelagic environment either as adults (holoplankton) or eggs and larvae (meroplankton). The planktonic forms with calcareous or siliceous shells or tests contribute to the bottom sediments. The zooplankton are more varied as compared to phytoplankton, their variability in any aquatic ecosystem is influenced mainly by patchiness, diurnal vertical migration and seasons. Environmental factors play a major role in the zooplankton distribution patterns and species composition in the marine ecosystem. Their abundance are not only associated with changes in food supply (phytoplankton crop) but also with a combined effect exerted by hydrographic conditions and pollution stress.

Mesozooplankton standing stock varied widely in terms of biomass (0.1-6.9 ml/100m^3, av. 1.5 ml/100m^3) and population (1.1 -7939 x10^3/100m^3, av. 373.5 ml/100m^3) during March 2019 (Table 2.3.11). Similarly during December 2019 the biomass and population ranged from 0.2 – 49.0 ml/100m^3 (av. 9.3 ml/100m^3) and 11.3 – 825.7 ml/100m^3 (av. 245.2 ml/100m^3) respectively (Table 2.3.12). The average zooplankton biomass of the zones during both sampling periods are given in Figure 2.3.9.

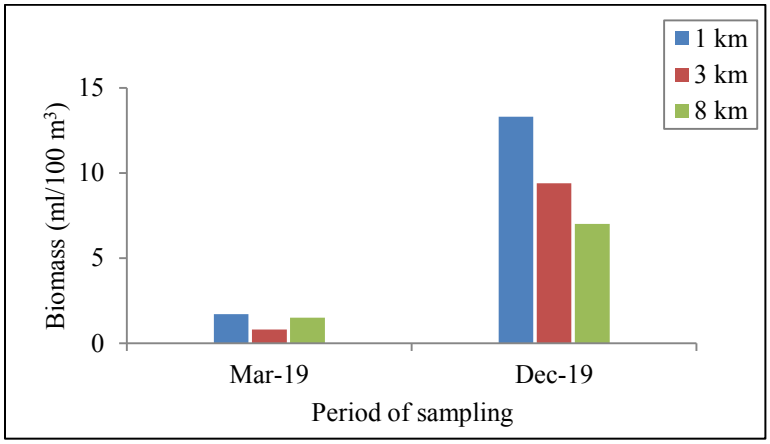


Figure 2.3.9: Mesozooplankton biomass distribution in the coastal waters off Mumbai during March and December 2019.

The biomass distribution study revealed that December 2019 recorded higher values when compared to March 2019 observation. There was a 5-7 fold increase in biomass in December 2019 at all the zones. The mesozooplankton population averages for the three zones during March and April 2019 are given in Figure 2.3.10.

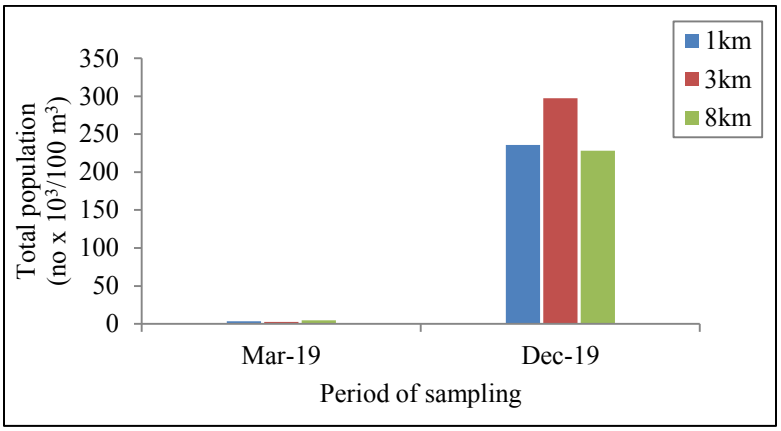


Figure 2.3.10: Mesozooplankton total population distribution in the coastal waters off Mumbai during March and December 2019.

Mesozooplankton population also followed the same trend as that of biomass with very less contribution during March 2019 (Figure 2.3.10). Total zooplankton groups ranged between 3 – 17 (av. 8) during March 2019 and 10- 18 (av. 13) during December 2019 (Table 2.3.11-2.3.12). The percentage composition of mesozooplankton composition revealed that copepod dominated throughout the study region during both sampling periods (Table 2.3.13 -2.3.14). In December 2019, copepods contributed 96.5% of mesozooplankton population, while in March 2019 it was in the order of copepod (70.7%)>fish eggs (12.3%)>decapods (11.7%) (Table 2.3.13-2.3.14).

The impact of tidal variation on mesozooplankton biomass, population and group distribution was investigated in the 1 km zone stations during March 2019 (Figure 2.3.11). The total number of zooplankton groups remained almost the same with minor variation. There was a change in contribution to biomass and population from full ebb (F.Ebb) to full flood (F.Fld) period (Figure 2.3.11).

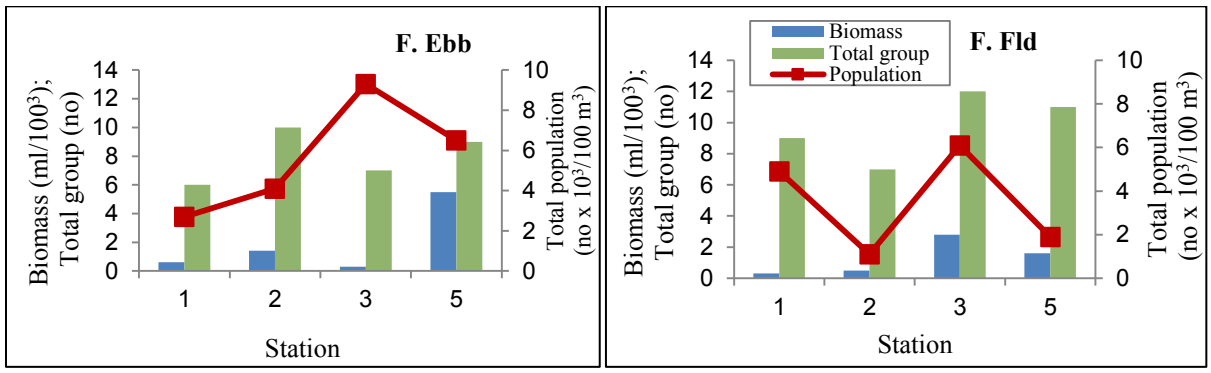


Figure 2.3.11: Tidal variation of mesozooplankton in the coastal waters off Mumbai during March 2019

The tidal biomass, population and total groups during December 2019 are depicted in Figure 2.3.12. Station 1 recorded the highest biomass and population during F.Ebb period otherwise the biomass and population was more or less the same during F.Ebb and F.Fld.

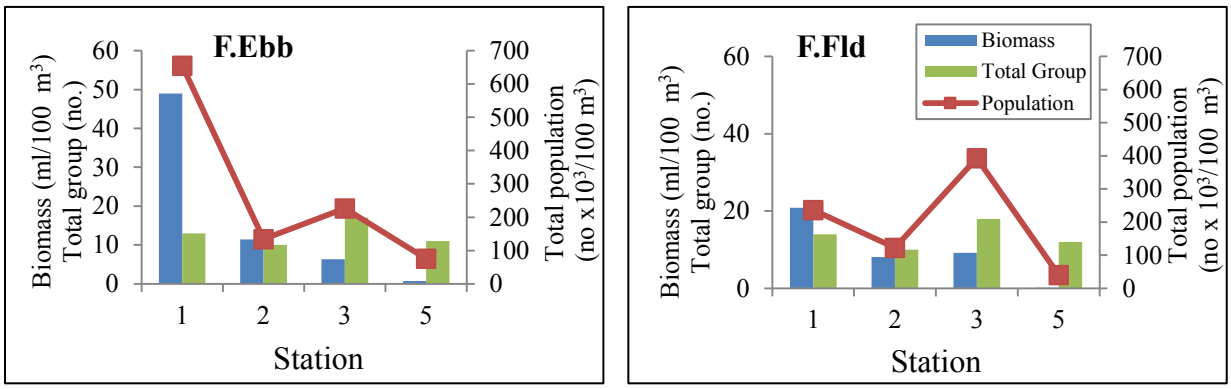


Figure 2.3.12: Tidal variation of mesozooplankton in the coastal waters off Mumbai during December 2019.

Table 2.3.11: Range and average (parenthesis) of mesozooplankton in the coastal waters off Mumbai during March 2019

Station	**Distance** (km)	**Biomass** (ml/100m^3)	**Population** (nox10^3/100 m^3)	**Total Groups** (no)	**Major group** (%)
1 (28/03/2019)	1 km	0.3-0.6 (0.5)	2.7-4.9 (3.8)	6-3 (8)	Copepods (79.2), fish eggs(7.3), decapod larvae (5.4), gastropods (3.9), medusae(2.4), fish larvae (0.8), appendicularians(0.5), ostracods(0.2), chaetognaths(0.2), *Lucifer* sp. (0.1), others (0.1).
2 (27/03/2019)		0.5-14 (1.0)	1.1-4.1 (2.6)	7-10 (9)	Copepods (48.2), fish eggs(42.4), appendicularians(4.3), Decapod larvae (3.0), lamellibranchs (1.2), medusae (0.3), gastropods (0.2), fish larvae (0.1), ostracods(0.1), amphipods(0.1), others (0.1).
3 (26/03/2019)		0.3-2.8 (1.6)	6.3-9.3 (3.5)	7-12 (10)	Copepods (82.7), fish eggs(9.7), decapod larvae (2.9), medusae (1.8), ctenophores (0.9), lamellibranchs (0.8), foraminiferans(0.5), gastropods (0.3), polychaetes(0.1) chaetognaths (0.1), amphipods(0.1), *Lucifer* sp. (0.1), others (0.1).
4 (25/03/2019)		1.0-4.1 (2.8)	1682-7939 (4810.5)	9-12 (11)	Copepods (44.0), medusae (25.8), decapod larvae (23.7), gastropods (3.7),

					fish eggs (1.0), fish larvae (0.7), lamellibranchs (0.6), appendicularians(0.2), ostracods(0.1), amphipods(0.1), *Lucifer* sp. (0.1), stomatopods(0.1), others (0.1).
5 (25/03/2019)		1.6-5.5 (3.6)	1.9-6.5 (4.2)	9-11 (10)	Copepods (80.9), decapod larvae (8.1), fish eggs (5.4), appendicularians(0.3), chaetognaths (0.3), lamellibranchs (0.3), fish larvae (0.2), polychaetes(0.1) medusae (4.4), cladocerans(0.1), others (0.1).
6 (28/03/2019)	3 km	0.5-0.6 (0.6)	2.5-3.7 (6.2)	4-5 (5)	Copepods(88.4), decapod larvae (6.1), fish eggs(5.3), chaetognaths (0.1), appendicularians(0.1), others (0.1).
7 (27/03/2019)		0.8-2 (1.4)	1.9-3.1 (2.5)	5-9 (7)	Copepods(53.7), fish eggs (44.2), decapod larvae (1.4), appendicularians(0.3), medusae(0.2), foraminiferans(0.1), fish larvae (0.1), others (0.1).
8 (26/03/2019)		0.5-0.5 (0.5)	1.4-8.7 (1.1)	5-6 (6)	Fish eggs (48.6), foraminiferans (28.5) Copepods(22.0), decapod larvae (0.5), fish larvae (0.2), ostracods(0.1), others (0.1).
9 (25/03/2019)		0.5-1.0 (0.8)	4.8-5.2 (2.6)	5-7 (6)	Copepods (86.8), fish eggs (6.8), decapod larvae (5.9), fish larvae (0.1), chaetognaths (0.1),

					appendicularians(0.1), amphipods(0.1), others (0.1).
10 (19/03/2019)	8 km	0.4-0.7 (0.6)	2.3-3.6 (3.0)	8-17 (13)	Copepods (80.2), fish eggs (9.6), decapod larvae (8.5), polychaetes(0.4), lamellibranchs (0.3), chaetognaths (0.3), appendicularians(0.2), foraminiferans (0.1) gastropods (0.1), *Lucifer* sp. (0.1), others (0.1).
11 (27/03/2019)		0.9-1.1 (1.0)	3.2-3.2 (3.2)	5-6 (6)	Copepods (82.1), fish eggs (13.4), decapod larvae (4.2), appendicularians(0.1), others (0.1).
12 (26/03/2019)		0.1-0.8 (0.5)	3.0-3.0 (3.0)	3-6 (5)	Copepods (87.0), fish eggs (12.3), decapod larvae (0.6), others (0.1).
13 (25/03/2019)		2.6-6.9 (4.8)	3.7-13.8 (8.7)	7-8 (8)	Copepods (50.3), decapod larvae (42.1), fish eggs (5.9), appendicularians(1.2), fish larvae (0.2), lamellibranchs (0.2), amphipods(0.1), others (0.1).

Table 2.3.12: Range and average (parenthesis) of mesozooplankton in the coastal waters off Mumbai during December 2019

Station	**Distance** (km)	**Biomass** (ml/100m^3)	**Population** (nox10^3/100m^3)	**Total Groups** (no)	**Major group** (%)
1 (07/12/2019)	1 km	20.9-49.0 (35.0)	236.2-655.4 (445.8)	13-14 (14)	Copepods (97.6) appendicularians (1.5) *Lucifer* sp. (0.3) fish Eggs (0.3) decapod larvae (0.2) others (0.1).
2 (06/12/2019)		8.1-11.4 (9.8)	123.0-134.7 (128.9)	10-10 (10)	Copepods (87.2), appendicularians (8.3), fish Eggs (3.8), decapod larvae (0.3), *Lucifer* sp. (0.1), gastropods (0.1), siphonophores (0.1), others (0.1).
3 (04/12/2019)		6.3-9.2 (7.8)	226.4-393.6 (310.0)	17-18 (18)	Copepods (97.6), cladocerans (0.6), decapod larvae (0.4), appendicularians (0.4), fish Eggs (0.3), lamellibranchs (0.3), gastropods (0.2), others (0.1).
4 (03/12/2019)		2.5-0.9 (1.7)	73.3-211.2 (142.3)	16-16 (16)	Copepods (93.6) fish Eggs (2.1) decapod larvae (2.0) appendicularians (1.3) *Lucifer* sp. (0.8) gastropods (0.1) others (0.1).
5 (03/12/2019)		02-0.7 (0.5)	40.5-75.2 (57.8)	11-12 (12)	Copepods (97.9), decapod larvae (1.3), fish Eggs (0.5), lamellibranchs (0.1), gastropods (0.1), chaetognaths (0.1), others (0.1).

6 (07/12/2019)		10.5-11.3 (10.9)	667.3-739.8 (703.5)	15-15 (15)	Copepods (98.6) appendicularians (0.6) fish Eggs (0.3) decapod larvae (0.2) others (0.1).
7 (06/12/2019)	3 km	14.9-18.8 (16.9)	207.3-455.2 (331.2)	10-10 (10)	Copepods (98.0) appendicularians (1.1) fish Eggs (0.8) decapod larvae (0.1) others (0.1).
8 (04/12/2019)		3.2-6.7 (5.0)	25.9-47.3 (36.6)	9-10 (10)	Copepods (86.9), fish Eggs (12.7), chaetognaths (0.1), lamellibranchs (0.1), decapod larvae (0.1), appendicularians (0.1), others (0.1).
9 (03/12/2019)		4.4-4.9 (4.7)	11.8-124.3 (118.0)	14-14 (14)	Copepods (95.0), fish Eggs (2.4), appendicularians (1.2), decapod larvae (0.9), lamellibranchs (0.1), chaetognaths (0.1), cladocerans (0.1), fish Larvae (0.1), others (0.1).
10 (07/12/2019)	8 km	9.1-13.0 (11.1)	425.2-825.7 (625.4)	15-15 (15)	Copepods (97.7), salpids (0.6), decapod larvae (0.6), lamellibranchs (0.3), fish Eggs (0.3), fish Larvae (0.2), appendicularians (0.2), others (0.1).
11 (06/12/2019)		10.9-11.9 (11.4)	82.1-109.0 (95.5)	17-17 (17)	Copepods (86.0), salpids (3.4), decapod larvae (2.7), lamellibranchs (2.0), fish Eggs (1.9), fish Larvae (1.5), appendicularians (1.3), gastropods (0.3),

					Lucifer sp. (0.3), polychaetes (0.2), siphonophores (0.2), ctenophores (0.1), stomatopods (0.1), amphipods (0.1), others (0.1).
12 (04/12/2019)		3.7-5.1 (4.4)	25.2-30.5 (27.9)	11-11 (11)	Copepods (95.9), fish Eggs (1.7), chaetognaths (1.5), appendicularians(0.2), gastropods (0.2), lamellibranchs (0.2), decapod larvae (0.1), salpids (0.1), others (0.1).
13 (03/12/2019)		1.1-1.2 (1.2)	83.8-246.0 (164.9)	10-10 (10)	Copepods (98.3), fish Eggs (0.7), appendicularians (0.6), chaetognaths (0.3), decapod larvae (0.1), others (0.1).

Table 2.3.13: Composition (%) of mesozooplankton in the coastal waters off Mumbai during March 2019

Faunal Groups	1	2	3	4	5	6	7	8	9	10	11	12	13	Av
	1 km					3 km				8 km				
Foraminiferans	-	-	0.5	-	-	-	0.1	28.6	-	0.1	0.03	-	-	0.8
Siphonophores	-	-	-	-	-	-	-	-	-	<0.1	-	-	0.1	<0.1
Medusae	-	0.3	1.8	36.6	4.4	-	0.2	-	-	-	-	<0.1	-	3.3
Ctenophores	-	-	0.9	-	-	-	-	-	-	-	-	-	-	0.1
Chaetognaths	0.1	<0.1	<0.1	-	0.3	0.1	-	-	0.1	0.3	<0.1	-	-	0.1
Polychaetes	-	-	0.1	-	0.1	-	<0.1	-	-	0.4	-	-	-	<0.1
Cladocerans	-	-	-	-	0.1	-	-	-	-	-	-	-	-	<0.1
Ostracods	-	0.1	-	0.1	-	-	-	0.1	-	<0.1	-	-	<0.1	<0.1
Copepods	88.5	48.3	82.7	62.4	80.9	88.5	53.7	22.0	86.4	80.2	82.1	87.0	50.3	70.7
Amphipods	-	0.1	0.1	0.1	-	-	-	-	0.1	<0.1	-	-	0.1	<0.1
Lucifer sp.	-	-	0.1	-	-	-	-	-	-	0.1	-	-	-	<0.1
Decapod larvae	6.1	3.0	2.9	0.7	8.1	6.1	1.4	0.5	6.7	8.5	4.2	0.6	42.1	11.7
Stomatopods	-	-	-	<0.1	<0.1	-	-	-	-	-	-	-	<0.1	<0.1
Gastropods	-	0.2	0.3	0.1	-	-	-	-	-	0.1	-	-	-	<0.1
Lamellibranchs	-	1.2	0.8	<0.1	0.3	-	-	-	-	0.3	-	-	0.2	0.2
Appendicularians	0.1	4.3	-	<0.1	0.3	0.1	0.3	-	0.1	0.2	0.1	<0.1	1.2	0.6
Fish Eggs	5.3	42.4	9.7	-	5.4	5.3	44.2	48.6	6.6	9.6	13.4	12.3	5.9	12.3
Fish Larvae	-	0.1	-	<0.1	0.2	-	0.1	0.2	0.1	<0.1	<0.1	-	0.2	0.1
Acetes sp.	-	-	-	-	-	-	-	-	-	-	-	<0.1	-	<0.1
Marine Insects	-	-	-	-	<0.1	-	-	-	-	-	-	-	-	<0.1

Table 2.3.14: Composition (%) of mesozooplankton in the coastal waters off Mumbai during December 2019

Faunal Groups	1	2	3	4	5	6	7	8	9	10	11	12	13	Av
	1 km					3 km				8 km				
Foraminiferans	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	<0.1
Siphonophores	<0.1	0.1	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	0.2	<0.1	0.1	<0.1
Medusae	<0.1	-	-	-	-	<0.1	<0.1	<0.1	-	-	-	<0.1	<0.1	<0.1
Ctenophores	-	-	-	-	<0.1	-	-	-	-	<0.1	0.1	-	0.1	<0.1
Chaetognaths	<0.1	-	<0.1	<0.1	0.1	<0.1	-	0.1	0.1	-	-	1.5	0.3	<0.1
Polychaetes	<0.1	<0.1	<0.1	-	-	<0.1	<0.1	-	-	<0.1	0.2	-	0.2	<0.1
Cladocerans	-	-	0.6	<0.1	<0.1	<0.1	-	-	0.1	-	-	-	-	0.1
Ostracods	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	-	<0.1	-	<0.1	-	<0.1	<0.1
Copepods	97.7	87.2	97.6	93.6	97.9	98.6	98.0	86.9	95.0	97.7	86.0	95.9	88.2	96.5
Amphipods	-	-	<0.1	<0.1	<0.1	-	-	<0.1	<0.1	<0.1	0.1	-	0.1	<0.1
Mysids	<0.1	-	-	<0.1	-	-	-	-	-	-	-	-	-	<0.1
Lucifer sp.	0.3	0.1	<0.1	0.8	<0.1	<0.1	<0.1	-	<0.1	<0.1	0.3	-	0.2	0.1
Decapod larvae	0.2	0.3	0.4	2.0	1.3	0.2	0.1	0.1	0.9	0.6	2.7	0.1	2.1	0.5
Stomatopods	-	-	<0.1	-	-	-	-	-	-	<0.1	0.1	-	0.1	<0.1
Heteropods	-	-	<0.1	<0.1	-	-	-	-	-	-	-	-	-	<0.1
Pteropods	-	-	<0.1	-	-	-	-	-	<0.1	-	<0.1	-	<0.1	<0.1
Gastropods	<0.1	0.1	0.2	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.2	0.2	0.1
Lamellibranchs	<0.1	<0.1	0.3	<0.1	0.1	<0.1	<0.1	0.1	0.1	0.3	2.0	0.2	1.6	0.2
Appendicularians	1.4	8.3	0.4	1.3	-	0.6	1.1	0.1	1.2	0.2	1.3	0.2	1.1	1.0
Salpids	-	-	-	-	-	-	-	-	-	0.6	3.4	0.1	2.6	0.3
Fish Eggs	0.2	3.8	0.3	2.1	0.5	0.3	0.8	12.7	2.4	0.3	1.9	1.7	1.9	0.9
Fish Larvae	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	0.1	0.2	1.5	<0.1	1.1	0.1
Isopods	-	-	-	<0.1	-	<0.1	-	-	-	<0.1	<0.1	-	<0.1	<0.1

2.3.4 Macrobenthos

Benthic communities are comprised of complex assemblages of fauna living in association with sea-floor sediments that play a central role in marine ecosystem functioning. They assimilate substantial quantities of organic matter settling on the seafloor, which are transferred to benthic and pelagic food webs. They are also important sources of food for demersal fishes and shellfish; and regions with high benthic production are also known to support commercial fishery sources. Changes in benthic community structure can be the harbinger for associated food web alterations. Depending upon their size, benthic animals are divided into three categories, microfauna, meiofauna and macrofauna. Benthic community responses to environmental perturbations are useful in assessing the impact of anthropogenic impact on water quality.

Macrobenthic organisms have been regarded as the best indicators of environmental changes caused by pollution, because of their constant presence, relatively long life span, sluggish habits and tolerance to differential stress. Limited mobility of benthic fauna makes them exposed to physical, chemical and ecological disturbances. Areas subject to stress, both anthropogenic as well as human, will result in a shift in benthic assemblages. Undisturbed systems are often dominated by K-selected species (large body, long lifespan, slow-growing) while r-selected species characterised by small body size, short lifespan, fast growth represent a disturbed community. Macrobenthic organisms which are considered for the present study are species with body size larger than 0.5 mm.

On the other hand, the meiofauna (species with body size <500 μm and >63 μm) are an important component of marine benthic community with vital roles in benthic energetics. They have an ecological significance in the testing of hypotheses and indices. The number and biomass of meiofauna can vary to a great extent, according to season, latitude, water depth etc. Certain taxa are restricted to particular sediment type. There is great degree of variation in the vertical distribution of meiofauna. Generally the density decreases with increasing depth in the sediment.

a) Macrobenthos

The macrofaunal standing stock in terms of population and biomass at subtidal stations varied from 25 to 1250 no/m^2 (av. 469 no/m^2) and from 0.04 to 18.9 g/m^2 (av. 3.6 g/m^2) (wet wt) during March 2019. Similarly, during December 2019, the population and biomass ranged between 0 to 2025 no/m^2 (av. 213 no/m^2) and from 0.0 to 9.6 g/m^2(av. 1.5 g/m^2) (wet wt) respectively. (Table 2.3.15-2.3.16). The comparative averages of macrobenthic biomass, population and groups at the three zones during the sampling periods are given in Figure 2.3.13-2.3.15.

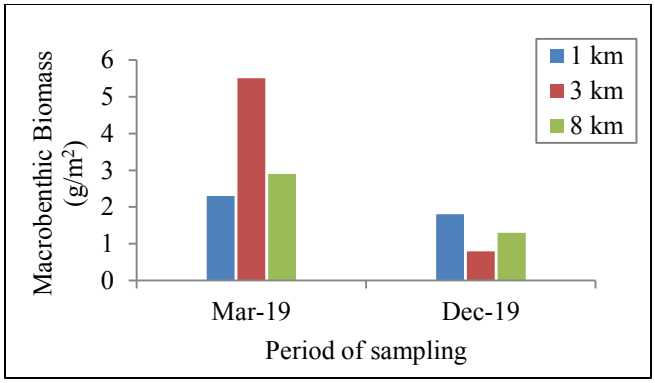


Figure 2.3.13: Macrobenthic biomass distribution in the coastal waters off Mumbai during March and December 2019.

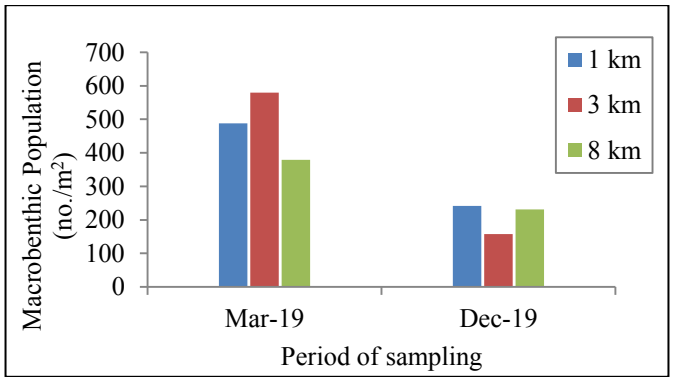


Figure 2.3.14: Macrobenthic population distribution in the coastal waters off Mumbai during March and December 2019.

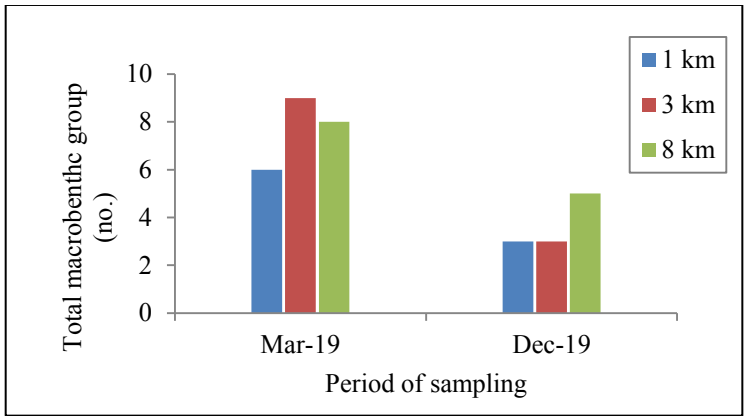


Figure 2.3.15: Macrobenthic total group distribution in the coastal waters off Mumbai during March and December 2019.

The macrobenthic biomass, population and groups were observed to be higher during March 2019 sampling period as compared to December 2019. These parameters were higher at the 3 km zone

during March 2019 whereas during December 2019 the averages of these parameters were comparable.

The percentage composition of subtidal macrobenthic community during March 2019 was dominated by Phylum Annelida (80%) followed by phylum Arthropoda (11.5%). The same groups were dominant during December 2019 also Phylum Annelida (68.1%) and Phylum Arthropoda (16.5%) (Table 2.3.17-2.3.18).Faunal group diversity (no) in the study region ranged from 1-13 (av. 8) during March 2019 and from 1-10(av. 4) during December 2019. A total of 50 and 43 macrobenthic taxa were identified in the study area during March and December 2019 respectively (Table 2.3.17-2.3.18). Polychaetes were the most dominant group and were present at all stations during both sampling periods. Amphipods were the second dominant group but were absent at some stations. Tanaidaceans which also contributed significantly to the total biomass was observed only at station 2 but in high density during March 2019 however during December they were present in other stations as well. *Paraprionospio patiens and Cossura coasta* were the most abundant polychaete species during both sampling periods. During December 2019, the amphipod, *Ampelisca aequicornis* was present only at station 8 that too abundantly.

The various statistical parameters of macrobenthic community status during March and December 2019 are given in Table 2.3.19-2.3.20. The macrobenthic species diversity index (*H'*) ranged from 2.5 to 4.1 during March 2019 and 0 to 3.5 during December 2019. The evenness index indicated that the macrobenthic assemblages were well balanced without any dominance of opportunistic species.

Table 2.3.15: Range and average (parenthesis) of subtidal macrobenthos in the coastal waters off Mumbai during March 2019

Station	**Distance** (km)	**Biomass** (wet wt.; g/m^2)	**Population** (no./m^2)	**Faunal Group** (no.)	**Major Group**
1	**1 km**	No collection			
2		No collection			
3		0.04-13.5 (3.5)	25-425 (169)	1-7 (3)	Ophiuroidea, *Cossura coasta, Sigambra parva*
4		0.2-2.0 (1.1)	325-1250 (806)	7-10 (9)	*Pagurapseudopsis gymnophobia*, *Paraprionospio patiens, Ampelisca* sp.
5		No collection			
6	**3 km**	0.4-3.0 (1.9)	225-850 (513)	4-12 (9)	*Cossura coasta, Parheteromastus tenuis, Ninoe* sp.
7		5.6-18.1 (11.4)	475-975 (813)	2-13 (9)	*Paraprionospio patiens, Aricidea longobranchiata, Cossura coasta*
8		0.5-10.9 (3.2)	150-675 (413)	4-13 (9)	*Ninoe*sp., *Aphelochaeta filiformis, Cirratulus* sp., *Capitella capitata*
9		No Collection			
10	**8 km**	0.4-1.3 (0.9)	150-325 (238)	4-8 (6)	*Ninoe* sp., *Cossura coasta*
11		0.9-18.9 (7.3)	225-650 (431)	7-13 (10)	*Sigambra parva, Ninoe* sp., *Cossura coasta, Cirratulus* sp.
12		0.1-3.0 (1.2)	75-675 (238)	2-8 (4)	*Cossura coasta, Ninoe* sp., *Capitella capitata*
13		1.5-2.8 (2.1)	400-775 (600)	8-12 (10)	*Ninoe* sp., *Cossura coasta, Sigambra parva, Magelona concta*

Table 2.3.16: Range and average (parenthesis) of subtidal macrobenthos in the coastal waters off Mumbai during December 2019

Station	Date	Biomass (wet wt.;g/m^2)	Population (no./m^2)	Faunal Group (no.)	Major Group
1	**1 km**	0.3 – 4.8 (1.4)	175-2025 (675)	2-10 (5)	*Paraprionospio patiens, Cossura coasta*
2		0 -2.1 (0.7)	0 – 350 (131)	0 -7 (3)	*Cossura coasta, Cheiriphotis* sp., Sipuncula, Tanaidacea
3		4.3 – 9.6 (7.3)	150 – 775 (344)	5-9 (8)	*Paraprionospio patiens,* Ophiuroidea
4		No collection			.
5		0.03 – 0.05 (0.04)	25 – 75 (56)	1*	*Cossura coasta, Magelona cincta*
6	**3 km**	0.1 – 0.3 (0.2)	50 – 250 (131)	2–4 (3)	*Cossura coasta,* Tanaidacea, Sipuncula
7		0 – 0.1 (0.05)	0 – 50 (32)	0–2 (1)	*Cossura coasta ,* Phoronida, Echiurida
8		0 – 0.5 (0.3)	0 – 200 (100)	0 – 7 (3)	*Cossura coasta,* Tanaidacea, *Cirratulus* sp.
9		0.4 – 5.5 (2.6)	50 – 1250 (369)	2 – 10 (5)	*Ampelisca aequicornis*
10	**8 km**	0.3– 1.9 (1.1)	50 – 300 (181)	2 – 8 (5)	*Cossura coasta, Capitella capitata*
11		0.2 – 6.1 (1.8)	75 – 250 (138)	3- 4 (3)	*Cossura coasta*
12		0.2-0.9 (0.5)	25-225 (88)	1-4 (2)	*Cossura coasta,* Pelecypoda, Phoronida
13		0.4-5.5 (1.9)	150- 450 (306)	5-8 (7)	*Cossura coasta, Glycera* sp., Ampharetidae

Table 2.3.17: Composition (%) of subtidal macrobenthos in the coastal waters off Mumbai during March 2019.

Faunal Groups	Station													Av
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Phylum Nemertea														
Nemertea								4.5		2.6	1.4		1.0	**0.9**
Phylum Sipuncula														
Sipunculida				2.3		7.3	1.5	1.5			2.9		3.1	**2.6**
Phylum Phoronida														
Phoronida											2.9		3.1	**0.8**
Phylum Mollusca														
Pelecypoda						6.1	3.1	1.5		2.6			1.0	**1.7**
Phylum Echiura														
Echiurida							0.8							**0.1**
Phylum Annelida														
Parheteromastus tenuis	NO COLLECTION	NO COLLECTION		4.7	R	11.0		3	NO COLLECTION	2.6	5.8		1.0	**3.4**
Magelona cincta			7.4	3.1	O	7.3		1.5		7.9	1.4		9.4	**3.9**
Cossura coasta			18.5	0.8	C	24.4	7.7	6.1		10.5	10.1	36.8	15.6	**11.8**
Levinsenia gracilis				1.6	K						2.9			**0.6**
Glycera natalensis			3.7	2.3	Y	1.2	0.8			5.3	1.4			**1.3**
Glycinde capensis				0.8										**0.1**
Chone filicaudata				1.6										**0.3**
Lumbrineris meteorana				0.8	B								2.1	**0.4**
Notomastus sp.				0.8	O									**0.1**
Paraprionospio patiens				25.6	T	6.1	38.5	4.5						**13.5**
Paraprionospio sp.			3.7	3.9	T		5.4			2.6				**2.1**
Aglaophamus dibranchis				1.6	O		0.8					2.6	2.1	**0.9**
Capitella capitata			11.1	3.9	M	2.4		9.1			2.9	15.8	1	**3.7**
Prionospio cirrobranchiata				0.8										**0.1**
Scalisetosus sp.				0.8										**0.1**
Ninoe sp.			3.7			8.5	4.6	16.7		36.8	11.6	26.3	29.2	**12.6**
Nephtys paradoxa													1	**0.1**
Nephtys sp.			3.7											**0.1**
Cirratulus sp.						3.7	4.6	10.6		5.3	8.7		2.1	**3.9**
Kirkegaardia sp.													3.1	**0.4**
Nereis sp.													1	**0.1**
Sigambra parva			14.8			1.2	0.8	7.6		7.9	17.4	2.6	15.6	**6.2**

Table 2.3.17 contd…

Faunal Groups	Station													Av
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Aphelochaeta filiformis							1.5	10.6		2.6	1.4	2.6	1	**1.9**
Heterospio indica										2.6		5.3	3.1	**0.9**
Aricidea longobranchiata						6.1	10				1.4	5.3	3.1	**3.5**
Protocirrineris chrysoderma				1.6		1.2	3.8			2.6	7.2			**2.1**
Maldanidae							1.5	4.5						**0.8**
Aricidea sp.						2.4	6.2	7.6			1.4	2.6		**2.5**
Poecilochaetus serpens											2.9			**0.3**
Ophiodromus berrisfordi											2.9			**0.3**
Caulleriella acicula											5.8			**0.6**
Glycera sp.								3			1.4			**0.4**
Prionospio sp.						2.4					1.4		1	**0.6**
Aedicira sp.								1.5		2.6				**0.3**
Oxydromus spinosus								1.5						**0.1**
Phylum Arthropoda														
Ampelisca sp.				5.4										**1.0**
Ampelisca aequicornis				0.8			5.4							**1.2**
Photis longicaudata				1.6										**0.3**
Cheiriphotis trifucata				1.6										**0.3**
Idunella chilkensis							0.8							**0.1**
Grandidierella sp.						7.3	1.5	3			1.4			**1.7**
Pagurapseudopsis gymnophobia				34.1										**6.5**
Copepoda						1.2				5.3				**0.4**
Phylum Echinodermata														
Ophiuroidea			33.3				0.8	1.5						**1.6**
Phylum Chordata														
Fish larvae											2.9			**0.3**

Table 2.3.18: Composition (%) of subtidal macrobenthos in the coastal waters off Mumbai duringDecember 2019

Faunal Groups	Station													Av.
	1	2	3	4	5	6	7	8	9	10	11	12	13	
	1 km					3 km				8 km				
Phylum Sipuncula														
Sipuncula	0.9	14.3	5.6		89.0	23.8				6.6			2.0	**3.8**
Phylum Phoronida														
Phoronida	2.8	4.8	3.6				39.2	6.0		6.6	9.3	14.5		**3.9**
Phylum Mollusca														
Gastropoda			1.8	NO										**0.2**
Pelecypoda	4.6								1.7		4.5	14.5		**2.2**
Phylum Echiura														
Echiurida							19.6	6.0	5.1					**1.2**
Phylum Annelida														
Cossura coasta	21.3	23.6	1.8	COLLECTION		42.9	39.2	50.0		24.2	49.9	49.7	32.0	**23.7**
Magelona cincta	7.5				11.0				5.1	3.5				**3.2**
Ninoe sp.								6.0		3.5	4.5		4.0	**1.2**
Aglaophamus sp.									3.4				4.0	**1.0**
Mediomastus sp.		4.8	1.8										2.0	**0.7**
Capitella capitata										20.7	4.5			**1.7**
Glycera longipinnis			3.6									7.1		**1.0**
Glycera natalensis		4.8							1.7					**0.2**
Glycera sp.			1.8						5.1	3.5			10.0	**2.4**
Glycera capitata										3.5				**0.2**
Paraonides sp.			3.6							3.5	4.5			**1.0**
Aricidia sp.								6.0		3.5	9.3	7.1		**1.2**
Levinsenia gracilis										3.5				**0.2**
Paradoneis sp.			1.8											**0.2**
Diopatra sp.									1.7				2.0	**0.5**
Trochochaeta sp.	0.9		1.8											**0.5**
Sthenelais sp.													4.0	**0.5**
Leocrates sp.										3.5	4.5		2.0	**0.7**

Table 2.3.18: contd…

Faunal Groups	Station													Av.
	1	2	3	4	5	6	7	8	9	10	11	12	13	
	1 km					3 km				8 km				
Paraprionospio patiens	57.4		36.3										8.0	**21.2**
Cirratulus sp.								13.0	1.7	3.5				**1.0**
Aphelochaeta filiformis		4.8								10			2.0	**1.2**
Tharyx sp.													2.0	**0.2**
Nephtys sp.											4.5		6.0	**1.0**
Ampharetidae			3.6	N									10.0	**1.7**
Maldanidae		4.8	5.6	O					5.1					**1.7**
Phylum Arthropoda														
Ampelisca sp.			1.8	C									4.0	**0.7**
Ampelisca aequicornis				O					50.8					**7.4**
Cheiriphotis trifucata	1.9			L										**0.5**
Cheiriphotis sp.	0.9	14.3		L										**1.0**
Cumacea	0.9			E										**0.2**
Brachyura		9.5		C									2.0	**0.7**
Tanaidacea	0.9	14.3	1.8	T		28.6		13.0	8.4					**4.4**
Stomatopoda			1.8	I					1.7					**0.5**
Anomura				O					1.7					**0.2**
Penaeidacea				N							4.5	7.1	2.0	**0.7**
Isopoda													2.0	**0.2**
Phylum Echinodermata														
Ophiuroidea			21.9			4.7			5.1					**3.9**
Phylum Chordata														
Fish larvae									1.7					**0.2**

Table 2.3.19: Diversity indices of macrobenthic community in the coastal waters off Mumbai during March 2019

Station	*S*	*N*	*d*	*J'*	*H'(log$_2$)*
3	9	168	1.56	0.86	2.72
4	22	808	3.14	0.71	3.18
6	17	514	2.56	0.88	3.59
7	20	815	2.83	0.76	3.29
8	19	414	2.99	0.91	3.85
10	15	238	2.56	0.82	3.21

11	23	433	3.62	0.89	4.02
12	9	239	1.46	0.77	2.45
13	20	601	2.97	0.78	3.35

Table 2.3.20: Diversity indices of macrobenthic community in the coastal waters off Mumbai during December 2019

Station	***S***	***N***	***d***	***J'***	***H'(log$_2$)***
1	11	675	1.534987	0.570755	1.974487
2	10	131	1.846079	0.919203	3.053526
3	17	344	2.739425	0.75907	3.10267
4	0	0	0	0	0
5	2	56	0.248425	0.491237	0.491237
6	4	131	0.61536	0.868914	1.737828
7	3	32	0.577078	0.951891	1.508712
8	7	100	1.302883	0.797698	2.239423
9	15	369	2.368547	0.702372	2.744089
10	14	181	2.500723	0.872585	3.322242
11	10	137	1.829275	0.760622	2.526732
12	6	88	1.116735	0.815355	2.107662
13	18	306	2.970166	0.842205	3.511932

b) Meiobenthos

The meiofaunal population and biomass varied from 35 to 977 no/10 cm^2 (av. 346 no/10 cm^2) and from 14.5 to 1009.9 µg/10 cm^2 (av. 299.2 µg/10 cm^2) (wet wt.) during March 2019 (Table 2.3.21). Faunal group diversity (no) in the study region ranged from 1-7; (av. 3). Similarly during December 2019, the population and biomass ranged between 0 to 1125 no/10 cm^2 (av. 184 no/10 cm^2) and from 0.0 to 1916.3 µg/10 cm^2 (av. 214.9 µg/10 cm^2) (wet wt.) respectively (Table 2.3.22). Faunal group diversity (no) in the study region ranged from during March 2019 ranged from 1-7 (av. 3) and ranged from 0 – 10 (av. 5) during December 2019 (Table 2.3.21-2.3.22). The average meiobenthic parameter values for the three zones during the two sampling periods are presented in Figure 2.3.16-2.3.18.

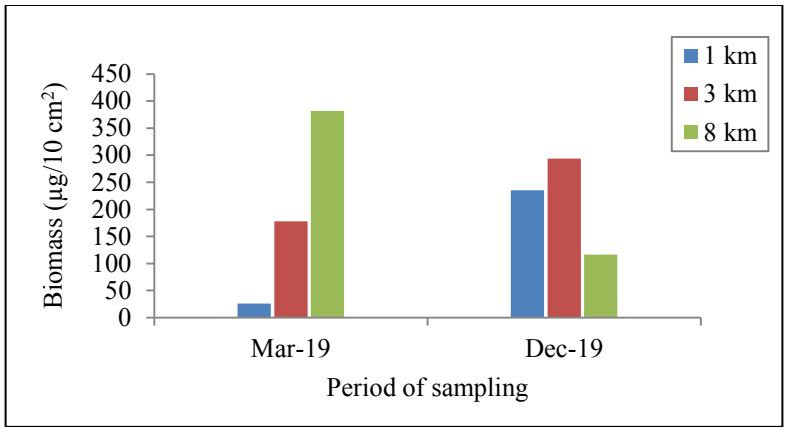


Figure 2.3.16: Meiobenthic biomass distribution in the coastal waters off Mumbai during March and December 2019

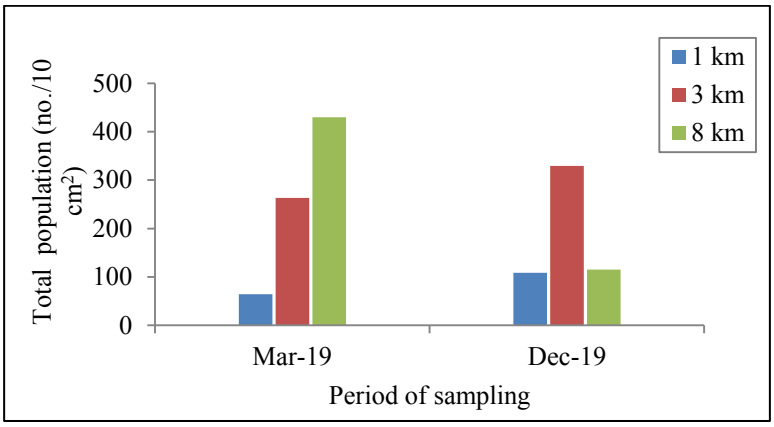


Figure 2.3.17: Meiobenthic population distribution in the coastal waters off Mumbai during March and December 2019

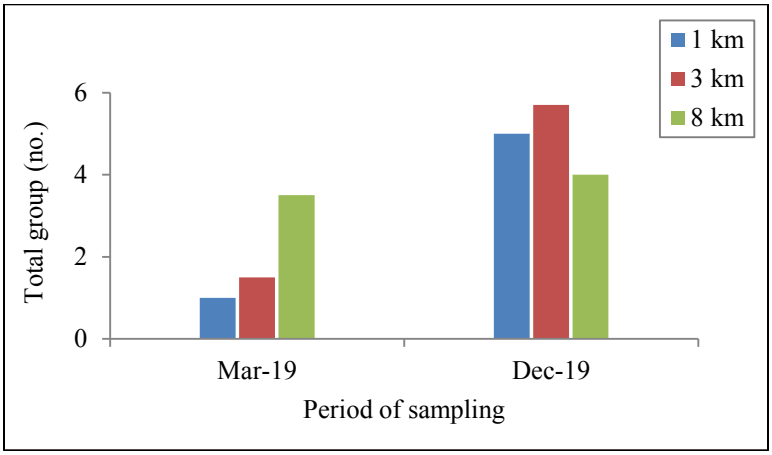


Figure 2.3.18: Meiobenthic total group distribution in the coastal waters off Mumbai during March and December 2019

Meiobenthic biomass distribution showed opposite trends at 1 km and 8 km stretch during the two sampling period (March and December 2019) with maximum biomass at 8 km zone during March 2019 (Figure 2.3.16-2.3.17). The stations which are 8 km away from the shoreline recorded maximum biomass and density during March 2019, while during December the maximum biomass and population were observed at 3 km stretch. Conversely, the total group was found to be high during December 2019 observation at all three transects (Figure 2.3.18). The percentage composition of meiobenthic community indicated that the study region was dominated by nematodes followed by foraminiferans and phoronids. Additionally the percentage composition of groups like ostracoda, fish egg, halacaroida, polychaeta, nemertina were encountered in stations which were 8 km away from the shoreline (Table 2.3.23 -2.3. 24).

Table 2.3.21: Range and average (parenthesis) of subtidal meiobenthos in the coastal waters off Mumbai during March 2019

Station	**Distance** (km)	**Biomass** (μg/10cm^2: wet wt.)	**Population** (no/10cm^2)	**Faunal Group** (no.)
1	1 km	No Collection		
2		No Collection		
3		14.5-34.8 (26.1)	35-85 (64)	1-1 (1)
4		221.5-575.2 (428.5)	170-361 (274)	3-5 (4)
5		No Collection		
6	3 km	23.2-34.8 (28.0)	57-92 (71)	1-2 (1)
7		202.3-231.7 (214.2)	170-226 (198)	2-3 (2)
8		356.5-611.5 (468.5)	623-977 (783)	3-4 (3)
9		No Collection		
10	8 km	162.3-336.1 (239.1)	212-283 (238)	2-4 (3)
11		480.96-1009.9 (791.6)	609-899 (724)	6-7 (6)
12		384.6-517.5 (431.8)	573-715 (628)	3-3 (3)
13		56.5-70.3 (65.2)	106-156 (130)	2-3 (2)

Table 2.3.22: Range and average (parenthesis) of subtidal meiobenthos in the coastal waters off Mumbai during December 2019

Station	**Distance** (km)	**Biomass** (µg/10 cm^2)	**Population** (no./10 cm^2)	**Faunal Group** (no.)
1	1 km	17.4-497.7 (293.0)	42-113 (90)	1-7 (4)
2		31.9-130.5 (71.5)	21-156 (71)	2-8 (6)
3		124.4-251.4 (180.3)	64-106 (90)	5-8 (6)
4		No Collection		
5		5.8-904.7 (394.5)	42-403 (184)	3-7 (5)
6	3 km	36.2-259.6 (178.1)	134-248 (175)	4-10 (7)
7		61.4-1916.3 (693.0)	42-559 (262)	5-6 (6)
8		57.9-559.3 (227.9)	545-1125 (830)	4-5 (5)
9		65.0-96.2 (76.4)	42-64 (50)	5-6 (5)
10	8 km	80.2-141.8 (104.5)	85-205 (130)	5-8 (6)
11		86.1-193.1 (152.4)	219-297 (248)	6-9 (7)
12		8.7-156.2 (66.8)	21-113 (71)	1-3 (2)
13		0.0-212.3 (141.5)	0-21 (12)	0-2 (1)

Table 2.3.23: Composition (%) of subtidal meiobenthos in the coastal waters off Mumbai during March 2019

Groups	1	2	3	4	5	6	7	8	9	10	11	12	13	Av
	1 km					3 km				8 km				
Nematoda	No collection	No collection	100	57.76	No collection	96.67	89.29	96.99	No collection	87.13	88.27	94.74	87.27	89.45
Foraminifera			0	12.07		0	9.52	0		0.99	5.54	2.63	0	3.57
Copepoda			0	25.86		0	0	0		0	1.3	0	10.91	3.03
Polychaeta			0	2.59		0	1.19	0.3		2.97	1.3	2.63	0	1.44
Nemertina			0	0		3.33	0	0		5.94	0.33	0	1.82	0.68
Ostracoda			0	0		0	0	0		2.97	1.63	0	0	0.61
Halacaroidea			0	1.72		0	0	0		0	1.3	0	0	0.46
Gastropoda			0	0		0	0	1.51		0	0	0	0	0.38
Amphipoda			0	0		0	0	1.2		0	0	0	0	0.3
Nauplius			0	0		0	0	0		0	0.33	0	0	0.08

Table 2.3.24: Composition (%) of subtidal meiobenthos in the coastal waters off Mumbai during December 2019

Groups	1	2	3	4	5	6	7	8	9	10	11	12	13	Av
	1 km					3 km				8 km				
Nematoda	31.58	60.00	47.37	No Collection	14.10	22.97	49.55	4.83	19.05	47.27	18.10	86.67	0.00	33.46
Phoronida	7.89	6.67	7.89		23.08	40.54	3.60	90.06	33.33	29.09	60.95	0.00	0.00	25.26
Foraminifera	42.11	6.67	10.53		16.67	5.41	34.23	3.13	14.29	3.64	6.67	0.00	0.00	11.94
Ostracoda	0.00	0.00	0.00		3.85	2.70	0.00	0.00	0.00	0.00	0.00	3.33	80.00	7.49
Fish egg	2.63	3.33	10.53		12.82	16.22	5.41	0.57	14.29	3.64	4.76	0.00	0.00	6.18
Halacaroida	5.26	0.00	0.00		0.00	2.70	0.00	0.00	14.29	3.64	2.86	0.00	0.00	2.40
Priapulida	0.00	0.00	0.00		0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	20.00	1.78
Copepoda	0.00	0.00	2.63		0.00	2.70	3.60	0.00	0.00	3.64	1.90	6.67	0.00	1.76
Gastropoda	0.00	0.00	0.00		16.67	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	1.46
Bivalvia	0.00	0.00	0.00		7.69	1.35	0.00	0.85	4.76	1.82	0.00	0.00	0.00	1.37
Nemertina	0.00	6.67	0.00		0.00	0.00	0.90	0.00	0.00	0.00	2.86	3.33	0.00	1.15
Polychaeta	2.63	3.33	5.26		0.00	0.00	0.00	0.00	0.00	1.82	0.00	0.00	0.00	1.09
Insecta	2.63	3.33	5.26		1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Nauplius	0.00	3.33	0.00		0.00	0.00	1.80	0.00	0.00	1.82	0.00	0.00	0.00	0.58
Amphipoda	0.00	0.00	5.26		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Turbellaria	0.00	3.33	0.00		0.00	0.00	0.00	0.00	0.00	1.82	0.00	0.00	0.00	0.43
Cnidaria	0.00	3.33	0.00		0.00	1.35	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.41
Oligochaeta	2.63	0.00	0.00		0.00	0.00	0.00	0.28	0.00	0.00	0.95	0.00	0.00	0.32
Pycnogonida	2.63	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Gastrotricha	0.00	0.00	0.00		2.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Polyplacophora	0.00	0.00	0.00		0.00	1.35	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.19
Ophiuroid	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	1.82	0.00	0.00	0.00	0.15
Bryozoa	0.00	0.00	0.00		1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Unidentified group	0.00	0.00	5.26		0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55

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COMPLETION REPORT

Baseline study on Impact of coastal road on fisheries and fisher livelihood, Mumbai, Maharashtra

CLIENT

Municipal Corporation of Greater Mumbai (MCGM),

Head Quarter, Mumbai C.S.T. - 400001.

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OCTOBER 2020

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LIST OF ACRONYMS AND ABBREVIATIONS

APL	:	Above Poverty Line
BPL	:	Below Poverty Line
CMFRI	:	Central Marine Fisheries Research Institute
EIA	:	Environmental Impact Assessment
GIS	:	Geographic Information System
GPS	:	Global Positioning System
ICAR	:	Indian Council of Agricultural Research
MMB	:	Maharashtra Maritime Board
MCGM	:	Municipal Corporation of Greater Mumbai
MoA&FW	:	Ministry of Agriculture & Farmers Welfare
MoEF&CC	:	The Ministry of Environment, Forest and Climate Change
MoFAH&D	:	Ministry of Fisheries, Animal Husbandry and Dairying
MPEDA	:	Marine Products Export Development Authority
ReALCraft	:	Registration and Licensing of Fishing Craft
SBN	:	Set Bag Net
OAL	:	Overall Length
SEETTD	:	Socio-Economic Evaluation and Technology Transfer Division

EXECUTIVE SUMMARY

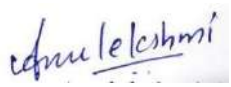
The Municipal Corporation of Greater Mumbai (MCGM) is developing Mumbai Coastal Road Project (South) from Princess Street Flyover to Worli end of Bandra Worli Sea Link along the western side of the Mumbai city. The proposed road plan, and the waters around it are partly including the regular and historic fishing areas of fishers based at Worli, Lotus Jetty and surrounding areas, which are likely to be affected by the development of the coastal road. This report is based on observations made during visits to the proposed coastal road project area from September 2019 to May 2020. However due to Covid 19 pandemic, the fishery surveys were collected till February, 2020 and subsequently by telephonic communication. In addition to surveys by ICAR-CMFRI, the published information from different government/ bodies, etc. were also collected and used for the preparation of the report. The present report documents the demography and socio-economic status of the fishers, besides fishing practices, boats, and fishery resources and economics that are likely to be influenced by the proposed coastal road and suggests mitigations options and livelihood improvement plans.

The proposed road has an approximated length of 9.98 km and the projected reclamation area is around 90 ha. The fishers based at Worli village and those boats operate from Lotus jetty fish in the nearshore waters adjacent to the proposed road plan. Fishing is the main occupation of these communities. Fishing is carried out by motorized, non motorised, mechanised fishing boats. The common marine fishing practices in the region are by gillnets and set bagnets (SBN) called as 'dol' net. Besides, these coastal communities find household food sources from the intertidal shell collections. In SBN, nets are attached to poles fixed to the sea bottom by spike while the gillnets are operated anywhere at the surface, column or bottom in the fishing area. The reclamations and construction will take a part of fishing area, and will modify the ecology of coast which may reduce income to fishers for at least for a short duration. Since other nearshore waters available for fishing major impacts on livelihood in minimized. The total fishermen population residing in the Worli villages is around 3055 in 800 households. Except for a landing place, there are no fisheries infrastructure facilities. Nearly 44 fishing boats operate from Lotus jetty. The annual profit of the single-day dol net (SBN) and multiday gillnet in these regions was estimated as Rs. 1,71,583/- after considering all the fixed and operational costs.

The fishery in the area is supported by a variety of fin-fishes and shellfishes. During September 2019 to February 2020, 116 species of commercially important fishes

were observed in fishery landing/catch. This includes 86 teleosts, 3 sharks, 17 crustaceans and 10 mollusc species however, only a few species formed a regular part of the fishery.

The area under study cannot be conclusively suggested as a breeding ground or nursery ground. No endemic or protected fishes were recorded in the proposed road plan area or in the fishery. Considering the possible impact on livelihood and expected loss of fishing area, it is suggested that the fishers likely to be affected may be supported by community development programs. Necessary steps may be taken to mitigate the economic impacts.



Mumbai / 19.10.2020

Dr. Anulekshmi Chellappan
Scientist & Principal Investigator

1. INTRODUCTION

i. Background:

The Municipal Corporation of Greater Mumbai (MCGM) is the governing civic body of Mumbai, the capital city of Maharashtra. The MCGM has proposed Mumbai Coastal Road Project (South) from Princess Street Flyover to Worli end of Bandra Worli Sea Link along the western side of the Mumbai city (here after mentioned as coastal road). The proposed coastal road has an approximate length of 9.98 km in the form of landfills, bridges, under-sea tunnels etc. and the projected reclamation area is around 90 ha. The proposed coastal road is mainly to address the traffic congestion in the ever-developing city and to improve the quality of life to citizens.

Central Marine Fisheries Research Institute (ICAR-CMFRI) is a nodal agency identified by the Government of Maharashtra and Maharashtra Maritime Board to study the impact of developments in the coastal areas or any activities affecting marine fisheries/fisher livelihood of the state. MCGM approached ICAR-CMFRI for conducting studies on the impact of the proposed Mumbai Coastal Road Project (South) on the coastal fisheries.

ii. Purpose & scope of the study:

The proposed Mumbai Coastal Road Project (South) is on the western side of the Mumbai city extending from Princess Street fly over to Worli end of the Sea link, on the seaward side. The proposed road has an approximated length of 9.98 km and the projected reclamation area is around 90 ha. When the reclamation and initial works have started for coastal road, multiple Public interest litigations were filed in Bombay High court against MCGM. One of the issues raised in the first hearing was fisheries impact and fishers concerns were not addressed. In this regard, Hon. High Court had directed MCGM, State Fisheries Department, Government of Maharashtra to call for the meeting of the representatives of the petitioners to discuss the issues of the fishermen in connection with the construction of the coastal road. It was decided that a competent authority will study the impact of the coastal road on fisheries and fisher's livelihood.

iii. Scope of the current study:

A baseline study on the fisheries, fish diversity/abundance in the nearshore waters of the proposed Coastal Road Project area and outside project area in the sea/seaward side during the pre-construction/development period is to be carried out. The study includes the estimation of fish abundance and species diversity of the marine fishes, the type of craft and gear used for fishing in the study area, identification of fishing pockets around the project site and impacts of the development on the fishing potential if any.

The objectives of the study are;

a. To estimate diversity and abundance of marine fishery resources in the nearshore areas of proposed Coastal road
b. Possible Impact of coastal road on the fish abundance and diversity
c. The extent of fishing areas and the fishing villages around the proposed survey region

Economics of various fishing activities around the survey area, loss of fishing area, and livelihood of the dependent population.

iv. Deliverables (ToR):

The study will be concentrated on the following objectives which have been discussed and mutually agreed by ICAR-CMFRI and MCGM.

1. Diversity and abundance of marine fishery resources in the nearshore areas of the proposed coastal road.
2. The possible impact of coastal road on the fish abundance and diversity.
3. The extent of fishing areas and the fishing villages around the proposed survey region.
4. Economics of various fishing activities around the survey area, loss of fishing area and livelihood of the dependent population.

2. METHODOLOGY

2.1. Area of study:

The proposed part of the Mumbai Coastal Road Project (south) addressed in the current study is the seaward portion of Phase one i.e. from Priyadarshini Park to Bandra-Worli Sea Link (Fig. 1 & Fig. 2).

Figure 1. Map of Mumbai coastal Road Project plan from MCGM website.

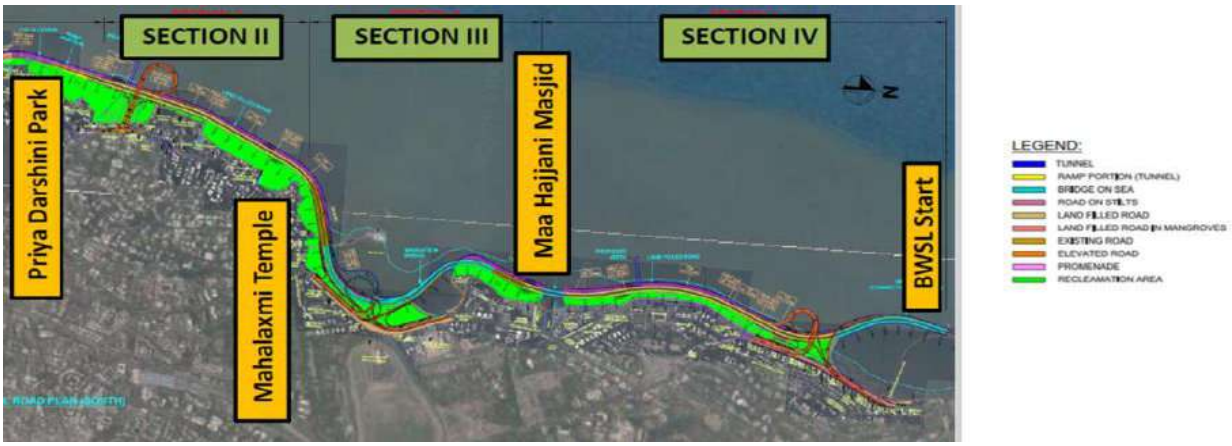


Figure 2. Map of Mumbai coastal Road Project (South) plan from MCGM.

2.2. Inception and Interaction Programs:

In the proposed study it is necessary to have direct interaction with the public, so it is necessary to inform the public about the plan of study and get their perception and concerns. Large level inception and appraisal meeting was conducted at Worli village and attended by nearly 100 fishers (Fig. 3). Similarly, multiple interactions and discussions were undertaken with fishers/allied workers based at Lotus jetty (Fig. 4).

Followed by multiple informal discussions and meetings during the period between September 2019 to February 2020.

Figure 3. Discussions with fishers of Worli village.

Figure 4. After discussions, with fishers operating vessels from Lotus jetty (Haji Ali).

2.3. Methods of data collection and analysis:

Baseline data related to fisheries, fish diversity, fishery and allied activities, fishermen and coastal communities, social and economic aspects related to fisheries were collected from both primary as well as secondary sources during the study. Worli is taken as fishing village and Lotus Jetty is considered only as a fishing operation base.

2.4. Fishery Studies:

Regular multi-objective experimental surveys and fishing surveys have been undertaken in the sea. Fishing was also conducted in fishable tide pools. Fishing survey locations were marked by using Global Positioning System (GPS). *Dol* net, gillnet, hook and line and other fishing operations were observed and additional georeferenced samples were procured for analysis. Experimental fishing operations were also conducted using gillnetter and dol netter in the nearshore area of the proposed project site. Fish samples were transported to Mumbai Research Station Laboratory for further analysis. Detailed taxonomic identification up to species level and biological analysis was undertaken. A comprehensive biology study was performed to know about the maturity and other biological information on the life stages of the fishes. Water samples from nearshore waters were collected and examined for phytoplankton, zooplankton, fish eggs and larvae.

2.5. Socio-Economic Analysis:

Socio-economic survey was conducted using a structured questionnaire covering village particulars (geographical area, population, number of households, infrastructure facilities, etc.), fishermen household information (family size, literacy, number of persons engaged in fishing and related activities, crafts and gears) and income and expenditure pattern of fishers. On request from the fishers of Worli village, the data collection task was assigned to the persons identified by the Fisheries societies from the village. Available unpublished information with ICAR-CMFRI was also used for the preparation of the report. The details of the boats and societies were provided by the State Fisheries Department, Maharashtra. In addition to this, the cost-benefit analysis for commercially operated fishery crafts and gears locally viz., *Dol* nets (bagnet),

gillnets, shore-seines, etc. was undertaken using fixed cost, operating cost and price data schedules in the villages falling in the project area over the study period.

3. RESULTS

3.1. Demographic features of the fishing villages:

The demographic features of the fishing villages depicted below are based on the available data set with ICAR- CMFRI and from government sources collected during surveys. This includes the fisher households of Worli and Haji Ali, population, details of boats and its registrations, societies in the villages, etc.

Table 1. Fisher household details around Mumbai Coastal Road Project (south) plan area.

Sl. No.	Name of village	Fishermen families (Nos.)	Traditional Fishermen families (Nos.)	Fisher Population
1	Worli (2010)	685	671	2934
2	Worli (2016)*	800	741	3055
3	Haji Ali (Lotus Worli) 2016*	41	1	227

*Unpublished data of ICAR-CMFRI.

Table 2. Details of age-wise fisher population from Worli.

Sl. No.	Year	Male			Female			Total
		Adult	Children (upto 5 years)	Children above 5 years	Adult	Children (upto 5 years)	Children (above 5 years)	
1	2010	879	158	442	872	174	409	2934
2	2016*	1232	96	210	1232	90	195	3055

*Unpublished data of ICAR-CMFRI.

Table 3. Details of active fishers from Worli.

Sl. No.	Year	Full Time Active Fishermen (Nos.)	Part Time Active Fishermen (Nos.)	Total
1	2010	412	160	572
2	2016*	365	88	453

*Unpublished data of ICAR-CMFRI.

Table 4. Details of fisher community from Worli.

Sl. No.	Village Name	Hindu Fishermen families	Muslim Fishermen families	Christian Fishermen families	Others	Total
1	Worli	632	2	163	3	800
2	Haji Ali (Lotus Worli)	14	23	2	2	41

*Unpublished data of ICAR-CMFRI.

Table 5. Number of boats operating from and Registered at Worli.

Sl. No.	Landing Centre	Vessels Registered in ReALCraft			Vessels holding Fishing License		
		Mechanized	Non-mechanized	Total	Mechanized	Non-mechanized	Total
1	Worli	196	43	239	122	04	126

*Department of Fisheries, Maharashtra.

Table 6 Actual number of boats operating according to sanctioned Diesel quota for the year 2018-2019.

Sl. No.	Landing Centre	No. of boats according to Cylinder					
		1 Cylinder	2 Cylinder	3 Cylinder	4 Cylinder	6 Cylinder	Total
1	Worli	28	38	05	21	02	94

*Department of Fisheries, Maharashtra.

Table 7. Boat details of Haji Ali (Lotus) (based on ICAR-CMFRI survey).

Sl. No.	Landing Centre	No. of boats					
		1 Cylinder	2 Cylinder	3 Cylinder	4 Cylinder	Non-motorised	Total
1	Haji Ali (Lotus)	19	10	2	1	12	44

Remarks: There will be a mismatch in the total number of boats available in the government database ReALCraft and the actual operational, registered, and licensed. All the registered or operational boats may not have fishing licenses and some of them are in the process of registration and waiting for the licenses. The registration of old and non-operational boats are also retained in the ReALCraft.

Table 8. Fisheries Societies in project area under consideration.

Sl. No.	Name of the Society	Society Registration Number & Date	Number of Members			Total Number of Boats
			Female	Male	Total	
1	Worli Machhimar Sarvoday Co-operative Society Limited	B.O.M./R.S.R./221/03/09/1964	175	221	396	33
2	Worli Koliwada Nakhawa Fisheries Co-Operative Society Limited	B.O.M./R.S.R./613/02/01/1973	154	415	569	157
3	Vanchit Machimar (Haji Ali) Sahakari Sanghatan Maraydit (not yet registered)	NA	NA	NA	NA	44
	Total		**329**	**636**	**965**	**190**

3.2. Fishing methods:

There are multiple types of fishing operations in the region, the major fishing method in the study area are gillnet fishing and bag net fishing. Besides, cast net fishing ('Pag'), hook and lines, handpicking of bivalves, and crab traps are also observed in the area. Details of major fishing methods are as follows:

3.2.1. Gillnet fishing: Gillnetting is a selective fishing method in which fish of a particular size are caught according to the mesh size. It's operated at the surface, column or bottom of the sea (Fig. 5). Because of its selective nature, gillnetting is one of the most suitable fishing methods from a conservation and stock regulation point of view. It is a passive method and the gear can be operated from even the most primitive craft. Depending on the mesh size and the twine used for the nets the gillnet fishing methods have several variants and local names. In the area under study, multiple variants of gillnet fishing (locally called '*Bhiljee*', Lobster Net, Floating/Bottom Set (*Tarti*/*Budi*/ *Waghara*/*Shahenshaha*/*Kargil*/*Vedhi*) are operated. Gillnet fishing operation needs good nets, which often gets damaged in the fishing operations and regular mending and repairing are often needed (Fig. 6 – 8).

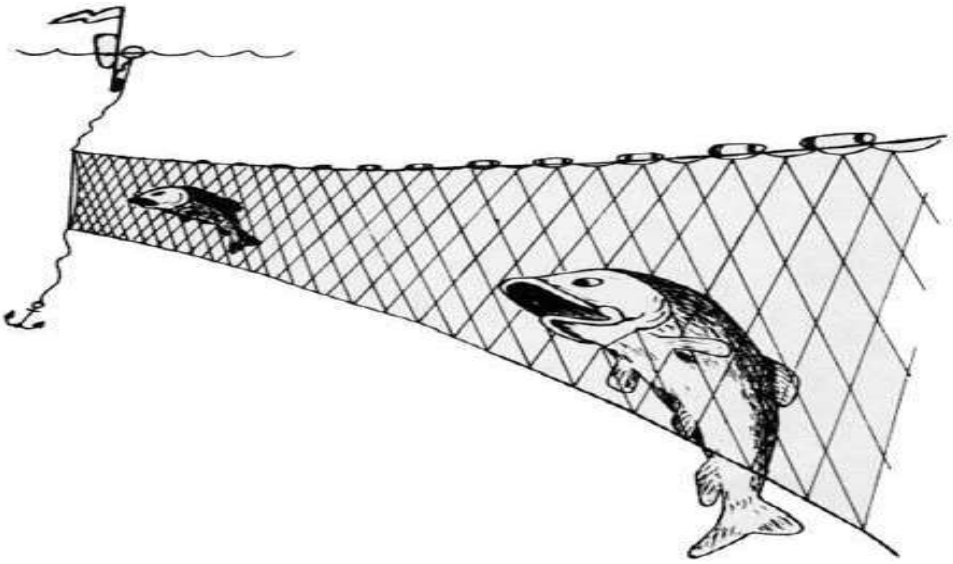


Figure 5. Gillnet fishing (example only).

Figure 6. Fishers mending gillnet at Lotus jetty (Haji Ali).

Figure 7. Fisher mending Gillnet at Worli.

Figure 8. Gillnet fishing in the nearshore waters (4 m depth).

3.2.2. Set Bag net fishing (Dol net): Set Bag net fishing is a passive fishing method as fish is caught inactively while water filters through a stationary bag-like net owing to tidal currents (Fig. 9). Therefore, the net is operated in waters where tidal current is strong enough to sustain the net horizontal and a boat is merely used to reach fishing location to set and haul the bag net and carry the catch to the landing centre. The areas with strong tidal currents in the coastal waters are identified by the fishers through indigenous knowledge. In such areas, the fishers use wooden spikes or anchors and insert into the seabed. Each spike/*sus* location is marked by a floating buoy (often specially marked bottles). The '*sus*' and the operational area around it are owned by fishers according to customs.

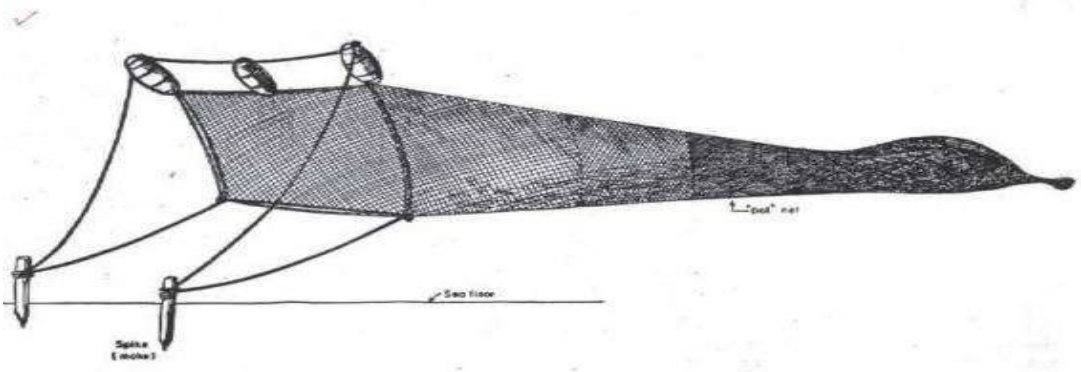


Figure 9. Set Bagnet '*Dol*' net (example).

The Set bag nets are of two major types, and accordingly, the fishing methods are locally called '*Dol*' net and *Kav* method. The '*Dol*' net is larger in dimension and operated in the open sea. The bag nets are kept horizontal by the flooding and ebbing tidal currents which are strong during the new moon and full moon phases. The tides around these phases are called spring tides (*Udhan*) while those between the phases are called neap tides (*Bhang*). The fishing is carried out when spring tides prevail and the currents are strong enough to sustain the net from 11th to 4th lunar calendar days (from *Ekadashi* to *Chaturthi*). However, during neap tides as the tidal currents are weak, the operations are suspended from 5th to 10th lunar days (*Panchami* to *Dashmi*). The effective period for bag net fishing, therefore, lasts for 16-20 days in a month.

Figure 10. Bagnet fishing in the nearshore waters off proposed coastal project area (7 m depth).

The fishing season in the zone commences in late August or early September and continues till the end of May. However, few *'Dol'* netters in the zone carry out fishing in monsoon as most of the other fishing activities in the open sea are suspended and the rates of fish are lucrative in the season.

3.2.3. Cast net fishing: Cast net or '*Pag*' is a simple circular net with lead weights at the periphery and a rope at the centre for hauling. The method is used in shallow nearshore waters for catching mullets, perches, clupeids and prawns.

3.2.4. Oyster, clam and bait collections:

Along the seaward side of coastal road project area, intertidal regions are covered with rocks and sandy bottoms where oysters and clams are present at patchy locations. Here, oysters and clams are collected mostly by women during low tide, from the exposed regions with the help of chisels and knives (Fig. 11-12). Annelid (worms) collection is an emerging activity in the area, especially along Haji Ali/Lotus region which is used as a bait in hook and line fishing and live feed for aquaculture firms (Fig. 13-14a).

Figure 11. Fisherwomen collecting oysters during low tide exposed regions.

Figure 12. Bivalves collected from Haji Ali region during low tide.

Figure 13. Bait collection during low tide (non-coastal communities).

Figure 14. Bait (Annelids) collected from the Haji Ali region.

Figure 14a. Worm collection during low tide by non-coastal communities.

3.3. Fishing boat operational bases in the proposed project area:

The main fishing boat operational base in the vicinity of project area, Worli is not falling under the proposed construction plan. However, all the fishers venturing to the sea has to cross through the pillars of the Bandra-Worli Sealink where one arm of the coastal road is connecting. It was informed by the MCGM that adequate space for safe navigation (60m span) was given for the movement of the fishing boats through the connecting arm of the proposed coastal road.

The proposed Mumbai Coastal Road project (South) covers Lotus jetty (Haji Ali), a minor operation base of smaller fishing vessels (less than 10 m OAL). Around 44 fishing vessels operate from here. The fishers operating/managing these boats reside in the nearby areas and Worli village. From the Coastal Road project proposal, it appears that a major reclamation and construction in the Haji Ali bay which may reduce safe berthing, landing space and navigable route. MCGM may undertake necessary steps to mitigate any impacts affecting the safe navigation and berthing (eg. desiltation). To

support the smaller fishing vessels and fishers, the Lotus jetty infrastructure should be improved by MCGM or other alternative arrangements has to be made.

Figure 15. Location of Lotus jetty in Haji Ali bay and ongoing developments.

Figure 16. Lotus jetty location after Mumbai Coastal Road Project (south) completion (visualization from MCGM video).

3.4. Fishing locations of the fishers from Worli and Lotus jetty:

The fishing locations were collected by using hired fishing boats from fishers and undertaken fishery monitoring surveys from Worli to Priyadarshini Park in regular intervals. In addition, regular land-based monitoring with high-resolution binoculars has also been undertaken. The major fishing gears operating in the nearshore waters of the proposed coastal road area are gillnets, *dol* nets and hooks and line. Very few cast nets operations were observed during the survey. The GPS location of the fishing boats in the sea when they were conducting the fishing operation was collected and plotted in the GIS platform (Fig. 17). Nearshore waters from 3m depth off the proposed project area are regularly fished. Fishing operations were also observed along the Bandra -Worli Sealink where the arm of coastal road is connecting. They are mainly operating gillnet for lobsters and fishes. Hand-picking of bivalves were also observed by the fisherwomen in the rocky areas. However, this area is not considered as major fishing areas or notable fishing ground due to lower fish abundance and a low quantity of large-sized/high-value fishes.

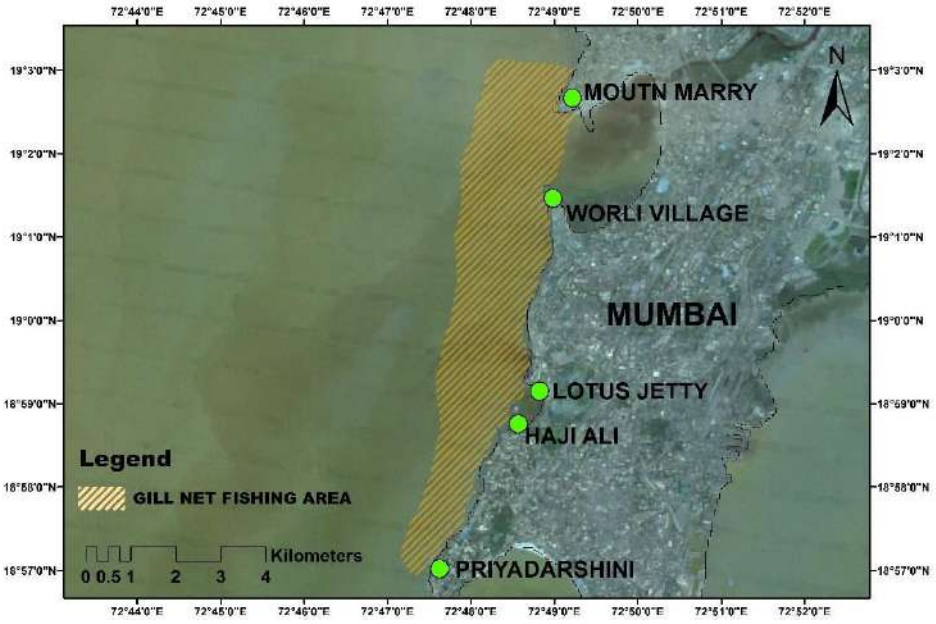


Figure 17. Nearshore fishing area mapped from fisher interviews.

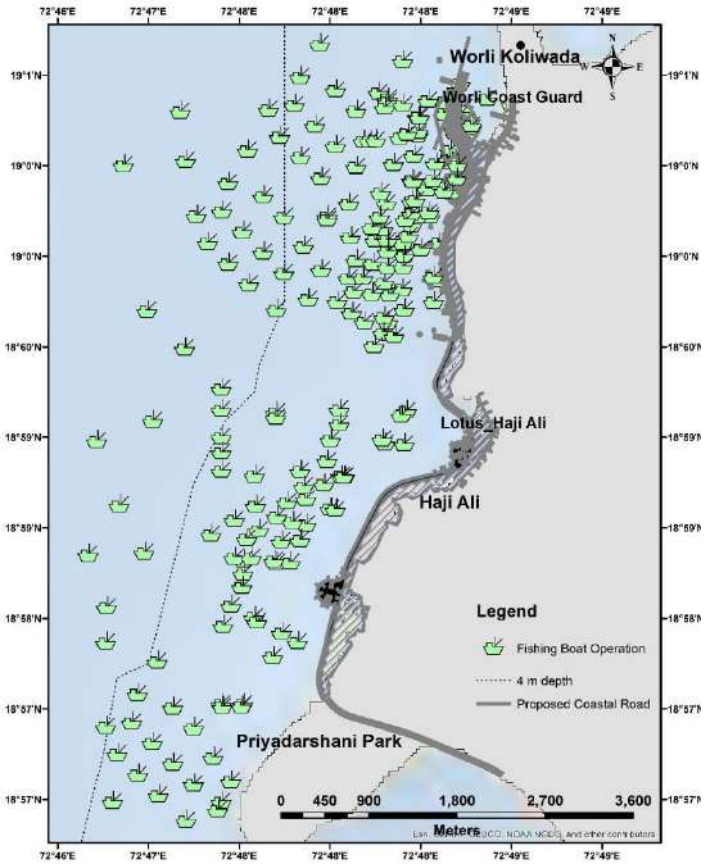


Figure 18. Location of fishing operation observed during the onboard survey and land-based monitoring.

3.5. Fishes exploited from nearshore waters around the proposed construction area:

ICAR-CMFRI team has conducted land-based monitoring and boat-based experimental survey to understand the catch composition and diversity of fishes in the proposed coastal road area. A total 116 species of commercially important fishes were observed in fishery landing/catch, however only a few species reported to be formed a regular part of the fishery (Table. 9). Most of the fishes caught are commercially important and have a good market value. This includes 86 teleosts, 3 sharks, 17 crustaceans and 10 mollusc species. During the survey, the team did not observe any large catch of brooder or spawner fish in the proposed project site, to recognize the nearshore areas adjacent to the proposed coastal road location as a spawning area. Similar to any nearshore area, a large number of juveniles were observed in the fishery.

The diversity is similar to any nearshore regions of Maharashtra, however the catch per unit was lower due to ecology of region and short duration fishing trips.

Table 9. Commercially important fishes exploited between Priyadarshini park to Worli with local name.

Family	***Species name***	**English common name**	**Local name**	**General name**
Mollusc				
Mactridae	*Mactra spp.*			
Gryphaeidae	*Gafrarium divaricatum*			Shells
Loliginidae	*Loligo duvaucelii*			squid
	Loliolus investigatoris			squid
Sepiidae	*Sepiella inermis*	Spineless cuttlefish	Ghoti/Makul	Cuttlefish
Crustacean				
Sergestidae	*Acetes indicus*		Jawala	
Penaeidae	*Penaeus spp.*	Prawn	Kolambi	Penaeid prawn
	Penaeus merguiensis	Banana prawn	Safet kolambi	Penaeid prawn
	Penaeus indicus	Giant tiger prawn	Tiger zinga	Penaeid prawn
	Parapenaeopsis stylifera	Kiddi prawn	Tiny	Penaeid prawn
	Metapenaeus brevicornis	Yellow prawn	Pollen	Penaeid prawn
	Metapenaeus monoceros	Speckled prawn	Kapshi	Penaeid prawn
	Metapenaeus dobsoni			
	Metapenaeus affinis			
Lysmatidae	*Exhippolysmata ensirostris*			
Portunidae	*Scylla tranquebarica*	Mud crab	Khekra	Crab
	Scylla serrata			
	Charybdis lucifera			
	Charybdis callianassa			
	Portunus pelagicus			
Menippidae	*Menippe rumphii*	Stone crab		
Palinuridae	*Panulirus polyphagus*	Mud spiny lobster	shevand	
Chondrichthyes				
Carcharhinidae	*Scoliodon laticaudus*	Spadenose shark	Mushi	Shark
	Carcharhinus sp			
Hemiscylliidae	*Chiloscyllium arabicum*	Arabian carpet shark	Mushi	shark
Teleostei				
Sparidae	*Acanthopagrus arabicus*	Arabian Yellowfin seabream	Kali kishi/Khadak Palu	Sea bream
Carangidae	*Alepes djedaba*	Shrimp scad	Katbangada/Karkara Bangada	Carangids

	Alepes klenii	Razorbelly scad	Kala bangada	Carangids
	Megalaspis cordyla	Torpedo scad	Bangada	Carangids
	Caranx sexfasciatus	Bigeye trevally		
	Scomberoides commersonnianus			
	Scomberoides lysan			
	Scomberoides tala		*Phalai*	
	Scomberoides tol			
	Trachinotus mooklee	Pompano	American paplet	Carangids
Scombridae	*Scomberomorus guttatus*	Indo-Pacific king mackerel	surmai	
	Rastrelliger kanagurta		Bangada	
Clupeidae	*Anodontostoma chacunda*	Chacunda guizzard shad	*Palu / Pala*	Clupeid
	Escualosa thoracata	White sardine	Bhiljee	Clupeid
	Sardinella albella			
	Sardinella gibbosa			
	Sardinella longiceps			
	Sardinella fimbriata			
	Tenualosa ilisha	Hilsa shad		
Dussumieriidae	*Dussumieria acuta*	Rainbow sardine		
Chirocentridae	*Chirocentrus dorab*	Dorab wolf-herring	Karli/datadi	
	Nematalosa nasus	Bloch's gizzard shad		
Engraulidae	*Coilia dussumieri*	Goldspotted grenadier anchovy	Mandeli	Anchovy
	Thryssa dayi	Day's thryssa	Kati	Thryssa
	Thryssa dussumieri	Dussumier's thryssa	Kati	Thryssa
	Thryssa mystax	Moustached thryssa	Kati	Thryssa
	Thryssa hamiltonii	Hamilton's thryssa		
	Thryssa setirestris	Longjaw thryssa	Kati	Thryssa
Pristigasteridae	*Pellona ditchela*	Indian pellona	Kati	Pellona
	Ilisha filigera		kati	
	Ilisha megaloptera	Bigeye ilisha	Kati	Ilisha
	Opisthopterus tardoore	Long-finned herring		
Synodontidae	*Harpadon nehereus*	Bombay duck	Bombil	Bombay duck
Hemiramphidae	*Hemiramphus far*	Half beak	Tol / toki	Half beak
	Hemiramphus archipelagicus	half beak	Tol	
	Hyporhamphus limbatus	Half beak	Tol / toki	Half beak
Belonidae	*Strongylura strongylura*	Spottail needlefish	Tol	Needlefishes
	Tylosurus crocodilus	Hound needlefish		
	Strongylura leiura	Banded needlefish		
Ariidae	*Arius maculatus*	Spotted catfish	Seenghala	Catfish
	Mystus sp.	Catfish	Seenghala	Catfish
	Plicofollis tenuispinis	Thin spine sea catfish	Seenghala	Catfish
	Plicofollis layardi			
	Nemapteryx caelata			
Plotosidae	*Plotosus lineatus*	Striped eel catfish		

Gobiidae	*Trypauchen vagina*	Pink worm goby	Newti	Goby
Polynemidae	*Eleutheronema tetradactylum*	Four finger threadfin	Dara	Polynemid
	Leptomelanosoma indicum	Indian threadfin		
Drepaneidae	*Drepane punctata*	Spotted sicklefish		
Serranidae	*Epinephelus diacanthus*	Spinycheek grouper	Hekru/Gobra	Grouper
	Epinephelus coioides	Orange-spotted grouper	Hekru	
Trichiuridae	*Eupleurogrammus muticus*	Smallhead hairtail	Vakati	Ribbon fish
	Lepturacanthus savala	Savalai hairtail	Bala/Vakati	Ribbon fish
Gerreidae	*Gerres filamentosus*	Whipfin silver-biddy	Shetak	Silver biddy
Sciaenidae	*Johnius belangerii*	Belanger's croaker	Dhoma	Croaker
	Johnius borneensis	Sharpnose hammer croaker	Dhoma	Croaker
	Johnius carouna			
	Johnius dussumieri	Sin croaker	Dhoma	Croaker
	Johnius elongatus	Spindle croaker	Dhoma	Croaker
	Johnius glaucus	Pale spot fin croaker	Dhoma	Croaker
	Johnius macrorhynus	Bigsnout croaker	Dhoma	Croaker
	Daysciaena albida	Bengal corvina	Barad	
	Otolithoides biauritus	Bronze croaker	Ghol	Croaker
	Protonibea diacantha	Spotted croaker	Koth	
	Otolithes cuvieri	Lesser tigertooth croaker		
	Otolithes ruber	Tigertooth croacker		
	Paranibea semiluctuosa	Half-mourning croaker		
Tetraodontidae	*Lagocephalus inermis*	Smooth blaasop	Kend	Pufferfish
	Takifugu oblongus	Lattice blaasop	Kend/Fugu masa	
	Lagocephalus spadiceus	Half-smooth golden pufferfish	Kend	Pufferfish
Lutjanidae	*Lutjanus argentimaculatus*	Mangrove red snapper	Tamb/Tamboshi	Snapper
	Lutjanus johni	John's snapper	Tamb	Snapper
Latidae	*Lates culcarifer*	Barramundi	Jitada	Snapper
Mugilidae	*Liza spp.*			
	Liza subviridis	Greenback mullet	Boi	Mullet
	Chelon sp.			
	Ellochelon vaigiensis	Squaretail mullet		
Cynoglossidae	*Cynoglossus arel*	Largescale tonguesole	Lep	Flatfish
Scatophagidae	*Scatophagus argus*	Spotted scat	Chaba	Butterfish
Terapontidae	*Terapon jarbua*	Jarbua terapon	Naviri hajam	Therapon perch
	Terapon puta			
Exocoetidae	*Hirundichthys indicus*	Arabian flying fish		
Megalopidae	*Megalops cyprinoides*	Indo-Pacific tarpon		
Stromateidae	*Pampus candidus*	Silver pomfret	Saranga/paplet	
	Pampus chinensis	Chinese silver pomfret	Kapri	
Haemulidae	*Pomadasys kaakan*	Javelin grunter		

3.6. Catch composition of Gillnets:

In the surface gillnets, 96% of the catch was constituted by the pelagic followed by demersal 3.5%. In the trammel nets 70% catch was by pelagic species. As gillnet is a selective gear, most of the fishes caught were adults and very few juveniles were present. There are diverse variants of gillnets are operated in the study area. In the bottom set gillnets catch was dominated by croakers and catfishes. Motorised (single engine) and non-motorised boats of size less than 12 m OAL are operating gillnets. Gillnet catch (combined for various gears) varied from 1 -120 kg with average catch of 38 kg for the study period.

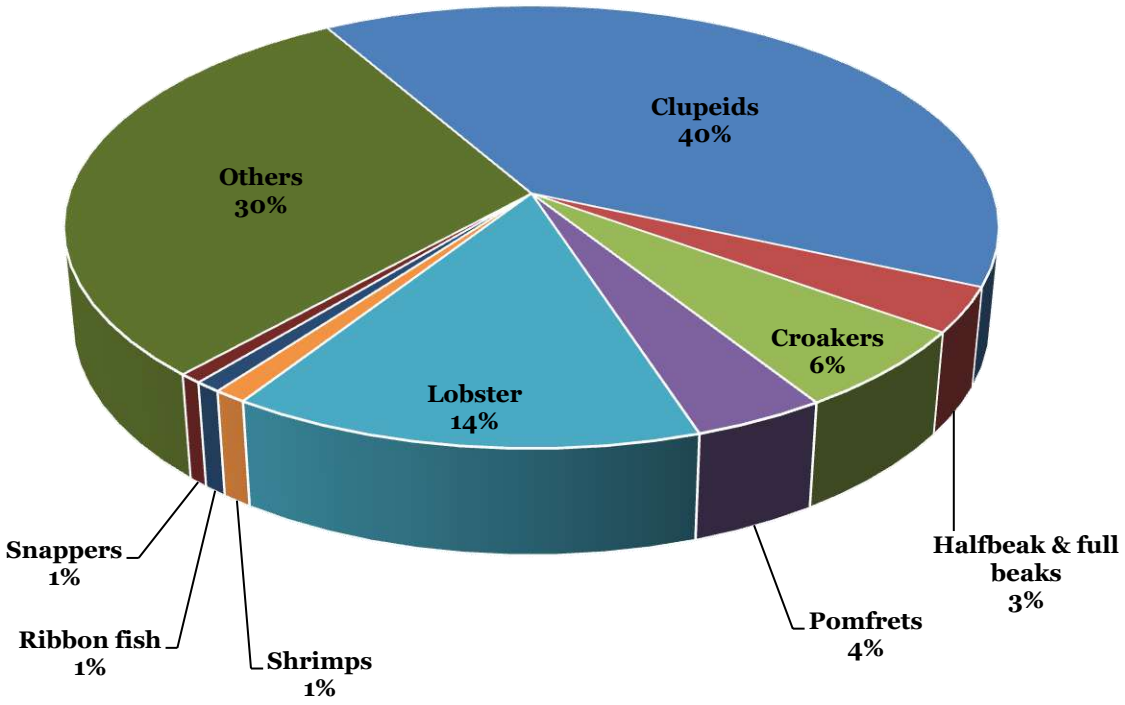


Figure 19. Groupwise species composition of gillnet catch (pooled for different variants of gillnet).

3.7. Catch composition of SBN (dol nets) operating around the proposed construction area:

During the survey, only thirteen *dol* netter fishing was observed in the vicinity of the proposed coastal road area (up to 6 m depth from LTL) near to the Bandra-Worli sealink. Crustaceans contributed major part of the catch (59%) followed by pelagic (18%) (Fig.). Most of the catch was constituted by juveniles. Operation is based on tides and smaller vessels less than 15 m OAL is used. The catch in dol net ranged from 18- 76 kg, with an average catch of 36 kg.

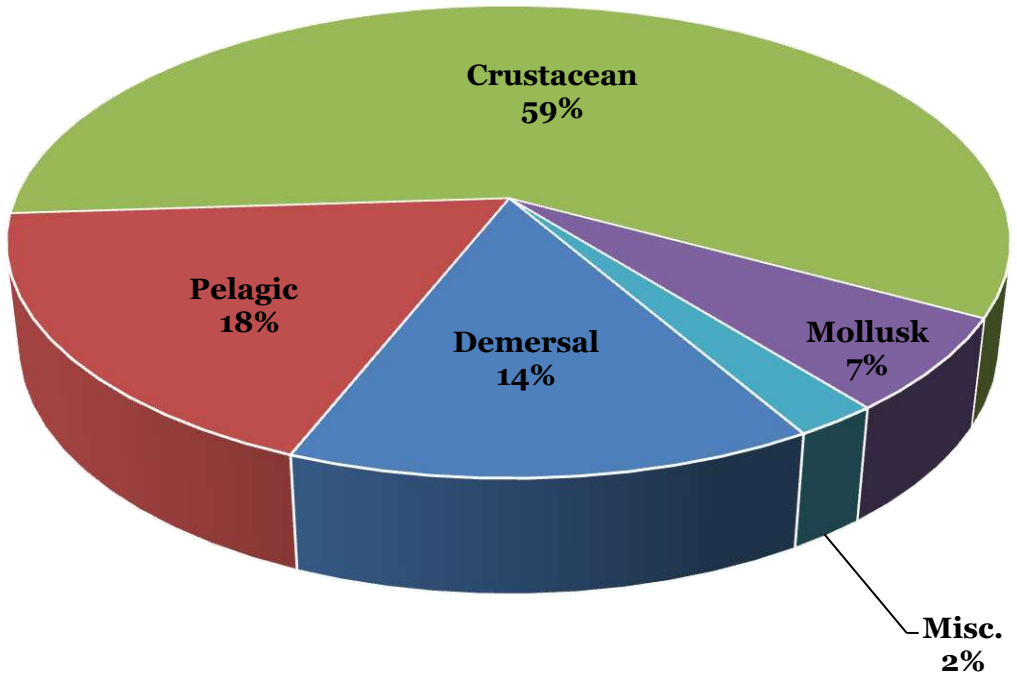


Figure 20. Group-wise species composition of *Dol* net catch.

3.8. Catch composition of Hook & line and cast net operating around the proposed construction area:

Hook & line and cast net operations are very limited in the region. The catch rate was very less with croakers, sparids, mullets, grunts and catfish.

3.9. Maturity stages of fishes caught from nearshore waters:

During the period of study, only juveniles were observed for the following species: *Arius maculatus, Alepes djedaba, Caranx sexfasciatus, Epinephelus coioides, Ilisha filigera, Lutjanus argentimaculatus, Lutjanus johnii, Plicofollis layardi, Pomadasys kaakan, Scomberoides commersonnianus, Scomberoides tol, Scylla serrata, Harpadon nehereus, Megalaspis cordyla, Sardinella fimbriata, Sardinella longiceps, Scomberomorus guttatus Metapenaeus affinis, Otolithes ruber, Plicofollis tenuispinis, Terapon puta, Lactarius lactarius, Otolithes cuvieri, Trichiurus lepturus, Exhippolysmata ensirostris* and *Loligo duvauceli.*

Commercially important species *like Pampus argenteus, Parastromateus niger, Panulirus polyphagus, Penaeus indicus, Penaeus merguiensis* were dominantly juveniles (60%).

Mature fishes were dominant for the following species like *Anodontostoma chacunda, Sardinella albella, Cynoglossus arel, Gerres filamentosus, Scatophagus argus, Thryssa mystax* and *Loliolus investigatoris* whose market value is comparatively less.

Escualosa thoracata was the major species in surface gillnets and the juveniles observed about 7.3 percent only. Juveniles percent in total numbers observed: *Opisthopterus tardoore* (92 %), *Johnius belangerii* (48 %), *Thryssa hamiltonii* (98 %), *Strongylura leiura* (90 %), *Rastrelliger kanagurta* (70 %), *Johnius macrorhynus* (25%), *Johnius vogleri* (65 %), *Hemiramphus archipelagicus*, (85 %), *Coilia dussumieri* (49%), *Liza subviridis* (12.5 %), *Eleutheronema tetradactylum* (83 %), *Johnius elongatus* (80%), *Johnius glaucus* (57 %), *Lagocephalus spadices* (86 %), *Lepturacanthus savala* (9 %), *Metapenaeus dobsoni* (25 %), *Parapenaeopsis stylifera* (35 %), *Sepiella inermis* (43 %), *Thryssa setirostris* (20 %) and *Scoliodon laticaudus* (75 %).

These results of fishery reveal the dominance of juveniles with smaller-size classes are characteristic of the nearshore tropical coastline and does not indicate as nursery/breeding grounds. Observed and analysed fishery samples during the study period did not show any unusual abundance of any particular species with spawning or ready to spawn maturity stages to be called as spawning area or breeding ground except for sedentary shellfishes.

3.10. Shell fishery (Oyster/Clam):

Regular observations were made at the proposed project area to examine the shell fishery, the extent of Oyster/shell beds, the density of oyster/shells and commercially important shells etc.

Near to Worli Sea link 18140 sq. m intertidal area was surveyed (Fig. 21, Pin-1). Oyster patches were observed during low tides. Here, women from nearby areas collect oyster and clams for household consumption and a few for local marketing. Using random quadrant method, density for Oyster (*Crassostrea madrasensis* and *Saccostrea cucullata)* and clam, *Gafrarium divaricatum* were estimated.

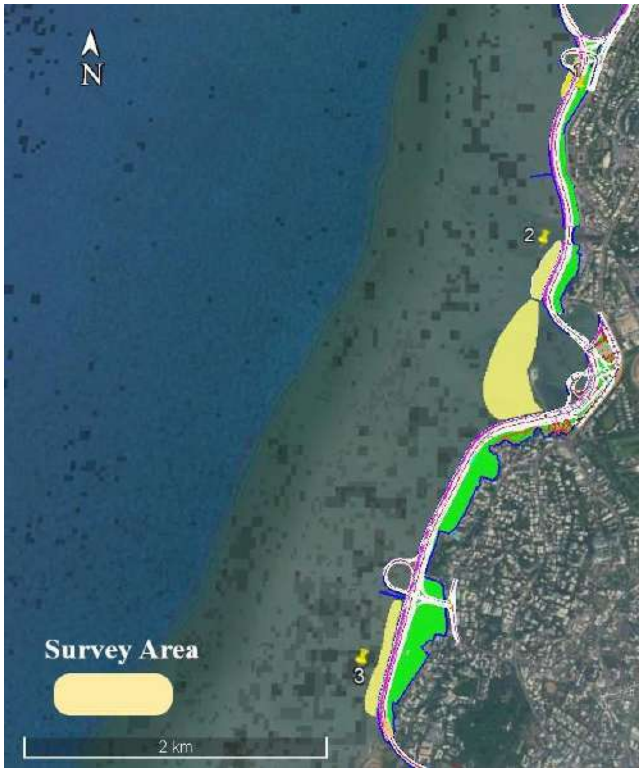


Figure 21. Surveyed area for Molluscan resources along proposed project area intertidal stretch.

Near Haji Ali (Fig. 20, Pin-2) approx. 50608 sq. m area were surveyed. Uneven/patchy beds of clams, oysters and mussels were observed. Mostly people from Malad, Nalasopara, Mahul are handpicking the clam *Gafrarium divaricatum* and Green mussel, *Perna viridis* during low tide for sales in local market and for household

consumption. During the survey, 10-30 individuals were noticed to be handpicking the clam oysters, and mussel, none of the interviewed shell collectors/vendors were from villages near to the proposed Mumbai Coastal Road (south) area. Green mussels' population were localized and very scattered, while the clam, *Gafrarium divaricatum* density varied from 5-10 nos. per sq. m. Condition index and percent edibility ranges of the samples indicated a healthy population. Biological observation showed that some of the females (Total length: 31-40 mm) were mature while sex ratio was (Male:Female) 1:1. Oyster patches were also observed along the intertidal area, but the average density of dead oyster (70-120/m^2) was higher than the live oyster (20-30/m^2). Green mussel observed had a total length ranged between 52-121 mm.

a

b

c

d

Figure 22. Nearshore sampling at for estimating extent, density, size composition, eggs and larvae and diversity of Molluscan fauna during lowtide.

The area surveyed near Priyadarshini park was approx. 60342 sq. m. Patchy Oyster settlements were observed near the proposed site. Resource density/abundance was monitored by making random quadrants in the study area to assess the abundance of the bivalve and gastropods. Near Priyadarshini (Fig. 21, Pin-3), oyster density was 58 (±4) live and 28 (±7) dead oyster per square metre. Observations were made to locate gastropods egg mass, but did not find any towards the proposed project area. Mostly, live and dead shell of *Crassostrea madrasensis* and *Saccostrea cucullata* were observed in quadrants. Few patches of a gastropod shells were also observed.

Destruction of the rocky area in the intertidal area will happen during the construction phase itself, thus the population of oysters in the rocky patch will be destroyed. As they are the sedentary organisms, a complete life cycle is happening there and it may livelihood of shell handpickers.

The Common molluscan species observed along the proposed Mumbai Costal Road (South) area were:

1. *Trochus radiatus*.
2. *Gafrarium divaricatum*.
3. *Crassostrea madrasensis*.
4. *Saccostrea cucullata*.
5. *Turbo bruneus*.
6. *Nerita polita*.
7. *Nerita albicilla*.
8. *Bursa granularis*.
9. *Domiporta circula*.
10. *Cantharus spiralis*.

Figure 23. Survey near Haji Ali.

Figure 23a. Survey near Bridge.

Figure 24. Interaction with clam hand-picker during low tide.

Figure 25. Women shell vendors/collectors at Lotus jetty.

3.11. Environmental monitoring:

Physico-chemical and biological parameters in the project area were monitored during the study period. Surface water and column water was collected for plankton studies. Three stations were identified from the study area.

Station I: Off Priyadarshini Park (18° 57'. 851 N/ 72° 47'796" E)

Station II: Off Haji Ali (18°58' 862" N/ 72° 48'224" E)

Station III: Off Worli (19° 00' 473" N/ 72° 48' 646" E)

A total of 18 surface water samples were collected to study the presence of ichthyoplankton and environmental parameters at about 8-10m depth. Zooplankton samples were collected with a 300-µm mesh conical-cylindrical plankton net using surface horizontal hauls lasting for 10 minutes.

During the study period, water samples were collected from tide pools during low tide at six randomly selected locations by filtering 100 L of water through 300-µm mesh conical-cylindrical plankton net. Zooplankton samples were preserved in 5% buffered formalin solution and used for qualitative and quantitative analysis.

The egg density is found to be highly variable ranging from 0.2 eggs.m^{-3} to 6.4 eggs.m^{-3}. Larval density ranged from 0.12 nos.$^{-3}$ to 2.14 nos.$^{-3}$ (Fig.. 30). The abundance of eggs were high in October, while the highest numbers of fish larval stages were observed in November. In comparison to other coastal areas, the fish egg and larvae density are very low in the proposed Mumbai Costal Road (South) area during the study period. Further, spatial and temporal variations and distribution of planktonic fish eggs and larvae in the near-shore waters or coastal waters are primarily determined by environmental factors such as rainfall, salinity, sea surface temperature, pH, dissolved oxygen, tidal cycle and productivity of the waters etc.

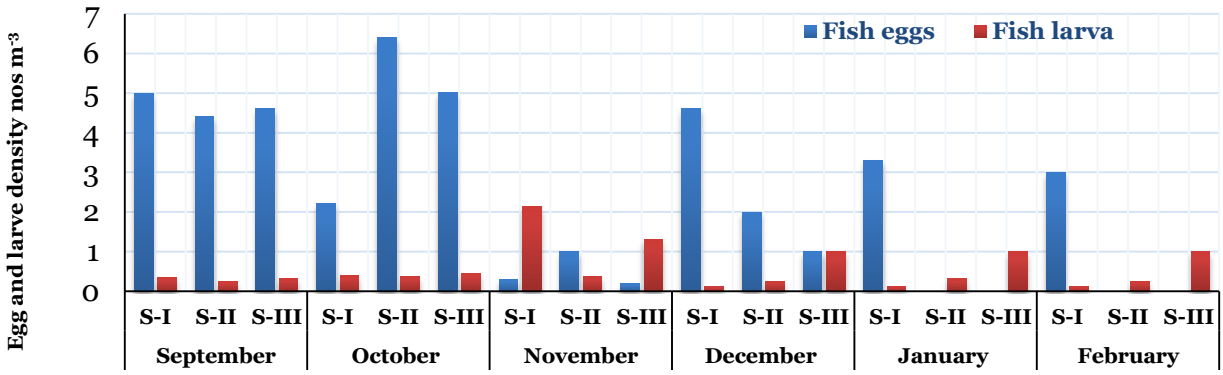


Figure 26. Eggs and fish larval density (nos. m^{-3}) in the study area.

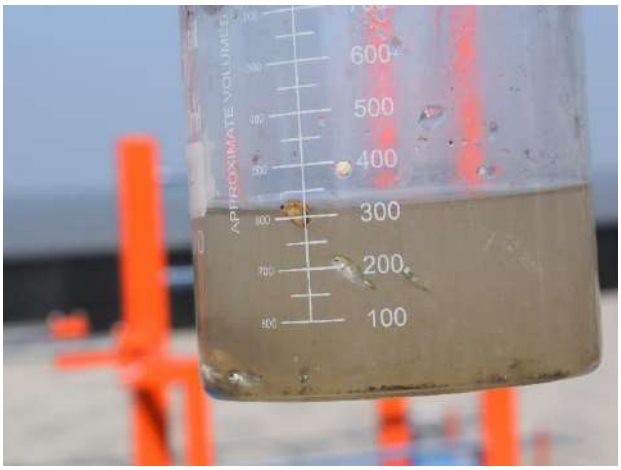
Phytoplankton Net Operation

Zooplankton Net Operation

Collection of plankton nearshore waters

ICAR-CMFRI Mumbai RC Team for onboard sampling

Tidepool sampling for zooplankton and larvae



Zooplankton and fish larvae

Figure 27. Environmental parameters collection.

3.12. Socio-economic studies in the proposed project area:

Worli (Fishing Village) is one of the seven islands of Mumbai located along North-eastern Arabian Sea. Worli *Koliwada* as known locally is inhabited dominantly by fisher community is a densely populated area. Fishers of Worli Koliwada land their marine fish catch at four landing centres located along the village or slightly far according to operational/berthing facility;

1. Worli Seaface / Cleveland Bunder,
2. Worli Killa / Worli Bateri Jetty,
3. Tare Jetty (mostly used during high tide time only) and
4. Lotus Jetty.

3.12.1. Socio-economic status of the respondents:

The socio-economic status of the stakeholders decides their motivation to adopt or reject any intervention or innovation or any technology. Thus with this aim, socio-economic status survey was conducted and responses were analysed and presented below.

Socio-economic information was collected using a detailed questionnaire developed by ICAR-CMFRI (Annexure 1). Information of 324 households/respondents was collected with the help of local enumerators identified by fishers and compiled for further analysis. The information of 1087 fishers comprising 455 adult males 460 adult

females and 172 children has been collected during the survey. The total number of males involved in fishing activities 306 and the total number of females involved in fishing (or allied) activities 304. Respondents of questionnaire survey were active members from Worli Machhimar Sarvoday Cooperative Society Limited and Worli Koliwada Nakhawa Matsyavyavasay Sahakari Society Limited.

Economic status:

The economic status of the respondents was studied based on the colour of the ration card they possess. It was found that the majority of respondents (87.3%) are in the Above Poverty Line (APL) category, followed by 12.7 % of respondents are in the category Below Poverty Line (BPL) (Table 10).

Table 10. The economic status of the respondents (n = 324).

Possession of Ration Card	No.	Percent
APL	283	87.3
BPL	41	12.7

Family type:

Family type is an important aspect that decides the economic status of households. The joint family is expected to bring strength to the family compared to the nuclear families. Study area have a large number of fishers belonging to *Koli* community. Most of the respondents are living in joint families (97.2%) whereas only 2.8% of respondents come from a nuclear family (Table 11).

Table 11. Family type (n = 324).

Family Type	No.	Percentage
Nuclear	9	2.8
Joint	315	97.2

Asset possession – House:

Ownership of house is a status symbol in the society and the villages are not an exception to this**.** Land price is very high in the area**.** It was found that most of the respondents (84.3%) owned a house and the remaining 15.7% reside in rented house (Table 12).

Table 12. Asset ownership: House (n = 324).

Own/Rental	**No.**	**Percent**
Owned	273	84.3%
Rental	51	15.7%

Housing pattern:

The prevailing housing patterns in a fishing village are huts, tiled and concrete houses. Most of the respondents (99.1%) live in *Pucca* houses followed by those living in *Kutcha* house (0.6%) and semi *Pucca* (0.3%) (Table 13).

Table 13. Housing pattern (n = 324).

Kutcha*/Semi *Pucca*/*Pucca	**No.**	**Percent**
Kutcha	2	0.6
Semi *Pucca*	1	0.3
Pucca	321	99.1

Occupational status:

According to the response, 94.2% of respondents depend on fishing and fishing allied activities for their livelihood. Remaining 5.8% of respondents rely on non-fishing activities as their main occupation. However, atleast one of their household/family members is involved in fishing or fishing allied activities (Table 14).

Table 14. Occupational status (n = 324).

Occupation	**No.**	**Percent**
Fishing	227	70.1
Fishing allied activities	78	24.1
Job/Service	17	5.2
Salesman/Store	1	0.3
Repair Work	1	0.3

Active fishers include boat owners, crew members working onboard fishing crafts and fishers undertaking traditional fishing activities, whereas, fishers involved in fresh

and dry fish marketing were considered to be involved in fishing allied activities (Table 15).

Table 15. Individuals involved in fishing and fishing allied activities.

Particulars	**Number of individuals involved**
Boat owners	146
Crew members	51
Traditional fishers	50
Fresh fish marketing	223
Dry fish marketing	44

Income from fishing:

The income of a person plays an important role in shaping the economic conditions of an individual. The study found that for most of the respondents (74.1%) monthly income from fishing ranged from Rs. 5,001/- to Rs.20,000/-. About 21 percent of the respondents earned between Rs. 20,001 to 35,000/- per month. Nearly, 2.5% earned Rs. 5000/- or less than Rs. 5000/- per month from fishing activities. Merely 0.9% of respondents were earning more than Rs. 50,000/- per month from fishing activities (Table 16).

Table 16. Income from fishing activities.

Sl. No.	**Monthly Income in Rs.**	**No.**	**Per cent**
1	<= 5,000	8	2.5
2	5,001 to 20,000	240	74.1
3	20,001 to 35,000	68	21.0
4	35,001 to 50,000	5	1.5
5	50,001 to 65,000	2	0.6
6	65,001 to 80,000	0	0.0
7	80,001 to 85,000	1	0.3

Income from non-fishing activities:

The study found that for most of the respondents (84.1%) monthly income from fishing ranged from Rs. 5,001/- to Rs.10,000/-. About 3.6 percent of the respondents earned up to Rs. 5,000/- per month. Only very few (0.11%) earned the highest observed income range of Rs. 15,001/- to Rs.25,000/-(Table 17).

Table 17. Non-fishing activities income status.

Sl. No.	Monthly Income in Rs.	No.	Percent
1	<= 5,000	12	3.6
2	5,001 to 10,000	62	84.1
3	10,001 to 15,000	9	11.2
4	15,001 to 20,000	3	0.7
5	20,001 to 25,000	2	0.4

Fishing crafts and gears operated:

Mostly marine fisheries activities off Worli are undertaken employing motorized, and non-mechanized crafts. Total 181 fishing crafts were recorded from 147 fishers during the survey. Details of fishing crafts are as below.

Table 18. Types of fishing crafts operated by fishers from Worli fishing village.

Fishing Craft Type	Number
Mechanized	4
Motorized	126
Non-mechanized	51

Fishers from Worli mostly operate Gillnet and its variants (76.8%) in nearshore waters. Some of the fishers operate *Dol* nets (23.2%), but most of the fishers operate both Gillnet and *Dol* net from their crafts depending on the fishing season and fish availability.

Table 19. Fishing craft and gear operated.

Fishing craft Type	**Gear operated**	**Nos.**
Motorized	Gillnet	94
	Dol Net	32
Non-mechanized	Gillnet	43
	Dol Net	8
Mechanized	Gillnet	2
	Dol Net	2

Artisanal Fishing:

Artisanal fishing practices like beach seine net operation, cast net, crab traps, hook & line, *Kargil* net (variant of Gillnet-operated in nearshore rocky sea bed), clam and oyster collection are undertaken by local fishers of Worli fishing villages in nearshore area. Fifty fishers were operating artisanal fishing gears / methods to support livelihood.

Table 20. Individual involved in traditional fishing activities.

Fishing practice	**No. of individuals practicing**
Cast net (*Pag*)	14
Kargil (variant of Gillnet)	2
Hook & Line (*Garavali*)	11
Gholwa (variant of beach seine / drag net)	13
Crab traps (*Pagolya*)	19
Clam (*Shivlya*) collector	14
Oyster (*Kalwa*) collector	7

Fish species caught by artisanal fishing methods in nearshore waters are *Polynemus indicus, Lates calcarifer, Epinephelus coioides, Lutjanus johnii, Lutjanus argentimaculatus, Protonibea diacanthus, Pampus argenteus, Scatophagus argus, Daysciaena albida*, *Lepturacanthus savala*, *Acanthopagrus latus*, *Abudefduf sordidus*, croakers, mullets, catfish ribbonfish and *Panulirus polyphagus*. Clams and oysters are

handpicked from rocky patches along nearshore area. Crab traps are used to catch *Scylla serrata* and *Scylla tranquebarica* along seashore off Worli.

Fishing crafts from Worli fishing village mostly operate from three landing centres located along village. However, sometimes to land commercially important fish catch fishers use Lotus jetty landing centre. Apart from fishing crafts of Worli fishing village 44 fishing crafts operate solely from Lotus jetty. During construction activities of proposed coastal road access to the Sea for fishing activities from Lotus jetty will be restricted. The Lotus Jetty itself is not a fishing village. The owners of the boats are residing in other villages like Mahul, Worli and adjacent areas. Therefore, the information of those fishers whos boats are operating at Lotus Jetty was collected along with the fishing activities and details of crafts.

Both motorized and non-mechanized fishing crafts operate from Lotus jetty exclusively in nearshore waters off Worli. Information of 44 fishing crafts was collected during the survey. These crafts mainly operate gillnet and its variants in nearshore waters. Moreover, fishers also operate other gears viz., *Dol* net, hook and line, cast net and crab traps according to fish availability in nearshore waters and fishing season. Fishers commonly practice hook and line fishing with the help of low price fish catch of gillnet as bait to catch costly fishes like eels, groupers, catfish, ray, snappers, etc. Details of the fishing crafts recorded from Lotus jetty are as follows;

Table 21. Crafts and gears operated from Lotus jetty.

Fishing Craft	**Gear Operated**	**Number**
Motorized	Gill net	34
	Dol net	1
Non-mechanized	Gill net	9

3.12.2. Fishers' perception on anticipated impacts due to the construction of proposed coastal road off Worli fishing village, Mumbai, Maharashtra:

An opinion survey was conducted to analyse the anticipated positive/negative impacts due to the construction of the proposed coastal road off Worli fishing village, Mumbai, Maharashtra. A total of 324 respondents were interviewed and information

based on a questionnaire was collected. The results are presented in Table 11. Most of the respondents (19.3%) opined that fishing activities are undertaken in the nearshore area and fishing will be hampered due to the proposed coastal road project. About 17.8% of respondents think that the proposed coastal road project will cause changes in fishing, breeding grounds of fish. Fishers (16.9%) expressed that the fisher community will face the problems and livelihood will be affected due to the proposed coastal road project. Respondents (16.9%) expressed their concern regarding the possible rise in seawater level which can lead to the intrusion of seawater in nearshore households. Local fishers also fear that (8.8%) traditional fishing activities undertaken in nearshore waters will be hampered due to proposed construction activities. The proportion of respondents (4.1%) opined that water current pattern will be affected (4.1%), fishing crafts and nets can be affected (2.7%), access of fishing crafts to the sea and landing centre will be affected (2.0%), and fish drying activities in a coastal area can be hampered (0.3%) due to proposed project.

Table 22a. Fishers' perception on anticipated negative impacts due to the construction of proposed coastal road off Worli fishing village, Mumbai, Maharashtra.

Pitfalls	Frequency
Will not able to do fishing in nearshore	6.5%
We will not get any fish	1.8%
Will lose/reduce the fishing area	7.8%
Fishes will not come near and there disappear affect traditional fishing	4.9%
We were not informed about the project	3.8%
Fishermen community will be affected and face financial loss	4.0%
Distortion of Fishing, breeding grounds & recruitment of different species in this area	10.0%
Water level/sea level will increase and house washed away	15.7%
Fishery will be destroyed and nature balance too.	4.1%
Fishing crafts and nets affected	2.7%
Marketing and sale of fish affected	1.9%
Water current and their pattern will affect	4.1%
Fish catch and fish production will affect and lead to fish famine	6.9%
Will be affecting our daily bread and earnings/loose our earnings	8.0%

Traditional fish and fishery resources destroyed	3.9%
Due to tidal change our houses may get washed away	1.2%
Survivability of family and financial issues	4.9%
The reclamation can pose problems to Worli village	0.8%
The incoming and outgoing of boats will be affected	2.0%
Sludge will develop in the area	0.8%
Drying and keeping fish affected	0.3%
Vehicle pollution & Environmental issues	1.9%
Disaster may take place due to reclamation	2.1%

Table 22b. Fishers' perception in general.

Sl. No.	Comments	% of total respondents Worli
1	1. Will not able to do fishing in nearshore 2. We will not get any fish 3. The fishery will be destroyed and nature balance too 4. Fish catch and fish production will affect and lead to fish famine	19.3%
2	1. Distortion of Fishing, breeding grounds & recruitment of different species in this area 2. Will lose/reduce the fishing area	17.8%
3	1. Fishermen community will be affected and face financial loss 2. Will be affecting our daily bread and earnings/lose our earnings 3. Survivability of family and financial issues	16.9%
4	1. Water level/sea level will increase and house washed away 2. Due to tidal change, our houses may get washed away	16.9%
5	1. Fishes will not come near and there disappear affect traditional fishing 2. Traditional fish ad fishery resources destroyed	8.8%

A total of 19 individuals were interviewed at Lotus jetty to on anticipated impacts of the Mumbai Coastal Road Project (South), the concerns and their issues were different from that of Worli. The issues were ranked according to response. There is a uniformity in the negative impacts perceived. The request as came in was “may be allowed to continue the livelihood and facilities to be ensured for safety”.

Table 23. Concerns of fishers based at Lotus jetty.

Issues	**Ranks**
Will lose free and regular access to sea for livelihood	1
Safety of vessels and loss of berthing space	2
Will lose/reduce the fishing area	3
Not able to do fishing in nearshore	4
Distortion of Fishing, grounds & recruitment of different species in this area	5
Fish catch will affect and reduce income	6
Access to common space restrictions	7

3.12.3. Retail fish marketing and economic account of fish marketing:

Fish retail marketing is one of the major marine fisheries allied activity practiced by fishers which are not involved in active fishing practices. In urban areas of Mumbai, fish retailers assess local fish demand and their purchasing power and accordingly supply fishes to the local market.

At Worli fishing village, marine fish landings are undertaken at Worli Seaface, Worli Killa landing centre and Lotus landing centre near Haji Ali. Fisherwomen purchase fresh edible fish from these landing centres and according to the local demand supply in Worli village vicinity areas and other fish markets in the city.

Predominantly fisherwomen contribute in retail fish marketing in nearby residential areas or commercial fish market located along Mumbai. According to the survey conducted by CMFRI in 2016, a total 763 fish retailers or vendors are operating from Worli village out of which 740 are women.

Assumptions:

1. Active marketing days in a year : 180 days.
2. Estimated average transportation cost required for marketing : Rs. 150/- per day.
3. Market charges : Rs. 200/- per month.
4. Estimated average daily earning from fish marketing : Rs. 500/-.

Considering the assumptions concluded through economic data collected from Worli fishing village and discussion with fishers estimated annual earning through fish marketing are Rs. 90,000/-. Annual estimated expenditure on transportation, ice, bags, market charges, baskets, selling platform and miscellaneous equipment's is Rs. 34,700/-. However, annual profit for a fisher through selling fish in the market is Rs. 49,900/-.

Table 24. Cost benefit analysis of retail fish marketing.

Market Charges for ten months	:	Rs. 2,000
Daily earning	:	Rs. 500
Basket (2 nos.)	:	Rs. 500
Fish selling platform (2 nos.)	:	Rs. 600
Miscellaneous (fish cutting tool, packing bags, etc.)	:	Rs. 1,000
Ice (Rs. 20/- per day)	:	Rs. 3,600
Income from fish selling for 180 days	:	Rs. 90,000
Total annual expenditure incurred for fish marketing	:	Rs. 40,100
Annual Profit / Loss	:	Rs. 55,300

3.12.4. Income and earnings of Gillnet fishing:

Gillnet is a major fishing gear at the national level and recognized as an efficient selective type gear. It can be operated by artisanal and small mechanized vessels in the sea. Gillnetting being a low-cost fishing method is of special interest for artisanal fisheries due to minimum input cost on nets and can be operated from inboard motorized crafts with low power and comparatively fewer crew members compared to other mechanized fishing methods. Small scale fishers from the study area employ traditional gillnet fishing targeting high-value fishes like pomfrets, seer fishes, shark,

rays, hilsa, pellona, eel, polynemids, lobster, etc. Single day gillnet fishing are widely practiced in the study area and estimated the detailed economics of single day fishing operations.

3.12.4.1. Single day gill net fishing (Disco / Tarti/ Shevand net):

Major investment for single day gillnet fishing is boat, engine and the nets. The fixed cost (capital investment) for craft and engine has been estimated at Rs.2.50 lakhs for the boat and Rs. 1.50 lakhs for engine. Depreciation for the fixed costs has been computed at 10% for the boat engine and G. P. S. device. Gillnet expenses estimated at Rs.3.50 lakhs for various nets like Bhiljee, Tarti/Boi, Shahenshaha, Daldi/Budi, Shevand/Paplet, Kargil, Waghra, etc. Several pieces of individual gillnet area used to cover more area during each haul. These net pieces are mostly manufactured by using monofilament twines. Monofilament gillnets bear less economic life compared to traditional dol nets operated in the area and therefore, depreciation @ 100% was considered for nets (nets can be operated for one fishing season).

In the case of single day gillnet fishing a boat goes for daily return basis in the sea and undertakes around 170 fishing days/trips in a year excluding fishing holidays and monsoon fishing ban period. The crew members are paid with a fixed salary at the rate of Rs. 400 per person per day. In some cases, crew members come for fishing along with their nets and the catch of their net will be their share, in return, they help boat owners for the operation of owner's nets. In this case, to avoid complexity in calculations, all crew members have been considered on a daily wage basis. A crew member earns about Rs. 68,000 during a fishing season and there are 3 crew members (Rs. 400 per day) on an average on each fishing boat. The average catch per boat per trip is 89 kg and per trip revenue of a single day gillnet is Rs. 6,675/-. The annual revenue from the sale is Rs. 11,34,750/-. The boat owner earns annual profit of Rs. 1,71,583/- after deducting the operating cost of Rs. 9,63,167/-. The earnings by sale of fish catch and costs for the fishing operations are presented following Table 25.

Table 25. Economics of single day gill net fishing activities.

A.	Fixed Cost		Amount (Rs.)	B.	Depreciation		Amount (Rs.)
1	Cost of Craft	:	2,50,000	1	On craft @ 10%	:	25,000
2	Cost of engine	:	1,00,000	2	On Engine @ 10%	:	10,000
3	Cost of gear	:	3,50,000	3	On Gear @ 100%	:	3,50,000
4	G. P. S.	:	25,000	4	On GPS @ 10%	:	2,500
	Total fixed cost		4,74,500		Total depreciation	:	3,87,500
C.	Operating Cost						
1	Fuel Cost @ Rs. 76/l			:			1,93,800
2	Food charges @ Rs. 150/day			:			17,000
3	Engine oil charges 20 l @ Rs. 300/l			:			6,000
4	Crew salary @ Rs. 300 / day / person			:			2,04,000
5	Annual maintenance of craft and gear			:			33,000
6	Insurance charges			:			1,700
7	Licence fees @ Rs. 200 for three years			:			66.67
8	Jetty fees			:			100
	Total Operating Cost						4,55,667
	Total Cost (Operating Cost+Depreciation+Interest @ 12% on fixed cost)						**9,63,167**
	Total annual fishing trips						170
	Catch per unit (kg's)						**89**
	Earning per trip						6,675
	Annual Earnings per boat						**11,34,750**
	Net Profit (Annual earnings-Total Cost)						**1,71,583**

4. CONCLUSIONS

The proposed Mumbai Coastal Road Project (South) is located on the western side of the Mumbai city extending from Princess Street fly over to Worli end of the sea link, on the seaward side. The proposed road has an approximated length of 9.98 km and the total reclamation area is around 90 ha. As there is no relocation/fishing restriction for fishers, major impact on livelihood is less. There were two fishing bases in the vicinity of the proposed coastal road plan, from which fishing boats are operated.

With the current plan, major concerns arise was on navigation issues, fishing area loss and disturbance of nearshore ecology during the construction and operation phase. It was informed by the MCGM that they had kept adequate facilities for smooth navigation. The proposed shore connected reclamation and other development plan cover limited regions with rocky and sandy patches having oysters and clam beds which will be destroyed. The fishers in the Lotus and Worli village were marginal and mostly conducts single day nearshore fishing using gillnetter/SBN/hook and line. The fishers in the Worli village also operate mechanised and motorised dolnetters and gillnetters.

Total fishermen population residing in the identified fishing villages (Worli and Lotus Worli) is around 3,282 in 841 families. The public infrastructure facilities supporting marine fisheries are found as poor. There is no ice factory/cold storage/market facility at the villages or near to landing centres. Three fishermen societies (registration of one is in the process) are functioning in these proposed project areas. Several meetings and consultations were undertaken with stakeholders for assessing their views on possible impacts on fisheries and their livelihood by the construction of the coastal road.

4.1. Predicted direct impacts:

1. Fishers operating from and around the proposed Mumbai Coastal Road Project (South) are likely to be affected as they will be losing a portion of the nearshore historical fishing area in the sea. This is a permanent impact and irreversible.

However, access to other parts of the sea is not restricted by any regulations as of now and can conduct fishing which reduces livelihood impacts.

2. Due to the reclamation and construction in the nearshore waters and intertidal regions, the water quality and ecology will be affected.
3. The fishing area operated by the small fishing vessels from Worli and Lotus have a seasonal aggregation lobster (mostly juveniles), which are harvested and traded. However, the catch is low (CPUE- 1-12 kg/trip with an average of 2.6kg/trip). The reclamation is likely to have ecological deterioration and can impact these fishing for the immediate months. This can lead to reduced income on targeted bottom gillnet fishers.
4. At some pockets along the intertidal region of proposed coastal road, occasional shell (oyster, bivalve and mussel) collection is conducted by coastal residents, local shell collectors and traders. Due to the proposed and ongoing reclamation, this activity are being affected. More than 90 % hand pickers are harvesting for household consumption and those collecting oysters and clams for sales are not from project-affected coastal community. During the survey observed and interviewed hand pickers (were mostly from Mahul, Malad and Nallasopara and only a few from Worli).
5. With drilling, sedimentation and noise disturbance during construction phase could cause a reduction in fish abundance near to construction areas, which will reduce the income of fishers during the construction phase. This is a short-term impact.
6. Bagnet fishers (*Dol* net) who operate their fixed fishing gear according to current pattern didn't share much information on the locality of their fixed gear (*sus*). In the present report, the places wherever '*Dol*' net are operated by the fishers could not be confirmed. The limited fishing location given in this report is based on the observation by ICAR-CMFRI. Since such fishing practices are location specific depends on the tidal currents, shifting them to the other areas will be extremely difficult. However, if in case these fishers come together to share information or details about operations depth etc (if not more than 1 km from shore) they may be compensated adequately to improve fishing methods/or shift fishing locations if appeared to be affected by the project.

7. From lotus Jetty 44 fishing boats (mostly motorised boats and *dinghis*) operate. The proposed reclamation and interlinking construction at Haji Ali Bay will affect the boat parking and smooth navigation to and from jetty.
8. A major portion of the examined fishes were immature or maturing stage. However, these nearshore waters along the plan cannot be considered as an active spawning ground for these immature fishes as these are general features of any coastal stretch and the abundance was low.
9. No specific nursery or breeding grounds for any particular important species was observed. The fishes/juveniles found in tide pools are mostly strays. No larger number of any commercially important fish species was observed in tidepools.
10. The zooplankton studies from the nearshore waters and tidepools along the Mumbai Coastal Road Project (South) indicated lower abundance of fish eggs and larvae of the fishes during the period of survey.
11. None of the fish species observed are endemic to the proposed area or protected under Wildlife (Protection) Act, 1972.

4.2. Predicted indirect impacts:

1. Possible reduction in fish abundance and productivity of the area due to, habitat modification, sound disturbance and increased turbidity during the construction phase. Fishers' income will be reduced for a period.
2. There is a visible loss of fishable areas, which will be further enhanced if additional activities related to coastal road development like security, protection to infrastructure and restrictions are placed.
3. Loss of shell collection area and seasonal income loss to hand pickers due to permanent removal of rocky patches along the proposed coastal road area. Destruction of the rocky bottom in the proposed coastal road area due to sedimentation/siltation and reclamation will affect the bottom set gillnet fishery.
4. With the modification in the nearshore coastal morphology affecting the ecology and lead to low fish abundance. The fishers may have to move farther from the normal fishing areas, which in turn increase the fishing operational cost.

4.3. Recommendations for mitigations:

1. As the breakwater wall is constructing with natural rocks (as informed by MCGM), the growth of sedentary organisms may not be affected as expected. During the period of CMFRI study, it was observed that the growth of marine life was already started at reclaimed areas of Priyadarshini Park and Haji Ali area.

2. Enhancement of fisheries resources and habitat by the installation of artificial reefs with suitable shapes and materials. These can supplement the damaged seascapes and bringing back normality to an extent. These habitat enhancements can act as a substratum for marine fauna.

3. An impact in income of coastal fishers is expected. To increase the income and better value for their fish adequate marketing and storage facilities should be developed through community development plans.

4. Proper access to the shore area, landing area, safe boat berthing spaces should be confirmed for all seasons. Adequate depth and space should be provided to the boats for the navigation. If in case there are siltation chances or navigation issues during the construction or post-construction phase it should be addressed.

5. Fishers based in the Lotus jetty needs special attention and support as their entire livelihood activity will be impacted during construction to operation phase of coastal road. Support for improved navigation aid, up-gradation of fishing vessels and better market facilities should be created.

6. Mumbai Coastal Road Project (South) may cause transformation of the coastal areas which will have an impact on ecology including fisheries. However, in the current state of extreme events and climate change, the magnitude of negative impact cannot be predicted. In view of this, regular fishery monitoring program during the construction phase and audit during the operational phase to analyse the fisheries impact are recommended.

7. If in case any additional, unpredicted and unforeseen impacts are detected following the project should be addressed by MCGM.

8. A social impact study must be conducted post-construction of the Mumbai Coastal Road Project (South) to identify the actual impact on fishing-based livelihoods.

5. Annexure

"प्रस्तावित कोस्टल रोड प्रकल्पामुळे सागरी मासेमारीवर होणा-या प्रभावांचा अभ्यास"
प्राथमिक माहिती

1.	नाव	:	
2.	पत्ता	:	
3	मोबाईल नंबर	:	
4.	मुख्य व्यवसाय पर्यायी / इतर व्यवसाय	:	
5.	एकूण उत्पन्न (वार्षिक / मासिक)	:	
6.	वय शिक्षण	: :	 अशिक्षित / प्राथमिक / माध्यमिक / उच्च माध्यमिक, डिप्लोमा, पदवीधर, पदव्युत्तर
7.	मुलांची संख्या (18 वर्षाखाली) पुरूषांची संख्या (18 वर्षांवर) स्त्रियांची संख्या (18 वर्षांवर)	:	
8.	कुटुंबाची स्थिती	:	एकत्र / विभक्त
9.	आर्थिक स्थिती	:	दारिद्रयरेषे खाली / दारिद्रयरेषेवर
9 अ	कुटूंबाचे महिन्याचे सरासरी उत्पन्न (रूपये) मच्छिमारी मच्छिमारी व्यतिरिक्त	:	
9 ब	कुटुंबातील मासेमारीच्या कार्यामध्ये गुंतलेल्या सदस्यांची एकूण संख्या पुरूषांची संख्या स्त्रियांची संख्या		
9 क	मासेमारीशी संबंधित कार्यां-मध्ये महिलांचा सहभाग आणि कामाचे ठिकाण		
9 ख	मासेमारीच्या ठिकाणाची माहिती (डोल जाळ्यासाठी मारलेल्या सस ची ठिकाणे) किंवा इतर संबंधित क्रिया		

10.	जमीन	:	घरा सहित / घर आणि जमिनीसहित अ) मालकीची जमीन ब) बिगर मालकीची जमीन क) सरकारी मालकीची जमीन जमिनीचे क्षेत्र .....हेक्टर / एकर / गुंठा / स्क्वेअर फूट / स्क्वेअर मीटर (अ) 1-3 (ब) 4-5 (क) 6-10 (ख) 10 पेक्षा जास्त
11.	घर	:	1) स्वत:चे 2) भाड्याचे
12.	घराचा प्रकार	:	1. कच्चा 2. अर्ध पक्के 3. पक्के
13.	संपत्ती	:	रेडियो / टि.व्ही. / दोन चाकी / चार चाकी / फ्रिज / वॉशिंग मशिन / ग्राइंडर / मिक्सर / इतर
14.	वर्तमान पत्र	:	होय / नाही
15.	साप्ताहिक / मासिक पत्रिका	:	होय / नाही
16.	दुरध्वनी	:	मोबाईल / लँडलाईन / यापैकी काही नाही
17.	संपर्क, संशोधन संस्था / महाराष्ट्र राज्य मच्छिमार विभाग / इतर संस्था	:	
18.	स्थानिक स्वराज्य संस्था	:	ग्राम पंचायत / महानगरपालिका / कार्यकर्ता

आर्थिक माहिती

स्थायी खर्च आणि मासेमारीचा प्रकार

1.	मासेमारी नौकेचा प्रकार	:	इंजिन व विंच / फक्त इंजिन / बिगर इंजिन मुख्य जाळी : इतर जाळी :
2.	नौकेचा नोंदणी क्रमांक	:	
3.	मासळी उतरण्याचे ठिकाण	:	
4.	स्थान / ठिकाण	:	तालुका : जिल्हा : पालघर राज्य : महाराष्ट्र

5. नौकेच्या मालकीची माहिती:

1.	नौकेच्या मालकीचा प्रकार	:	स्वत / भागीदारी / कुटुंब / इतर
2.	आर्थिक स्रोत	:	स्वत / बैंक / सहकारी सोसायटी / खाजगी स्रोत / इतर किंमत (रू.): अनुदान असल्यास (रू.):
3.	नौका खरेदीचे वर्ष	:	
4.	नौका नविन / वापरलेली	:	
5.	वापरलेली विकत घेत असताना नौकेचे आयुष्य	:	

6. नौकेची तांत्रिक माहिती:

अ. क्र.	घटक	वर्णन			
1	नाळ	लांबी(फूट/मीटर)	लाकडी / फायबर	रूंदी (फूट/मीटर)	खोली(फूट/मीटर)
2	इंजिन	कंपनीचे नाव :		अश्वशक्ती :	इंधन (लि. प्रति तास):
3	जाळ्यांची एकूण संख्या :	जाळ्यांची एकूण लांबी (मीटर):		डोल जाळ्याच्या खोल्याचा आस:	
4	मासे साठविण्याची क्षमता (टनांमध्ये) :				

7. मासेमारीची माहिती

हंगाम	पावसाळ्यापूर्वी (फेब्रुवारी ते मे)	पावसाळ्यादरम्यान (जून ते सप्टेंबर)	पावसाळ्यानंतर (ऑक्टोबर ते जानेवारी)
कालावधीचा उल्लेख			
मासेमारीचा प्रकार: एकदिवसीय / अनेक दिवसीय			
मासेमारी बोटींच्या फे-यांची संख्या			
मासेमारीचे दिवस / आठवडे			
मासेमारीचे तास / प्रति फेरी			
मासेमारी सुट्ट्यांचे दिवस			
मासेमारी बंदीचा कालावधी			
दुरूस्ती आणि देखभाल करण्यासाठी लागणारे दिवस			
मुख्य मासेमारीची जागा (अक्षांश / रेखांश)			

गुंतवणुकीचे तपशिल (रूपये):

अ. क्र.	घटक	तपशील	खरेदीची किमंत	खरेदीचे वर्ष	आर्थिक आयुष्य	अनुदान
1	नौका					
2	फायबर कोटिंगची किंमत					
3	इंजिन					
4	बर्फाची पेटी					
5	भिलजी (19 – 22)					
6	तरती / बोय (36 – 46)					
7	शहेनशहा (46 – 52)					
8	दालदी / बुडीची (63 – 81)					
9	शेवंड / पापलेट (87 – 114)					
10	कलेट / कारगिल (150 – 200)					
11	वाघरा (187 – 220)					
12	डोल (खोल्याचा आस)					
13	इतर जाळी					
14	इतर जाळी					
15	दोरी					
16.	वायरलेस सेट					
17.	जी. पी. एस. सेट					
18.	बैटरी					
19.	बोया / फ्लोट					
20.	नांगर					
21.	सिंकर / शिसे					
22.	पंखा					
23.	इतर उपकरण अ) लाईफ जॅकेट					
	ब) रिंग बोया					
	एकून					

टिप : - वरील घटकापैकी जे लागू असतील ते रकान्यात भरणे.

9. इतर स्थायी खर्च असलेले घटक

अ) विम्याचा हप्ता रूपयांमध्ये (वार्षिक)

आ) कर (असेल तर)

इ) इतर (मासेमारीच्या परवान्याची किंमत)

10. मासेमारीशी निगडीत कोणत्या कार्यांमध्ये गुंतलेले असल्यास त्याची माहिती ?

आर्थिक माहिती
2. किरकोळ मासळी विक्रेत्यांकरिता

१. विक्रेत्याचे नाव:

२. कुटुंबप्रमुखासोबतचे नाते:

३. मोबाईल नंबर:

४. बाजाराचे ठिकाण:

५. बाजाराची नोंदणी (होय / नाही).

६. बाजाराचे शुल्क रूपयांमध्ये (असेल तर):

७. मासळी उतरण्याचे ठिकाण (विकत घेण्याचे):

८. वाहतुकीचा खर्च:

९. बाजाराचे वार्षिक दिवस:

१०. सरासरी महिन्याचे बाजाराचे दिवस:

११. मासेमारीशी निगडीत कार्यांसाठी दिला जाणारा सरासरी वेळ (दिवसातील एकूण तास)?

१२. केल्या जाणा-या कामाची सरासरी किंमत / मजूरी (रूपये प्रति दिवस)?

१३. सुकी / ताजी मासळी:

१४. बाजारातील माश्यांच्या प्रमुख जाती:

१५. मासळीची किंमत (५ प्रमुख जाती):

१६. मासळी विक्रीतून मिळणारे उत्पन्न (रूपयामध्ये): रोज..... मासिक ..... वार्षिक .....

१७. मासळीचा साठा करण्याची सोय:

१८. बाजारात उपलब्ध असलेल्या सुविधा : पाणी / खळे / बर्फ

१९. बाजाराची वेळ: सकाळ / दुपार / संध्याकाळ

आर्थिक माहिती

पारंपारिक मासेमारांसाठी (पाग / पगोळ्या (खेकड्यांसाठी) / गरवली / शिवल्या, कालवं काढणारे / घोळवा)

१. मासेमारी करणा-यांचे नाव:

२. कुटुंबप्रमुखासोबतचे नाते:

३. मोबाईल नंबर:

४. मासेमारीचा प्रकार: (पाग / पगोळ्या (खेकड्यांसाठी) / गरवली / शिवल्या, कालवं काढणारे / घोळवा)

५. जाळ्यांची संख्या आणि किंमत :

६. बोटीची / नौकेची किंमत (असेल तर):

७. मासेमारी करण्याचे ठिकाण:

८. मासेमारीचे एकूण दिवस (वार्षिक):

९. मासेमारीशी निगडीत कार्यांसाठी दिला जाणारा सरासरी वेळ (दिवसातील एकूण तास)?

१०. केल्या जाणा-या कामाची सरासरी किंमत / मजूरी (रूपये प्रति दिवस)?

११. पकडल्या जाणा-या माशांच्या प्रमुख जाती:

१२. मासळीचा साठा करण्याची सोय:

१३. मासळी विकण्याचे ठिकाण:

१४. बाजारात उपलब्ध असलेल्या सुविधा: नळ / खळे / बर्फ

१५. बाजाराची वेळ: सकाळ / दुपार / संध्याकाळ

१६. मासेमारीचे उत्पन्न :वार्षिक..... मासिक..... प्रति दिवस.....

आर्थिक माहिती
मासळी सुकविणा-यांसाठी

१. मासळी सुकविणा-याचे नाव:

२. कुटुंबप्रमुखासोबतचे नाते:

३. मोबाईल नंबर:

४. मासळी विकत घेण्याचे ठिकाण:

५. वर्षातील मासळी सुकविण्याचे एकूण दिवस:

६. मासेमारीशी निगडीत कार्यांसाठी दिला जाणारा सरासरी वेळ (दिवसातील एकूण तास)?

७. केल्या जाणा-या कामाची सरासरी किंमत / मजूरी (रूपये प्रति दिवस)?

८. सुकविल्या जाणा-या माशांच्या प्रमुख जाती:

९. मासळीचा साठा करण्याची सोय:

१०. मासळी विकण्याचे ठिकाण:

११. बाजाराची वेळ: सकाळ / दुपार / संध्याकाळ

१२. मासळी सुकविण्यातून मिळणारे उत्पन्न :वार्षिक..... मासिक..... प्रति दिवस.....

सर्वेक्षण मत

प्रस्तावित सागरी मार्ग / कोस्टल रोड प्रकल्पाबद्दल तुम्हाला कल्पना आहे काय ? हो / नाही.
प्रस्तावित सागरी मार्ग / कोस्टल रोड प्रकल्पाबद्दलचे तुमचे मत:

क्रमांक	फायदे	तोटे
1.		
2.		
3.		
4.		

प्रस्तावित सागरी मार्ग / कोस्टल रोड प्रकल्पाच्या धर्तीवर उपशमनासांठी कोणते उपाय योजले पाहिजेत ?

(अ) सहकारी संस्थांची मदत
(ब) सरकारी मदत
(क) इतर पर्यायी जोडधंद्याची उपलब्धता
(ख) इतर

तुमच्या मतानुसार मासेमारीला इतर कोणते पर्यायी जोडधंदे उपलब्ध असू शकतात ? असल्यास तपशील.