MUNICIPAL CORPORATION OF GREATER MUMBAI

No. Ch.E/9246/ Coastal Road, date: 04/02/2020

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, Cilvil 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

Sir,

With reference to above referred CRZ clearance dated 11.05.2017, the half yearly compliances report for the period of April 2019 to September 2019 was due for submittal by 1st Dec 2019. However, the Hon'ble High Court vide order dated 16.07.2019 in Writ Petition (L) No.560/2019, PIL (L) No. 25,36,39/2019, PIL (L) No.40,44/2019 etc. quashed the approval granted by MCZMA on 4.01.2017 and approval granted by EAC on 17.03.2017 and final approval granted by MoEF&CC on 11.05.2017 and restrained from execution of work. Therefore the half yearly compliances report for the Period from April2019 to September 2019 could not be submitted.

MCGM filed SLPs in the Hon'ble Supreme Court against the said final order and judgement of Hon'ble High Court dated 16.07.2019. The aforementioned SLPs were listed before the Hon'ble Chief Justice court and after hearing the parties concerned the Hon'ble Supreme Court passed the order on 17.12.2019 as below

"The petitioners are free to reclaim the land, build the road thereon and secure the road. They shall however not carry out any other development work until further orders of this court"

The matter is now listed on 08.04.2020 for hearing at Hon'ble Supreme Court of India.

Hence this office has now submitted the half yearly compliances report for the period of April 2019 to September 2019. The data sheet 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	13.102018

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,

04/10/2020

V.S.Nighot

Chief Engineer (Coastal Road)

ANNEXURE-I

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. and 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): • 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 95 Ha. • Road : 4+4 lanes • Project Cost: 12,721.59, 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 b. Others	Not Applicable being Coastal Road Project.
	a. Total plot Area	As submitted earlier
	b. Built – up Area (Including Road)	Not applicable since Coastal Road Project

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

Louis Berger Consulting Pvt. Ltd.

AECOM Asia Company Limited MUMBAI

	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.	12,721.59, Cr
	b. Allocation made for Environmental Management Plan with item wise & Year wise breakup.	1. April 2019 to September 2019 =Rs. 3.95 (Cr) 2. April 2019 to March 2020 = 7.35 (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	160.51 Cr.
	f. Actual expenditure incurred on the Environmental Management Plan so far	3.95 (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
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	1. Contractors for Package – I and Package IV-M/s L & T Limited . Date




	(Actual and/or Planned)	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 2019 till September 2019) for three Packages are attached as Annexure IV. 2. MoEF&CC- CRZ Clearance compliance report & MCZMA – Compliance report attached as Annexure V

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

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MUMBAI COASTAL ROAD PROJECT PKG II (EGIS-CGHEUKI) JV

Chief Engineer (Coastal Road)
MCGM, Mumbai -18

18/9/2020
EE(2).

MUMBAI COASTAL ROAD PACKAGE -I

Description	Unit	Scope	Planned % till 25th Sep 19	Achieved till 25th Sep 19
GTI Works	nos	329	100.0%	92.4%
Temporary Jetty Construction- Piling & Deck	Rm	182.4	68.4%	0.0%
Piling Gantry Erection & Commissioning at Amarson garden	LS	1	100.0%	100.0%
Piling Gantry Erection & Commissioning at Haji Ali	LS	1	100.0%	0.0%
1st Set Test Piles- Amarsons Garden	nos	3	100.0%	100.0%
2nd Set Test Piles- Amarsons Garden	nos	3	100.0%	100.0%
3rd Set Test Piles- Haji Ali	nos	3	100.0%	0.0%
4th Set Test Piles- Haji Ali	nos	3	100.0%	0.0%
Amarsons Garden Interchange TAB & Fingers- Piling & Deck	Rm	480	49.3%	0.0%
Haji Ali Interchange TAB & Fingers- Piling & Deck	Rm	486	49.9%	0.0%
Piling	nos	924	8.8%	0.0%
Pile cap	nos	231	3.9%	0.0%
Seawall				
Core placement- Stage 1	Rm	3,800	34.2%	13.4%
Armour placement- Stage 1	Rm	3,800	30.7%	13.4%
Core placement- Stage 2	Rm	3,800	7.9%	13.4%
Crown wall PCC	Rm	3,800	2.6%	0.0%
Crown wall Raft	Rm	3,800	2.6%	0.0%
Crown wall Vertical	Rm	3,800	2.6%	0.0%
Reclamation upto +4.42m CD	Sqm	603,400	7.5%	2.9%

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

Larsen & Toubro Limited Berger Consulting Pvt. Ltd.

MUMBAI COASTAL ROAD PROJECT PKG II (EGIS-GRUCH) JV

AECOM Asia Company Limited MUMBAI

MUMBAI COASTAL ROAD PACKAGE -II

S.NO.	ITEM DESCRIPTION	Unit	Scope of Work	Planned Qty from Apr'19 - Sep'19	Actual Quantity achieved from Apr'19 -Sep'19	% Progress w.r.to Scope till Sep '19
1	Geo Technical Investigations	NOS	174	0	18	56%
2	Seawall- Quarry Run	Cum	239020	69629	26829.85	17%
3	Seawall - Bedding Layer	CUM	7336	1287	1069.766	15%
4	Sea wall - Geotextile Layer	SQ.M	28096	3075	2555	9%
5	Sea wall - Armour Layer	CUM	99258	13732	6488	6%
6	Reclamation Works +1.92 MSL	CUM	530000	26988	77627	17%
7	Selected Fill +6.00MSL	CUM	567573	9496	30593	5%
8	Car Park-1 Excavation	CUM	13000	2345	623	5%

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

Louis Berger Consulting Pvt. Ltd.

MUMBAI COASTAL ROAD PROJECT PKG II JV (HGIS CGRCUK)

AECOM Asia Company Limited MUMBAI

MUMBAI COASTAL ROAD PACKAGE -IV

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	698 RM	0 Rmtrs
Secant Piling – Launching Shaft	540 Nos	515 Nos Completed
Secant Piling – Retrieval Shaft	188 Nos	69 Nos Completed

ANNEXURE - II

CONSENT TO ESTABLISH

MUMBAI COASTAL ROAD PACKAGE-01

Present Status of Consent to Establishment / Operate from CPCB/SPCB
Status as on Date: January 07, 2020

Consent to Establishment for Batching Plant has been applied online– Status – In process Please refer S. No 01 (MPCB-CONSENT-0000085647)

महाराष्ट्र प्रदूषण नियंत्रण मंडळ

Industries

Applications | Dashboard | Change Password | Industry Documents | Logout

Ticketing system has been rolled out for your convinience.Kindly find the guidelines here Click here

Bank Guarantee module has been rolled out for your convinience.Kindly find the guidelines here Click here

Select Unit: All Units Select Plant: All Plants Filter Applications View Unit Information

My Applications

Sr No.	UAN No.	Application Name	Application IIN	Application Date	Amount	Documents
1	MPCB-CONSENT-0000085647	CONSENT		26-12-2019	Rs 15000	Documents Payments Download
	Status: Waiting for payment approval					
	Above application is not under process as payment is not yet approved					
2	MPCB-CONSENT-0000069006	CONSENT		14-03-2019	Rs 15000	Documents Payments Download
	Download certificate					

C/25

C/27

Maharashtra Pollution Control Board

महाराष्ट्र प्रदूषण नियंत्रण मंडळ

Application for Consent/ Authorisation

Sir,
I/We hereby apply for*

1. Consent to Establish/Operate/Renewal of consent under section 25 and 26 of the Water (Prevention & Control of Pollution) Act, 1974 as amended.

2. Consent to Establish/Operate/Renewal of consent under Section 21 of the Air (Prevention and Control of Pollution) Act, 1981, as amended.

3. Authorization/renewal of authorization under Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 in connection with my/our/existing/proposed/altered/ additional manufacturing/processing activity from the premises as per the details given below.

Consent Information

UAN No:
MPCB-CONSENT-0000085647

Application submitted on:
26-12-2019

Industry Information

Consent To:
Establish (New)

IIN No.:

Submit to:
SRO - Mumbai I

Type of institution:
Industry

Industry Type:
G37 Ready mix cement concrete

Category:
Green

Scale:
S.S.I

EC Reqd.
No

EC Obtained
No

EC Ref. No.
-

Whether construction-buildup area is more than 20,000 sq.mtr.(Existing Expansion Unit)
No

General Information

1. Name, designation, office address with Telephone/Fax numbers, e-mail of the Applicant Occupier/Industry/Institution / Local Body.

Name
RAKESH SINGH SISODIA

Designation
PROJECT DIRECTOR

Area
Parking Place, Amarsons Garden, Near Tata Tea Garden, AMARSONS GARDEN, AMARSONS GARDEN, MUMBAI CITY,

Telephone
9870061308

Email
jadhavani@lntecc.com

Address
TOWER-B, TC-II, 1ST FLOOR,L&T GATE-5, POWAI,Mumbai City,Mumbai City

Taluka
Mumbai City

District
Mumbai city

Fax

Pan Number
AHFPS2369L

AECOM Asia Company Limited MUMBAI

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

Louis Berger Consulting Pvt. Ltd.

MUMBAI COASTAL ROAD PROJECT PKG II JV

2. (a) Name and location of the industrial unit/premises for which the application is made (Give revenue Survey Number/Plot number name of Taluka and District, also telephone and fax number)

Industry name
Larsen & Toubro Ltd.

Location of Unit
Mumbai Coastal Road Project PKG 1

Survey number/Plot Number
Amarson Garden & Haji Ali

Taluka

District
Mumbai city

(b) Details of the planning permission obtained from the local body/Town and Country Planning authority/Metropolitan Development authority/ designated Authority.

Planning permission

Planning Authority

Name of the local body under whose jurisdiction the unit is located and Name of the licence issuing authority

Name of Local Body

Name of the licence issuing authority

3. Names,addresses with Telephone and Fax Number of Managing Director / Managing Partner and officer responsible for matters connected with pollution control and/or Hazardous waste disposal.

Name of Managing Director
Rakesh Singh Sisodia

Telephone number
9870061308

Fax number

Officer responsible for day to day business
Rakesh Singh Sisodia

4. (a.) Are you registered Industrial unit ?

No

Registration number
L99999MH1946PLC004768

Date of registration
Oct 13, 2018

5. Gross capital investment of the unit without depreciation till the date of application (Cost of building, land, plant and machinery). (To be supported by an affidavit/undertaking on Rs.20/- stamp paper, annual report or certificate from a Chartered Accountant for proposed unit(s), give estimated figure)

Gross capital (in Lakh)	**** Verified***	**** Terms***	**** Consent Fee***
286.75	CA Certificate	1	15000.00

6. If the site is located near sea-shore/river bank/other water bodies/Highway, Indicate the crow fly distance and the name of the water body, if any.

Distance From	***Distance(Km)***	**** Name***
SH/NH	88.00	Mumbai-Pune Highway
River	23.00	Mithi
Human Habitation	0.20	
Religious Place	0.30	Maha Laxmi Temple
Historical Place	0.10	
Creek/Sea	0.10	Creek/Sea

6b. Enter Latitude and Longitude details of site

Latitude

Longitude

7. Does the location satisfy the Requirements Under relevant Central/State Govt. Notification such as Coastal Regulation Zone. Notification on Ecologically Fragile Area, Industrial Location policy etc. If so, give details.

Location	***Approved Industry Area***	***Sensitive Area***	***If Yes, Name Of Area***	***Industry Location with Reference to CRZ***

No No

8. If the site is situated in notified industrial estate,

		Details
(a) Whether effluent collection, treatment and disposal system has been provided by the authority.	No	
(b) Will the applicant utilize the system, if provided.	No	
(c) If not provided, details of proposed arrangement.		

9.

(a) Total plot area (in squear meter)	***(b) Built up area and (in squear meter)***	***(c) Area available for the use of treated sewage/ trade effluent for gardening/irrigation. (in squear meter)***
2500	2000	500

10. Month and year of commissioning of the Unit.

2020-03-15

11. Number of workers and office staff

Workers	***staff***	***Hrs. of shift***	***Weekly off***

12.

(a) Do you have a residential colony Within the premises in respect of Which the present application is Made ? No

(b) If yes, please state population staying

Number of person staying	***Water consumption***	***Sewage generation***	***Whether is STP provided?***
			No

(c) Indicate its location and distance with reference to plant site.

Number of person staying	***Water consumption***

13. List of products and by-products Manufactured in tonnes/month, Kl/month or numbers/month with their types i.e.Dyes, drugs etc. (Give figures corresponding to maximum installed production capacity

Products Name and Quantity

Product Name	***UOM***	***Product Name***	***Existing***	***Consented***	***Proposed Revision***	***Total***	***Remarks***
RMC	m3/day	Concrete	0	12000	0	12000	NA

Products Name and Quantity

Product Name	***UOM***	***Quantity***	***Remarks***
Concrete	m3/month	12000	NA

14. List of raw materials and process chemicals with annual consumption corresponding to above stated production figures, in tonnes/month or kl/month or numbers/month

Name of Raw Material	***UOM***	***Quantity***	***Hazardous Waste***	***Hazardous Chemicals***	***Remarks***
Cement	MT/M	6600	No	No	NA

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MUMBAI COASTAL ROAD PROJECT PKG II AF (JV) GRCL(JV)

Admixtures	MT/M	132	No	No	NA
Aggregates	MT/M	15000	No	No	NA
sand	MT/M	15000	No	No	NA
water	MT/M	3600	No	No	NA
Micro-Silica	MT/M	3000	No	No	NA

15. Description of process of manufacture for each of the products showing input, output, quality and quantity of solid, liquid and gaseous wastes, if any from each unit process.

Part B : Waste Water aspects

16. Water consumption for different uses (m3/day)

Purpose	***Consumption***	***Effluent Generation***	***Treatment***	***Remarks***	***Disposal***	***Remarks***
Domestic Pourpose	10000	8000	Septic Tank	Sedimentation tank	Recycle	NA
Water gets Polluted & Pollutants are Biodegradable	4000	3200	OTHERS	Sedimentation tank	Recycle	NA
Water gets Polluted,Pollutants are not Biodegradable & Toxic	0	0	--NA--	NA	--NA--	NA
Industrial Cooling,spraying in mine pits or boiler feed	5000	4000	--NA--	NA	--NA--	NA
Others	NA					

17. Source of water supply, Name of authority granting permission if applicable and quantity permitted.

Source of water supply ***Name of authority granting permission*** ***Qauntity permitted***

18. Quantity of waste water (effluent) generated (m3/day)

Domastic ***Boiler Blowdown*** ***Industrial*** ***Cooling water blowdown***

Process ***DM Plants/Softening*** ***Washing*** ***Tail race discharge from***

* 19. Water budget calculations accounting for difference between water consumption and effluent generated.

20. Present treatment of sewage/canteen effluent (Give sizes/capacities of treatment units).

Capacity of STP (m3/day)

Treatment unit ***Size (mxm)*** ***Retention time (hr)***

21. Present treatment of trade effluent (Give sizes/capacities of treatment units) (A schematic diagram of the treatment scheme with inlet/outlet characteristics of each unit operation/process is to be provided. Include details of residue management system (ETP sludges)

Capacity of ETP (m3/day)

Treatment unit ***Size (mxm)*** ***Retention time (hr)***

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PROJECT MANAGER (PMC) MCR (PKG-4)

22.

(i) Are sewage and trade effluents mixed together? No

If yes, state at which stage-Whether before, intermittently or after treatment.

23. Capacity of treated effluent sump, Guard Pond if any.

Capacity of treated effluent sump (m3)	
Effluent sump/Guard pond details	No
If yes, state at which stage-Whether before, intermittently or after treatment.	No

24. Mode of disposal of treated effluent With respective quantity, m3/day

(i) into stream/river (name of river)

(ii) into creek/estuary (name of Creek/estuary)

(iii) into sea

(iv) into drain/sewer (owner of sewer)

(v) On land for irrigation on owned land/ase land. Specify cropped area.

(vi) Connected to CETP

(vii) Quantity of treated effluent reused/ recycled, m3/day Provide a location map of disposal arrangement indicating the outler(s) for sampling.

Treated effluent reused / recycled (m3/day)

25. (a) Quality of untreated/treated effluents (Specify pH and concentration of SS, BOD,COD and specific pollutants relevant to the industry. TDS to be reported for disposal on land or into stream/river.

Untreated Effluent

pH	NA	
SS (mg/l)	NA	
BOD (mg/l)	NA	
COD (mg/l)	NA	
TDS (mg/l)	NA	
Specific pollutant if any	***Name***	***Value***
1	NA	NA

Treated Effluent

pH	NA	
SS (mg/l)	NA	
BOD (mg/l)	NA	
COD (mg/l)	NA	
TDS (mg/l)	NA	
Specific pollutant if any	***Name***	***Value***
1	NA	NA

(b) Enclose a copy of the latest report of analysis from the laboratory approved by State Board/ Committee/Central Board/Central Government in the Ministry of Environment expected characteristics of the untreated/treated effluent

26. Fuel consumption

Fuel Type	UOM	Fuel Consumption TPD/LKD	Calorific value
--NA--	--NA--	0	0
Ash content	**Sulphur content**	**Quantity**	**Other (specify)**
0	0	1	NA

27. (a) Details of stack (process & fuel stacks: D. G.)

(a) Stack number(s)	(b) Stack attached to	(c) Capacity	(d) Fuel Type
01	0	0	Diesel
(e) Fuel quantiy (Kg/hr.)	**(f) Material of construction**	**(g) Shape (round/rectangular)**	**(h) Height, m (above ground level)**
0	metal	round	6m
(i) Diameter/Size, in meters	**(j) Gas quantity, Nm3/hr.**	**(k) Gas temperature °C**	**(l) Exit gas velocity, m/sec.**
0	0	0	0
(m) Control equipment preceding the stack	**(n) Nature of pollutants likely to present in stack gases such as Cl2, Nox, Sox TPM etc.**	**(o) Emissions control system provided**	**(p) In case of D.G. Set power generation capacity in KVA**
0	0	0	250

27. (B) Whether any release of odoriferous compounds such as Mercaptans, Phorate etc. Are coming out from any storages or process house.

28. Do you have adequate facility for collection of samples of emissions in the form of port holes, platform, ladder\etc. As per Central Board Publication "Emission regulations Part-III" (December, 1985)

Poart hole	No	**Details**
Platform	No	**Details**
Ladder	No	**Details**

29. Quality of treated flue gas emissions and process emissions. Quantity of treated flue gas emissions and process emissions.

Sr. No.	Stack attached to	Parameter	Concentration mg/Nm3	flow (Nm3/hr)
1				

(Specify concentration of criteria pollutants and industry/process-specific pollutants stack-wise. Enclose a copy of the latest report of analysis from the laboratory approved by State Board/Central Board/ Central Government in the Ministry of Environment & Forests. For proposed unit furnish expected characteristics of the emissions..

Part - D: Hazardous Waste aspect

30. Information about Hazardous Waste Management as defined in Hazardous Waste (Management & Handling) Rules, 1989 as amended in Jan.,2000. Type/Category of Waste as per

Waste (Annually) Schedule I					
Cat No		**Type**		**Qty**	**UOM**
5.1		5.1 Used or spent oil		0.2	KL/A
Max		**Method of collection**		**Method of reception**	**Method of storage**

	manual	NA	Temp. with Secondary conatiners

Method of transport	***Method of treatment***	***Method of disposal***
Vehicle	NA	Authorized agenncy

Waste (Annually) Schedule II

31. Details about use of hazardous waste

Name of hazardous waste/Spent chemical	***Quantity used/month***	***Party from whom purchased***	***Party to whom sold***

32.

a. Details about technical capability and equipments available with the applicant to handle the Hazardous Waste

b. Characteristics of hazardous waste(s) Specify concentration of relevant pollutants. Enclose a copy of the latest report of analysis from the laboratory approved by State Board/Central Board/Central Govt. in the ministry of Environment & Forests. For proposed units furnish expected characteristics

33.

Copy of format of manifest/record Keeping practiced by the applicant.

34.

Details of self-monitoring (source and environment system)

35.

Are you using any imported hazardous waste. If yes, give details.

36.

Copy of actual user Registration/certificate obtained from State Pollution Control Board/Ministry of Environment & Forests, Government of India, for use of hazardous waste.

37.

Present treatment of hazardous waste, if any (give type and capacity of treatment units)

38. Quantity of hazardous waste disposal

(i) Within factory

(ii) Outside the factory (specify location and enclose copies of agreement.)

(iii) Through sale (enclosed documentary proof and copies of agreement.)

(iv) Outside state/Union Territory, if yes particulars of (1 & 3) above.

(v) Other (Specify)

Part - E: Additional information

39.

a. Do you have any proposals to upgrade the present system for treatment and disposal of effluent/emissions and/or hazardous waste.

b. If yes, give the details with time- schedule for the implementation and approximate expenditure to be incurred on it.

40.

Capital and recurring (O & M) expenditure on various aspect of environment protection such as effluent, emission, hazardous waste, solid waste, tree- plantation, monitoring, data acquisition etc. (give figures separately for items implemented/to be implemented).

41.

To which of the pollution control equipment, separate meters for recording consumption of electric energy are installed ?

42.

Which of the pollution control items are connected to D.G. Set (captive power source) to ensure their running in the event of normal power failure

43. Nature, quantity and method of disposal of non- hazardous solid waste generated separately from the process of manufacture and waste treatment. (Give details of area/capacity available in applicant's land)

Type	*Quantity*	*UOM*	*Treatment*	*Disposal*	*Other Details*
Municipal Waste	10	Kg/Day	Locally	Local Body	NA
C&D	1.5	m3/day	Recycle /Reuse	Recycle /Reuse	NA

44. Hazardous Chemicals – Give details of Chemicals and quantities handled and Stored.

(i) Is the unit a Majot Accident Hazard unit as per Mfg.Storage Import Hazardous Chemicals Rules ?

(ii) Is the unit an isolated storage as defined under the MSIHC Rules ?

(iii) Indicate status of compliance of Rules 5,7,10,11,12,13 and 18 of the MSIHC Rules.

(iv) Has approval of site been obtained from the concerned authority?

(v) Has the unit prepared an off-site Emergency Plan? Is it updated ?

(vi) Has information on imports of Chemicals been provided to the concerned authority?

(vii) Does the unit possess a policy under the PLI Act?

45. Brief details of tree plantation/green belt development within applicant's premises (in hectors)

Open Space Availability	*Plantation Done On*	*Number of Trees Planted*
Square meter	Square meter(%)	

46.

Information of schemes for waste Minimization, resource recovery and recycling - implemented and to be implemented, separately.

Reuse & Recycle

47.

(a) The applicant shall indicate whether Industry comes under Public Hearing, if so, the relevant documents such as EIA, EMP, Risk Analysis etc. shall be submitted, if so, the relevant documents enclosed shall be indicated accordingly.

(b) Any other additional information that the applicants desires to give

(c) Whether Environmental Statement submitted ? If submitted, give date of submission.

AECOM Asia Company Limited MUMBAI ARD

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

48.

I/We further declare that the information furnished above is corect to the best of my/our knowledge.

49.

***I/We hereby submit that in case of any change from what is stated in this application in respect of raw materials, products, process of manufacture and
treatment and/or disposal of effluent, emission, hazardous wastes etc. In quality and quantity; a fresh application for Consent/Authorization shall be made and
until the grant of fresh Consent/Authorization no change shall be made.***

50.

I/We indertake to furnish any other information within one month of its being called by the Board

Yours faithfully

Signature : Rakesh
Name : Rakesh Singh Sisodia
Designation : Project Manager

Additional Information

Air Pollution

Sr No.	Air Pollution Source	Pollutants	APCS Provided	Remark
1	Vehicular Movement	PM SO2 , NO2 , CO	yes	Water sprinkling
2	Loading & Unloading	PM	No	Water sprinkling

Separate EM Provided	No	***Other Emission Sources***	NA
Measures Proposed	NA	***Foul Smell Coming Out***	No
Air Sampling Facility Details	0		

D.G. Set Details

Description	Capacity(KVA)	Remarks
DG	250	Will be used as stand by

Hazardous Waste Generation

Hazardous Waste	Quantity	UOM	Treatment	Disposal	Other Details

CHWTSDF Details

Member of CHWTSDF	CHWTSDF Name	Remarks

Cess Details

Cess Applicable	Cess Paid	If Yes, UpTo
No	No	Jan 1 1900 12:00:00:000AM

Legal Actions

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

Louis Berger Consulting Pvt. Ltd.

MUMBAI COASTAL ROAD PROJECT PKG II JV (CGRCUKI) IRBIS

AECOM Asia Company Limited MUMBAI

Legal Action Taken	Legal Record Of Company	Legal Action Details	Remarks
No			

MUMBAI COASTAL ROAD PACKAGE-02

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/ 1901000695 **Date: 10.1.2019**

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. HCC HDC JV Mumbai Coastal Road Project Package II, Worli ,
Address - HCC HDC JV Mumbai Coastal Road Project Package II, Worli Sea - Face Khan Abdul Gaffar Khan Road , Oppo ,Mumbai City Ward G – South , Opposite Worli Dairy , Worli , Mumbai 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 is granted for a period upto **commissioning of the Unit OR 5 year Period whichever is earlier**

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

Sr. No.	Product Name	Maximum Quantity	UOM
1.	**Ready Mix Concrete**	**10000.0**	**M^3/Month**

3. CONDITIONS UNDER WATER ACT:

(i) The daily quantity of trade effluent from the factory shall be **0.25 M^3**.

(ii) The daily quantity of sewage effluent from the factory shall not exceed **2.0 M^3**.

(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 recycled into the process.

(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) ... 95.00 CMD

(iii) Water gets Polluted, Pollutants are not Biodegradable & Toxic ... 0.00 CMD

(iv) Industrial Washing, spraying in mine pits or boiler feed ... 2.00 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;

(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;

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.

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

6. Standards for Stack Emissions:

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

Sr. No.	Type Of Fuel	Quantity	UOM
1.	**Diesel**	**2000 as and when required**	**Lit/D**

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

Sr. No.	Chimney Attached To	Height in mt
1.	D.G. Set	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.

7. 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.

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. 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 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.

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.**
12. **The Board may make the standards stringent for the RMC / batching plants located within Corporation areas.**
13. **The Proposed Capital investment of the industry is Rs. 315.00 Lakhs**
14. **The Board reserve right to revoke, amend or suspend the consent granted**
15. **The Industry shall submit Bank Guarantee of Rs. 1.0 Lakh towards Operation & maintenance of pollution control system.16.**
16. **This consent is issued as per permission of MCGM chief enginner Coastal Road .vide letter no. 1720 dtd. 1.1.2019**
17. **The Applicant shall obtain consent to operate From Maharashtra Pollution Control Board Before Commissioning of the Project .**

For and on behalf of the
Maharashtra Pollution Control Board

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

Maharashtra Pollution Control Board Sub Regional Office 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 Sea – Face Khan Abdul Gaffar Khan Road , Oppo ,Mumbai City Ward G – South , Opposite Worli Dairy , Worli , Mumbai 400018

Received Consent fee of –

Sr. No.	Amount(Rs.)	Transaction No.	Transaction Date
1	15000/-	TXN1812002493	22.12.2018

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

MUMBAI COASTAL ROAD PROJECT PKG II HCC-HDC JV

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

Louis Berger Consulting Pvt. Ltd.

AECOM Asia Company Limited APD MUMBAI

MUMBAI COASTAL ROAD PACKAGE-04

C/147

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.

(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.

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

Louis Berger Consulting Pvt. Ltd.

MUMBAI COASTAL ROAD PROJECT PKG II JV (EGIS-CGRCUK)

AECOM Asia Company Limited 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-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	100 mg/l.

(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 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 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.

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

MUMBAI COASTAL ROAD PROJECT PKG II AF (I) GRUPJKI

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

Louis Berger Consulting Pvt. Ltd.

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-1

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.

Annexure III:

Salient Features of Site Environment Management Plan

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)

Name: Priyadarshini Park to Baroda Palace

Compliance Status of Environmental Issues

S. No.	Description	Sample Photograph	Remarks
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.	 	
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 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.

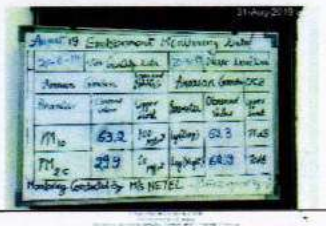
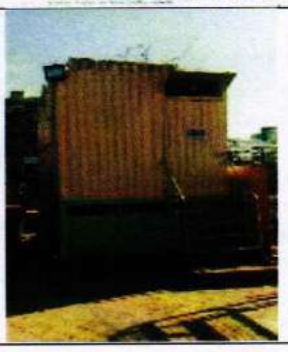
AECOM Asia Company Limited MUMBAI

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

L&T-KEIS-GRUCH JV MUMBAI COASTAL ROAD PROJECT PKG-4

Louis Berger Consulting Pvt. Ltd.

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 will be 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.	Will be provided in near future.	
	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. Preventive Maintenance schedule for all construction Machinery at site are maintained. Copy of PUC certificate is provided herewith.	 	
	6. 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.
7.	Bio-Toilets are provided at site.		

Package -2 (Appendix 2)

Name: Baroda Palace to Worli End

Compliance Status of Environmental Issues

S. No.	Description	Sample Photograph	Remarks
1.	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.	 	
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 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.

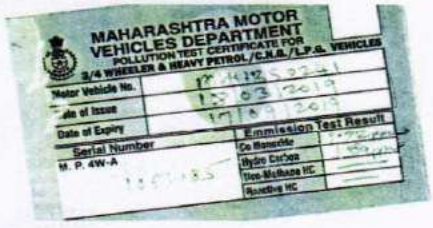
3.	For controlling Dust: 1. On-site Water Sprinkling is being carried out on regular basis. The frequency is defined as two times a day. 2. Load carrying vehicles are covered to control the spread of dust particles while transportation. 3. Wheel wash facility will be provided. 4. Sedimentation tank (two chambered) will be provided maximum recycling and Reuse of Water.	 	
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.	Will be provided in future	
	2. 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
	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.		IRC SP 55 type IV (Board).
	4. 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

	5. 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
	6. 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	
	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	
	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

MCRP Package - 4 (Appendix 3)
Name: Princess street flyover to Priyadarshini Park
Compliance Status of Environmental Issues

S. No.	Description	Sample Photograph	Remarks
1.	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.		
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 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.

3.	For controlling Dust: 1. On-site Water Sprinkling is being carried out on regular basis. The frequency is defined as once a day. 2. Road cleaning is being carried out on regular basis. 3. Load carrying vehicles are covered to control the spread of dust particles while transportation. 4. Wheel wash facility will be provided. 5. Sedimentation tank (two chambered) will be provided maximum recycling and Reuse of Water. 6. Noise barrier along the residential apartments also restrict the dust to mix in the outer environment.	  	
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 erection work is in progress.
	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.		IRC SP 55 type IV (Board).

			
	4. DG is provided with acoustic enclosures noise reduced up to 75 dB at 1 m distance		
	5. Preventive Maintenance schedule for all construction Machinery/vehicle at site are maintained. Copy of PUC certificate is provided herewith.		
	6. 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.	The Environmental Monitoring Data will be displayed on sites at conspicuous places like site & offices.	

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

MUMBAI COASTAL ROAD PROJECT PKG II (EGIS-GBRCUCL) JV

Louis Berger Consulting Pvt. Ltd.

AECOM Asia Company Limited MUMBAI

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.		

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

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MUMBAI COASTAL ROAD PROJECT PKG II AECOM

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ANNEXURE V

The following Specific and General Conditions in CRZ Clearance letter no. 19-74/2016-IA.III

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.	Noted
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.	Noted. There are no mangroves in Mumbai Coastal Road (South)
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.	Noted, norms of Statutory Regulatory Authority will be followed.
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 can be controlled.

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

MUMBAI COASTAL ROAD PROJECT PKG II JV (EGIS CGRCUK)

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. Any variations will be with due process.
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's published circular. Copy of the same is submitted in previous compliance.
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 in reclaimed land after construction of super structure, as final activity.

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

MUMBAI COASTAL ROAD PROJECT PKG-II (EGIS-CGRCUK) JV

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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 and suitable policy is being formulated accordingly. Interim report attached. At present navigational span of existing Bandra Worli Sea link is 29m. However, adequate navigational spans of 60m are proposed in Coastal Road.
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 is being prepared by CSIR-National Institute of Oceanography, Versova , Mumbai and copy of the progress report by NIO is submitted in previous compliances.
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 human habitations and shore morphology of adjacent areas during and after the construction of the coastal road and its findings and mitigating steps report will be submitted. Now the Interim report 1 is attached 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.

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YOOSHIN TEC-4 PROJECT MANAGER (PMC)

MUMBAI COASTAL ROAD PROJECT PKG II JV (EGIS-CGRCUK)

Sr. No.	Condition	Compliance
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 MCGM deposited as first installment of Rs.25.00 Crs to the Mangrove Foundation of Maharashtra. The receipt is submitted in previous 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 is proposed to be complied as directed.
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 produced.
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.

AECOM Asia Company Limited MUMBAI

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

MUMBAI COASTAL ROAD PROJECT PKG II

Sr. No.	Condition	Compliance
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 for other emergencies including disasters.
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 smoothness of road are "Roughness Indices". The care is taken in RFP documents as per IRC and high International standards to measure riding quality. During construction we will adhere to better quality as per standard.

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
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 done. Reports are attached as annexure IV

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.

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MUMBAI COASTAL ROAD PROJECT PKG II JV

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.
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.

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MUMBAI COASTAL ROAD PROJECT PKG II (EGIS-CGRCUK) JV

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.
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.	Noted, being complied.
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.

AECOM Asia Company Limited MUMBAI

Louis Berger Consulting Pvt. Ltd.

YOOSHIN TEC-4 PROJECT MANAGER (PMC)

MUMBAI COASTAL ROAD PROJECT PKG II JV (EGIS-CGRCUK)

Chief Engineer (Coastal Road)
MCGM, Mumbai -18

ECC2)
18/01/2020

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

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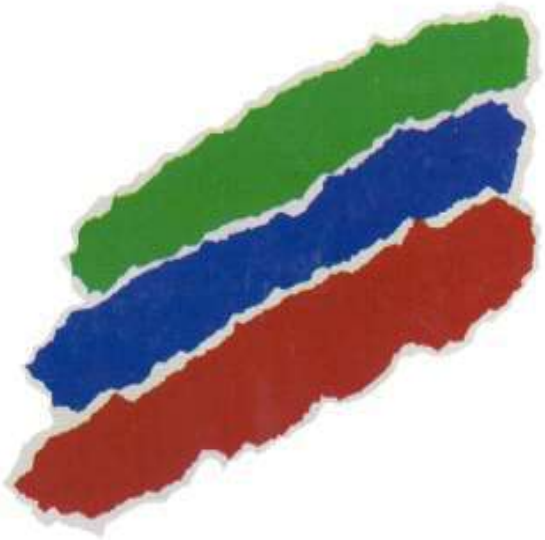
Mumbai



Interim Report - 1

June 2019

सीएसआईआर – राष्ट्रीय समुद्र विज्ञान संस्थान
CSIR-NATIONAL INSTITUTE OF OCEANOGRAPHY
(वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद)
(COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH)
दोना पावला, गोवा भारत / **DONA PAULA, GOA - 403004 India**
फ़ोन/**Tel : 91(0)832-2450450/ 2450327**
फैक्स /**Fax: 91(0)832-2450602**
इ-मेल/**e-mail : ocean@nio.org**
http:// www.nio.org

PROJECT TEAM

Dr. Jaya Kumar Seelam
Dr. Soniya Sukumaran
Dr. C. Mohandas
Dr. Mani Murali R
Dr. Haridevi
Dr. Umesh Pradhan
Dr. P.S. Rakesh
Dr. Abhay Fulke
Dr Sabyasachi Sautya
Dr. Udabha Dora
Mr. D. Sundar
Dr. R. Gowthaman
Mr. Jai Singh

Contents

1. Introduction

Municipal Corporation of Greater Mumbai (MCGM) has proposed a coastal road, approximately 35.6 km long, along the Mumbai coast to ease the vehicular traffic. The proposed coastal road comprises a combination of reclamation, bridges, elevated roads and tunnels along the western side of Mumbai. This coastal road is divided into two parts, i.e., North Part and Southern Part. The south part is approximately about 9.98 km from Princess Flyover to Worli Sea Link, and north part is 25.62 km from Bandra Sea Link to Kandivali Junction. It includes constructions Tunnels, Bridges, Road on stilts, Land fill Road; Land fill road without obstructing Mangroves and Elevated roads. The southern part comprises of 2 tunnels each of about 3.452 km in length. A total reclamation area for the southern part will be about 90 ha.

The proposed southern section has various sections as follows:

South Section (Princess Flyover to Worli End of Sea Link)
Section 1: Princess Flyover Road to Priya Darshini Park
Section 2: Priya Darshini Park to Mahalaxmi
Section 3: Mahalaxmi to Baroda Palace
Section 4: Baroda Palace to Bandra Worli Sea Link (Start)

The Environmental Clearance (EC) is obtained for the southern part and as per the EC conditions, coastal environment is to be monitored. MCGM awarded a project to CSIR-National Institute of Oceanography (NIO), to monitor the coastal environment along the southern part.

The scope of work for the study is as follows:

> To undertake monitoring of waves, currents, water levels and shoreline changes at two points along proposed southern side of the coastal road and to investigate the impacts of the project on the physical parameters, if any.
>
> To undertake monitoring of seawater quality parameters at 13 points off the proposed southern side of the coastal road and to investigate the impacts of the project on the seawater quality parameters, if any.

1.1 Study Area

The Mumbai coastal stretch is the most urbanized and consists of the coastal area between Bassein/Ulhas River in north and Thal in south. There are several bays and creeks around Mumbai, prominent among them being the Thane Creek – Mumbai harbour (hereinafter termed as “Bay”), the Ulhas estuary and the Bassein, Manori, Versova and Mahim creeks. The high terrestrial runoff during June-September (monsoon period) associated with heavy precipitation causes efficient annual flushing of inshore areas thereby substantially improving their ecological quality on an annual basis. The vast intertidal mudflats that get exposed during low tide sustained rich and luxurious mangroves in the past however, due to the pressure of development; these habitats have been either destroyed or

severely degraded in large stretches. Colaba, on the north-western side of the Bombay Harbour is a narrow peninsula extending south-westward from Bombay Island, and is covered by buildings. Prongs reef which dries, extends about 4.4 km south-southwestward from Colaba point, the southern extremity of Colaba peninsula. Foul ground extends upto 2.2 km south-westwards, south-eastward and eastward from Colaba light house situated on Prongs reef. Back Bay is the bight formed by the coastline between Colaba point and Malabar Point about 6.6 km north-north-westward. It is encumbered with rocks and reefs. Reefs which dry extend about 2.2 km offshore on the western side of Colaba peninsula. The Backbay has been partially reclaimed and has given rise to commercial buildings. From Backbay to Malabar Point the coastal road popularly called as 'Marine Drive' is protected by huge tripods. At the end there is 'Girgaon Chowpati', the famous sandy beach most frequently visited by people. Malabar Point lies at the southern extremity of the western ridge of low hills on Bombay Island. From Malabar Point the west coast of the island trends about 12 km north-north-eastward to Worli Point. It is fringed by a drying reef and shoal water with low depths extending about 1 km off the southern part and upto 1.1 km off the northern part. A fort in ruins stands about 0.6 km within Worli point. Between Worli point and Bandra point, the southern extremity of Salsatte Island about 1.1 km north-north-eastward is Mahim Bay which is shallow and a rocky entrance of Mahim creek (Mithi River). A coastal road on rocks runs along the coast ending at Bandra, Jamsatiji causeway extends across the mouth of Mahim Bay and connects the northern Bombay Island to the southern end of Salsette Island. Shoals with least depth of about 4 m lie about 3.3 km west-north-westward and westward of Bandra point. A sea link between Worli and Bandra, a wired bridge has become a prominent land mark of this area.

Mahim creek is a mouth area of Mithi River and receives sewage through non-point sources. Most of the sewage is directly released to the Mahim creek without treatment. In addition, the Mahim creek receives a variety of wastes from industries located along its banks. The total effluent load retained in the Mahim estuary/creek has been estimated at 9.3×10^4 m^3 that formed 16% of the spring tide and 40% of the neap tide volume of the creek. The ecology of Mahim creek is rapidly deteriorating due to poor flushing and high input of anthropogenic wastes. The distribution of trace metals in coastal sediments was patchy with enhanced levels of Cd, Pb and Zn. The P and C_{org} content did not indicate any enrichment. PHc revealed minor increases. TVC count in water and sediment was normal with high faecal contamination. The Worli outfall located about 3.7 km off Worli in the Arabian Sea is being used to dispose sewage into the sea after preliminary treatment through large diffuser at the depth of 7 m CD. All the water quality parameters were in the normal range and comparable with coastal area except minor depletion in DO suggesting no significant impact of release. The water quality beyond 1 km of the outfall was good with high DO, low BOD, normal nutrients and low PHc. Bacterial counts were found to be low in water and sediment as compared to the adjacent coastal ecosystem. Phytoplankton, zooplankton and macrobenthos distribution suggest normal productivity.

Uarashi is a reef, the southern end of which is situated about 4.4 km northward of Bandra point. Offshore some rocks lie about 1.7 km north westward of the light beacon situated on the southern

end of the reef called as Khar Danda. The landward area is known as Khar. Juhu Island, the southern extremity of which is situated about 2.2 km east-north- eastward of Uarashi light beacon has a sandy coast. It is covered with coconut and date palms and is connected with Salsette Island eastward by a dry reef. The coast has a sandy beach known as Juhu Beach, a popular tourist spot. A small reef which dries lies at the northern extremity of Juhu Island. Versova Island further northward of Juhu is covered with palms. The place, a fishing village is a busy fish landing centre with several big trawlers and small boats around. Madh Island is about 37 m high having well cultivated coconut and fruit trees. There is a fort, in ruins and fishing village at Madh. These two islands are connected by a ferry service across Malad Creek.

1.1.1 Mumbai Metropolitan Region (MMR)

MMR, the largest coastal urban settlement in India extends over an area of 4400 km^2. The region is typical of the Deccan Basaltic terrain with flat top mountains bordering the narrow low lying coastal strip that is traversed by five rivers and many creeks / inlets. Historical records of 1670 reveal that Mumbai consisted of several islands. Today, these islands have become continuous landmass, which is known as "Greater Mumbai". There are two major creeks namely Vasai or Bassein Creek towards North and Thane Creek towards South East. The other minor creeks are Manori, Malad, Mahim, Panvel, Nava - Sheva, Dharamtar etc. The general coastal circulation off MMR is dominated by the annual cycle of monsoon winds. The nearshore waters of MMR are subjected mainly to semi-diurnal tides, and there exists an asymmetry in both period and range. The mean tide ranges at Mumbai are 1.6 and 3.9 m during neap and spring respectively. The spatial variability of the nearshore currents is considerable due to the presence of rocky outcrops, tidal creeks, bays and islands. Mangroves are the most important component of MMR coastal ecosystem which prevent soil erosion and provide habitat for aquatic species such as shrimps and fishes as well as for avifauna. MMR coastal region is considered as the industrial capital of India with around 9000 industries which include chemical, fertilizer, iron and steel, oil refining and thermal power. The main issues in MMR coastal region are land use pattern, residential and industrial water supply, waste disposal, coastal pollution and depletion of coastal habitats like wetlands and mangroves etc. As a result, many coastal ecosystems are highly disturbed and seriously threatened encountering problems like pollution, habitat destruction, reclamation, siltation, erosion, flooding, saltwater intrusion and many other human induced activities.

1.1.2 Mumbai Bay

The length of the Mumbai Bay from the mouth to the head, is about 27 km with a width of 15 km at the mouth (off Colaba) narrowing to a few hundred meters at the head represented by the inner Thane Creek. Differential weathering of the interlayered soft tuffs and resistant basaltic flows (Deccan Traps) by seawater has created several bays and creeks around Mumbai including the Mumbai Bay. The Bay is V shaped semi-enclosed basin that opens to the Arabian Sea at its southwest approach and connected at its northern extremity to the Ulhas Estuary through a narrow channel (Kalva Creek). The Bay though broad is shallow, forcing frequent dredging to maintain the navigational depths in the channel and at the berths. The water depth decreases in the upstream due

to the positive bed gradient and the creek is barely navigable beyond the Vashi bridge for medium size fishing crafts. The tidal inlets of Dharamtar, NavaSheva and Panvel are the major tributaries to the Bay discharging into its eastern shore. Mumbai and Jawaharlal Nehru Ports located within the Bay are the major gateways for India's import-export and handle over 45 million t traffic annually which includes crude oil and its products, fertilizers, rock phosphate, sulphur, food grains, metals, chemicals, containerized cargo etc.

Mumbai City with a human population density of 25,000 persons/km^2 generates 2200 mld of domestic sewage out of which a considerable volume enters the Bay, largely untreated. The satellite city of Navi Mumbai and other townships in the Vashi-Panvel sector also release sewage to the Bay. Nearly 8% industries of the country are located around Mumbai in 2 large industrial clusters namely, Chembur-Thane-Belapur belt and Kalyan-Ulhasnagar-Ambarnath belt. These industries release their effluents into the Bay / Ulhas Estuary.

1.2.1 Hydrography

The quality of water-spread area of the Bay is mainly influenced by tides which induce flushing and dispersion of pollutants entering the system. The monsoonal freshwater flow, though important in flushing the inner zone, is not high enough to cause significant changes in the hydrography of the outer Bay. Tides (1.2-5m) in the region are semi-diurnal type with an appreciable diurnal inequality. The flood tidal front advances in north-easterly direction and ebbs to south-west.

The tidal variations of the Mumbai Bay are as follows:

Location	**Range (m)**		**Time lag from Apollo Bander (min)**
	Spring	**Neap**	
Apollo Bander	5.0	1.6	
Pir Pau	4.3	1.4	10-15
Vashi	4.2	1.2	10-30
Airoli	4.9	1.6	12-45
Thane	4.9	1.5	15-60

It is evident that the tidal ranges markedly decrease upto Vashi as compared to that at the Apollo Bander but increase in the inner creek and the ranges at Thane are only marginally lower than that at the Apollo Bander. This increase appears to be due to the funnel shape geometry of the Bay that is conducive for accumulation of seawater with the advance of the tidal front in the lower creek. The tide at Thane lags by 15 to 60 min with respect to the tide at the Apollo Bander with the lag more pronounced for the neap tide.

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. The specification of typical coastal met-ocean buoy that is to be procured is shown in Annexure-1. Two such coastal met-ocean buoys will be deployed in the study region. The process of procuring these systems is in progress and the order placement is likely to be complete by Mid-August 2019. The systems are likely to be put in place by November 2019, after which the details pertaining to waves, currents and water levels would be available.

1.2.2 Coastline

The coast of Mumbai is indented with bays, rocky outcrops and pocket beaches. Very narrow strip of beaches exist at few locations e.g., Juhu to Versova, Mahim Bay, Girgaum Chowpatty. Due to a variety of coastal geomorphological features along Mumbai coast, it is not always possible to physically monitor the coastline through conventional field measurements. Therefore limited coastline measurements of beach profiles will be carried out. However, periodic satellite imageries will be used to monitor the coastline changes over the study period.

1.2.3 Water quality

The water quality of the Mumbai Bay would be a balance between the fluxes of pollutants received by the water body and their dispersion by tidal flushing as well as their decay and removal from the water column by processes such as degradation, adsorption on suspended solids, sedimentation and biotic uptake. Although the bulk contaminants through the domestic wastewater are organic matter and nutrients, substantial quantities of heavy metals and PHc are also associated with these releases. The monthly variations of water temperature in the Bay exhibit a bimodal pattern with maximum during May and October, and minimum during August and February in accordance with the air temperature. Temporal variations are small as expected for tropical areas and changes in the vertical are minor suggesting a thermally well-mixed water body.

The average pH in the Bay varies between 7.6 and 8.3 and the variations are random. The average SS (23 - 53 mg/l) in the Bay is relatively high and renders the waters turbid and muddy. Spatial and temporal trends are not discernible though at a given sampling time the bottom water invariably sustains higher SS. This is because the SS is largely of natural origin and results from the dispersion of fine-grained material from the bed and the intertidal mudflats under the influence of tidal currents and turbulence during rough sea conditions. Markedly enhanced SS can occur during monsoon due to high wind induced turbulence and the values often exceed 200 mg/l in the outer Bay when the measurements coincide with the increased wave activity.

Salinity in the inner Bay is generally low (5 - 25 ppt) during July-September due to influence of freshwater runoff while at the port area it exceeds 30 ppt, except during the days of high precipitation. This results in a longitudinal salinity gradient increasing from Thane at the head to Colaba at the mouth of the Bay. There is a sharp increase in salinity in the inner Bay after the withdrawal of monsoon and values upto 35.7 ppt are common. Salinity then increases gradually in

the following months and reaches 37 to 38 ppt from late May to early June. With the salinity in the central and outer Bay areas remaining around 36 to 37 ppt, a weak salinity gradient, but in the reverse direction, develops along the length of the creek. Average DO of about 4.5 ml/l at the Bay mouth decreases progressively in the upstream direction and falls to below 3.5 ml/l at the head of the Bay during August. This decrease is from about 4 ml/l to around 2 ml/l during May at the respective locations. This trend is attributed to the non-availability of oxygen rich monsoon flow during May for the oxidation of organic matter and the increase in temperature decreases the solubility of oxygen and also accelerates microbial mediated oxidation of organic matter. Under the influence of high organic load, the DO seldom exceeds 2.5 ml/l in the interior Bay and values falling below 1 ml/l have been recorded during March-May.

The concentrations of PO_4^{3-}-P and NO_{3-}-N in the coastal waters along the Maharashtra coast are generally below 3 and 15 µmol/l respectively while those of NO_{2-}-N and NH_{4+}-N are often below 1 µmol/l. Hence, there is a marked enhancement of nutrient levels in the Bay. Their sources can be wastewaters from domestic sectors, fertilizer industries and spillages of fertilizers during unloading operations in the port. It is also evident that the inner Bay area often sustains abnormal levels of NO_{2-}-N and NH_{4+}-N. This is typical of inshore waters under environmental stress. In toxic waters, the nitrite is an intermediate product of bacterial oxidation of ammonia to nitrate. The accumulation of nitrite is an indication of proliferation of *Nitrobactor* bacteria under stress conditions. These contents however are highly variable in monsoon depending upon the extent of drainage which has an ability to restrict the ingress of tidal seawater.

The concentrations of PHc and phenols in water do not indicate deterioration in water quality due to these contaminants and their levels are comparable to the nearshore waters along the coast of Maharashtra. The concentrations of PHc even in the vicinity of the Marine Oil Terminal (MOT) at the Butcher Island are low. It is possible that by virtue of high SS and significant tide-generated turbulence the PHc is adsorbed and removed from the water column and swift currents transport the contaminants and distribute them over a wide area.

1.2.4 Sediment quality

Sediment of the Bay is largely derived from weathering of surrounding basaltic landmass. The strong currents sweeping the Bay disperse the fine-grained and poorly sorted sediment from the bed and from extensive mudflats along the intertidal zone into the water column. This fine grained SS can scavenge the trace pollutants entering the Bay and ultimately transfer them to the bed on settling, thus enriching the bed material with pollutants.

The sediment is dominated by montmorillonite, degraded chlorite, illite and to some extent silica. The 10 to15 m thick acoustically transparent clay beds as revealed through shallow seismic reflections indicate recent sedimentation. A yearly load of 8.4 million m^3 of fine grained sediment is estimated to be transported to the central reaches of the Bay via Ulhas, Panvel and Dharamtar creeks. The oscillating tidal movements spread this material fairly uniformly over the 240 km^2 area of the

Bay. Based on $_{210}$Pb profiles a sedimentation rate of 1.9 cm/y has been established for the inner Bay which decreases to 0.4 cm/y in the outer zone.

The pollutants of major concern are heavy metals and some organic compounds, the concentrations of which even in waters receiving their fluxes are often low and variable making assessment of level of contamination difficult through analysis of water. However, most of such micro-pollutants are adsorbed by the SS in water and transported to the bed on settling of particles. Hence, the concentration of such pollutants progressively increases in sediments of areas receiving their fluxes. It is therefore possible to assess the status of marine environmental quality through analyses of sediment and comparing the observed levels with a suitable background. The constituents considered for the assessment of the sediment quality are heavy metals, Corg, phosphorus and PHc.

Natural sediments always carry heavy metals to a varying degree depending on the source rock as well as the environment of deposition. This lithogenic contribution may be taken as a background for assessment of sediment contamination by anthropogenic metals. As the sediment in the Bay is derived from basalts, which are generally rich in heavy minerals, the concentration of some metals may be naturally high in the sediment of the Bay. Based on the concentrations of metals in marine sediment about 15 to 20 km off the mouth of the Bay and off Murud about 110 km south of Mumbai) it is considered that the sediment in the open Bay area is largely free from accumulation of heavy metals excepting chromium, mercury and to some extent zinc. The concentration of mercury suggested an enhancement (by 3 to 4 folds) in sediment with respect to the baseline value (0.1 μg/g; dry wt) in some zones of the Bay.

The Bay receives 1.8 million kg/d of BOD load through domestic wastewater alone. Part of this organic load gets deposited on the bed when the particles settle. In view of the high BOD load entering the Bay – mainly through sewage, the surficial sediment is expected to sustain high concentrations of Corg. However, the Corg content in the sediment barely exceeds 2.5%. This load is marginally higher than expected (1 - 2%, dry wt) for nearby unpolluted marine sediments and is much lower than anticipated. It is possible that under tropical temperatures, the excess organic loads are rapidly oxidised and re-mineralised by rich bacterial populations at the sediment water-interface apart from being consumed by detritivorous benthic organisms such as polychaetes and mollusks which thrive in the Bay.

Domestic wastewater is also a potential source of phosphorus to the sediment. However, the observed concentrations indicate insignificant accumulation (770 - 1500 μg/g, dry wt) in basalts of the central west coast of India. Nearshore sediments along the coast which is free from direct influence from oily wastes, sustain PHc of < 0.1 to 0.3 μg/g (wet wt). The concentrations in the Bay which vary in the range of 0.2 to 10.1 μg/g (wet wt) indicate patchy distribution. The average PHc levels are higher by about 3 times than expected for clean areas. In areas of high PHc contamination, the levels in excess of 10 μg/g (wet wt) and ranging upto 1000 μg/g (wet wt) have been reported

particularly around oil terminals. However, even off MOT, the concentrations of 0.3 to 0.7 μg/g (wet wt) have been commonly observed. This may be because; the strong currents prevailing in the Bay may not allow settling the lighter residue which gets transported to a longer distance beyond the mouth of the Bay.

1.2.5 Flora and fauna

The populations of pathogen-like organisms such as total coliforms are markedly high in the interior Bay perhaps due to the influence of sewage releases in the vicinity and their decrease in the eastern segment, as expected. The availability of nutrients in high concentrations triggers high growth of phytoplankton resulting in an enhanced chlorophyll *a* content of the Bay with the average at different stations varying between 4.6 and 39.2 mg/m^3. Though the concentrations vary over a wide range, the overall trend suggests a decrease in their levels from the interior to the outer Bay. The levels of phaeophytin are generally lower than those of chlorophyll *a* and average is between 0.3 and 14.3 mg/m^3. Hence, the prevailing ecological condition in the Bay is conducive to the growth of phytoplankton even in the presence of high turbidity. Phytoplankton cell counts vary from 103 x 10^3 to 5024 x 10^3 no/l and indicate comparable trend exhibited by chlorophyll *a*. Generic diversity is high and varies from 11 to 20 genera averaging at 15 no with the phytoplankton community dominated by *Skeletonema, Nitzschia, Thalassiosira* and *Rhizosolenia.* Mangroves occur in varying density along the banks of the Thane, Dharamtar, Karanja and Panvel creeks. *Avicennia marina* and *Avicennia alba* are predominant and form thick stands in the more saline regions. The supralitoral regions support mangroves like *Salvadora persica* and obligate halophytes such as *Suaeda maritima* and *Sesuvium portulacastrum*. The mangrove habitats however have been destroyed or degraded in several areas due to human interference. Species like *Bruguiera parviflora, B.gymnorrhiza, Carapa obovata, Kandelia candel, Lumnitzera racemosa, Rhizophora mucronata* and *Sonneratia caseolaris* have either disappeared from many areas or under severe threat of extinction.

Zooplankton biomass varies widely (0.1 – 281.6 ml/100m^3) with high biomass confined to the inner and the Central Bay associated with high phytoplankton production. The average population also varies widely (100 -779.4x10^3 no/100m^3) though not necessarily proportionate to the variations in the biomass. In line with the biomass and population, the group diversity also varies widely (4 - 17 no) and randomly. The populations are generally dominated by copepods, cladocerans and decapods often contributing more than 80% to the community. Decapods are higher in number, sometimes contributing more than 10% to the population. They are mainly represented by *Lucifer, alpheids, Acetes* and zoea. Larvae of economically important species like *Macrobrachium* sp, *Metapenaeus affinis, M. monoceros, M. dobsoni* and Palaemonids are only occasionally encountered. The contribution of fish eggs and larvae to the zooplankton population is low and seldom exceeds 0.2%. Within the Bay, *Stolephorus indicus* dominate the larval population followed by *Coilia dussumieri, Johnius dussumieri, Thryssa purava* and *Chromogobius quadrivittatus*. Other economically important species like *Harpadon nehereus, Ilisha elongata* and Mugilidae are occasionally present.

Macrobenthic faunal standing stock in terms of population (0 – 2850 no/m^2) and biomass (0 – 19.3 g/m^2, wet wt) at the intertidal segment vary widely. The macrobenthos is dominated by polychaetes and crustaceans over other important groups like mollusks and foraminiferans in the Bay region. In all, about 103 species of polychaetes have been recorded in the intertidal regions of the Bay. In the subtidal zone, the high populations are confined to the interior Bay, while, the dredged areas sustain low macrobenthic standing stock. The faunal group diversity of the subtidal macrobenthos varies between 0 and 6 no with the populations dominated by polychaetes followed by amphipods. Sassoon Dock and Ferry Wharf located within the Bay together contribute more than 60% and 20% to the total fish landings of the Mumbai District and the Maharashtra State respectively. However, fishes are harvested from the open sea and contribution of the fish caught in the Bay to the landings is insignificant. In fact, commercial-scale fishing operations are absent in the Bay.

The Mumbai coast offers assorted intertidal marine habitats (110.5 km^2) like rocky/sandy/muddy and mangroves for a variety of resident and migratory birds. Marine turtles are sometimes sighted along the Mumbai coast and are mainly represented by Logger head (*Caretta caretta*) and Olive Ridley (*Lepidochelys olivacea*). Other turtles like Hawksbill (*Eretmochelys imbricata*), Leather back (*Dermochelys coriacea*) and Green (*Chelonia mydas*) turtles are occasionally sighted. The marine mammals are chiefly represented by Dolphin and Porpoise in the coastal waters of Mumbai though whales are rare.

2. Studies carried out

2.1 Shoreline

Landsat-8 satellite image of 9th March 2019 taken at 10:33hrs was used for digitizing the shoreline of Mumbai coast. This shoreline will be considered as a base line for the future monitoring. Erosion/Accretion regions with respect to March 2019 will be highlighted. The tide level at the time of satellite image is about 2.38m. This shoreline also will be compared with the past archived shoreline available with CSIR-NIO, Goa. Apart from the satellite imageries, field measurements of shoreline using beach profiles will carried out at select locations where the monitoring can be carried out periodically.

In order to establish the marine environmental status of the nearshore waters of Mumbai extending from Rajiv Gandhi Sea Link in the north to Nariman Point in the south, around 13 locations positioned in a grid like manner covering the coastal waters at different distances (1km, 3 km, 8 km) from the area of development were sampled. The field observations were made from 25.03.2019 to 28.03.2019.

2.2 Water quality 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 3.1.2. The total area covered by these sampling stations works

out be ~ 80 km^2. The geographical positions of the sampling stations, sampling depths and their distance from the coastline are given in the Table 3.1.1.

Figure 3.1.1 Landsat image of 9th March 2019

Table 3.1.1: Geographical co-ordinates of sampled locations in the coastal waters of Mumbai

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° 1'7.45"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	

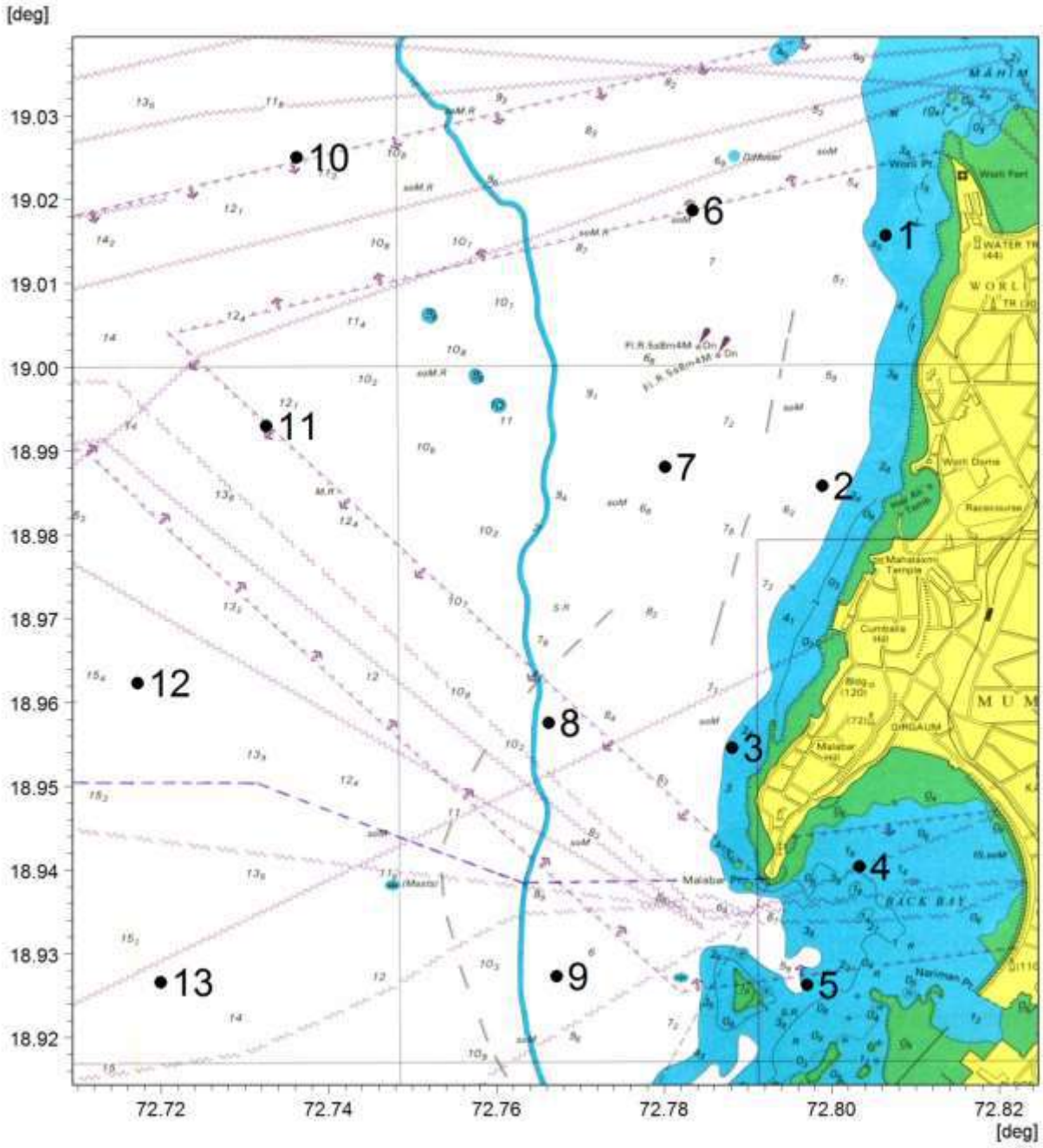


Figure 3.1.2: Study area with sampling locations

2.3. Sampling frequency

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

2.4 Water quality parameters

2.4.1 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.

2.4.2 Methods of analyses

Majority of the water quality parameters were analysed within 24 h of collection in the laboratory. Nutrients were measured by colorimetric method using a Shimadzu (Model 1240) spectrophotometer. Shimadzu (Model RF-5301 PC) spectro-fluoro-photometer was used for estimating PHc. The analytical methods of estimation were as follows:

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

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 standardised with IAPSO standard sea water (OSIL, UK).

iv) Total Suspended Solids (SS): Total Suspended solids of a known volume of the sample were measured by filtration using Filtration pump (Aspirator Vacuum) (Preston and Summers, 1997). Seawater samples were filtered through pre-weighed Millipore filter papers (dia, 47 mm; nominal pore size, 0.45 μm) using Millipore Vacuum Pump. The filter papers were then dried (40 °C) and weighed again. TSS was calculated from the initial and final weights of the filter paper after filtration and concentrations of TSS are 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 WA (manganese chloride) and WB (alkaline potassium

iodide) immediately after collection. The precipitate so formed was then decomposed with concentrated HCl and the released iodine was titrated against $Na_2S_2O_3$ with starch indicator. Concentrations of DO are expressed as mg/l. Samples for the determination of Biochemical Oxygen Demand (BOD3) were collected in triplicate. The dissolved oxygen (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 was 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 BOD3 and expressed as 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) 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.

ix) Nitrite-Nitrogen (NO_2^--N): Nitrite was determined by the method of Grasshoff (1983) wherein the nitrite in the samples was measured after diazotising it with sulfanilamide and coupling with N (1-Naphthy)-ethylene diamine dihydrochloride. The absorbance of the resultant azo dye was measured at 543 nm by a Shimadzu UV mini 1240 spectrophotometer.

x) Nitrate-Nitrogen (NO_3^--N): Nitrate in the samples was first reduced quantitatively to nitrite by heterogeneous reduction by passing each buffered sample through an amalgamated cadmium reduction column and the resultant nitrite was analyzed 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.

2.5 Sediment quality parameters

2.5.1 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.

2.5.2 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.

2.6 Flora and fauna

2.6.1 Sampling procedure

For microbiological analyses, surface waters representing the water column was 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 held on 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.

2.6.2 Methods of analyses

Microbiology: To detect the presence of faecal contamination in seawater certain microbial indicators such as Faecal indicator bacteria (FIBs) are 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 Coliform (TC), faecal coliforms (FC), *Escherichia coli* like organisms (ECLO) and *Streptococcus faecalis* like Organism (SFLO) were studied.

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 24-48 hours. 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 24-48 hours.

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 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).

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 (10

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 labeled and, stored for further examination. In the laboratory, the sediments were washed again under tap water and the material 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 is expressed as ind./m^2. Macrofaunal biomass was determined by taking weight measurements on an electronic balance and is 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, labelled 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 was considered as meiofauna. All the meiobenthic organisms were counted and identified up to group level under Stereo-zoom microscope. The density counts of meiofauna were converted to number of organisms per 10 cm^2.

2.7 Data presentation

In order to identify changes, if any, in the ecology of the marine segment off Mumbai due to the coastal road, the data of the stations were clubbed as per their distance from the coast as presented below and compared.

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

2.8 Water Quality

2.8.1 Temperature

Water temperature generally regulates distribution, composition and activity of living organisms in aquatic environment. Majority of the aquatic animals are cold blooded; therefore, the water temperature regulates their metabolism and ability to survive and reproduce effectively. In shallow coastal areas, seawater temperature varies in accordance with the prevalent air temperature. An upper threshold limit of 35 °C is considered for tropical aquatic species though many may be less tolerant.

The overall air temperature in the study area varied from 26.0−32.0°C during March 2019. The average air temperature value was relatively lower at 1 km zone as compared to that in 3 km and 8 km zones, presented in Table below.

Distance from coastline	AT (°C)	Water temperature (°C)
1 km	26.0 - 32.0 (28.8)	25.5 - 29.0 (27.4)
3 km	27.5 - 31.0 (29.6)	26.0 - 29.0 (27.4)
8 km	27.0 - 32.0 (29.3)	25.5 - 29.0 (27.3)

AT = Air temperature; average values in parenthesis

The water temperature varied within a wide range in surface (25.5−29.0°C) as well as in bottom waters (25.5−28.5°C), and the difference between surface and bottom water temperatures was significant. Average water temperature during high tide and low tide at 1km zone were 28.1°C and 26.5°C, respectively. On an average, the water temperature values were nearly similar among the 1km, 3km and 8km zones indicating well-mixed conditions. 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.

2.8.2 pH

The principal system that regulates pH of the seawater are carbonate system (CO_2, HCO_3^- and CO_3^{2-}), salt content and borate alkalinity. Generally, seawater pH varies within a range between 7.8 and 8.3. The major carbon reservoir in the ocean is dissolved inorganic carbon (DIC), which is total of aqueous CO_2, bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions. The pH of seawater generally varies from 7.9–8.3 in the present day, with predominant HCO_3^- ions. The concentrations of CO_3^{2-} ion increase with increasing pH, so as to become more acidic due to more dissolved CO_2. The atmospheric CO_2 reacts with seawater to form carbonic acid (H_2CO_3), which is unstable and get dissociated to form HCO_3^- and CO_3^{2-} ions. The CO_3^{2-} ions react with calcium ions (Ca^{2+}) present in seawater to form calcium carbonate ($CaCO_3$) mainly utilized by organisms to build their exo-skeleton. In shallow and biologically active tropical water, diurnal pH varies between 7.3 and 8.3; this may be due to photosynthesis process. In nearshore environment, mixing of freshwater, especially during monsoon season, can affect the buffering effect, thus pH remains below 8.0. Also, this area is vulnerable to pH

change owing to release of anthropogenic low pH water discharges. Albeit, the pH range of 5 to 9 is not directly harmful to aquatic life but such changes can make many common pollutants more toxic.
The pH of surface and bottom water varied from 8.0−8.1 and 8.0−8.3 respectively, without any significant variation, which indicate well-mixed conditions. The average pH during high tide and low tide at 1km zone were 8.1 and 8.0 respectively. The average values of pH in all the three zones were nearly similar as presented below;

Distance from coastline	pH
1 km	8.0 - 8.3 (8.1)
3 km	8.1 - 8.2 (8.1)
8 km	8.1 - 8.3 (8.1)

2.8.3 Salinity

Normally seawater salinity is 35.5 ppt, which may vary depending on the balance between evaporation and precipitation, also freshwater addition. Salinity is an ecological factor of considerable importance, influencing the types of organisms that live in a water body. Biota is generally acclimatized to a certain range of salinity where they thrive. Hence, wide variation in salinity levels can result in adoption, with modification and dominance of selected species in the lower order, while higher order biota may migrate. Sudden changes in salinity may cause high mortality of biota including fish due to salinity shock.
Salinity values in surface and bottom were ranged at 35.7−36.7 psu and 36.2−36.6 psu, respectively, without any significant variation during the study period. The average salinity at high tide (36.6 psu) and low tide (36.2 psu) were nearly similar. The average salinity values in all the three zones were nearly similar during the study period indicating mixing condition, as presented below;

Distance from coastline	Salinity (psu)
1 km	35.7−36.5 (36.2)
3 km	35.9−36.5 (36.3)
8 km	36.4−36.7 (36.5)

2.8.4 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. 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 the 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 be ceased, 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.

The SS concentrations ranged between 9−41 mg/l and 10−74 mg/l in surface and bottom waters respectively and varied significantly during this study. The values of SS varied within a narrow range during the high tide as well as low tides and averaged at 38 mg/l and 44 mg/l, respectively. The average SS values decreased from 1 km zone towards 8 km zone as presented below, indicating settling of SS in marine water.

Distance from coastline	SS (mg/l)
1 km	16−74 (38)
3 km	14−39 (30)
8 km	9−32 (25)

2.8.5 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 settleable 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.

The turbidity levels in surface and bottom significantly varied from 1−41 NTU and 2−47 NTU, respectively, during this study. Like SS, average values of turbidity varied within a narrow range during high tide (38 NTU) as well as low tide (44 NTU). The average limits of turbidity observed during this study is presented in the Table below. The variation of turbidity closely follows SS and decreased from 1km to 8km zone indicating dilution of turbid water.

Distance from coastline	Turbidity (NTU)
1 km	3−47 (10)
3 km	1−7

	(4)
8 km	2−5 (3)

2.8.6 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 19400 mg/l. 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^- off Mumbai ranged from 19800 to 20300 mg/l in surface and 20000 to 20200 mg/l in bottom, without any significant difference. The average Cl^- concentrations during high tide (20100 mg/l) and low tide (20038 mg/l) were nearly similar. The average limits of Cl^- at different zones are presented in table below. More or less, the average Cl^- values roughly increased from 1km zone to 8km zone, indicative towards general mixing condition due to tidal incursion of seawater.

Distance from coastline	Chloride (mg/l)
1 km	19800−20200 (20040)
3 km	19900−20200 (20138)
8 km	19900−20300 (20138)

2.8.7 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 a combination of photosynthesis, atmospheric 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.

The DO values in surface and bottom were ranged at 4.9−7.7 mg/l and 3.9−7.5 mg/l, respectively, also varied significantly between surface and bottom water column. The high tide and low tide averages of DO at 1km zone were 6.3 mg/l and 5.8 mg/l, respectively. As indicated in the below Table, the average DO values were >6 mg/l in all the three zones highlighting that well oxygenated water column prevailed for the healthy aquatic life to sustain in the study area.

Distance from coastline	DO (mg/l)	BOD (mg/l)
1 km	3.9−7.7 (6.1)	0.8−4.6 (2.9)
3 km	6.1−7.1 (6.5)	1.2−3.9 (2.6)
8 km	6.2−7.7 (7.0)	1.6−4.5 (2.9)

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 ^{o}C soon after the collection. Presence of sufficient DO through replenishment keeps this demand low. However, input of oxidizable organic matter often cause enhancement of BOD, which is the indicator of unfavourable conditions for the aquatic life.

The BOD values in surface and bottom were ranged at 1.2−4.6 mg/l and 0.8−4.3 mg/l, respectively and varied significantly between surface and bottom water column. The high tide and low tide averages of BOD at 1km zone were 2.5 mg/l and 3.1 mg/l, respectively. As indicated in the above table, average BOD values were nearly similar in all the three sampled zones of this study. BOD of >4 mg/l was associated with fairly high DO (>7 mg/l) observed in the northern transect (Table 3.1.1), could be related with efficient biochemical oxidation by the heterotrophs present in those water or could be due to localized impact of sewage, which were absent in other regions.

2.8.8 Nutrients

The nutrients such as forms of phosphate, nitrogen and silicon, along with trace metals are used by phytoplankton during primary productivity. Amongst, 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) 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 aquatic environment. NO_3^--N is the end product of oxidation and the most stable form at pH 7. The principal source of nitrogen in marine environment is fixation of atmospheric N_2. NO_2^- occur 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. However, occurrence of high levels of these nutrients in creek and nearshore regions may hamper the coastal nutrient status and in extreme cases it can lead to eutrophication.

(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-}−P in coastal marine environment include domestic sewage, detergents, effluents from agro-based and fertilizer industries, agricultural runoff, organic detritus such as leaves, cattle waste etc.

Distance from coastline	PO_4^{3-}−P (µmol/l)
1 km	0.4−5.0 (1.9)
3 km	0.9−2.2 (1.4)
8 km	0.6−1.0 (1.0)

During March 2019, PO_4^{3-}−P concentrations in surface and bottom were ranged at 0.4-5.0 µmol/l and 0.8-2.3 µmol/l respectively, with significant variation of PO_4^{3-}−P found between surface and bottom water column. The average limits of PO_4^{3-}−P during high tide and low tide were 1.8 µmol/l and 2.0 µmol/l, respectively. As presented in Table, the average concentrations of PO_4^{3-}−P decreased from 1km to 8km zone in this study.

(ii) Nitrate (NO_3^- −N)

The ranges of NO_3^-−N in surface water was between 0.2 and 17.1 µmol/l, whereas in bottom water NO_3^-−N concentration was between 0.2 and 13.5 µmol/l, thus varying significantly in surface and bottom waters during this study. The average limits of NO_3^-−N during high tide and low tide were 8.2 µmol/l and 10.9 µmol/l, respectively. As presented in the Table, the average concentrations of NO_3^-−N decreased from 1km to 8km zone in this study.

Distance from coastline	NO_3^--N (µmol/l)
1 km	1.6−17.1 (9.8)
3 km	0.2−13.5 (6.5)

8 km	0.2−4.3 (3.3)

(iii) Nitrite (NO_2^- −N)

Likewise, NO_2^-−N in surface and bottom water were ranged at 0.1−5.5 µmol/l and 0.3−3.7 µmol/l, respectively, and varied significantly during this study. The average limits of NO_2^-−N during high tide and low tide were 2.5 µmol/l and 3.2 µmol/l respectively. As presented in the Table, the average concentrations of NO_3^-−N decreased from 1km to 8km zone in this study.

Distance from coastline	**NO_2^--N (µmol/l)**
1 km	0.7−5.5 (2.8)
3 km	0.3−4.0 (2.0)
8 km	0.1−2.7 (1.2)

(iv) Ammonium (NH_4^+ −N)

The NH_4^+-N is unstable in natural surface waters, therefore it is further oxidized to NO_3^--N via NO_2^--N. The concentration of NH_4^+-N in surface and bottom water column were ranged at 0.5–5.8 µmol/l and 0.7-3.8 µmol/l respectively, with significant variation of NH_4^+-N in surface and bottom water samples.

Distance from coastline	**NH_4^+-N (µmol/l)**
1 km	0.5−5.8 (1.7)
3 km	1.0−5.8 (2.3)
8 km	0.8−2.2 (1.4)

The average limits of NH_4^+-N during high tide and low tide were 1.6 µmol/l and 2.2 µmol/l respectively. As presented in the Table, the average concentrations of NH_4^+-N was relatively lower in the 8km zone as compared to the 1km and 3km zones off Mumbai. Collectively, the average nutrient levels were relatively lower towards 8km zone, with minimal variability from 1km to 8km zones, also during the epochs of tidal conditions in this study. The higher levels of DO in all the three-zone associated with lower BOD suggests a natural nutrient variability in the region.

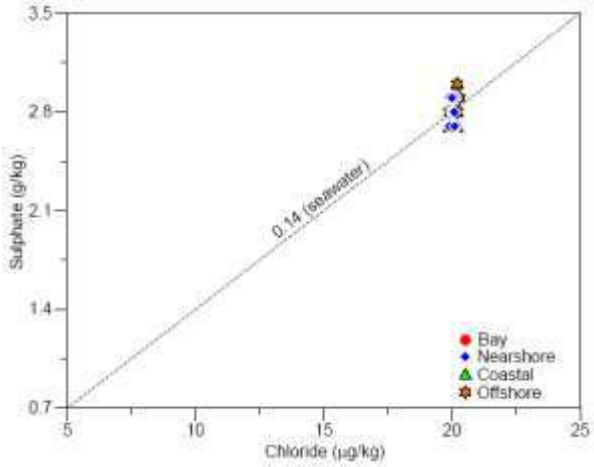
(v) Sulphate (SO_4^{2-})

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.

The sulphate concentrations varied at nearly similar range (3-38 g/kg) in surface as well as bottom waters during this study. The concentrations of average sulphate (g/kg) in water samples collected at different locations off Mumbai during March 2019 is given in the Table below.

Distance from coastline	Sulphate (g/kg)	SO_4^{2-}:Cl
1 km	2.8−3.0 (2.9)	0.14−0.15 (0.15)
3 km	2.8−3.1 (2.9)	0.14−0.15 (0.14)
8 km	2.9−3.1 (2.9)	0.14−0.15 (0.15)

There was no significant variation in average sulphate levels among all the sampled zones of this study. Likewise, the SO_4^{2-}: Cl ratio varied within a very narrow range in surface as well as bottom water samples i.e. between 0.14 and 0.15. From the table it is evident that the average SO_4^{2-}: Cl at all the stations are nearly identical and, in the range, observed for the natural seawater. The SO_4^{2-} vs. Cl plot for all data collected during March 2019 around Mumbai waters is presented below:



The results indicated that all the data points (2□ sv.) 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 observation 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 is no build up or removal of sulphate in the study area.

2.8.9 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 was collected 1m below the surface water.

Distance from coastline	PHc (µg/l)
1 km	2.5−6.8 (4.1)
3 km	2.7−3.5 (3.2)
8 km	1.6−3.1 (2.4)

The concentration of PHc measured in the surface layer (1m water depth) around off Mumbai were ranged at 1.6–6.8 µg/l (av. 3.4 µg/l) during March 2019. As presented in the table, the average values of PHc decreased from 1km Zone towards 8km zone during the study period, indicating minimal contamination due to petroleum compounds in the 8km zone off Mumbai.

2.9 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 removed through adsorption are 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 sinking interface dependent upon the balance between their receiving fluxes, accumulation and removal rates. Moreover, the accumulation of metals, C_{org} and pollutants in sediment over period of time can substantially indicate the quality of sediment that is essential for a sustainable healthy benthic ecosystem. The grainsize (texture) and petroleum hydrocarbon (PHc) analyses were performed on un−grinded dry and wet sediment respectively and results are presented in Table. The contents of metals and other sedimentary parameters varied among different zones off Mumbai during this study is presented in Table 3.2.1.

2.9.1 Texture

Overall, the bed sediments within the off Mumbai region showed a wide range of texture property (clay, silt and sand), mainly dominated with silt. The average percentage of silt is higher in 1km zone, whereas the average clay content in sediment increased from 1km towards 8km zone as presented in table below.

Distance from coastline (km)	Sand (%)	Silt (%)	Clay (%)
1 km	1−8 (4)	82−92 (87)	7−10 (9)
3 km	1−20 (7)	57−94 (80)	6−23 (13)
8 km	1−11 (5)	63−91 (79)	6−37 (16)

The distribution of sediment texture did not indicate any pattern from the 1km zone to 8km zone. Predominantly silty sediment with fairly low clay content present in the study area. The variability in sediment texture at a given location could be due to seasonal changes, high wave action and active transport by currents especially during monsoon season.

2.9.2 Metals

Bed sediment in uncontaminated areas has lithogenic metal concentrations, which are derived from rocks and soils encountered. However, these levels can get altered when the coastal water receive discharges of industrial 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 grain size composition of bed sediment. For example, smaller grain size and higher clay matter may result in higher levels of metals in 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 pollution in the marine environment. The results of metal content in subtidal sediment of the present monitoring are presented in Table 3.1.2. The ranges and average contents of different metals in the three different zones of this study are presented below.

Metals	Distance from coastline		
	1 km	3 km	8 km
Al (%)	6.7-7.6 (7.2)	6.8-7.2 (7.0)	6.7-7.4 (7.0)
Cr (μg/g)	93-116 (105)	104-150 (121)	96-168 (117)
Mn (μg/g)	807-1260 (1034)	650-769 (716)	682-883 (778)

Fe (%)	8.0-8.8 (8.4)	8.0-8.4 (8.2)	8.0-8.6 (8.4)
Co (μg/g)	23-28 (26)	26-30 (28)	24-38 (28)
Ni (μg/g)	52-59 (56)	56-65 (59)	53-78 (60)
Cu (μg/g)	78-87 (83)	78-92 (83)	74-108 (86)
Zn (μg/g)	94-105 (100)	87-190 (124)	84-164 (107)
Hg (μg/g)	0.3-0.4 (0.3)	0.2-0.3 (0.2)	0.2-0.3 (0.2)

Average values in parenthesis

Results of the present monitoring highlighted the enrichment of metals in sediments along the dispersal pathways e.g. from 1km zone to 8km zone off Mumbai did not follow any significant trend. Variations in lithogenic fraction of metals in sediment across the eastern Arabian Sea are 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. Thus, though metals such as Cr and Zn were increased towards at 3km and 8km zone, these may be invariably associated with Al and/or Fe contents.

2.9.3 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, thereby eventually deposited on the sediment. Hence, PHc levels in sediment serve as a useful indicator of cumulative effect of oil contamination. The average concentrations of PHc in sediments from different zone is presented below.

Distance from coastline	PHc (μg/g wet wt.)
1 km	0.1−1.5 (0.8)
3 km	1.5−2.5 (2.0)
8 km	0.1−2.1 (0.7)

There was no significant trend of PHc variations observed in the sediment from the study area. The average PHc limits were relatively lower in 1km and 8km zone as compared to 3km zone.

2.9.4 Organic carbon (C_{org})

Generally, organic matter in nearshore and coastal sediments contributed from terrestrial runof are mainly utilized by the benthic organisms present in the same region. Anthropogenic organic inputs however can increase the content of C_{org} to abnormal levels disturbing the equilibrium of the

ecosystem. Organic matter settling on the bed is scavenged by benthic organism to a large extent. The balance is 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} in subtidal sediments from all the three zones of this study are presented below

Distance from coastline	C_{org} (%)
1 km	1.5−1.6 (1.55)
3 km	0.2−1.4 (0.9)
8 km	1.2−1.7 (1.4)

The average content of C_{org} did not vary significantly from 1km zone towards the 8km zone, which may be due to their similar source or origin. The contents of C_{org} varies negatively with sand in the sediments during this study. The contents of C_{org} often corresponds to their nature and origin, however the content itself may not represent with any specific source but when compared alongside of other parameters such as total nitrogen content and the isotopic signatures, the potential C_{org} sources can be identified.

2.9.5 Total Phosphorus (P)

Lithogenic phosphorus in nearshore marine sediments 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 average contents of sedimentary P around all the three zones off Mumbai region did not vary significantly. Relatively higher average P in 3km and 8km zones as compared to 1km zone could be related with re-accumulation of P during sedimentary bed resuspension and settling owing to strong tidal condition. The average contents of sedimentary P in all the three zones of this study are presented below

Distance from coastline	P (μg/g)
1 km	1171−1274 (1223)
3 km	1059−1866 (1345)
8 km	1095−1848 (1301)

In summary it was considered that the sedimentary parameters such as texture, metals, PHc, C_{org}, and P in the subtidal sediments around off Mumbai though varied within the region, but hardly indicate any abrupt rise in values as compared to the previous monitoring results across the same region. Nevertheless, regular periodic monitoring of ecology off Mumbai is desirable to establish the trends in variation of sediment quality in future.

Table 3.1.1: Water quality parameters at different locations off Mumbai during March 2019.

Stations		1			2			3			4	5		
Parameter	**Level**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**	**Avg.***	**Min.**	**Max.**	**Avg.**
Temperature (°C)	S	27.5	27.5	27.5	27.0	29.0	28.0	25.5	28.5	27.0	28.5	26.5	28.5	27.5
	B	26.5	27.0	26.8	26.5	28.5	27.5	25.5	27.5	26.5	27.5	26.5	28.0	27.3
	AT	27.0	28.0	27.5	29.0	32.0	30.5	26.0	30.0	28.0	29.0	27.0	31.0	29.0
pH	S	8.0	8.1	8.0	8.1	8.1	8.1	8.0	8.1	8.0	8.0	8.0	8.1	8.0
	B	8.1	8.3	8.2	8.1	8.1	8.1	8.0	8.2	8.1	8.0	8.0	8.1	8.0
SS (mg/l)	S	33	41	37	30	41	36	29	37	33	16	18	29	23
	B	45	47	46	46	74	60	42	44	43	32	38	63	51
Turbidity (NTU)	S	3.0	6.1	4.6	3.2	3.6	3.4	9.6	19.7	14.7	11.9	8.1	10.1	9.1
	B	3.5	5.2	4.3	4.6	4.9	4.7	11.6	22.4	17.0	13.3	16.3	17.8	17.1
Salinity (ppt)	S	36.2	36.2	36.2	36.0	36.1	36.0	35.7	36.3	36.0	36.3	36.3	36.3	36.3
	B	36.2	36.4	36.3	36.4	36.5	36.4	36.2	36.3	36.2	36.2	36.3	36.4	36.3
DO (mg/l)	S	7.5	7.7	7.6	4.9	5.9	5.4	5.9	6.2	6.0	6.4	5.9	6.8	6.4
	B	6.8	7.1	6.9	3.9	4.8	4.4	5.4	6.0	5.7	5.9	5.9	6.5	6.2
BOD (mg/l)	S	4.1	4.6	4.3	1.7	3.6	2.6	3.0	4.5	3.8	2.3	2.0	3.0	2.5
	B	3.0	4.1	3.6	0.8	2.0	1.4	2.6	2.7	2.6	2.9	2.3	2.9	2.6
PO_4^{3-}-P (µmol/l)	S	0.8	5.0	2.9	1.6	2.4	2.0	2.1	2.4	2.3	1.6	0.4	1.9	1.1
	B	1.6	1.9	1.7	1.1	1.5	1.3	2.0	2.0	2.0	1.9	1.2	2.3	1.7
NO_3^--N (µmol/l)	S	1.6	5.9	3.7	13.8	17.1	15.4	12.4	13.3	12.8	10.5	8.3	10.5	9.4
	B	3.1	4.1	3.6	8.5	11.8	10.2	10.0	13.5	11.8	11.3	7.5	11.2	9.4
NO_2^--N (µmol/l)	S	0.7	2.6	1.7	4.6	5.5	5.1	3.1	4.5	3.8	2.4	1.8	2.8	2.3
	B	1.2	1.4	1.3	3.5	3.7	3.6	2.9	3.0	3.0	2.4	1.5	2.2	1.9
NH_4^+-N (µmol/l)	S	1.9	2.3	2.1	1.2	1.4	1.3	2.3	5.8	4.0	0.5	0.7	2.1	1.4
	B	0.7	0.9	0.8	1.0	1.7	1.4	3.0	3.8	3.4	0.7	0.8	1.2	1.0
PHc (µg/l)	1m	2.7	5.7	4.2	3.9	9.6	6.8	2.0	4.2	3.1	3.7	2.7	2.3	2.5
Sulphate (g/kg)	S	2.9	3.0	2.9	3.0	3.0	3.0	2.8	2.9	2.8	3.0	3.0	3.0	3.0
	B	2.8	2.9	2.8	2.8	2.8	2.8	3.1	2.9	3.0	2.9	2.9	3.0	2.9
Chloride (mg/l)	S	20100	20000	20000	19900	20000	19900	19800	20100	19900	20100	20100	20100	20100
	B	20100	20000	20100	20200	20200	20200	20000	20100	20000	20000	20100	20100	20100

*Average of two readings; AT: air temperature; S: Surface; B: Bottom

Table 3.1.1: Continued

Stations	Level	6	7	8	9	10	11	12	13
Parameters		**Avg.***	**Avg.***	**Avg.***	**Avg.***	**Avg.***	**Avg.***	**Avg.***	**Avg.***
Temperature(°C)	S	26.5	29.0	27.5	28.5	26.5	29.0	27.0	28.0
	B	26.0	28.5	26.5	27.0	25.5	28.5	26.0	27.5
	AT	27.5	31.0	29.0	31.0	27.0	31.0	29.0	30.0
pH	S	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
	B	8.1	8.1	8.2	8.2	8.4	8.1	8.1	8.1
SS (mg/l)	S	34	34	24	14	31	34	9	17
	B	36	39	29	28	32	39	10	25
Turbidity (NTU)	S	2.5	1.3	2.2	5.5	1.7	1.3	2.5	2.3
	B	2.0	3.7	3.8	7.2	2.0	3.7	1.6	4.8
Salinity (ppt)	S	36.5	36.4	35.9	36.3	36.5	36.4	36.4	36.5
	B	36.5	36.4	36.4	36.5	36.6	36.4	36.4	36.4
DO (mg/l)	S	6.2	6.6	6.8	7.1	7.7	6.6	7.0	7.2
	B	6.1	6.2	6.2	6.9	7.5	6.2	6.4	6.7
BOD (mg/l)	S	2.3	1.2	3.9	3.2	4.5	1.2	3.1	3.0
	B	1.3	2.9	2.8	3.2	4.3	2.9	2.0	2.1
PO_4^{3-}-P (µmol/l)	S	1.0	1.4	1.9	0.9	0.7	1.4	0.9	0.6
	B	1.0	1.7	1.4	2.2	0.8	1.7	1.0	1.0
NO_3^--N (µmol/l)	S	1.2	8.7	13.5	7.3	0.2	8.7	4.3	2.1
	B	0.2	7.1	8.2	6.0	0.2	7.1	3.0	1.0
NO_2^--N (µmol/l)	S	0.7	3.4	4.0	1.5	0.1	3.4	2.7	0.2
	B	0.3	2.9	2.5	0.9	0.0	2.9	0.3	0.3
NH_4^+-N (µmol/l)	S	1.8	1.3	5.8	1.4	2.2	1.3	1.6	1.3
	B	2.1	1.0	3.0	1.7	0.9	1.0	0.9	1.6
PHc (µg/l)	1m	2.7	3.4	3.3	3.5	3.1	3.4	1.6	1.6
Sulphate (g/kg)	S	2.9	3.1	2.8	2.8	2.9	3.1	2.9	2.9
	B	2.9	2.9	2.8	2.8	2.9	2.9	2.9	3.0
Chloride (mg/l)	S	20200	20200	19900	20100	20200	20200	19900	20200
	B	20200	20100	20200	20200	20200	20100	20200	20100

Table 3.1.2: Sediment quality off Mumbai during March 2019.

Distance from coastline	Station Code	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)
1km	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	3	1	91.8	7.2	7.6	116	807	8.8	28	59	87	105	0.35	1.5	1274	1.5
	4	7.5	82.1	10.4	6.7	93	1260	8	23	52	78	94	0.33	1.6	1171	0.1
	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3km	6	0.6	94	5.5	7.1	104	730	8.3	26	56	79	87	0.32	1.4	1109	2.5
	7	19.8	57.3	22.9	6.8	150	650	8	30	65	92	190	0.18	0.2	1866	1.5
	8	1.3	88.4	10.3	7.2	109	769	8.4	27	56	78	94	0.24	1.3	1059	1.9
	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8km	10	7.8	86.2	6	7.4	102	883	8.6	25	56	84	91	0.3	1.4	1095	2.1
	11	10.5	74.8	14.7	7	168	682	8..4	38	78	108	164	0.16	1.2	1848	0.1
	12	0.7	62.6	36.7	7	103	797	8.4	26	54	76	87	0.22	1.4	1155	0.6
	13	0.7	90.8	8.4	6.7	96	748	8	24	53	74	84	0.24	1.7	1107	0.1

Dash indicates no collection

2.10 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 3.4.1- 3.4.12.

2.11 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. As we learn about the diversity of microorganisms and their associated processes, our view of the marine ecosystem is being transformed, and the relevance of microbes to marine resiliency and marine resource management is becoming undeniable. The sheer number of microorganisms act as sentinels for health status within marine ecosystem as well as their vast diversity and different functions has led to the realization of threats from emerging pathogens. 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.

The principal source of waterborne diseases such as cholera, typhoid and hepatitis is due to contamination of water by sewage and animal wastes. Apart from potable water, bacterial

contamination occurs in surface waters such as those used for shell fishing areas, beaches, fisheries and recreational facilities. Though 90% of the intestinal bacterial population dies off within 2 days in natural waters, the remaining 10% decline much more slowly. 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 8 stations in coastal waters off Mumbai region. Total Viable Counts (TVC), Total Coliform (TC), *Escherichia coli* like organisms (ECLO) and *Streptococcus faecalis* like Organism (SFLO) were studied. The microbiological results for water and sediments are given in Tables 3.4.1-3.4.2.

a) Water

The microbial study demonstrated that the average Total Viable Count (TVC) of bacteria was comparatively higher at 3 km distance as can be seen in the table given below.

Distance from coastline	TVC x 10^3	TC	FC	ECLO	SFLO
	(CFU/mL)				
1 km	10-620 (147.8)	NG-100 (20)	NG-50 (7.8)	NG-10 (2.2)	NG-50 (8.9)
3 km	30-960 (297.5)	NG-100 (25)	NG-20 (5)	NG-20 (5)	NG-30 (7.5)
8 km	30-650 (340)	NG	NG	NG	NG

NG=No Growth

However, higher abundance of total coliforms (TC) were encountered at 1 km distance. Pathogenic bacteria like ECLO, SFLO were completely absent at 8 km distance. Their presence in 1 km and 3 km distance could be due to the influence of nearshore seawater (Table 3.4.1).

b. Sediment

The TVC counts in the coastal sediments of the study area followed the trend of the overlying seawater with maximum count at 3 km distance. TC, FC, ECLO and SFLO were not detected in the sediments of the study region (Table 3.4.2). Distance based zone wise range and average are presented in the below table

Distance from coastline	TVC x 10^4	TC	FC	ECLO	SFLO
	(CFU/g)				

1 km	40-140 (73.3)	NG	NG	NG	NG
3 km	20-520 (193.3)	NG	NG	NG	NG
8 km	10-360 (117.5)	NG	NG	NG	NG

NG=No Growth

Table 3.4.1. Microbial counts in surface water (CFU/mL) at Mumbai during March 2019

Station/ 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								
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 3.4.2. Microbial counts in Sediments (CFU/g) at Mumbai during March 2019

Station/ Types of bacteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
	1 Km					**3 Km**				**8 Km**			
TVC x10^4	ROCKY BOTTOM	ROCKY BOTTOM	40	140	40	40	520	20	ROCKY BOTTOM	10	360	60	40
TC			NG	NG	NG	NG	NG	NG		NG	NG	NG	NG
FC			NG	NG	NG	NG	NG	NG		NG	NG	NG	NG
ECLO			NG	NG	NG	NG	NG	NG		NG	NG	NG	NG
SFLO			NG	NG	NG	NG	NG	NG		NG	NG	NG	NG

2.12 Phytoplankton

Phytoplanktons 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 3.4.3-3.4.4.

a. Phytoplankton Biomass

Results revealed that chlorophyll *a* was found to be higher at 1 km distance compared to 3 and 8 km zones. The enhanced concentration of chlorophyll *a* at 1 km distance could be probably because the area received nutrients from the nearshore waters. The chlorophyll *a*: phaeophytin ration which indicates the health of the phytoplankton cells revealed that the study area was not under any kind stress as the ratio was >1 (Tables 3.4.3-3.4.4). The range and average values of phytopigments and the Chla to Phaeo ratios are presented below

Distance from coastline	Chlorophyll *a* (mg/m^3)		Phaeophytin (mg/m^3)		Ratio of Chl *a* to Phaeophytin	
	S	B	S	B	S	B
1 km	1.5-13.5 (6.6)	2.5-8.1 (4.5)	0.5-1.4 (0.8)	0.5-1.7 (0.9)	1.3-10.0 (7.8)	3.2-9.3 (5.3)
3 km	1.9-5.5 (3.9)	2.6-7.7 (4.3)	0.2-0.6 (0.5)	0.3-1.4 (0.7)	7.7-9.9 (8.9)	2.0-9.9 (7.2)
8 km	2.5-8.4 (4.1)	1.2-3.4 (2.2)	0.3-0.9 (0.5)	0.3-0.7 (0.5)	7.3-9.8 (8.8)	3.6-8.0 (5.1)

The impact of tidal variation on chlorophyll *a* was also studied along the 1 Km stretches of coastal waters of Mumbai (Figure. 3.4.1). Enhanced chlorophyll *a* during full flood (F.Fld) in surface water and during full ebb (F.Ebb) in the bottom chlorophyll *a* periods could probably be due to the contribution of chlorophyll *a* from coastal waters during full flood period and re-suspension during full ebb period respectively.

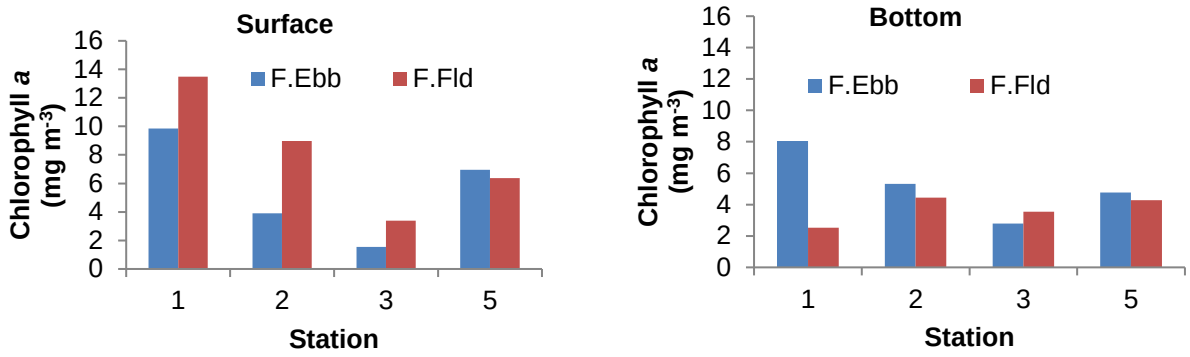


Figure.3.4.1 Tidal variation of Chlorophyll *a* at Mumbai during March 2019

b. Phytoplankton population and total genera

Phytoplankton cell count (abundance) and community structure in the 1 km to 8 km stretch in coastal waters of Mumbai is illustrated in Table. 3.4.4. Surface and bottom water phytoplankton cell count followed the trend of phytopigments and was maximum at 1 km which could be probably due to entrainment of nutrients from nearshore waters which augmented the cell count. The number of phytoplankton genera remained comparable in all the areas as can be seen in the table below.

Distance from coastline	Cell Count (x 10^3 Cell l^{-1})		Total Genera (no.)	
	S	B	S	B
1 km	597.4-3975.4 (1644.8)	585.1-4232.0 (1254.1)	6-20 (12)	6-20 (11)
3 km	138.2-2394.4 (899.2)	351.4-3473.8 (1192.7)	9-15 (12)	11-17 (14)
8 km	86.2-3136.0 (1151.7)	60.4-881.0 (336.6)	10-16 (13)	8-16 (12)

During the study period a total of 44 phytoplankton species were encountered with diatoms as the major class followed by dinoflagellates. The dominance of phytoplankton species was in the order of: *Thalassiosira subtilis*>*Skeletonema costatum*>*Chaetoceros lorenzianus*>*Dactyliosolen fragilissimus*>*Thalassionema nitzschioides*>*Psuedo-nitzschia seriata* (Table 3.4.4). In general, the phytoplankton abundance and generic diversity depend on favourable environmental conditions in the coastal marine waters. Availability of essential nutrients in adequate quantities and optimum light are the most important factors regulating the phytoplankton abundance. The nutrient concentrations in the coastal waters of in the study region supported the healthy growth of phytoplankton as reflected in the phytoplankton density and diversity.

Table 3.4.3. Range and average (parenthesis) of phytopigments at Mumbai during March 2019

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

Table 3.4.4. Percentage (%) composition of phytoplankton population at Mumbai during March 2019

Station/Distance	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Total**
Species name	**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**
Asteromphalus flabellatus							<0.1							
Bacteriastrum hyalinum	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**
Coscinodiscus granii		<0.1	<0.1	<0.1	<0.1			0.45	<0.1			0.16		**<0.1**
***Cyclotella* sp.**					0.16									**<0.1**
Cylindrotheca closterium	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-nitzschia seriata	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**

Station/Distance	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Total**
Species name	**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 acuminata										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**
Prorocentrum nana	<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**
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

2.13 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 biomass, population and group diversity were found to be higher in the 1 km stretch from shoreline when compared to 3 km and 8 km zones as can be concluded from the zone-wise table given below.

Distance from coastline	Biomass (ml/100 m^3)	Population (no x 10^3/100 m^3)	Total Group (no.)
1 km	0.3-14 (1.9)	1.1-7939 (964.9)	6-12 (10)
3 km	0.5-2 (0.8)	1.4-8.7 (3.1)	4-9 (6)
8 km	0.1-6.9 (1.7)	2.3-13.8 (4.5)	3-17 (8)

These results can be correlated with the high phytoplankton biomass availability in this region. The percentage contribution of mesozooplankton composition revealed that copepods dominated the throughout the study region followed by fish eggs, decapods larvae and medusae (Table. 3.4.6). Mesozooplankton components indicated wide variations from Full Ebb (F.Ebb) to Full Flood (F.Flood). The overall biomass and population was found to be high during full ebb except station 3. However, the number of groups were found to be high in full flood which may be due to the influence of advecting coastal waters during flood (Figure. 3.4.2).

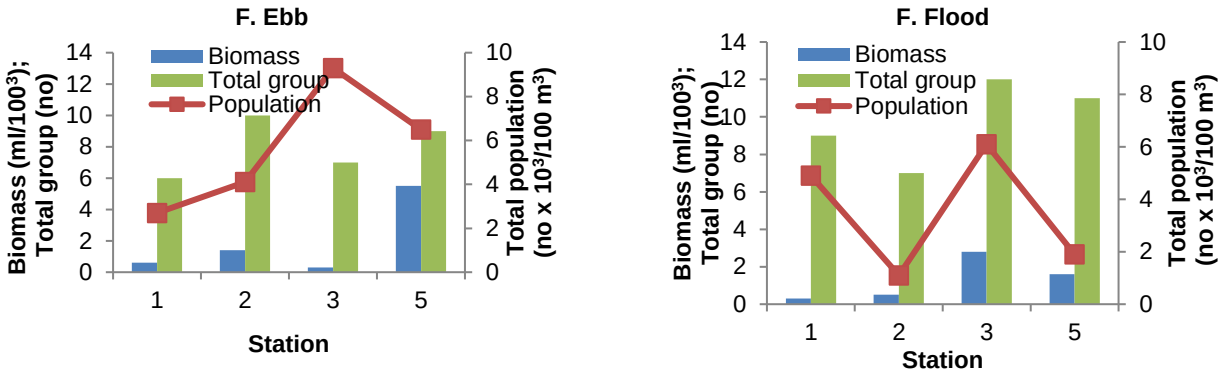


Figure 3.4.2 Tidal variation of mesozooplankton at Mumbai during March 2019

Table 3.4.5. Range and average (parenthesis) of mesozooplankton at Mumbai during March 2019

Station (Date)	Distance (Km)	Biomass (ml/100m^3)	Population (nox10^3/100m^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		0.5-0.5	1.4-8.7	5-6	fish eggs (48.6),

(26/03/2019)		(0.5)	(1.1)	(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).

2.14 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 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.

Table 3.4.6. Percentage Composition of mesozooplankton at Mumbai during March-2019

Distance/	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**% compo**
Faunal Groups	**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

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

Sediment samples were not obtained at stations 1, 2, 7 and 9 due to rocky substratum. The macrobenthic parameters are presented in Table 3.4.7. The percentage composition of subtidal macrobenthic community was dominated by the annelids (80%) followed by the arthropods (11.5%) (Table 3.4.8). A total of 50 macrobenthic taxa were identified in the study area. Polychaetes were the most dominant group and were present at all stations. Amphipods were the second dominant group but were absent at stations 10, 12 and 13. Tanaidaceans which also contributed significantly to the total biomass was observed only at station 2 but in high density (Table. 3.4.9). *Paraprionospio patiens, Ninoe* sp. *and Cossura coasta* were the most abundant polychaete species. The zone-wise range and average of macrobenthic parameters are given below.

Distance from the coastline	**Biomass (wet wt.; g/m^2)**	**Population (no./m^2)**	**Total Group (no.)**
1 km	0.04-13.5 (2.3)	25-1250 (487.5)	1-10 (6)
3 km	0.4-18.1 (5.5)	150-975 (579.7)	2-13 (9)
8 km	0.1-18.9 (2.9)	75-775 (376.7)	2-13 (8)

The macrobenthic biomass, abundance and group diversity was comparatively higher in the 3 km zone. However, the species diversity index (*H'*) was higher in the 3 km (av. 3.57) and 8 km zones (av. 3.26) as compared to the 1 km zone (av. 2.95). The evenness index indicated that the macrobenthic assemblages were well balanced without any dominance of opportunistic species (Table. 3.4.10).

Table 3.4.7. Range and average (parenthesis) of subtidal macrobenthos at 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**	ROCKY BOTTOM			
2		ROCKY BOTTOM			

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		ROCKY BOTTOM			
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		ROCKY BOTTOM			
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*
OVERALL AVERAGE		**0.04-18.9 (3.6)**	**25-1250 (469)**	**1-13 (8)**	*Paraprionospio patiens*, *Ninoe* sp., *Cossura coasta*

Table 3.4.8: Composition (%) of Subtidal macrobenthos at 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	R	R		4.7	R	11.0		3	R	2.6	5.8		1.0	**3.4**
Magelona cincta	O	O	7.4	3.1	O	7.3		1.5	O	7.9	1.4		9.4	**3.9**
Cossura coasta	C	C	18.5	0.8	C	24.4	7.7	6.1	C	10.5	10.1	36.8	15.6	**11.8**
Levinsenia gracilis	K	K		1.6	K				K		2.9			**0.6**
Glycera natalensis	Y	Y	3.7	2.3	Y	1.2	0.8		Y	5.3	1.4			**1.3**
Glycinde capensis				0.8										**0.1**
Chone filicaudata				1.6										**0.3**
Lumbrineris meteorana	B	B		0.8	B				B				2.1	**0.4**
Notomastus sp.	O	O		0.8	O				O					**0.1**
Paraprionospio patiens	T	T		25.6	T	6.1	38.5	4.5	T					**13.5**
Paraprionospio sp.	T	T	3.7	3.9	T		5.4		T	2.6				**2.1**
Aglaophamus dibranchis	O	O		1.6	O		0.8		O			2.6	2.1	**0.9**
Capitella capitata	M	M	11.1	3.9	M	2.4		9.1	M		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 3.4.8 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 3.4.9. Macrobenthic mean densities (ind m^{-2}) at Mumbai during March 2019.

	Station								
	3	**4**	**6**	**7**	**8**	**10**	**11**	**12**	**13**
Nemertea	0	0	0	0	19	6	6	0	6
Sipunculida	0	19	38	13	6	0	13	0	19
Phoronida	0	0	0	0	0	0	13	0	19
Pelecypoda	0	0	31	25	6	6	0	0	6
Echiurida	0	0	0	6	0	0	0	0	0
Copepoda	0	0	6	0	0	13	0	0	0
Ophiuroidea	56	0	0	6	6	0	0	0	0
Fish larvae	0	0	0	0	0	0	13	0	0
Polychaeta (total)	**112**	**438**	**401**	**702**	**364**	**213**	**382**	**239**	**551**
Parheteromastus tenuis	0	38	56	0	13	6	25	0	6
Magelona cincta	13	25	38	0	6	19	6	0	56
Cossura coasta	31	6	125	63	25	25	44	88	94
Levinsenia gracilis	0	13	0	0	0	0	13	0	0
Glycera natalensis	6	19	6	6	0	13	6	0	0
Glycinde capensis	0	6	0	0	0	0	0	0	0
Chone filicaudata	0	13	0	0	0	0	0	0	0
Lumbrineris meteorana	0	6	0	0	0	0	0	0	13
Notomastus sp.	0	6	0	0	0	0	0	0	0
Paraprionospio patiens	0	206	31	313	19	0	0	0	0
Paraprionospio sp.	6	31	0	44	0	6	0	0	0
Aglaophamus dibranchis	0	13	0	6	0	0	0	6	13
Capitella capitata	19	31	13	0	38	0	13	38	6
Prionospio cirrobranchiata	0	6	0	0	0	0	0	0	0
Scalisetosus sp.	0	6	0	0	0	0	0	0	0
Ninoe sp.	6	0	44	38	69	88	50	63	175

	Station								
	3	**4**	**6**	**7**	**8**	**10**	**11**	**12**	**13**
Nephtys paradoxa	0	0	0	0	0	0	0	0	6
Nephtys sp.	6	0	0	0	0	0	0	0	0
Cirratulus sp.	0	0	19	38	44	13	38	0	13
Kirkegaardia sp.	0	0	0	0	0	0	0	0	19
Nereis sp.	0	0	0	0	0	0	0	0	6
Sigambra parva	25	0	6	6	31	19	75	6	94
Aphelochaeta filiformis	0	0	0	13	44	6	6	6	6
Heterospio indica	0	0	0	0	0	6	0	13	19
Aricidea longobranchiata	0	0	31	81	0	0	6	13	19
Protocirrineris chrysoderma	0	13	6	31	0	6	31	0	0
Maldanidae	0	0	0	13	19	0	0	0	0
Aricidea sp.	0	0	13	50	31	0	6	6	0
Poecilochaetus serpens	0	0	0	0	0	0	13	0	0
Ophiodromus berrisfordi	0	0	0	0	0	0	13	0	0
Caulleriella acicula	0	0	0	0	0	0	25	0	0
Glycera sp.	0	0	0	0	13	0	6	0	0
Prionospio sp.	0	0	13	0	0	0	6	0	6
Aedicira sp.	0	0	0	0	6	6	0	0	0
Oxydromus spinosus	0	0	0	0	6	0	0	0	0
Amphipoda (total)	**0**	**76**	**38**	**63**	**13**	**0**	**6**	**0**	**0**
Ampelisca sp.	0	44	0	0	0	0	0	0	0
Ampelisca aequicornis	0	6	0	44	0	0	0	0	0
Photis longicaudata	0	13	0	0	0	0	0	0	0
Cheiriphotis trifucata	0	13	0	0	0	0	0	0	0
Idunella chilkensis	0	0	0	6	0	0	0	0	0
Grandidierella sp.	0	0	38	13	13	0	6	0	0
Tanaidacea (total)	**0**	**275**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Pagurapseudopsis gymnophobia	0	275	0	0	0	0	0	0	0

Table 3.4.10. Diversity indices of macrobenthic community at Mumbai during March 2019

Station	S	N	d	J'	H'(loge)	H'(log2)	1-Lambda'
3	9	168	1.56	0.86	1.88	2.72	0.81
4	22	808	3.14	0.71	2.21	3.18	0.81
6	17	514	2.56	0.88	2.49	3.59	0.89
7	20	815	2.83	0.76	2.28	3.29	0.82
8	19	414	2.99	0.91	2.67	3.85	0.92
10	15	238	2.56	0.82	2.23	3.21	0.83
11	23	433	3.62	0.89	2.79	4.02	0.92
12	9	239	1.46	0.77	1.70	2.45	0.76
13	20	601	2.97	0.78	2.32	3.35	0.85

b) Meiobenthos

The overall distribution of meiobenthic community in the study region is depicted in Table 3.4.11. The range and average of the same indicated that stations which are 8 km away from the shoreline recorded maximum biomass and density as can be seen in the Table given below.

Distance from the coastline	Biomass (wet wt.; g/m^2)	Population (no./m^2)	Total Group (no.)
1 km	14.5-575.2 (227.3)	35-361 (169)	1-5 (3)
3 km	23.2-611.5 (236.9)	57-977 (350.7)	1-4 (2)
8 km	56.5-1009.9 (381.9)	106-899 (430)	2-7 (4)

The percentage composition of meiobenthic community indicated that the study region was dominated by nematodes followed by foraminiferans. Also groups like Polychaeta, Nemertina and Ostracoda were encountered more in number at stations which were 8 km away from the coastline (Table 3.4.12).

Table 3.4.11: Range and average (parenthesis) of subtidal meiobenthos at Mumbai during March 2019

Station	Distance (Km)	Biomass (wet wt.; g/m^2)	Population (no./m^2)	Faunal Group (no.)
1	**1 Km**	ROCKY BOTTOM		
2		ROCKY BOTTOM		
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		ROCKY BOTTOM		
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		ROCKY BOTTOM		
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)
OVERALL AVERAGE		**14.51-1009.91 (299.2)**	**35-977 (345.5)**	**1-7 (3)**

Table 3.4.12. Composition (%) of subtidal meiobenthos at Mumbai during March 2019

Groups	Stations													
	1	2	3	4	5	6	7	8	9	10	11	12	13	Av.
	1 Km					3 Km				8 km				
Nematoda	ROCKY BOTTOM	ROCKY BOTTOM	100	57.76	ROCKY BOTTOM	96.67	89.29	96.99	ROCKY BOTTOM	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
Total			**100**	**100**		**100**	**100**	**100**		**100**	**100**	**100**	**100**	**100**

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Annexure – 1: Coastal Met-Ocean Buoy Features & Specifications

Met-Ocean buoy system comprising of sensors/instruments to measure and transmit the data to a shore station with the following general specifications:

S.NO	SPECIFICATION
1.0	General
	The multi-parameter buoy system is to be deployed in 8-12m water depths using a floating buoy. The tidal variation can be between 1-6m.
	There should be access for installation/retrieval of sensors/payload without having to completely remove the buoy out of water, and without the need for divers.
	Structure stability calculations of the buoy system should be provided to prove it's suitability for deployment in a significant wave height of 8m. If stability calculations are not provided, a certificate must be provided stating (i) stability of the system for 8m significant wave height and (ii) in case the system fails for 8m of <8m significant wave height within a period of 10 years, the entire buoy system will be replaced.
	A power budget calculation for complete system for 15 days of power autonomy should be provided to explain the battery capacity and solar panel sizing for the complete system.
	The buoy should be light weight (should not exceed 500 Kg).
	The buoy hull diameter should not exceed 2m (± 0.25m)
	The buoy hull material preferably made of rotationally moulded UV15 stabilized polyethylene with seamless hull, filled with marine grade foam; suitable for harsh conditions with proper mooring frame and other component suitable for integrating all sensors. Alternate proven material with proof of working in tropical waters can also be considered.
	The buoy manufacturer should be registered with IALA.
	The buoy colour (appropriate as per marine standard guidelines) should not fade in colour and no painting of the buoy surface should be ever required for the lifetime of the buoy (at least 10 years).
	The buoy should have a top (lantern) light to warn & avoid collision. The lantern should at least be 3NM range and self-contained and compliant to IALA guidelines.
	The buoy should have other navigational AIDS such as RADAR reflector, Top Mark, Marine Beacon, etc.
	The buoy should have minimum two mooring points and min two lifting points.
	Load test certification for mooring and lifting points should be provided.
	Mooring accessories and sinker should be provided
	The complete buoy system is to be deployed in a self-powered floating buoy equipped with data logger electronics, GSM/GPRS Telemetry, Solar Panels, Solar charge controllers and batteries with adequate back up.
	The buoy should have powder-coated aluminium tower with MET sensor mounting ring and mounting bracket
	The buoy should have suitable number of solar panels with required wattage adequate for

	15 days back up. A detailed power budget calculation leading to the sizing of solar panel and battery capacity should be included in the offer.
	The buoy should have suitable enclosure including electronics mounting bracket, Internal temperature/humidity sensor, diagnostic cable and connector
	The buoy should have suitable and sufficient enclosure for placing not limiting to: 2nos 12V batteries; Solar regulator Electronics and power enclosures mounted on top of hull and should be removable for maintenance and repair.
	The buoy should have external antenna system
	Marine grade underwater connectors' should be used.
	The buoy system should have secure means of opening for access to the sensors/instruments
	The buoy system should be capable of operating in a self-powering mode from an internal power supply using a set of rechargeable batteries that are available for purchase in the local market.
	The buoy system should be deployed at specified location within 15 days of delivery of the system
2.0	Sensor Requirement & Specification
2.1	Meteorological Sensors
	Air temperature and relative humidity • Temperature range: - 40 ^{O} C to + 60 ^{O} C • Resolution: 0.1 ^{O} C • Accuracy: ± 0.3 ^{O} C • Relative humidity range: 0-100% R.H. • Resolution: 1% • Accuracy: ±2% RH Barometric pressure • Range: 600 to 1100 hPa or better • Resolution: 0.1hPa • Accuracy: ±0.5 hPa Wind speed & Direction • Type: Ultrasonic • Wind speed range: 0 to 60 m/s • Wind speed resolution: 0.1 m/s or better • Wind speed accuracy: ±5% Wind direction range: 0°-359° • Wind direction resolution: 1 ^{O} • Wind direction accuracy: ±5° Precipitation • Range: 0 to 50 mm • Resolution: 1 mm • Accuracy: 3% over the range Solar Radiation • Wavelength Sensitivity- 300 to 3000 nm • Output Range- 0 to 1600 W/m-2 (Resolution- 1 W/m-2)
2.2	Acoustic Doppler Current Profiler
	Current Speed:

	Range: 0-3m/s Resolution: 1 mm/s Mean Accuracy: ±15mm/s Relative: ±1.5% of reading Current Direction: Range: 0–360° Resolution: 0.01° Accuracy: ±5° for 0-15° tilt Vertical layers: Minimum Cell/bin size: 0.5m; Blanking: not more than 0.50m Internal Battery with an option to supply power from external source Transducer: 4 or 5 beams with optional bottom tracking; Beam angle 20°-25°
2.3	Wave Sensor
	Wave Height: Range: 10m Resolution: 0.1m or better Accuracy: ±0.1m or better Wave Period: Range: 1 - 30s Resolution: < 0.05s Accuracy: < 1% Wave Direction: Range: 0 to 360° Resolution: < 0.5° Accuracy: < 2° Integration Time: 5 -60 minutes Current drain: 110mW @ 12V or lower Depth rating: 30m Operating temperature: 0 to +50°C Materials: Stainless steel 316, POM, Brass or better
3.0	Instrument/Sensor Features
	The instrument/sensor should be ideally suited for extended deployments in remote, biologically rich environments with field proven sensors to ensure long term data stability.
	The Instrument/sensors should have good bio-fouling protection and should have approved anti-fouling devices
	The instrument/sensor should be factory calibrated and should not have the necessity for calibration during its life time.
	The instrument/sensor system should have internal memory and should also be capable of integrating with an external data logger with Data transmission system to transmit the data to the department using GSM/GPRS.
	On-board processing of wave parameters resulting in lower demands for bandwidth and power is suggested. The instrument/ sensor should be able to distinguish direction of swells and wind driven waves and should be able to measure waves accurately; High sampling rate and mechanical dampening, ensuring low noise is required.
4.0	Data Logger / Communication Features & Specification

	The buoy system should have dedicated data logger/ communication system.	
	The data logger system should be of high performance data logger & communications device for unattended, remote, real-time data acquisition & control. The system should be a multi-tasking logger capable of making measurements & transmitting multiple communications simultaneously.	
	Data Logger should have user friendly interface for remote setup & configuration of the system.	
	Data Logger should be able to configure digital inputs to trigger measurement processing, including logging & telemetry.	
	Should have the option for Analog and digital I/O sensor modules that plug into RS232, RS485, SDI-12.	
	Each measurement should be independently scheduled with Sample intervals from 1 sec. to 24 hours, in 1 sec. increments.	
	System events should be logged independently of measurement data with built-in functions for min, max, average, & accumulation calculations.	
	Changes made to logging setup should not affect logged data and logged data should be compressed.	
	Should have inbuilt memory and option for the storage expansion via removable SD card.	
	Data logger should have option for data transfer through USB devices or SD cards or MMC cards.	
	The data logger system should have the option for integrating additional sensors in future.	
	Specification	
	Measurement Interval	1.0 second to 24 hours (programmable)
	Measurements Supported	Unlimited
	Analog Channels	Minimum 8
	Input Voltage	-0.1 to 5V with respect to ground, single ended or differential
	Resolution	12 bits or more
	Expandable	via SDI-12
	Digital Inputs	6 (2 Bi-Directional)
	Telemetry	System supports data output to RS-232/485 lines, modems and cellular phones (SMS, GPRS, 3G), radio-modems and satellites.
	Operating Temperature	-10°C to +60°C
	Memory	
	Built-In	RAM: 32MB – 128 MB Non-volatile: 65MB (1 -3,000,000 readings)
	SD Card	2 to 8 GB For download data & read/write setups or additional log memory
	Power Requirements	10-16VDC (20VDC max)
	Current Drain	Typically 3mA standby, 70mA active

	Communication Protocols Supported	FTP server, FTP client, HTTP server, telnet, SMTP, SMTPS, MODBUS RS485,
5.0	Software Specification	
	Software should allow any PC to remotely setup & operate data logger without using the front panel.	
	Software should automatically display the graphic display of the data logger.	
	Easy file transfer for up/downloading of setups, programs, data files.	
	Automatically prompts for login account & password when needed	
	Displays system information on running processes, threads, & memory usage	
6.0	Accessories	
	External DC power supply fitted with sufficient number of Solar panels. The solar panels should be sufficient to keep the ocean buoy system working for long-term (6 months minimum) deployments.	
	The complete system with instruments / sensors / data logger is to be deployed in a self-powered floating buoy equipped with data logger electronics, GSM/GPRS Telemetry, Solar Panels, Solar charge controllers and batteries with adequate back up.	
	The data measured by the multi-parameter sensor compartment should be transmitted in near-real time using GPRS/GSM telemetry to a shore based PC/workstation within 30km aerial distance.	
7.0	Training	
	Comprehensive training on the operation & maintenance of the entire buoy system (not limiting to on board sensors, data logger, data transmission, mooring, etc) should be provided to at least 3 NIO personnel. The training should be conducted before deployment of the system, during installation on site, and after deployment.	
8.0	WARRANTY	
	The buoy system including the sensors/ equipment/ data logger/ telemetry system/ mooring system/ hull structure/ solar panels/ batteries/ accessories/ etc., should perform without fail for 1 year from the date of deployment of the system at site.	
9.0	Additional Warranty & Comprehensive Maintenance (optional)	
	Additional warranty & Comprehensive maintenance for 5 years after warranty	

C/733

Mid-term Report on Consultancy Project

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

CONSULTANT:

Mumbai Research Centre of

ICAR- Central Marine Fisheries Research Institute

2nd Floor, CIFE Old Campus, Fisheries University Road,

7 Bungalows, Versova, Mumbai -400061

15th December 2019

C1735

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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 the 8 lane Mumbai Coastal Road Project (South) from Princess Street Flyover to Worli end of Sea Link along the western side of the Mumbai city. The proposed road has approximate length of 9.98 km in the form of landfills, bridges, under sea tunnels etc. and the total reclamation area is around 90 ha. The proposed coastal road is mainly to address the traffic congestion in ever developing city and to improve the quality of life to citizens.

CMFRI is a nodal agency identified by the Government of Maharashtra and Maharashtra Maritime Board to study impact of such developments in the coastal areas or any activities affecting fisheries of the state. MCGM approached CMFRI for conducting studies on impact of the proposed coastal road on the coastal fisheries.

ii) Purpose & Scope of study:

The proposed coastal road is located on the western side of the Mumbai city extending from Princess Street fly over to Worli end of sea link, on the seaward side. The proposed road has approximate length of 9.98 km and the total reclamation area is around 90ha. When the reclamation and initial works have started for coastal road started multiple Public interest litigations were filed in Bombay high court against MCGM. One of the issues raised in the first hearing was fisheries/fishers' issues was not addressed and Hon. High Court had directed MCGM, State fisheries Department, Govt. 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 coastal road. It was decided that a competent authority will study the impact of the coastal road on fisheries and fisher's livelihood.

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 (Phase I) and outside project area in the sea/seaward side during pre-construction/development period is to be carried out. The study includes 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 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. Extent of fishing areas and the fishing villages around the proposed survey region
d. Economics of various fishing activities around the survey area, loss of fishing area and livelihood of dependent population.

iii) Deliverables (TOR):

The study will be based on following guidelines which have been discussed and mutually agreed by CMFRI and MCGM.

1. Diversity and abundance of marine fishery resources in the nearshore areas of proposed coastal road
2. Possible impact of coastal road on the fish abundance and diversity
3. 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 dependent population

METHODOLOGY

i) Area of study:

The proposed part of the coastal road addressed in the current study is the seaward portion of Phase one i.e. from Priyadarshini Park to Worli Sea bridge.

Fig 1. Map of coastal road plan from MCGM website

ii) Inception programs

As it is necessary to have direct interaction with public it is necessary to inform the public about the study and get the knowledge and opinions on the same. Large level inception and appraisal meeting was conducted at Worli village and attended by nearly 100 fishers (Fig. 2). Similarly, multiple interaction and discussions were undertaken with fishers/allied workers based at Lotus jetty (Fig 3).

Fig. 2. Discussions with fishers of Worli village

Fig 3. Discussions with fishers operating from Lotus jetty (Haji Ali)

iii) Methods of data collection & Analysis

Baseline data related to fisheries, fish diversity, fishery and allied activities, fishermen and coastal communities, social and economic aspects related to fishery will be collected from primary as well as secondary source.

Fishery studies:

Regular synoptic fishing attempts have been undertaken during the survey by using Global Positioning System (GPS) Device. Dol net, gill net, hook and line and other fishing operations were observed. Conducted fishing operations with gill netter and dol netter in the proposed project area. Fish samples were transported to Mumbai Research Centre Laboratory for further analysis. Detailed taxonomic identification up to species level and biological analysis were undertaken. Detailed biology study was conducted to know about the stage of life cycle of the fishes. The samples of corals and associated fauna were collected and analysis is in progress.

Socio-economic analysis:

Socio-economic survey will be conducted using structured proforma 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. The process of data collection and the analysis is ongoing. In this report the unpublished data collected by ICAR-CMFRI is used which will be updated after completing the survey. The details of the boats and societies were provided by the State Fisheries Department, Maharashtra. In addition to this, cost

benefit analysis for commercially operated fishery crafts and gears locally viz., dol nets, gill nets, shore seines, etc. will be undertaken using fixed cost, operating cost and price data schedules in the villages falling in the study area over the study period.

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PRELIMINARY FINDINGS

i) Demographic features of the fishing villages:

Demographic features of the fishing villages depicted below are based on the Marine Fisheries Census data.

Table 1. Fisher households' details from proposed project area

Sl. No.	Name of village	Fishermen families (Nos.)	Traditional Fishermen families (Nos.)	Fishermen Population
1	Worli (2010)	685	671	2934
2	Worli (2016)	800	741	3055

Table 2. Details of age-wise fisher population from proposed project area

Sl. No.	Koliwada	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	26	210	1232	90	195	3055

Table 3. Details of active fishers from proposed project area

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

Table 4. Details of fisher Community from proposed project area

Sl. No.	Koliwada	Hindu Fishermen families	Muslim Fishermen families	Christen Fishermen families	Others	Total
1	Worli	632	2	163	3	800

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

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

Table 7. Fisheries Societies in Worli

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	NA	NA	NA	NA	NA
	Total		**329**	**636**	**965**	**190**

ii) Fishing methods

There are multiple types of fishing operations in the region, major fishing method in the study area is bag net and gillnet fishing. In addition, cast net fishing ('Pag'), hook and lines and small contrivances such as crab traps and hand picking is also practiced in the area. Details of various fishing methods are as follows:

Bag net fishing: 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. 4). Therefore, the net is operated in waters where tidal current is strong enough to sustain the net and a boat is merely used to set and haul the bag net and to 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 a frame of ropes anchored in the muddy or sandy sea bottom with the help of wooden spikes or anchors. The frame with a floating indicator buoy attached by means ropes is called '*sus*'. The area and the '*sus*' are traditionally owned for fishing rights by the fisher families, community and villages.

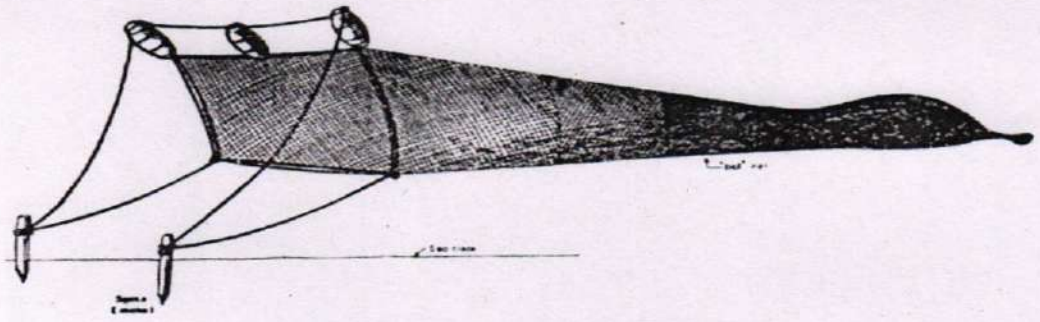

Fig 4. Set Bagnet 'Dol' net (example)

The 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 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 11^{th} to 4^{th} lunar calendar days (from *Ekadashi* to *Chaturthi*). However, during neap tides as the tidal currents are weak, the operations are suspended from 5^{th} to 10^{th} lunar days (*Panchami* to *Dashmi*). The effective period for bag net fishing therefore, lasts for 16-20 days in a month.

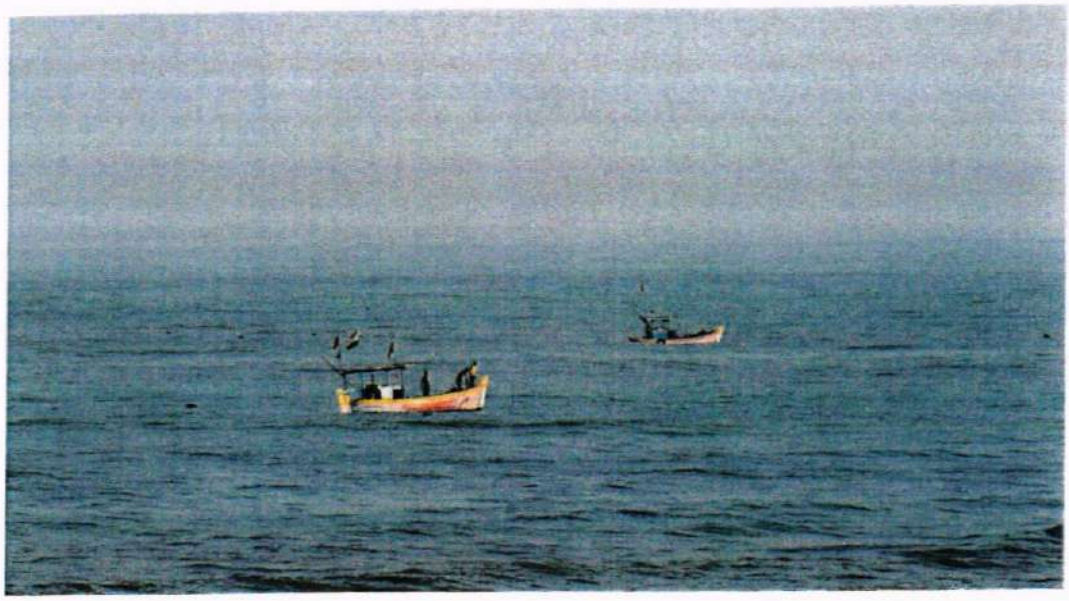

Fig. 5. Bagnet fishing in the nearshore waters of proposed project area

The fishing season in the zone commences in late August or early September and continues till end of May. However, few *'dol'* netters in the zone carry out fishing in monsoon as most of other fishing activities in the open sea are suspended and the rates of fish are lucrative in the season. During the survey the team ICAR-CMFRI team observed 37 dolnetter in and around proposed coastal road project (Fig. 5).

Gill net fishing: Gill netting is a selective fishing method in which fish of desired size is caught by gills while swimming at the surface, column or bottom of the sea (Fig. 6). Because of its selective nature, gill netting is one of the most suitable fishing methods from 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 gill net fishing methods have local names. In the area under study, multiple gill net fishing is called '*Bhiljee*', Lobster Net, Floating / Bottom Set (*Tarti / Budi*) *Waghara / Shahenshaha/ Kargil/ Vedhi* are operated. During the visit by ICAR-CMFRI team, not only gill net fishing operation but also activities like net mending and repairing of gill net is also taking place in the area (Fig. 7-9).

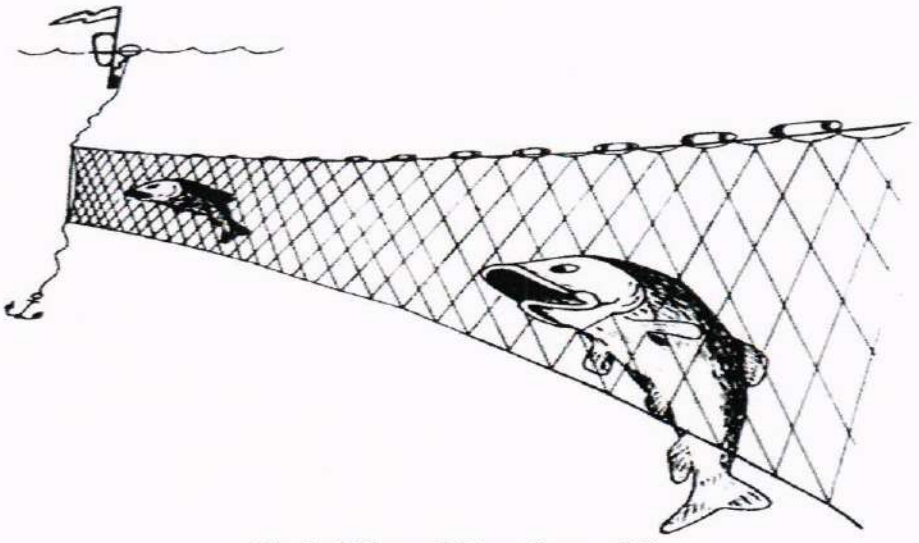

Fig 6. Gill net fishing. (example)

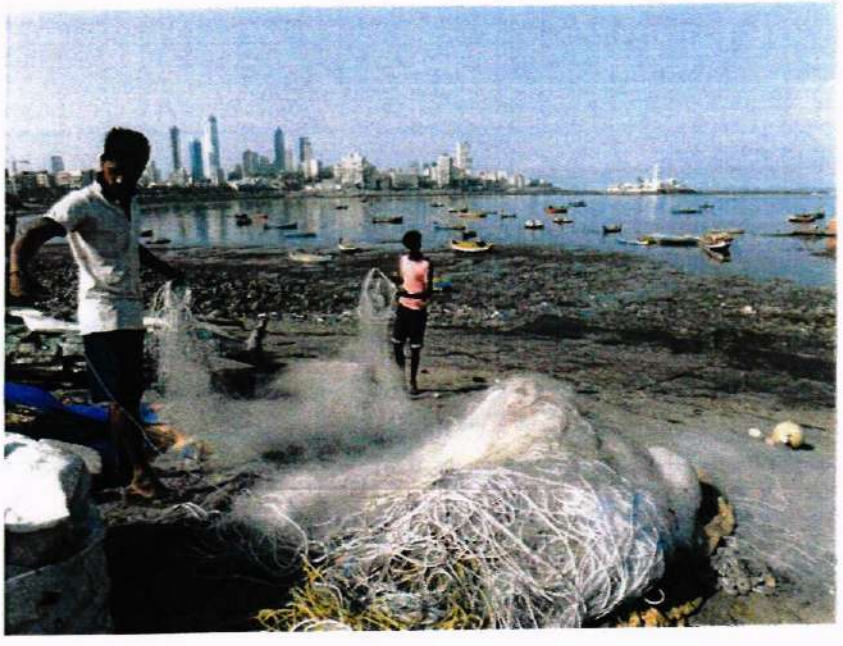

Fig. 7. Fisher repairing gill net at Lotus jetty

Fig. 8. Fisher mending gill net at Worli

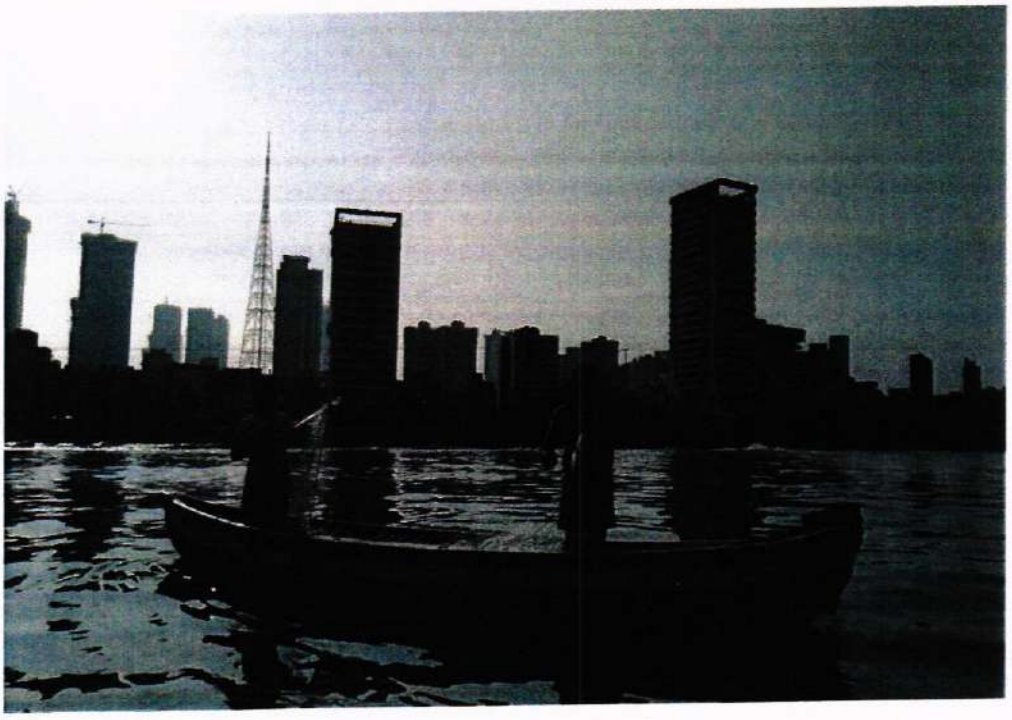

Fig. 9. Gill net fishing in the nearshore waters

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 waters for catching mullets, perches, clupeids and prawns.

Oyster & clam collectors, bait collections

The intertidal region of the proposed coastal road area is the covered with rocks where the oysters and clams are present. These were collected mostly by women from the exposed regions during the low tide time with the help of chisels and knifes (Fig.10-11). The baits for catching bigger fish using hooks are collected by hand (Fig 12-13).

Fig. 10. Fisherwomen collecting oysters during low tide exposed regions

Fig 11. Bivalves harvested from Haji ali coastal region

Fig. 12. Bait collection for line fishing

Fig. 13. Collected baits from the project area

Fishing locations of the fishers from Worli and Lotus Village

The fishing locations of the fishers were collected by conducting cruises by ICAR-CMFRI from Worli to Priyadarshini Park by using hired fishing boats from Worli Fishermen Society. The major gears operating in the proposed coastal road area are gill nets, dol nets and hooks and line. Very few cast net operations were observed during the survey. Till now (October, 2019) 27 gill netter, 3 hook and liner and 1 dol netter were observed from Worli to Priyadarshini Park operating their nets in and around the proposed project area. The GPS location of the boat when they were conducting fishing operation was collected and plotted in the GIS platform (Fig. 14). The registration number of the boat and the type of nets used during operation were collected and recorded (Table 00).

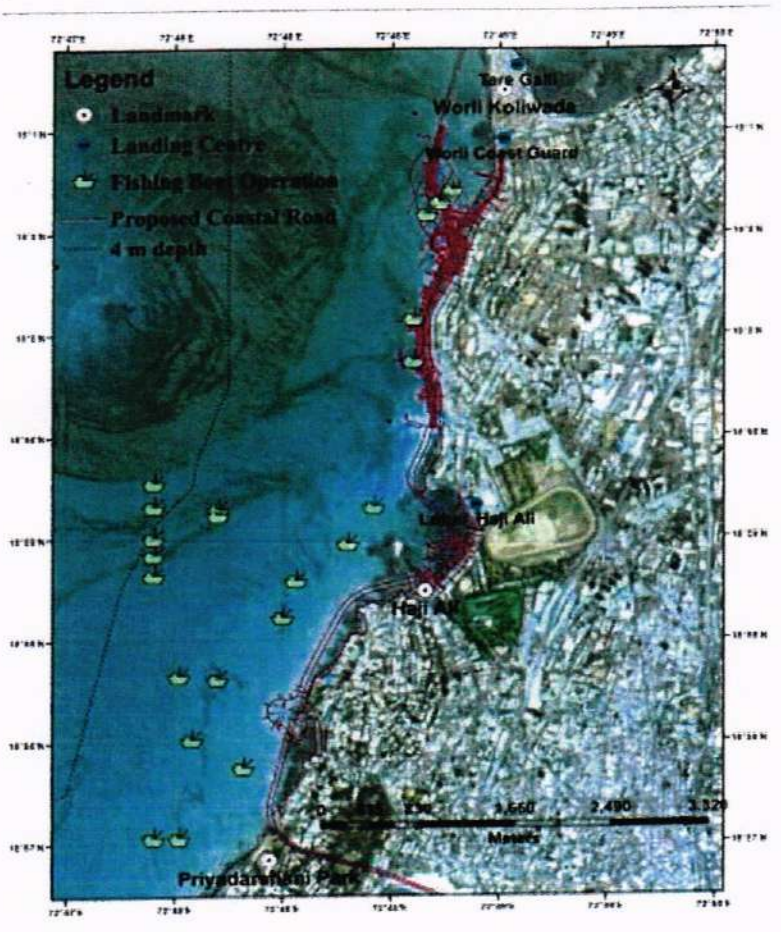

Fig. 14. Location of fishing operation during the survey

Table. 8. Registration number and type of gear observed during the survey

Sr. No.	Craft Registration No.	Gear Type (Trawl/Dol/Surface Gill/Bottom Gill/Trammel Gill)	Number
1.	IND MH 7 MM878	GILLNET (BHILJI JALI)	1
2.	MAHALAXMI	GILL NET (KARGIL NET)	
3.	IND MH 7 MM1114	GILL NET (KARGIL NET)	
4.	IND MH 7 MM1304	GILL NET (KARGIL NET)	3
5.	IND MH 7 MM 1844	GILL NET (PAPLET)	
6.	IND MH 7 MM 1108	GILL NET (PAPLET)	
7.	IND MH 7 1380	GILL NET (PAPLET)	
8.	IND MH 7 MM854	GILL NET (PAPLET)	
9.	IND MH 7 MM 2678	GILL NET (PAPLET)	
10.	IND MH 7 MM 2382	GILL NET (PAPLET)	
11.	IND MH 7 MM 1331	GILL NET (PAPLET)	
12.	INDMH 7 NM 851	GILL NET (PAPLET)	8
13.	IND MH 7 MM 2748	GILL NET (PAKAT JALI)	1
14.	IND-MH-7-MM-1114	Bottom Set Gill Net (Budi)	
15.	IND-MH-7-NM-1341	Bottom Set Gill Net (Budi)	
16.	IND-MH-7-MM-2915	Bottom Set Gill Net (Budi)	
17.	IND-MH-2-MM-3401	Bottom Set Gill Net (Budi)	
18.	IND-MH-7-MM-844	Bottom Set Gill Net (Budi)	
19.	IND-MH-7-MM-855	Bottom Set Gill Net (Budi)	
20.	IND-MH-2-MM-3200	Bottom Set Gill Net (Budi)	
21.	MHF-BDR/1404848	Bottom Set Gill Net (Budi)	
22.	IND-MH-7-MM-594	Bottom Set Gill Net (Budi)	
23.	No Registration No.	Bottom Set Gill Net (Budi)	
24.	IND-MH-2-MM-3667	Bottom Set Gill Net (Budi)	
25.	IND-MH-7-MM-854	Bottom Set Gill Net (Budi)	
26.	IND-MH-7-MM-1108	Bottom Set Gill Net (Budi)	
27.	IND-MH-7-MM-853	Bottom Set Gill Net (Budi)	14
		GILL NET (TOTAL)	**27**
28.	IND MH 07 MM 850	Hook and liner (Khanda)	
29.	MH 2 NM 4500	Hook and liner (Khanda), Mhavra Jali	
30.	IND-MH-7MM-2208	Hook and liner (Khanda)	3
31.	IND MH 7 MM 3725	Dol net (Bag net)	1
		TOTAL	**31**

Catch composition of Gill nets operating around the proposed construction area

ICAR-CMFRI team has conducted land based and boat-based survey to understand the catch composition in the proposed coastal road area. Around 22 species of pelagic fishes, 15 species of demersal fishes, 2 species of crustaceans and 2 species of molluscs were collected from the area. Most of them are commercially important and have good market value. There were 27 gillnetters observed in the proposed area. 96% of the catch was constituted by the pelagic fishes followed by demersal 3.5%. Crustaceans and molluscs contributed less than 1% of the total catch. The catch per

unit is estimated as 71.32 kg/hr. As gill net is a selective gear, most of the fishes caught were adults and very few juveniles were present. During the survey the team didn't observed any brooder or spawner fish in the proposed project area, to recognise the same as a spawning area.

Table. 9. Type of fishes with local name observed from gill net

Type of fish	Species	Common name
Pelagic	*Escualosa thoracata*	*Bilji*
	Rastrelliger kanagurta	*Bangada*
	Lepturacanthus savala	*Baga/Wagati*
	Strongylura leiura	*Tol*
	Hemiramphus sp.	*Tol*
	Hemiramphus far	*Tol*
	Hemiramphus archipelagicus	*Tol*
	Eupleurogrammus muticus	*Wagati*
	Anodontostoma chacunda	*Palu / Pala*
	Sardinella sp.	*Haid/Tarli*
	Ilisha Sp.	*Kati*
	Scomberoides tala	*Phalai*
	Coilia dussumieri	*Mandeli*
	Tylosurus sp.	*Tol*
	Alepes sp.	*Karkara Bangada*
	Hilsa sp.	*Bhing / Palu / Pala*
	Chirocentrus dorab	*Karli/Datadi*
	Hyporhamphus limbatus	*Tol*
	Scomberomorus guttatus	*Surmai*
	Thryssa sp.	*Kati*
	Pellona sp.	*Kati*
	Liza sp.	*Boi*
Demersal	*Pampus argenteus*	*Saranga / Pamplet*
	Pampus chinensis	*Kapri*
	Parastromateus niger	*Halwa*
	Scatophagus argus	*Chand Masa / Vada*
	Eleutheronema tetradactylum	*Dara*
	Arius sp.	*Shingala*
	Lutjanus sp.	*Tamb / Tamboshi*
	Epinephelus diacanthus	*Hekaru / Gobra*
	Plotosus sp.	*Shingala*
	Johnius dussumieri	*Dhoma*
	Johnius glaucus	*Dhoma*
	Dayscina albida	*Barad*
	Lagocephalus lunaris	*Kend / Fugu Masa*
	Takifugu oblongus	*Kend / Fugu Masa*
	Cynoglossus arel	*Lep*
	Chiloscyllium arabicum	*Mushi*
Crustaceans	*Panulirus polyphagus*	*Shevand*
	Crab *(Menippe rumphii)*	Khekada
Molluscs	*Sepiella inermis*	*Goti / Mhakul*
	Sea snake	

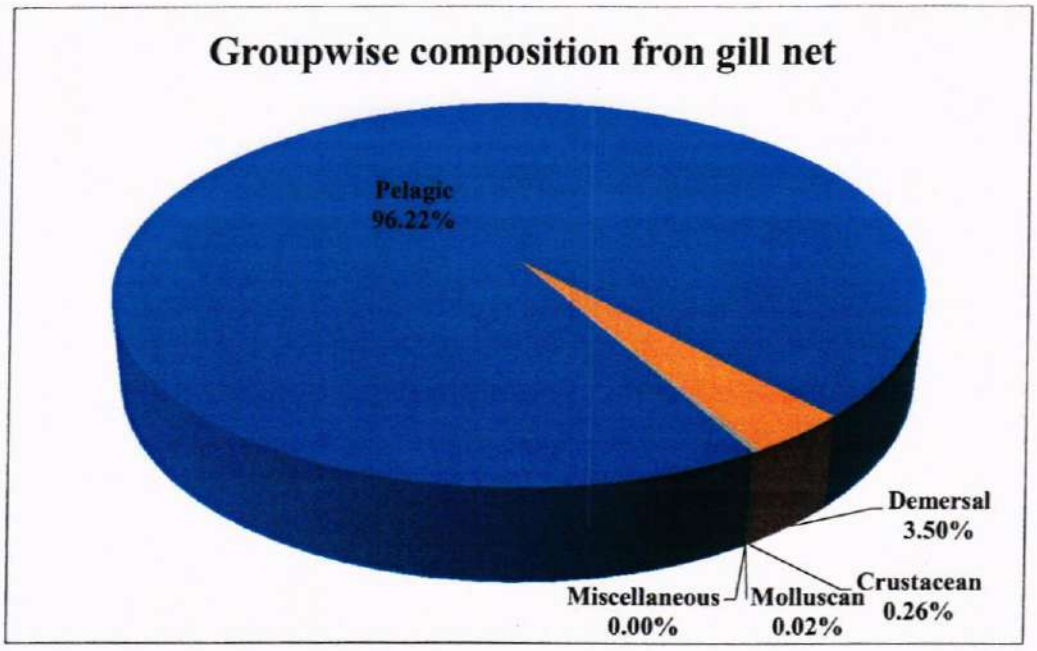

Fig.15. Groupwise species composition of gillnet catch

Catch composition of dol nets operating around the proposed construction area

During the survey only one dol net was observed around proposed coastal road area. 11 species of fishes belong to pelagic, demersal; crustaceans and molluscs were recorded. Crustaceans contributed major part of the catch (44.5%) followed by pelagic (30). The catch rate was estimated as 25.25kg/hr. Most of the catch was constituted by juveniles.

Table. 10. Type of fishes with local name observed from dol net

Type of fish	Species	Common name
Pelagic	*Escualosa thoracata*	*Bhiljee*
	Lepturacanthus savala	*Baga / Wagati*
	Ilisha sp.	*Kati*
	Harpadon nehereus	*Bombil*
Demersal	Sciaenids	*Dhoma*
	Pampus chinensis	*Kapri*
	Lagocephalus sp.	*Kend / Fugu Masa*
Crustaceans	*Charybdis callianassa*	*Khekada*
	Parapenaeopsis stylifera	Tiny
	Acetes indicus	*Jawala*
Molluscs	*Sepiella innermis*	Goti / Mhakul
Miscellaneous	Sea snake and Box jelly fish	

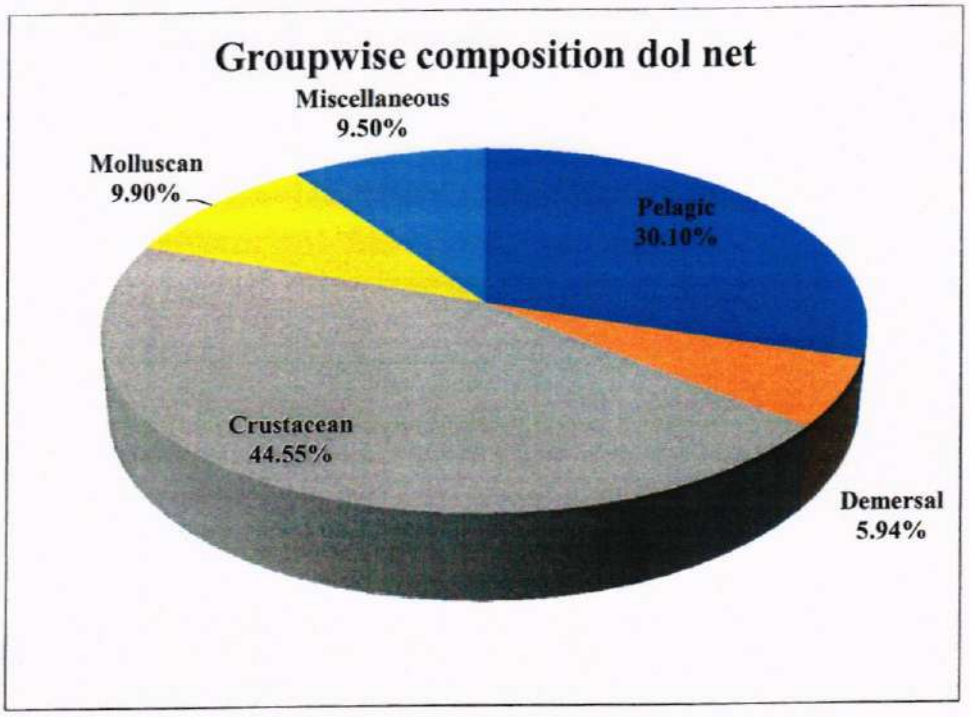

Fig. 16. Groupwise species composition of dolnet catch

Catch composition of Hook and line operating around the proposed construction area

Three hook and line operator were observed during the survey. The catch rate was very less with a few Sciaenid fishes and crabs.

Intertidal diversity study

The observation was made in the intertidal region of the proposed project area to study the extent of oyster beds, density of oyster, gastropod diversity, molluscan eggs and larvae availability and bivalve handpicking at Priyadarshini Park and Haji Ali.

Station I: Off Priyadarshini Park (18° 57'38.67" N/ 72° 47'55.52" E)

Station II: Off Haji Ali (18° 59' 13.37" N/ 72° 48'48.18" E)

Near Priyadarshini taking all quadrant together, oyster extent ranged from 16 to 20 m^2 towards land filled seashore. The extent of each quadrant was less than 1 m^2. The oyster density in the observed area was 58 (±4) live and 28 (±7) dead oyster per square metre. Mostly, live and dead shell of *Crassostrea madrasensis* and *Saccostrea cucullata* were observed in the sampling. During the observation time no handpicking activities by local fishers/people were noticed.

The molluscan diversity during field observation 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*

a b

Fig. 17. Near shore sampling for extent, density, size composition, eggs and larvae and diversity of Molluscan fauna

Fishery environmental parameters

To fulfil the objective shore based environmental sampling during low tide was conducted at Priyadarshini Park and Haji Ali. However, for vessel-based observations following stations were finalised and sampling were undertaken.

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)

Team of multi-disciplinary trained staff conducted field observation from Worli landing Centre to Priyadarshini park with the help of local fisher in M.F.V Nageshwar Prashana [Reg No. IND-MH-7-MM-1118]. Samples for phytoplankton, zooplankton, & chlorophyll collected from each location. Physical parameters such as Air temperature, SST, Turbidity, Dissolved Oxygen, Salinity, Conductivity, pH and TDS etc. were recorded *in-situ* (on-board); however, samples for nutrient, plankton & chlorophyll were collected and brought to office for further laboratory

analysis. Laboratory analysis of parameters was conducted by following standardised procedures, multi-parameter probes and methods.

Observed values of physico-chemical parameters in the study area are given in the table. Laboratory analysis of the nutrient and qualitative & quantitative estimation of ichthyoplankton is in process. However, rapid analysis of zooplankton including early life stages of marine organism at station- I revealed that the total zooplankton volume by displacement method was 4 ml and available zooplankton biomass was 0.0410ml/m^3. Zooplankton groups were identified during analysis were copepods, decapod larvae, brachyuran larvae, Lucifer, Chaetognaths, Fish larva, *Acetes* larvae and fish eggs etc.

Table 11. Physico-chemical parameters recorded during shore-based observations

Parameters	**Unit**	**Priyadarshani Park**	**Haji Ali**
Air Temperature)	°C	34	34
SST (°C)	°C	31	30
Salinity (PPT)		34.0	32.06
Dissolved Oxygen	mg/l	2.10	1.53
pH		8.11	7.62
Chlorophyll-*a*	mg/m^3	RA	RA
Phosphate	mg/l	2.77	5.00
Nitrate	mg/l	0.6	0.4
Nitrite	mg/l	0.05	0.07
Silicate	mg/l	2.66	3.81
Ammonia	mg/l	0.13	0.11
TSS	mg/l	0.59	0.51
TDS	ppt	47.28	44.24
Turbidity	NTU	94.2	41.3

** RA Result Awaited*

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Table 12. Physico-chemical parameters recorded during vessel-based observations

Parameters	Unit	ST -I Off Priyadarshini Park	ST- II Off Haji Ali	ST- III Off Worli
Air Temperature)	°C	29	29	29
SST (°C)	°C	28	28	28
Salinity (PPT)		36.36	35.71	36.54
Dissolved Oxygen	mg/l	1.54	RA	2.45
pH		8.35	8.28	8.21
Chlorophyll-a	mg/m3	RA	RA	RA
Phosphate	mg/l	RA	RA	RA
Nitrate	mg/l	RA	RA	RA
Nitrite	mg/l	RA	RA	RA
Silicate	mg/l	RA	RA	RA
Ammonia	mg/l	RA	RA	RA
TSS	mg/l	RA	RA	RA
TDS	ppt	49.53	48.77	49.69
Turbidity	NTU	12.35	6.63	15.59

** RA Result Awaited*

Phytoplankton Net Operation

Zooplankton Net Operation

Collectionof plankton

CMFRI Mumbai RC Team for onboard sampling on M.F.V Nageshwar Prashana

Shorebased sampling for of early life stages at Priyadarshani park during low tide

Fig. 18. Sample collection and field observation

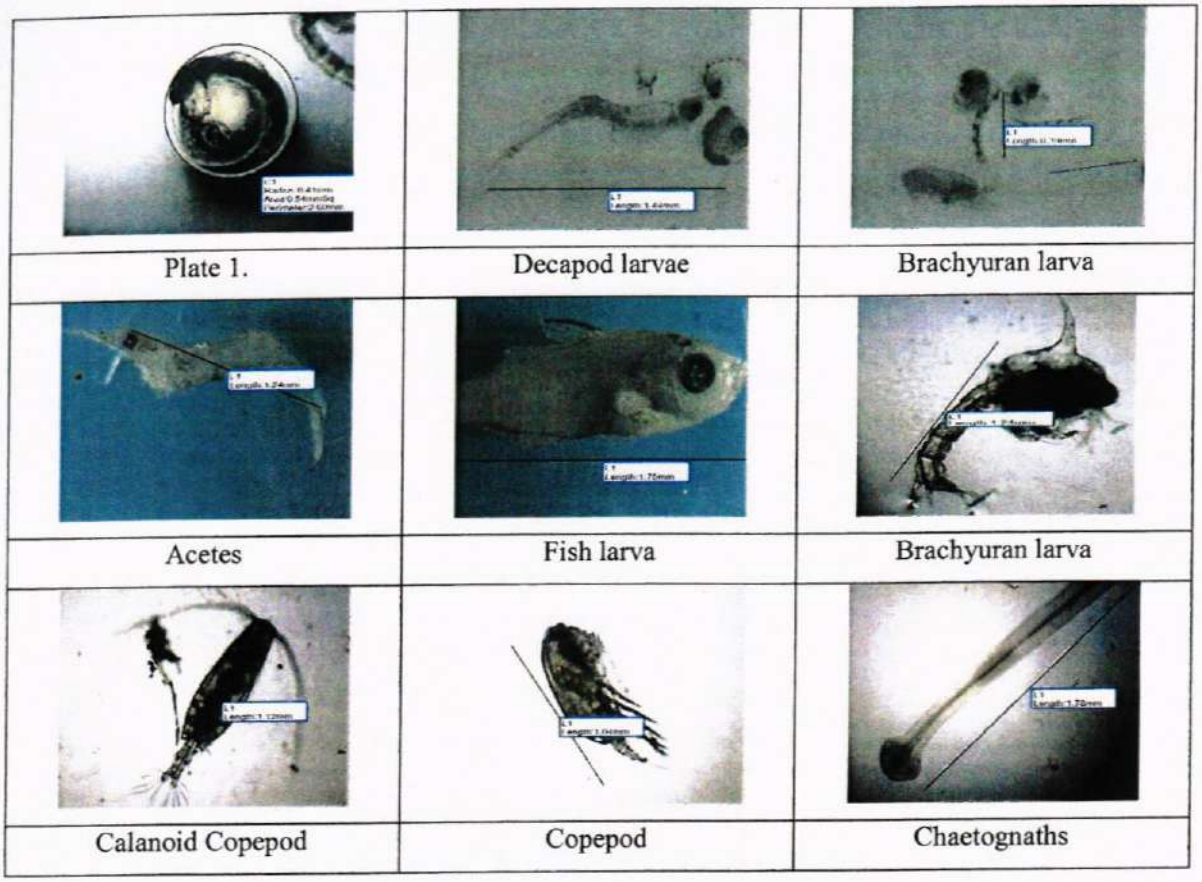

Fig. 19. Zooplankton in the study area

CONCLUDING REMARKS

- This mid-term report is purely based on the observation and survey made by ICAR-CMFRI for the last three months.
- The fishers were cooperative for the survey, how ever yet to respond to a request to provide location of set bag nets/stakes in the sea which is not available with any management bodies.
- During the survey we observed gillnet, bagnet (dol net), cast net and hook and line operation in and around the proposed project area.
- During the survey we didn't observed any brooder or spawner fishes in and around the proposed project area.
- The survey will continue till January.
- The socio- economic analysis is under process

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